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ENGINEERING, TECHNOLOGY AND MATERIALS

BIOTECHNOLOGICAL PRODUCTION OF *TRICHODERMA* BIOFUNGICIDE ON STARCH-RICH WASTEWATER

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ABSTRACT:

*In order to reduce the use of pesticides and protect plants with as little risk as possible, it is necessary to introduce biopesticide preparations. Usually, for the biotechnological production of microbial biofungicides, synthetic or semi-synthetic medium are mostly used. However, the price of the cultivation medium can significantly affect the cost of production so, it is necessary to find alternative medium. Accordingly, the goal of this research was to investigate the possibility of using starch-rich wastewater in the production of *Trichoderma* biofungicide. Wastewater obtained from the potato processing industry was used as a cultivation medium in this research. Different concentrations of wastewater were used as a medium for the cultivation of *Trichoderma harzianum* K179. Cultivation was carried out in Erlenmeyer flasks on a shaker at 170 rpm for 5 days. After 5 days of cultivation, the cultivation broth was tested in vitro against two phytopathogenic isolates, *Fusarium graminearum* and *Aspergillus flavus*, both isolated from infected maize cobs. The statistical analysis of the obtained in vitro results of the inhibition zones diameter showed that undiluted wastewater has the greatest potential as a medium for the production of *Trichoderma* biofungicide. After validation experiment in Woulff bottle on the undiluted wastewater media, the success of the bioprocess was confirmed. The maximum mean values of the inhibition zone diameter formed against isolates of *F. graminearum* and *A. flavus* were 54.33 mm and 31.33 mm, respectively. The obtained results are the basis for the continuation of research and further development and scale-up of this bioprocess.*

Keywords: *Trichoderma harzianum*, biotechnological production, wastewater utilization, biocontrol, maize disease

1. INTRODUCTION

In recent years, the issue of environmental protection has become one of the most important priorities of international politics. The sustainable management of industrial waste is an economic and ecological strategy for protection of natural resources and preservation of environmental quality [1]. Wastewater from the food industry represents a major polluter of the environment. Because potato processing wastewater contains high concentrations of biodegradable components in addition to high concentrations of

chemical oxygen demand (COD), total suspended solids (TSS) and total kjeldahl nitrogen (TKN), the potato processing industry presents potentially serious water pollution problems [2]. However, over the past years, biotechnological processes for obtaining market-valuable products have received a considerable attention for reuse of waste generated by the different industries [3]. In general, starch-rich wastewater contains a significant amount of carbohydrates, protein, nutrients and thus represents a potentially good medium for the cultivation of microorganisms [4].

Usually, for the biotechnological production of microbial biofungicides, synthetic or semi-synthetic medium are mostly used. However, the price of the cultivation medium can significantly affect the cost of production, which is why it is necessary to find alternative medium. Therefore, the cultivation of microorganisms on media containing native or enriched wastewater, with the aim of producing high-value products, has become increasingly important in recent years [5]. The biotechnological production of biopesticides is one of the priority productions from the aspect of environmental protection and the replacement of harmful synthetic preparations with new biological preparations. *T.harzianum* appears one of the most promising biocontrol agent. It can colonize roots and compete for space and nutrients with plant pathogenic fungi [6].

In this work, the potential of using starch-rich wastewater as a medium for the production of *T. harzianum* K179 biofungicide was investigated. Given that inadequate concentrations of a nutrient in the medium can lead to the inhibition of microorganisms by the substrate [7], within the first set of experiments, the potential of using different concentrations of starch-rich wastewater was examined. The wastewater selected after first set of experiment was used as a medium in a validation experiment, in a vessel with a volume 10 times larger. The aim of the second set, validation, was to confirm the efficiency and analyze the flow of *T. harzianum* K179 production bioprocess on the selected medium. The antagonistic effect of the produced biofungicide was tested against two phytopathogenic isolates, *F. graminearum* and *A. flavus*, both isolated from infected maize cobs. Maize is a cereal that is widely used in the world, which is why it is necessary to take measures to protect this plant from various phytopathogens [8]. In this regard, selected phytopathogens were isolated from infected maize cobs in the field, and the biocontrol potential of the obtained *T. harzianum* K179 biofungicide against selected phytopathogens was tested.

2. MATERIAL AND METHODS

2.1. Microorganisms

As a production microorganism, the soil isolate *Trichoderma harzianum* K179 [9] was used in this work. This microorganism is stored as a pure culture in the Microbial Culture Collection of the Institute of Field and Vegetable Crops, Novi Sad, Serbia.

Within the work, two phytopathogenic isolates, *Fusarium graminearum* and *Aspergillus flavus* were used as test microorganisms. Both fungi were isolated from maize cobs with typical symptoms of infection. Isolation of phytopathogenic fungi was performed

according to the method described in the study by Tančić Živanov et al. [10]. Microorganisms are stored at the PDA medium in the Microbial Culture Collection of Faculty of Technology Novi Sad, Serbia.

2.2. Inoculum preparation

Microorganisms used in this work were initially grown on PDA for seven days at 28°C. After seven days, a small amount of mycelium was transferred to a PDB (Potato Dextrose Broth) medium for propagation.

T. harzianum K179 inoculum was further used to inoculate ten experiments with a different concentration of wastewater in the medium, while inoculum of pathogenic fungi, *F. graminearum* and *A. flavus*, was filtered through double layer of sterile cheesecloth and used for *in vitro* analysis. The inoculums were prepared on a rotary shaker at 170 rpm for 72 h at 28°C [11].

2.3. Experiment

Water obtained from the waste stream of the potato processing industry was filtered through a triple layer of sterile cheesecloth and used as a medium for the production of *Trichoderma* biofungicide. The research was carried out as 10 individual experiments with different dilutions of the obtained starch-rich wastewater. The obtained wastewater was marked as 100% and it represented the medium for the first experiment. For the next nine experiments, diluted wastewater was used (% v/v): 90, 80, 70, 60, 50, 40, 30, 20, 10. Distilled water was used for dilution.

For each experiment, 150 ml of medium was prepared in Erlenmeyer flasks, which were sterilized at 121°C for 20 minutes and then, after cooling, inoculated with *T. harzianum* K179.

Cultivation was carried out on a shaker at 170 rpm for 120 h at 28°C. After 120 h of cultivation, the cultivation broth was tested *in vitro* against two phytopathogenic isolates, *F. graminearum* and *A. flavus*.

2.4. Validation experiment

Validation experiment was performed in Woulff bottle containing 1500 ml of selected media. Cultivation was carried out under aerobic conditions (air flow rate of 2 vvm) [12] and with additional external mixing on a shaker. Cultivation temperature was 28°C and the total time of cultivation was 120 h. Sampling of the cultivation liquid for the purpose of examining the course of the bioprocess was carried out every 12 hours.

2.5. In Vitro Testing

In order to examine the activity of the *T. harzianum* K179 cultivation broth on phytopathogenic isolates, *F. graminearum* and *A. flavus*, wells diffusion method was

applied [13]. Three wells with a diameter of 15 mm represented one treatment. To each well 100 µl of cultivation broth pre-filtered on two layers of sterile cheesecloth, was added. In control plates, 100 µl of sterile distilled water was added to wells. The formed inhibition zone diameters were measured after 7 days of incubation at 25°C.

2.6. Sample Analysis

For determination of *T. harzianum* K179 biomass, samples (10 ml) were centrifuged at 10000 g for 10 min at 22°C. The supernatants were discarded and the cell pellet re-suspended in an equal volume of distilled water and re-centrifuged as above. The biomass was dried at 105°C overnight and weighed. All determinations were performed in duplicate.

2.7. Data Analysis

The results obtained in this experiment were processed by one-way ANOVA using Software Statistica, version 13.0 (StatSoft Inc., USA). Duncan multiple range test was used to test significance of differences ($p \leq 0.05$) between mean values of measured diameter of inhibition zones.

3. RESULTS AND DISCUSSIONS

3.1. Experiment I - Erlenmayer Flasks

It is well known that microorganisms need an optimal amount of carbon sources in the medium for normal growth and reproduction [14], [15]. Very often, amounts smaller or larger than optimal can lead to a significant decrease in growth, reproduction, but also the synthesis of metabolites [16]. In accordance with the above, this research examined the possibility of producing *T. harzianum* K179 biofungicide on a medium with different concentrations of starch-rich wastewater. Since PDA (Potato Dextrose Agar) has become a commercial medium for fungal cultivation, the idea of replacing the commercial medium with an alternative medium led to the idea of using starch-rich wastewater as an alternative substitute.

After cultivation, which included 10 experiments with different concentrations of wastewater in the *T. harzianum* K179 cultivation medium, the antifungal activity of each cultivation medium was tested *in vitro* against two maize phytopathogens, *F. graminearum* and *A. flavus*, and the obtained results were processed statistically. The results showed that there is a statistically very significant difference in the influence of the medium on productivity and antagonistic activity of the *T. harzianum* K179 against *F. graminearum* and *A. flavus*.

In order to obtain more information about differences in the significance of medium concentration on the antagonistic activity of the produced *T. harzianum* K179 cultivation

broth, a more detailed post-hoc analysis was performed using Duncan's multiple range test. Tables 1 and 2 show the results of Duncan's multiple range test obtained for *F. graminearum* and *A. flavus*, respectively.

Table 1. Duncan test: Mean values of inhibition zone diameter formed around wells for isolate *F. graminearum*

WW concentration (% v/v)	Inhibition zone diameter - IZD (mm)
50	22.67 ^a
60	24.00 ^{ab}
10	24.67 ^{ab}
30	25.00 ^{abc}
40	26.33 ^{bcd}
20	27.67 ^{cd}
70	28.67 ^d
80	38.00 ^e
90	40.00 ^e
100	45.33^f

*Values in same column followed with the same letter are not significantly different at 0.05 level

The results of the Duncan test show that the smallest impact on the productivity of *T. harzianum* K179 biofungicide effective against *F. graminearum* has a wastewater concentration of 50% v/v (IZD=22,67 mm), while the undiluted wastewater medium has the most statistically significant effect and it is also at the highest level of statistical significance with IZD of 45,33 mm (lower case *f*).

Table 2. Duncan test: Mean values of inhibition zone diameter formed around wells for isolate *A. flavus*

WW concentration (% v/v)	Inhibition zone diameter - IZD (mm)
50	19.33 ^a
40	21.33 ^b
60	21.33 ^b
30	22.33 ^{bc}
10	23.00 ^{bcd}
70	23.67 ^{cde}
80	24.00 ^{cde}
90	24.33 ^{de}
20	25.00 ^e
100	26.67^f

*Values in same column followed with the same letter are not significantly different at 0.05 level

Similar results can be observed in the activity of produced *T. harzianum* K179 cultivation broths against phytopathogenic isolate *A. flavus*. Namely, at the highest level of statistical significance (lower case *f*), there is also wastewater medium which is not diluted. Using this medium, produced *T. harzianum* K179 cultivation broth forms the maximum mean value of inhibition zone diameter against *A. flavus* of 26.67 mm. If we compare the antagonistic activity of *T. harzianum* K179 cultivation broth against both phytopathogenic isolates, it can be observed that the isolate *F. graminearum* is significantly more sensitive than isolate *A. flavus*.

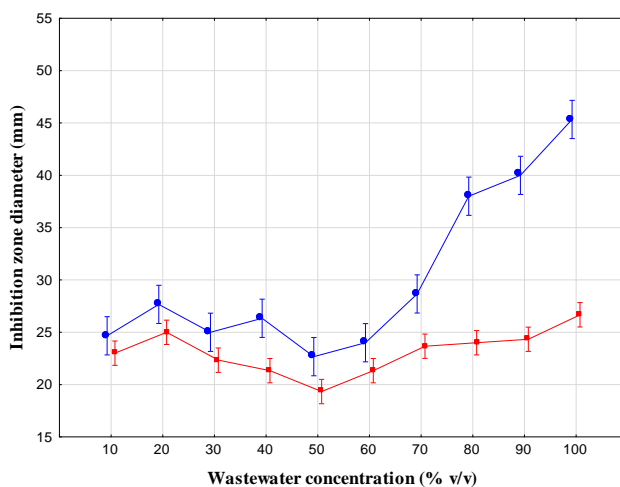


Fig. 1. Mean values of the inhibition zone diameters obtained by produced bioagent *T. harzianum* against (●) *F. graminearum* and (●) *A. flavus* on different wastewater concentration

On Figure 1 are shown mean values of the inhibition zone diameters obtained by produced biofungicide *T. harzianum* K179 against *F. graminearum* and *A. flavus* on different wastewater concentration medium. Using the MEGK-TSTA total starch assay kit for determining the content of total soluble starch in wastewater, it was determined that the wastewater used in the experiment contained 27.6 g/l of total soluble starch, which coincides with the research of Kumar Muniraj et al. [17]. Certainly, in accordance with the statement of Tadijan et al. [18], that each zone diameter greater than 22 mm shows that the applied agent has high activity, it can be conclude from Table 1 that each of the applied medium can potentially be adequate for the production of *T. harzianum* K179 biofungicide effective against *F. graminearum*. This is not the case with *A. flavus*, where three medium do not have the characteristics required for the production of *T. harzianum* K179 biofungicide (40%, 50% and 60% WW concentration).

According to the obtained results, it can be concluded that the best medium for the production of *T. harzianum* K179 biofungicide effective against both tested

phytopathogens is a medium that has not been diluted. This medium will be used in validation experiment in a 10 times larger volume, where the course of cultivation will be analyzed.

3.2. Experiment II - Woulff Bottle validation experiment

In order to examine the production of *T. harzianum* K179 biofungicide on the selected wastewater medium in a volume ten times larger than Erlenmeyer volume, experiment in the Woulff bottle was realized. In order to monitor the course of the bioprocess, sampling was performed every 12 h during five days. Figure 2 shows mean values of the inhibition zone diameters obtained by activity of produced biofungicide *T. harzianum* K179 against two phytopathogenic fungi, *F. graminearum* and *A. flavus* (Figure 2a), and produced biomass during 120 h of bioprocess (Figure 2b).

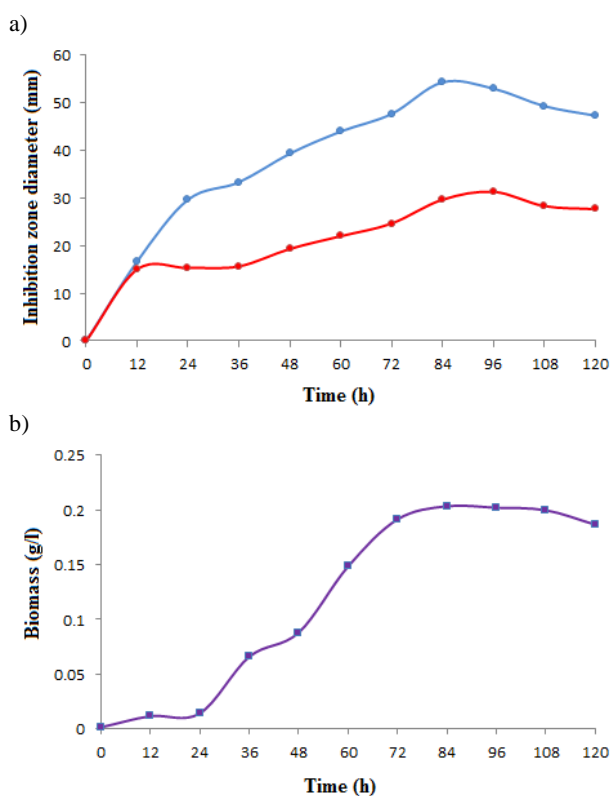


Fig. 2 Mean values of the inhibition zone diameters obtained by produced bioagent *T. harzianum* against (●) *F. graminearum*, (●) *A. flavus* (a) and produced biomass during 120 h of bioprocess (b)

From Figure 2a, it can be seen that the largest diameters of inhibition zones against isolate *F. graminearum* and *A. flavus* were formed between 3 and 4 days of cultivation. *F. graminearum* also showed that it is significantly more sensitive to the activity of *T. harzianum* K179 biofungicide, forming a maximum inhibition zone diameter of 54.33 mm in 84 h of cultivation. On the other hand, maximum activity of *T. harzianum* K179 cultivation broth against phytopathogenic isolate *A. flavus* was observed in 96 h of cultivation with an inhibition zone diameter of 31.33 mm.

The larger zones obtained in this bioprocess compared to the experiment with Erlenmeyer flasks are expected, given that the bioprocess conditions in the Woulff bottle are better controlled. This is also the reason why this bioprocess could be shortened from 120 h to 96 h, which also contributes to energy saving, and consequently to the reduction of the price of the final product [11]. So, it can be assumed that the aeration applied in the experiment with larger vessel volumes (Woulff bottle) contributes to a better production of *T. harzianum* K179 biofungicide. Figure 2b shows the growth of *T. harzianum* K179 cell biomass during 120 h of bioprocessing. It can be observed that the biomass growth is correlated with the tested antifungal activity, from which it can be concluded that the biomass of *T. harzianum* K179 is most responsible for antifungal activity.

Therefore, in order to improve the bioprocess of *T. harzianum* K179 biofungicide production on a medium with starch-rich wastewater, in the continuation of the research it would be necessary to carry out experiments in a bioreactor in order to optimize process conditions and improve the production procedure.

4. CONCLUSIONS

Many industries release wastewater that can be used as raw material in another industry. Through this research, we have shown that starch-rich wastewater can be successfully used as a medium in the cultivation of *T. harzianum* for the purpose of producing a high-value product, biofungicide. The use of alternative medium for the cultivation of microorganisms enables the reduction of the production cost, the reduction of the final product price, but also affects the protection of the environment. In addition, the use of biological instead of synthetic preparations in plant protection has a number of benefits for the environment and human health. Certainly, in order to commercialize such a preparation, it is necessary to carry out a lot of additional research, but certainly this research represents the first and significant step in a series of research.

ACKNOWLEDGMENT

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PROCJENA EKOTOKSIČNOSTI TEŠKIH METALA VODE RIJEKE BREGAVE I NJIHOV UTICAJ NA ZDRAVSTVENO STANJE ČOVJEKA

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SAŽETAK:

Ekotoksični metali, su metali koji su u svojoj rastvorenoj fazi "otrovni" za živi svijet. Toksičnost teških metala može smanjiti razinu energije i oštetiti funkcionisanje mozga, pluća, bubrega, jetre, sastava krvi i drugih važnih organa. Dugotrajno izlaganje može dovesti do postepenog napredovanja fizičkih, mišićnih i neuroloških degenerativnih procesa koji imitiraju bolesti poput multiple skleroze, Parkinsonove bolesti, Alzheimerove bolesti i mišićne distrofije. Uzastopno i dugotrajno izlaganje nekim metalima i njihovim spojevima može čak uzrokovati i rak. Čak i ako nemaju nikakvu biološku funkciju, toksični učinci tih metala, ostaju u nekim drugim oblicima koji su štetni za ljudsko tijelo i njegovo ispravno funkcionisanje.

U radu su analizirane koncentracije ekotoksičnih metala vode rijeke Bregave u gradu Stocu, i to u četiri različita godišnja doba kada je vodostaj rijeke različit. Dobiveni rezultati su poređeni sa MDK vrijednostima i doneseni su odgovarajući zaključci.

Ključne riječi: ekotoksičan, otrov, bolest, koncentracija, zdravlje

1. UVOD

Metali su važan faktor u vodenom sistemu, jer u mnogim slučajevima o njima ovisi i bioraznolikost vodenog ekosistema [1]. Osim održanja života, tragovi metala sudjeluju u nizu drugih procesa unutar vodenog sistema (npr. kada su cink i bakar u vodenom sistemu prisutni u tragovima, vrlo su važan faktor u fiziološkom funkcionisanju živih organizama, te regulišu mnoge biohemijske procese) [2]. Međutim, isti metali, ako su prisutni u povećanim koncentracijama mogu imati različite toksične efekte na živa bića unutar vodenog ekosistema, a time posredno i na čovjeka [3]. Neki metali kao što su živa, kadmij i olovo toksični su već kod vrlo niskih koncentracija [4]. Zagađenje voda ekotoksičnim metalima uslijed ljudskih aktivnosti (transport, poljoprivrede, industrija, komunalne otpadne vode...) postaje ozbiljan ekološki problem, jer metali nisu biorazgradivi te jednom uneseni u okoliš postaju trajno njegov dio. Tako su koncentracije ekotoksičnih metala vrlo bitan parametar u ocjeni stanja kvaliteta prirodnih voda, a granične vrijednosti za koncentraciju ekotoksičnih metala su navedene u tabeli 1.

2. EKOTOKSIČNOST TEŠKIH METALA I NJIHOV UTICAJ NA ZDRAVLJE ČOVJEKA

Da bi mogli utvrditi antropogeni uticaj na neki riječni vodeni sistem moramo znati njen prirodni sastav od izvora do ušća. Prateći literaturu, svjedoci smo da se zadnjih tridesetak godina objavljene koncentracije tragova metalu u prirodnim vodam smanjuju. Tome nažalost nije razlog to da vode postaju čistije nego smo s razvojem instrumenata i analitike u stanju izmjeriti sve niže koncentracije tragova metala [5].

Onečišćenje vodenih ekosistema teškim metalima uzrokuje različite štete u organizmima, na razini populacije okoliša, te bioraznolikosti [6]. Rezultati brojnih studija potvrđuju konstantno obogaćivanje sedimenta metalima kao posljedica povećanih emisija metala iz antropogenih izvora [7]. Zbog visoke rastvorljivosti u vodenom okolišu, mogu se apsorbirati u živim organizmima. Također, na akumulaciju i rastvorljivost metala u vodenim sredinama znatno utiče razina pH, salinitet i temperatura vode [8]. Kada vodeni organizmi akumuliraju teške metale, oni se mogu prenijeti kroz gornje klase prehrambenog lanca. Mesožderi na vrhu hranidbenog lanca, uključujući čovjeka, dobivaju većinu svog teškog metalnog tereta iz vodenog ekosistema putem njihove hrane, posebno gdje su prisutne ribe, tako da postoji potencijal za znatnu biomagnifikaciju [9].

Treba istaknuti da su neki metali u malim koncentracijama neophodni, kako za vodene organizme tako i za čovjeka, međutim, u suvišku su vrlo otrovni. Neki od njih, poput željeza, cinka, nikla, mangana, hroma, bakra i kobalta, esencijalni su za pravilno funkcionisanje organizma, stoga njihov nedostatak može biti štetan, ali isto tako, štetna je i visoka koncentracija tih elemenata u organizmu [10]. U neesencijalne se ubrajaju živa, olovo, kadmij, arsen i kalaj koji nemaju poznatu funkciju u organizmu, a izrazito su toksični te mogu biti štetni po zdravlje čovjeka [11]. Njihovi štetni učinci ovise o unesenoj koncentraciji, oksidacijskom stanju i hemijskom obliku [12].

Granične vrijednosti koncentracija teških metala u površinskim vodama regulisane su „Odlukom o kategorizaciji površinskih voda, sl. Novine FBiH 01/14“ [13].

Tabela 1. Vrijednosti parametara za ocjenu ekološkog stanja vodenih tijela (ekotoksični metali) površinskih voda i njihov uticaj na zdravlje čovjeka [14]

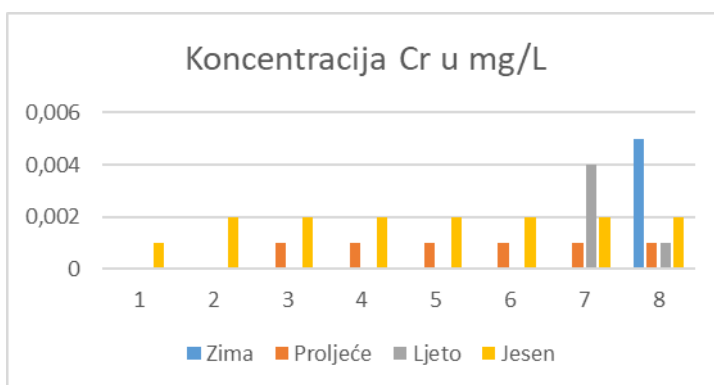
Teški metali	MDK	Granične vrijednosti površinske vode	Ciljni organ	Klinički učinci
Arsen (As)	50 µg/L	0,1 mg/L	Pluća i živčani sistem, koža	Perforacija nazalnog septuma, rak dišnog sistema neuropatija, dermaomi, koća, rak
Olovo (Pb)	10 µg/L	0,5 mg/L	Živčani sistem, hematopoetski sistem, bubrezi	Encefalopatija, periferna neuropatija, središnji živčani sistem, anemija
Hrom (Cr)	50 µg/L	0,5-2,0 mg/L	Plućni	Ulkus, perforacija nazalnog septuma, rak dišnog sistema
Nikal (Ni)	20 µg/L	0,5 mg/L	Plućni koža	Rak dermatitis
Bakar (Cu)	2 mg/L	0,5 -1,0 mg/L	Bubrezi, živčani sistem	Wilsonova bolest
Željezo (Fe)	200 µg/L	200 µg/L	Kardiovaskularni i imunološki sistem, koža	Alzheimerova bolest, anemija
Mangan (Mn)	50 µg/L	2 mg/L	Živčani sistem	Središnja i periferna neuropatija
Živa (Hg)	1µg/L	0,001 mg/L	Živčani sistem, bubrezi	Proteinurija

U nastavku teksta opisane su osnovne toksikološke osobine teških metala koji su pronađeni u analiziranim uzorcima vode rijeke Bregave, idući od izvora rijeke i to u četiri različita godišnja doba, kada je vodostaj rijeke različit. Također, dat je slikoviti prikaz koliko dobivene eksperimentalne vrijednosti odstupaju od MDK za površinske vode, na osnovu čega se procjenjuje da li će analizirani teški metal imati toksikološki uticaj za čovjeka.

2.1. Hrom

Hrom je kancerogen, mutagen i teratogen [15]. Toksičnost usljed ekspozicije hromu u različitim medijima (vazduh, voda i sediment), generalno je povezana sa sadržajem Cr (VI), koji je poznat po svom negativnom uticaju na zdravlje i životnu sredinu te ekstremnoj toksičnosti (1000 puta je toksičniji od trovalentnog hroma) [16].

Mehanizam toksičnosti zavisi od pH vrijednosti. Unutar ćelije, Cr (VI) se redukuje do Cr (III) koji dalje gradi komplekse sa intracelularnim makromolekulima, uključujući genetski materijal i na kraju je odgovoran za toksični i mutageni kapacitet hroma. Zdravstveni efekti povezani s izlaganjem heksavalentnom hromu uključuju dijareju, želučana i crijevna krvarenja, grčeve i oštećenje jetre i bubrega. Heksavalentni hrom jak je oksidans. Otapanjem nastaje hromova kiselina koja nagrizava organe. Može uzrokovati grčeve i paralizu. Smrtonosna doza je otprilike 1-2 g. Većina zemalja primjenjuje zakonsko ograničenje od 50 ppb hroma u vodi za piće.



Slika 1. Koncentracija hroma u uzorcima analizirane vode na odabranim lokalitetima u četiri različita godišnja doba

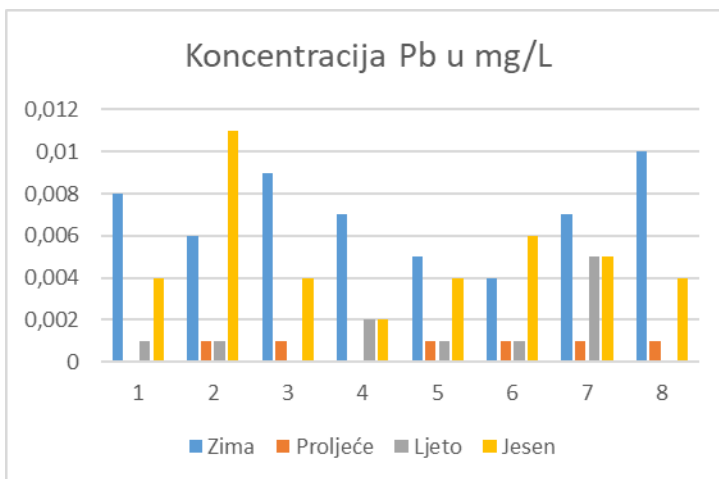
Na slici 1. se vidi da su ukupne koncentracije hroma u vodi rijeke Bregave, na svim lokalitetima i svim godišnjim dobima, daleko ispod MDK vrijednosti za ovaj metal u površinskim vodama (ispod 0,5 mg/L). Eksperimentalne vrijednosti za koncentraciju ovog metala govore nam da hrom, prema Graničnim vrijednostima za koncentraciju teških

metala u površinskim vodama [14], nema nikakav negativan toksikološki učinak na vodeni sistem rijeke Bregave, živi svijet u samoj rijeci, a samim tim ni na čovjeka.

2.2. Olovo

Kada je u pitanju ekotoksični metal olovo, isti je toksičan za sve organizme. Generalno posmatrano, organoolovna jedinjenja toksičnija su od neorganskih olovnih komponenti, a mladi, nezreli organizmi su osjetljiviji na efekte olova. Predstavlja sistematičan otrov, što znači da jednom kad je apsorbovan unutar cirkulacionog sistema prenosi se kroz čitavo tijelo, ozbiljno narušavajući zdravlje čovjeka.

Predstavlja kumulativni otrov za ljude, akutno trovanje je ekstremno rijetko, tipični simptomi povećanog trovanja olovom su opstipacija, anemija, gastrointestinalne smetnje, osjetljivost i postepena paraliza mišića, posebno ruku sa mogućim slučajevima letargije i mrzovoljnosti. Glavni efekat kod ljudi je smanjenje sinteze hemoglobina i porfirina.



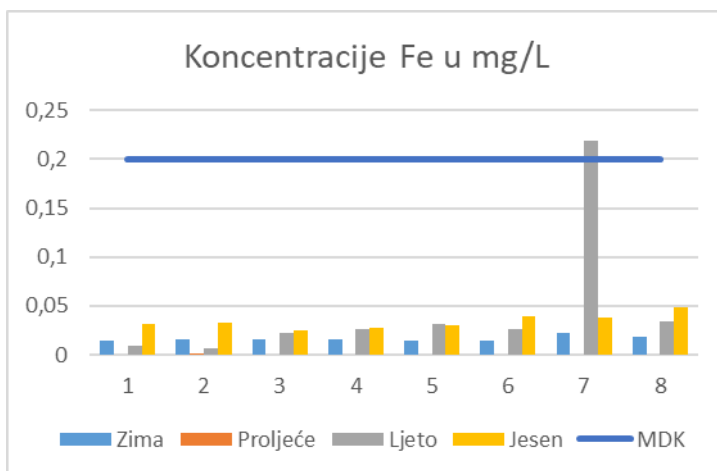
Slika 2. Koncentracija olova u uzorcima analizirane vode na odabranim lokalitetima u četiri različita godišnja doba

Na slici 2. se vidi da su ukupne koncentracije olova u vodi rijeke Bregave, na svim lokalitetima i svim godišnjim dobima, daleko ispod MDK vrijednosti za ovaj metal u površinskim vodama (ispod 0,5 mg/L). Eksperimentalne vrijednosti za koncentraciju ovog metala nam govore da olovo u vodi rijeke Bregave, prema Graničnim vrijednostima za koncentraciju teških metala u površinskim vodama [14], nema nikakav negativan toksikološki učinak na vodeni sistem i živi svijet u samoj rijeci, a samim tim ni na čovjeka.

2.3. Željezo

Željezo je esencijalni element široko rasprostranjen na zemlji. Ima važnu ulogu kao konstituent citohroma i katalaza, kao i proteina odgovornih za prenos kisika (hemoglobina

i mioglobina). Međutim, i pored vitalnog značaja koji ima za većinu živih organizama, željezo je potencijalno štetno pri visokim koncentracijama. Uticaj željeza na vodene organizme i njihova staništa uglavnom je indirektan.



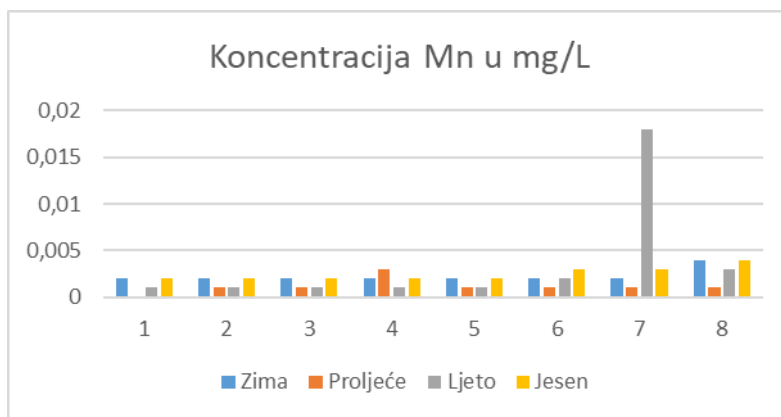
Slika 3. Koncentracija željeza u uzorcima analizirane vode na odabranim lokalitetima u četiri različita godišnja doba

Na slici 3. se može vidjeti da eksperimentalne vrijednosti za koncentraciju željeza u vodi rijeke Bregave pokazuju da samo u ljetnom periodu, i to na lokalitetu broj 7., imamo povećanu koncentraciju željeza, odnosno koncentraciju iznad MDK vrijednosti, prema Graničnim vrijednostima za koncentraciju teških metala u površinskim vodama [14]. Razlog povećane koncentracije posljedica je antropogenog učinka, budući da na mjesto uzimanja uzoraka broj 7. dolazi sva gradska kanalizacija, otpad iz septičkih jama, štala, ugostiteljskih objekata. Dugotrajna ekspozicija ovoj koncentraciji može imati negativan učinak na vodeni sistem rijeke Bregave, akvatičnu floru i faunu, a samim tim i na čovjeka, jer čovjek većinu teškog metalnog tereta iz vodenog ekosistema dobiva putem hrane (riba iz rijeke).

2.4. Mangan

Mangan je tek u posljednje vrijeme postao predmet zabrinutosti sa aspekta zaštite životne sredine [17]. Mangan je esencijalan element za sve oblike života, a u tijelu riba se akumulira primarno preko ishrane. Međutim, do sada još niko nije ukazao na štetne efekte kod riba povezane sa njihovom ekspozicijom manganu preko ishrane. Akutna toksičnost mangana na životinjama ispoljava se prije svega na nervnom sistemu odnosno, mangan djeluje kao neurotoksin ometajući neurotransmisiju i utičući na nivo enzima u mozgu.

Na slici 4. se vidi da su koncentracije rastvorenog mangana u vodi rijeke Bregave, na svim lokalitetima i svim godišnjim dobima, daleko ispod MDK vrijednosti za ovaj teški metal u površinskim vodama (ispod 2 mg/L) [14]. Eksperimentalne vrijednosti za koncentraciju ovog metala govore nam da isti, prema Graničnim vrijednostima za koncentraciju teških metala u površinskim vodama [14], nema nikakav negativan toksikološki učinak na vodeni sistem rijeke Bregave, živi svijet u samoj rijeci, a samim tim ni na čovjeka.



Slika 4. Koncentracija mangana u uzorcima analizirane vode na odabranim lokalitetima u četiri različita godišnja doba

3. ZAKLJUČAK

Na osnovu rezultata istraživanja došlo se do sljedećih zaključaka:

- Dobiveni rezultati ukupnih koncentracija teških metala potvrđuju da su sadržaji metala uzorkovani u zimu i proljeće relativno niži u odnosu na vrijednosti tokom jesenjeg i ljetnog perioda, što je posljedica klimatskog uticaja.
- Cr, Pb, i Mn su teški metali čije dobivene koncentracije ne odstupaju od MDK za površinske vode, i procjenjuje se da isti nemaju nikakav negativni toksikološki uticaj na vodeni sistem rijeke Bregave, živi svijet u samoj rijeci, a samim tim ni na čovjeka.
- Koncentracija željeza u ljetnom periodu, nakon ulijevanja kanalizacionih voda, je iznad MDK za površinske vode. Dugotrajna ekspozicija ovoj koncentraciji može imati negativan učinak na vodeni sistem rijeke Bregave, akvatičnu floru i faunu, a samim tim i na čovjeka.

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ASSESSMENT ECOTOXICITY OF THE HEAVY METALS IN THE WATER OF THE BREGAVA RIVER AND THEIR IMPACT ON HUMAN HEALTH

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ABSTRACT:

Ecotoxic metals are metals that in their dissolved phase are "poisonous" to living world. The toxicity of heavy metals can reduce energy levels and damage the functioning of the brain, lungs, kidneys, liver, blood composition and other important organs. Long-term exposure can lead to gradual progression of physical, muscular and neurological degenerative processes that cause diseases like multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy. Repeated and long-term exposure to some metals and their compounds can even cause cancer. Even if they do not have any biological function, the toxic effects of these metals remain in some other forms that are harmful to the human body and its proper functioning.

In this paper analyzed the concentrations of ecotoxic metals in the water of the Bregava River in the city of Stolac, in four different seasons when the water level is different. The obtained results were compared with the MDK values and appropriate conclusions were reached.

Keywords: *ecotoxic, poison, disease, concentration, health*

ZNAČAJ VIZUELNOG PREGLEDA U OKVIRU VERIFIKACIJE KVALITETA NISKONAPONSKIH ELEKTRIČNIH INSTALACIJA – DEO 1 – PREVENTIVNA ZAŠTITA OD POŽARA

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SAŽETAK:

U radu je objašnjen značaj kvalitetno izvršenog vizuelnog pregleda niskonaponskih električnih instalacija koji se radi u okviru periodične verifikacije kvaliteta električnih instalacija. U zavisnosti od vrste opasnosti, primećene neregularnosti uočene vizuelnim pregledom mogu da se razvrstaju u dve kategorije: neregularnosti koje mogu da izazovu požar i neregularnosti koje mogu da izazovu električni udar. U radu su navedene najčešće neregularnosti koje mogu da izazovu požar sa kojima se tim stručnjaka Elektrotehničkog fakulteta Univerziteta u Beogradu susretao prilikom vršenja periodične verifikacije kvaliteta niskonaponskih električnih instalacija u javnim, poslovnim i industrijskim objektima u periodu 2012–2023. godine. U radu je predstavljena i ček-lista koja se može koristiti za preventivne vizuelne preglede kako bi se na vreme uočile opasnosti koje mogu da izazovu požar.

Ključne reči: niskonaponske električne instalacije, verifikacija kvaliteta, vizuelni pregled, požar

1. UVOD

Kvarovi na niskonaponskim električnim instalacijama mogu da budu uzrok početnog požara. Statistički podaci pokazuju da npr. u Sjedinjenim Američkim Državama (SAD), gde se zaštiti od požara posvećuje velika pažnja, električni kvarovi na instalacijama i prijemnicima električne energije izazovu prosečno godišnje 46.700 registrovanih požara u domaćinstvima, prosečno pogine 390 građana i da prosečna materijalna šteta nastala u tim požarima prevazilazi milijardu i po dolara [1]. U periodu 2010–2020. godine statistički podaci za Evropsku uniju pokazuju da su kvarovi na električnim instalacijama uzrokovali 25–30% ukupnog broja požara, i da se u tom periodu broj požara uzrokovanih kvarovima na električnim instalacijama povećao za 5–10% [2]. Upravo iz bezbednosnih razloga za svaki građevinski objekat, pre nego što dobije upotrebnu dozvolu, postoji zakonska obaveza da se u okviru tehničkog prijema objekta izvrši početna verifikacija kvaliteta izvedenih niskonaponskih električnih instalacija. Standard [3] određuje zahteve koji se odnose i na početnu i na periodične verifikacije kvaliteta niskonaponskih električnih instalacija. Verifikacija kvaliteta podrazumeva da se prema standardu [3] izvrše odgovarajuća ispitivanja električnim merenjima i obavezan vizuelni pregled izvedenih

električnih instalacija. Ispitivanje električnih instalacija električnim merenjem podrazumeva sledeće provere:

- provera neprekidnosti zaštitnih provodnika,
- merenje otpornosti izolacije električne instalacije,
- provera efikasnosti sistema zaštita automatskim prekidanjem napajanja (merenjem otpornosti petlje kvara),
- ispitivanje zaštitnog uređaja diferencijalne struje (ZUDS-a, odnosno FID sklopke ili eng. Residual Current Device (RCD)), ...

Vizuelnim pregledom treba da se utvrde vidljiva oštećena na električnoj instalaciji koja bi mogla da ugroze bezbednost korisnika objekta u slučaju nastanka požara, ili nastanka opasnih situacija koje mogu da izazovu električni udar. Prema standardu [3] vizuelnim pregledom se vrše sledeće provere:

- prisustvo protivpožarnih pregrada i ostalih mera predostrožnosti za sprečavanje brzog širenja požara,
- izbor provodnika prema maksimalnoj trajno dozvoljenoj struji,
- prisustvo i ispravnost položaja odgovarajućih uređaja za rastavljanje i rasklapanje,
- izbor opreme i zaštitnih mera u zavisnosti od spoljašnjih uticaja,
- identifikacija neutralnih i zaštitnih provodnika,
- prisustvo jednopolnih šema,
- identifikacija strujnih kola i uređaja za zaštitu od prekomernih struja, izbor prekidača,
- prisustvo zaštitnih provodnika, uključujući i provodnike glavnog i dopunskog izjednačenja potencijala,
- pristupačnost opremi (razvodnim ormanima, glavnim prekidačima i sl.)...

Važno je naglasiti da se vizuelni pregled prilikom početne (inicijalne) verifikacije električnih instalacija uobičajeno vrši u njihovom beznaponskom stanju, a da prilikom vršenja periodične verifikacije one treba da budu pod naponom. Takođe, velika razlika je i u tome što se prilikom periodične verifikacije vizuelni pregled može proširiti i na priključene potrošače električne energije (prijemnike) što ne može biti slučaj prilikom vršenja početne verifikacije (nov građevinski objekat). Svakako treba imati na umu da kada objekat dobije upotrebnu dozvolu svako ko je korisnik prostora u objektu uvek treba da bude svestan opasnosti koje mogu prouzrokovati kvarovi na električnim instalacijama i da bude sposoban da primeti efekte pojave kvara na njima, čime praktično neprekidno (čak i nesvesno) vrši njihov vizuelni pregled. Na primer – najopasniji kvarovi koji se ne mogu detektovati klasičnim zaštitnim komponentama, loš električni kontakt [4] i redni električni luk [5], predstavljaju najčešće uzročnike požara izazvanih kvarovima na električnim instalacijama, a jedino ih korisnik objekta, koji se zatekao u objektu u trenutku razvoja tih kvarova, može detektovati čulom vida, sluha ili mirisa. U zavisnosti od vrste

opasnosti, otkrivene neregularnosti uočene vizuelnim pregledom mogu da se razvrstaju u dve kategorije: neregularnosti koje mogu da izazovu požar i neregularnosti koje mogu da izazovu električni udar. U ovom radu pažnja će biti usmerena na neregularnosti koje predstavljaju opasnost od nastanka početnog požara, dok će neregularnosti koje mogu da izazovu električni udar biti predstavljene u drugom radu [6].

U poglavlju 2 rada predstavljene su najčešće neregularnosti iz kategorije koje predstavljaju opasnost od nastanka požara sa kojima se tim stručnjaka Elektrotehničkog fakulteta Univerziteta u Beogradu susretao prilikom vršenja periodičnih verifikacija kvaliteta niskonaponskih električnih instalacija u javnim, poslovnim i industrijskim objektima u periodu 2012–2023. godine. Za većinu od njih obaveza utvrđivanja vizuelnim pregledom nije eksplicitno navedena u standardu [3], a svakako predstavljaju značajnu opasnost sa aspekta potencijalnog izazivanja požara. U poglavlju 3 rada predstavljena je ček-lista koja se može koristiti za preventivne vizuelne preglede kako bi se na vreme uočile neregularnosti koje predstavljaju opasnost od nastanka požara, razvijena i formirana na osnovu dugogodišnjeg iskustva vršenja verifikacije kvaliteta na terenu. Ona predstavlja značajno proširenje broja provera koje treba izvršiti u odnosu na one navedene u standardu [3], a koje se odnose na preventivnu zaštitu od požara. Na kraju rada rezimirano je kako se kvalitetnim vizuelnim pregledom, uočenim i otklonjenim neregularnostima nivo zaštite od požara podiže na viši nivo.

2. PRAKTIČNA ISKUSTVA STEČENA VRŠENJEM VIZUELNOG PREGLEDA

Za vreme vršenja periodičnih verifikacija kvaliteta niskonaponskih električnih instalacija u javnim, poslovnim i industrijskim objektima u periodu 2012–2023. godine u najvećem broju slučajeva vizuelnim pregledom nailaženo je na slične neregularnosti. Uočene neregularnosti mogle su da se grupišu u dve kategorije prema tome da li one predstavljaju opasnost od požara ili od električnog udara. Važno je napomenuti da nakon početne verifikacije velika većina električnih instalacija više nikada ne bude podvrgnuta ispitivanjima, što se posebno odnosi na stambene objekte u kojima su stanari praktično jedini verifikatori stanja električnih instalacija na osnovu vizuelnog pregleda. Električne instalacije vremenom postaju sve podložnije nastanku kvarova koji predstavljaju jedan od najčešćih uzroka požara. Razvoj uslova za nastanak kvara dešava se usled normalnog ili ubrzanog starenja izolacije (ako je ona izložena nepovoljnim ambijentalnim uslovima – povećanoj temperaturi, vlazi, koroziji itd.), usled mikrometarskih pomeraja na mestima električnih spojeva provodnika sa stezaljkama, kao i usled mehaničke i električne „ishabanosti“ komponenti električnih instalacija (zbog raznih mehaničkih pritisaka na provodnike električnih instalacija, električne preopterećenosti provodnika itd.). Važno je naglasiti značaj vizuelnog pregleda niskonaponskih električnih instalacija, posebno prilikom vršenja periodičnih verifikacija, kada se očekuje da su usled dužeg korišćenja nastale razne neregularnosti na njihovim elementima. Najveća pažnja vizuelnom pregledu električnih instalacija poklanja se u SAD-u, gde na tržištu rada i usluga postoji mnoštvo servisnih organizacija koje mogu biti angažovane da vizuelno provere nedostatke na električnim instalacijama, uz obavezu da ih odmah i otklone [7].

Ilustracija najčešće uočenih neregularnosti (iz kategorije opasnosti od požara) koje su uočene prilikom vizuelnih pregleda niskonaponskih električnih instalacija u zgradama u kojima su izvršene njihove verifikacije data je u Tabeli 1.

Tabela 1. Najčešće neregularnosti na niskonaponskim električnim instalacijama koje mogu da izazovu požar, primećene vizuelnim pregledima

Fotografija primećene neregularnosti vizuelnim pregledom (ilustrativni primeri)	Opis problema
	<p>Prisustvo „licnovanih“ umetaka osigurača u razvodnim tablama i ormanima može da omogući preopterećenje strujnog kola koje će izazvati degradaciju PVC izolacije, a u kasnijoj fazi i početni požar [8]</p>
	<p>Pregrejane monofazne i trofazne utičnice na koje su priključeni prijemnici velike snage (na primer, TA peći) kao posledica lošeg električnog kontakta [9,10]</p>
	<p>Nastavljanje napojnih kablova prijemnika (posebno ukoliko se radi o napojnim kablovima prijemnika velikih nazivnih snaga) potencijalno može dovesti do pojave lošeg električnog kontakta i početnog požara [9,10]</p>
	<p>Termički oštećeni produžni kablovi ukazuju na potencijalni loš kontakt koji je nastao između „bananice“ utikača i „gnězda“ utičnice što može da izazove početni požar [9,10]</p>
	<p>Nedozvoljeno povezivanje klima uređaja na mrežu preko produžnog kabla (koji, uz to, može da bude nesertifikovan ili da trpi konstantnu mehaničku silu ako visi u vazduhu) iako proizvođač uređaja u uputstvu za upotrebu naglašava da se isključivo priključuje direktno na mrežu</p>

	<p>Upotreba dotrajalih ili oštećenih električnih rešoa, ispod kojih se, kao dodatna nepovoljna okolnost, ne nalazi nezapaljiva podloga (po pravilu ispod rešoa je potrebno postaviti keramičku ploču)</p>
	<p>Nepropisno izvedeni delovi električnih instalacija najčešće mogu na potencijalno loše izvedenim električnim vezama (kontaktima) da izazovu početni požar [9,10] ili da se usled instalacije provodnika smanjenog poprečnog preseka desi preopterećenje strujnog kola</p>
	<p>Razvodni ormani izrađeni od zapaljivog materijala – drveta, iako važeći tehnički propisi zahtevaju da razvodni ormani budu izrađeni od metala – dva puta dekapiranog lima</p>
	<p>Termičko oštećenje PVC izolacije faznog provodnika usled porasta temperature na lošem električnom kontaktu (redna klema) [9,10]</p>

3. ČEK-LISTA ZA VRŠENJE VIZUELNOG PREGLEDA U CILJU OTKRIVANJA NEREGULARNOSTI OPASNIH ZA NASTANAK POŽARA

Na osnovu iskustva stečenog na terenu prilikom vršenja verifikacije kvaliteta niskonaponskih električnih instalacija u brojnim objektima različite namene sastavljena je ček-lista (predstavljena Tabelom 2) koja budućim verifikatorima skreće pažnju na važnost vizuelnog pregleda i čijim korišćenjem je omogućeno da se izvrši kvalitetan vizuelni pregled kojim može blagovremeno da se spreči požar u objektu korisnika. Treba napomenuti da ova ček-lista uključuje i provere koje se vrše na prijemnicima električne energije i na produžnim kablovima koji nisu deo fiksne ugrađene električne instalacije. Najveći broj navedenih neregularnosti u predstavljenoj ček-listi ne mogu se detektovati električnim merenjima koja takođe predstavljaju obavezni deo verifikacije kvaliteta električnih instalacija. Zanimljivo je da veći deo vizuelnih provera prema predstavljenoj

ček-listi može da izvrši i sam korisnik objekta (osoba koja je formalno nekvalifikovana za oblast električnih instalacija) bez opasnosti da dođe do njegove povrede.

Tabela 2. Ček-lista za preventivni vizuelni pregled niskonaponskih električnih instalacija u zgradama (kategorija: neregularnosti koje predstavljaju opasnost od nastanka požara)

Provere vizuelnim pregledom (opasnost od požara)	Opasnost postoji Da/Ne
Provera mogućnosti nesmetanog pristupa razvodnom ormanu ili tabli. Napomena: ukoliko dođe do požara neophodno je isključiti deo električne instalacije koji je pod naponom, što može da bude otežano i sporo ukoliko je nemoguće fizički pristup razvodnom ormanu.	
Provera da li su neki delovi razvodnog ormana ili table izrađeni nepropisno (npr. od zapaljivog materijala – drveni razvodni orman).	
Provera prisustva prljavštine (paučine, prašine, insekata, otpadnog materijala itd.) u razvodnom ormanu. Napomena: nakupljanje nečistoća pogoduje razvoju visokih temperature na potencijalnom lošem električnom kontaktu – laboratorijski dokazano [11].	
Provera da li postoji mehaničko ili termičko oštećenje električne izolacije provodnika u razvodnom ormanu ili na razvodnoj tabli.	
Provera da li postoje licnovani umeci topljivih osigurača (najčešće u slučajevima kada nedostaje signalna pločica na licnovanom topljivom umetku). Napomena: Licnovanjem topljivih umetaka se potencijalno omogućava strujno propterećenje koje može da dovede do požara.	
Provera da li postoje mehanička ili termička oštećenja električnih komponenti u razvodnom ormanu ili tabli: kućišta ili kapa niskoučinskih osigurača, noževa ili postolja visokoučinskih osigurača, automatskih prekidača, prekidača, bimetalnih zaštitnih relea, stezaljki, itd. Napomena: Posebnu pažnju obratiti ako se primete istopljeni ili ugljenisani delovi električnih komponenti.	
Provera zategnutosti kapa topljivih osigurača.	
Provera da li postoje mehanička ili termička oštećenja produžnog kabla.	
Provera kvaliteta konstrukcije produžnog kabla (debljina napojnog kabla).	

Provera kvaliteta konstrukcije produžnog kabla (tvrdoća plastičnog kućišta i njegova težina, kao i ispravnost prekidača (ukoliko postoji)).	
Dodirom proveriti zagrevanje kućišta opterećenog produžnog kabla.	
Laganim povlačenjem napojnog voda produžnog kabla proveriti čvrstoću spojeva njegovih žila sa ožičenjem unutar kućišta produžnog kabla.	
Provera postojanja termičkih oštećenja napojnog kabla prijemnika (istopljeni ili ugljenisani delovi kabla ili njegovog šuko-utikača).	
Provera da li su prijemnici veće snage (klima-uređaji, TA peći, grejalice, rešoi, električni radijatori) priključeni preko produžnih kablova (ukoliko jesu, o tome treba odmah obavestiti odgovornu osobu korisnika zgrade). Napomena: Proizvođači snažnih potrošača u uputstvu za upotrebu naglašavaju da ovakvi potrošači moraju da se priključuju direktno na šuko-utičnicu.	
Provera da li postoje uslovi za pregrevanje provodnika usled lošeg odvođenja toplote (namotani provodnik (klupko), napojni kablovi prekriveni toplotno izolacionim materijalom).	
Provera da li je električni rešo direktno položen na zapaljivu podlogu. Napomena: Preporuka je da se ispod rešoa umeću keramičke ploče.	
Dodirom proveriti čvrstoću spoja između utikača na napojnom kablju prijemnika i utičnice, a ako se radi o prijemniku veće snage (snage preko 1 kW) i zagrevanje tih spojeva.	
Dodirom proveriti da li dolazi do pregrevanja utikača na napojnom kablju prijemnika, naročito ukoliko se radi o termičkim prijemnicima veće snage (TA peć, električni radijator, grejalica, šporet...).	

4. ZAKLJUČAK

U radu je ukazana neophodnost za izvođenjem detaljnih periodičnih vizuelnih pregleda niskonaponske električne instalacije kao preventive od nastanka početnog požara. Dati su primeri najčešćih opasnih situacija iz iskustava koja su autori rada stekli verifikacijama kvaliteta električnih instalacija u javnim, poslovnim i industrijskim objektima. Usled nekompletnosti regulative u ovoj oblasti predložena je ček-lista za vizuelni pregled električne instalacije (za proveru opasnosti od nastanka požara). Verifikatorima kvaliteta niskonaponskih električnih instalacija omogućeno je da korišćenjem predstavljene ček-liste mogu da izvrše kvalitetan vizuelni pregled i preduprede potencijalne požare u građevinskim objektima. Zanimljivo je da veći deo vizuelnih provera prema datoj ček-listi može da izvrši i sam korisnik objekta (osoba koja je formalno nekvalifikovana za oblast električnih instalacija) bez opasnosti da dođe do njegove povrede. Ta mogućnost je od posebnog značaja imajući u vidu činjenicu da ne postoji praksa (a ni obaveza) vršenja

periodične verifikacije kvaliteta niskonaponskih električnih instalacija u stambenim jedinicama.

5. ZAHVALNICA

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THE SIGNIFICANCE OF VISUAL INSPECTION WITHIN THE QUALITY VERIFICATION OF LOW-VOLTAGE ELECTRICAL INSTALLATIONS – PART 1 – PREVENTIVE FIRE PROTECTION

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ABSTRACT:

The paper explains the importance of a well-executed visual inspection of low-voltage electrical installations conducted within the periodic verification of the quality of electrical installations. Depending on the type of hazard, identified irregularities observed by visual inspection can be classified into two categories: irregularities that may cause a fire and irregularities that may lead to an electric shock. The paper outlines the most common irregularities that may cause a fire encountered by the team of experts from the Faculty of Electrical Engineering, University of Belgrade, during the periodic quality verification of low-voltage electrical installations in public, commercial and industrial facilities in the period 2012–2023. Additionally, the paper presents checklist that can be used for preventive visual inspections to timely identify hazards from irregularities that may cause a fire.

Keywords: low-voltage electrical installations, quality verification, visual inspection, fire

ZNAČAJ VIZUELNOG PREGLEDA U OKVIRU VERIFIKACIJE KVALITETA NISKONAPONSKIH ELEKTRIČNIH INSTALACIJA – DEO 2 – PREVENTIVNA ZAŠTITA OD ELEKTRIČNOG UDARA

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SAŽETAK:

U radu je objašnjen značaj kvalitetno izvršenog vizuelnog pregleda niskonaponskih električnih instalacija koji se odnosi na neregularnosti na njima koje mogu da prouzrokuju električni udar. Navedene su najčešće neregularnosti na koje se u praksi nailazilo prilikom vršenja vizuelnog pregleda niskonaponskih električnih instalacija u javnim, poslovnim i industrijskim objektima, koje je tim stručnjaka Elektrotehničkog fakulteta Univerziteta u Beogradu izvršio u periodu 2012–2023. godine. U radu je predstavljena ček-lista, nastala na osnovu iskustva vršenja verifikacije kvaliteta niskonaponskih električnih instalacija, koja se u okviru vizuelnog pregleda može koristiti za blagovremeno uočavanje opasnosti koje mogu da izazovu električni udar.

Ključne reči: niskonaponske električne instalacije, verifikacija kvaliteta, vizuelni pregled, električni udar

1. UVOD

Kvarovi na niskonaponskim električnim instalacijama mogu da budu uzrok početnog požara ili električnog udara. U referenci [1] su analizirane neregularnosti koje mogu da budu uzrok početnog požara, a u ovom radu se analiziraju neregularnosti koje mogu da budu uzročnik električnog udara. Statistički podaci pokazuju da je broj povreda kao i nesreća sa smrtnim ishodom znatno veći na niskom naponu (oko 80%) od broja nesreća na visokom naponu (oko 20%). Takođe, statistički podaci ukazuju da se oko 50% nesreća izazvanih električnim udarom završava smrću, dok najveći broj preživelih ostaju invalidi [2]. Rezultati istraživanja predstavljani u [3] pokazuju da se u SAD-u kao posledica zadobijenih povreda od električnog udara dogodi oko 1.000 smrtnih slučajeva godišnje. Takođe, dogodi se još najmanje 30.000 električnih udara godišnje koji nisu fatalni. Svake godine otprilike 5% svih primljenih pacijenata na odeljenjima za opekotine u SAD-u nastaje kao posledica električnih povreda (električni udar ili požar na električnim instalacijama). Otprilike 20% svih električnih povreda javlja se kod dece. Kod odraslih, ove povrede se dešavaju uglavnom na radnom mestu i predstavljaju četvrti vodeći uzrok traumatske smrti na radnom mestu, dok se kod dece električne povrede najčešće javljaju kod kuće. Direktni dodir delova pod naponom podrazumeva direktan kontakt, bez zaštitnih sredstava, sa delom koji je pod naponom (goli provodnik, nož prekidača, i sl.),

dok indirektni dodir delova pod naponom podrazumeva direktan kontakt, bez zaštitnih sredstava, sa delom opreme koja u normalnom pogonu nije pod naponom i samo u slučaju kvara može doći pod napon (metalna kućišta motora, šporeta, električni alat sa metalnim kućištem i sl.) [2]. Upravo iz bezbednosnih razloga za svaki građevinski objekat, pre nego što dobije upotrebnu dozvolu, postoji zakonska obaveza da se u okviru tehničkog prijema objekta izvrši početna verifikacija kvaliteta izvedenih niskonaponskih električnih instalacija. Verifikacija kvaliteta podrazumeva da se prema standardu [3] izvrše odgovarajuća ispitivanja električnim merenjima i obavezan vizuelni pregled izvedenih električnih instalacija [1]. Treba napomenuti da ispitivanja električnim merenjima (provera neprekidnosti zaštitnih provodnika, merenje otpornosti petlje kvara i ispitivanje zaštitnog uređaja diferencijalne struje (ZUDS-a, odnosno FID sklopke ili eng. Residual Current Device (RCD))) imaju za cilj proveru efikasnosti sistema zaštite od električnog udara. Provera efikasnosti sistema zaštite automatskim prekidanjem napajanja u slučaju kvara vrši se merenjem otpornosti petlje kvara (ova provera uključuje i proveru neprekidnosti zaštitnog provodnika). Ispitivanjem zaštitnog uređaja diferencijalne struje proverava se vreme i struja njegovog reagovanja. Ispravan rad ZUDS-a onemogućava da strani metalni delovi koji u normalnom pogonu nisu pod naponom dođu pod napon usled zemljospoja (npr. usled oštećenja električne izolacije i struje curenja faznog provodnika prema metalnoj masi – npr. kućištu uređaja). Ukoliko je struja kvara (zemljospoja) veća od struje reagovanja ZUDS-a, otvaraju se kontakti prekidača i on prekida napajanje dela električne instalacije u kome je došlo do kvara. Više detalja o principu rada ZUDS-a koji se, pravilno izabran, primenjuje kao efikasna zaštita od zemljospoja (električnog udara) može se naći u [5].

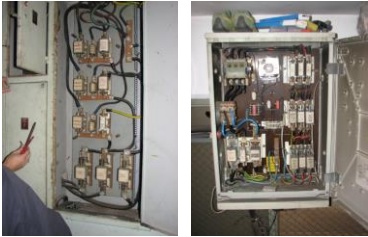



Vizuelnim pregledom treba da se utvrde vidljiva oštećena na električnoj instalaciji koja bi mogla da ugroze bezbednost korisnika objekta u slučaju nastanka opasnih situacija koje mogu da izazovu električni udar. U standardu [4] navedene su zahtevane provere koje se vrše vizuelnim pregledom. U okviru njih nisu navedene brojne neregularnosti koje se susreću u praksi na terenu prilikom vršenja verifikacije kvaliteta niskonaponskih električnih instalacija. Treba naglasiti, kao i u referenci [1], da se periodične verifikacije vizuelnim pregledima mogu proširiti i na priključene potrošače električne energije (prijemnike) i na dodatnu elektroinstalacionu opremu (npr. produžni kablovi).

U poglavlju 2 rada predstavljene su najčešće detektovane neregularnosti iz kategorije opasnosti od električnog udara. Za većinu njih obaveza utvrđivanja vizuelnim pregledom nije eksplicitno navedena u standardu [4], a svakako predstavljaju značajnu opasnost sa aspekta potencijalnog izazivanja električnog udara. U poglavlju 3 rada predstavljena je ček-lista koja se može koristiti za preventivne vizuelne preglede kako bi se na vreme uočile neregularnosti električnih instalacija koje mogu da izazovu električni udar, takođe razvijene i formirane na osnovu dugogodišnjeg iskustva vršenja verifikacije kvaliteta na terenu. Ček-lista predstavlja značajno proširenje broja provera koje treba izvršiti u odnosu na one navedene u standardu [4]. Na kraju rada rezimirano je kako se kvalitetnim vizuelnim pregledom, uočenim i otklonjenim neregularnostima upotrebom ček-liste za otkrivanje neregularnosti kojima se uočavaju opasnosti od nastanka požara [1], kao i ček-liste koja je data u ovom radu za otkrivanje neregularnosti koje mogu da izazovu električni udar, nivo zaštite u objektu podiže na viši nivo.

2. PRAKTIČNA ISKUSTVA STEČENA VRŠENJEM VIZUELNOG PREGLEDA

Za vreme vršenja periodičnih verifikacija kvaliteta niskonaponskih električnih instalacija, koje je tim stručnjaka Elektrotehničkog fakulteta Univerziteta u Beogradu izvršio u periodu 2012–2023. godine, uočene neregularnosti mogle su da se grupišu u dve kategorije prema tome da li one predstavljaju opasnost od požara [1] ili od električnog udara. Ilustracija najčešće uočenih neregularnosti iz kategorije opasnosti od električnog udara, a koje su uočene prilikom vizuelnih pregleda niskonaponskih električnih instalacija u zgradama u kojima su izvršene njihove verifikacije, date su u Tabeli 1.

Tabela 1. Neregularnosti koje mogu da prouzrokuju električni udar, primećen vizuelnim pregledom

Fotografija primećene neregularnosti vizuelnim pregledom (ilustrativni primeri)	Opis problema
	Nepropisno izvedeni fazni provodnici (kao provodnici sa izolacijom žuto-zelene ili svetloplave boje, koje su redom rezervisane za obeležavanje zaštitnog i neutralnog provodnika) u razvodnim ormanima i tablama
	Nepropisno ili nedovoljno čvrsto izvedene galvanske veze u razvodnim ormanima i tablama (na primer, u razvodnim ormanima se često sreću prekinute ili na spojevima olabavljene bakarne pletenice koje vrata razvodnog ormana spajaju sa njegovim kućištem)
	Postojanje razvodnih kutija koje nisu propisno zatvorene elektroinstalacionim poklopcem (u njima je bilo i neizolovanih faznih provodnika pod naponom)
	Upotreba nesertifikovanih produžnih kablova (njihovi uobičajeni nedostaci su da su bez zaštitnog provodnika iako imaju zaštitne kontakte i da su žile provodnika premalog poprečnog preseka za deklarisanu maksimalnu jačinu struje) [6,7]

		<p>U razvodnom ormanu ne postoji zaštitna elektroizolaciona pregrada koja sprečava direktan dodir delova električne instalacije pod naponom (uobičajene su pregrade izrađene od pleksiglasa, pertinaksa ili plastike)</p>
		<p>Elektroinstalacione komponente (primer – šuko-utičnice) sa oštećenom (polomljenom) PVC maskom – omogućen direktan dodir delova instalacije pod naponom, ili oštećena električna izolacija napojnih kablova prijemnika [8]</p>
		<p>Nepropisno izvedene utičnice i nepropisno izvedeni produžni kablovi (bez zaštitnog kontakta) – povećana opasnost od električnog udara jer sistem automatskog isključenja napajanja u slučaju kvara nije efikasan</p>
		<p>Mehanički odvojene šuko-utičnice od podloge (zida) kada delovi električne instalacije pod naponom postaju slobodno dostupne dodiru – izuzetno opasna situacija za decu ranog uzrasta</p>
		<p>Na osnovu vizuelnog pregleda detektovane su šuko-utičnice čiji je zaštitni kontakt bio uvučen u podnožje kućišta utičnice, i samim tim bio van funkcije. Napomena: Ovaj problem se može detektovati i električnim merenjem pod uslovom da su ove utičnice obuhvaćene ispitivanjem.</p>

3. ČEK-LISTA ZA VRŠENJE PERIODIČNOG VIZUELNOG PREGLEDA U CILJU OTKRIVANJA NEREGULARNOSTI OPASNIH ZA NASTANAK ELEKTRIČNOG UDARA

Na osnovu iskustva stečenog na terenu prilikom vršenja verifikacije kvaliteta niskonaponskih električnih instalacija u brojnim objektima različite namene, koje je tim stručnjaka Elektrotehničkog fakulteta Univerziteta u Beogradu izvršio u periodu

2012–2023. godine, sastavljena je ček-lista za proveru neregularnosti koje mogu da izazovu električni udar (predstavljena Tabelom 2). Zajedno sa ček-listom za otkrivanje neregularnosti koje mogu da izazovu požar [1], budućim verifikatorima je omogućeno da se izvrši kvalitetan vizuelni pregled kojim može blagovremeno da se spreči požar i električni udar u objektu korisnika. Najveći broj navedenih neregularnosti u predstavljenoj ček-listi ne može se detektovati električnim merenjima koja takođe predstavljaju obavezni deo verifikacije kvaliteta električnih instalacija.

Tabela 2. Ček-lista za preventivni vizuelni pregled niskonaponskih električnih instalacija u zgradama (kategorija: neregularnosti koje predstavljaju opasnost od električnog udara)

Provere vizuelnim pregledom (opasnost od električnog udara)	Opasnost postoji Da/Ne
Provera postojanja eventualnih nepovoljnih mikroklimatskih i drugih uslova na mestu ugradnje razvodnog ormara ili table (npr. povećana temperatura, vlažnost, zaprašivanje, korozija, vibracije itd.).	
Provera postojanja bakarne pletenice za galvansko povezivanje metalnih vrata i kućišta razvodnog ormara.	
Provera čvrstoće spojeva bakarne pletenice koja povezuje metalno kućište i vrata razvodnog ormara.	
Postojanje galvanske veze između zaštitne i neutralne sabirnice u razvodnom ormanu u slučaju primene nulovanja kao sistema zaštite u slučaju kvara.	
Provera tačnosti boje električne izolacije faznih, neutralnih i zaštitnih provodnika. Napomena: čest je slučaj da se u nedostatku provodnika crne, smeđe ili sive boje za fazne provodnike koriste provodnici plave ili žuto zeleno boje PVC izolacije.	
Provera ispravnosti bravice i mogućnosti potpunog otvaranja vrata razvodnog ormara. Napomena: razvodni ormari moraju biti zaključani zbog moguće opasnosti neovlašćenog pristupa (posebno je opasno zbog dece razvodne ormara držati otključane).	
Provera čvrstoće galvanske veze između zaštitne i neutralne sabirnice u razvodnom ormanu kada je primenjen sistem zaštite automatskim isključenjem napajanja u slučaju kvara – nulovanje.	
Provera funkcionalnosti glavnog prekidača za uključenje/isključenje napajanja razvodnog ormara ili table.	
Provera funkcija uključjenja i isključenja zaštitnih uređaja diferencijalne struje (FID sklopka) instaliranih u razvodnom ormanu ili tabli.	

Postojanje mehaničkih oštećenja posmatrane električne komponente (naprsline ili polomljeni delovi komponente, deformacije itd.). Napomena: Česta su mehanička oštećenja (polomljena kućišta npr. produžnih kablova) kada su delovi unutar kućišta produžnog kabla pod naponom direktno pristupačni.	
Provera da li su sve utičnice u prostoriji istog tipa (sa ili bez kontakta za uzemljenje).	
Provera da li šuko-utičnica ima zaštitni kontakt koji nije oštećen (zakrivljen, uvučen u podnožje utičnice itd.). Napomena: Neretko u starim instalacijama „ušice“ zaštitnog kontakta se uvuku u kućište šuko-utičnice i tada je to analogno prekidu zaštitnog provodnika.	
Provera da li je razvodna kutija propisno zatvorena.	
Provera postojanja provodnika sa slobodnim neizolovanim krajevima (koji, uz to, mogu biti pod naponom). Proveriti da li među provodnicima sa slobodnim neizolovanim krajevima koji mogu da se dodirnu (ukoliko postoje) ima onih pod naponom (ukoliko ima, o tome treba odmah obavestiti odgovornu osobu korisnika zgrade).	
Provera da li postoje šuko-utičnice potpuno mehanički odvojene od podloge za koju su bile pričvršćene. Napomena: Tada delovi električne instalacije pod naponom postaju slobodno dostupni.	
Postojanje sijaličnog grla koje je na dohvat ruke (na nebezbednom rastojanju), a ne sadrži sijalicu.	
Provera ispunjenosti bezbednosnih rastojanja ukoliko je primenjena mera zaštite postavljanjem van dohvata električnih komponenti koje sadrže izložene delove pod naponom.	
Provera postojanja eventualnih nepovoljnih mikroklimatskih i drugih uslova na mestima ugradnje električnih komponenti (npr. povećana temperatura, vlažnost, zaprašivanje, korozija itd.). Napomena: u takvim sredinama morala bi da se koristi kućišta sa odgovarajućim stepenom IP zaštite.	
Provera postojanja mehaničkih oštećenja napojnog kabla prijemnika (nastavljan, priklješten, odsečen,...).	
Provera postojanja oštećenja napojnog kabla prijemnika usled dotrajlosti izolacije i/ili nepovoljnih uticaja okoline (ispucao kabl, otpali delovi izolacije kabla,...).	
Provera da li postoje neophodni provodnici za premošćenje na delovima mašinskih instalacija (pumpe, ventili, cevi, itd.) u slučaju da je neophodno galvansko spajanje svih stranih metalnih delova (u svrhu izjednačenja potencijala).	

4. ZAKLJUČAK

U radu su prikazani brojni primeri neregularnosti koje predstavljaju opasne situacija koje mogu da izazovu električni udar. Pošto se u regulativi iz ove oblasti ne zahtevaju brojne proveru koje treba izvršiti u okviru vizuelnog pregleda, u radu je predložena detaljna ček-lista za proveru opasnosti od električnog udara u okviru vizuelnog pregleda električnih instalacija. Verifikatorima kvaliteta niskonaponskih električnih instalacija omogućeno je da korišćenjem ove ček-liste (zajedno sa ček-listom za otkrivanje opasnosti od požara predstavljenom u [1]) mogu da izvrše kvalitetan vizuelni pregled. Periodičnom verifikacijom kvaliteta niskonaponskih električnih instalacija koja uključuje detaljan vizuelni pregled, kome se inače u praksi posvećuje manja pažnja od ispitivanja električnim merenjima, značajno može doprineti smanjenju broja požara i električnih udara.

5. ZAHVALNICA

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THE SIGNIFICANCE OF VISUAL INSPECTION WITHIN THE QUALITY VERIFICATION OF LOW-VOLTAGE ELECTRICAL INSTALLATIONS – PART 2 –PREVENTIVE PROTECTION AGAINST ELECTRIC SHOCK

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ABSTRACT:

The paper explains the importance of a well-executed visual inspection of low-voltage electrical installations, focusing on irregularities that could lead to an electric shock. It outlines the most common irregularities encountered during visual inspections of low-voltage electrical installations in public, commercial, and industrial facilities, conducted by the team of experts from the Faculty of Electrical Engineering, University of Belgrade, in the period 2012–2023. The paper introduces a checklist, derived from the experience of quality verification of low-voltage electrical installations, which can be used within the visual inspection for timely identification of hazards that may cause an electric shock.

Keywords: *low-voltage electrical installations, quality verification, visual inspection, electric shock*

INFLUENTIAL FACTORS ON THE RESPONSE OF A BODY EXPOSED TO MULTIAXIAL VIBRATIONS

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ABSTRACT:

Whole-body vibrations represent one of the causes of spinal disorders in humans. Prolonged exposure to multiaxial vibrations can lead to harmful consequences for the musculoskeletal system, while repetitive occurrences may result in the development of pathological changes in the spinal column. The biodynamic responses of seated passengers exposed to whole-body vibrations have been extensively studied in terms of the apparent mass or seat-head transfer functions across a wide frequency range of vibrations. In this work, the subjects were exposed to multiaxial vibrations. Seat-head transfer functions were determined in order to evaluate the biodynamic response of the body and influencing factors on the frequency response.

Keywords: *biodynamic responses, multiaxial vibrations, musculoskeletal system, transfer function*

1. INTRODUCTION

Vibrations in the car represent a key factor in driving that directly affects passenger comfort and can have a significant impact on human health. Uneven roads often generate vibrations that are transmitted to the car, and the sensation of these vibrations can significantly influence the perception of comfort [1]. Modern technologies in the automotive industry, such as impact absorption systems and adaptive suspensions, are designed to reduce these vibrations and improve the feeling of comfort during driving. However, there is also a significant impact of vibrations on human health. Prolonged exposure to vibrations can lead to various issues, including fatigue, back and neck pain, as well as other musculoskeletal problems [2]. This is particularly significant for professional drivers or individuals who spend extended periods of time in the car. Contemporary research focuses on developing innovative vibration management systems to enhance passenger comfort and reduce potential negative effects on health. Technologies such as active vibration control systems and smart suspensions play a crucial role in optimizing the driving experience and minimizing the impact of vibrations on human health [3], [4].

Exposure to vibrations elicits varying effects on the human body, ranging from mild discomfort to a reduction in work efficiency and disturbances in health [5]. Current guidelines outlined in the international standard ISO 2631-1:1997 provide criteria for

determining the tolerances of the human body exposed to whole-body vibrations. This standard, ISO 2631-1:1997, is employed for evaluating exposure to elevated levels of vibrations and impacts. The vibrations absorbed by the human body can induce muscle contractions, leading to muscular fatigue, particularly at resonant frequencies [6]. Resonance occurs in the thorax-abdominal system due to vertical vibrations within the 5 Hz - 10 Hz range (4 Hz - 8 Hz in the chest, 20 Hz - 30 Hz in the head, neck, and shoulders, and 60 Hz - 90 Hz in the eyes) [7].

Most everyday exposures to whole-body vibrations in a vehicle encompass vibrations in multiple axes. Through the analysis of research, it has been concluded that multi-axial vibrations induce greater discomfort compared to single-axis vibrations, whether they are vertical or longitudinal vibrations. Characterizing the biodynamic responses of the human body to multi-axial vibrations provides a better understanding of human reactions to real vibrations in a vehicle and contributes to the development of multidimensional biodynamic models.

2. METHDOS

To induce vibrations of varying amplitudes and frequencies, we employed an electro-hydraulic pulsator HP-2007, equipped with a car seat for subject exposure to vibrations. This apparatus has the capability to generate vibrations in two directions. A system of three-axis accelerometers, utilizing the AC102-1A accelerometer with a weight of 90 g, sensitivity of 100 mV/g, and a frequency range of 0.5 – 15,000 Hz, was mounted on the subject's spinal region. The measurement system utilized the 01dB-Metravib NetdB PRO-132 acquisition system. The experimental parameters included a sampling rate of 51,200 Hz, block duration of 80 ms, 4,096 samples, 2 averages, and a sampling step $\Delta t = 0.0195$ ms. Signal overlap was set at 75%. The frequency step was $\Delta f = 0.390625$ Hz, and the bandwidth was 39 Hz.

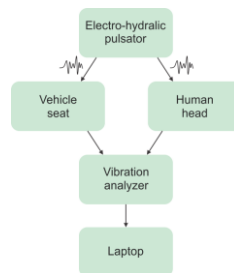


Fig. 1. Position of the three-axial accelerometers

20 male subjects participated in the experiment. Subjects were seated in an upright position with their hands on their thighs. At the same time, 6 acceleration signals were recorded (in the direction of the x, y and z axes for each measurement place). Subjects were exposed to random vibrations of the whole body for two excitation values 0.45 m/s^2 and 1.1 m/s^2 r.m.s., in the frequency range 0.1 Hz - 20 Hz, the most significant for studying the response of the human body according to the resonances of body parts (Rasmussen ,

1982). Also, at the same time, the angle of inclination of the seat back was varied, where the values were 90° and 110° in relation to the seat part of the seat.

3. RESULTS

Experimental investigations have produced many results, so only the most significant ones will be presented in the paper.

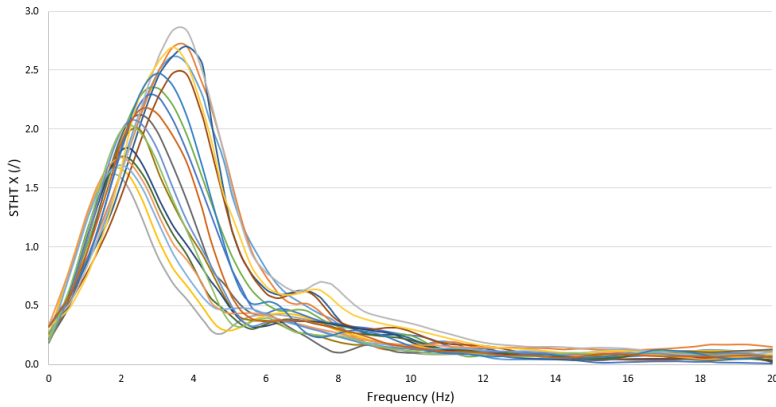


Fig. 2. STHT responses in the fore-and-aft direction for 20 subjects (excitation 0.45 m/s² r.m.s., angle of inclination of seat back 90°)

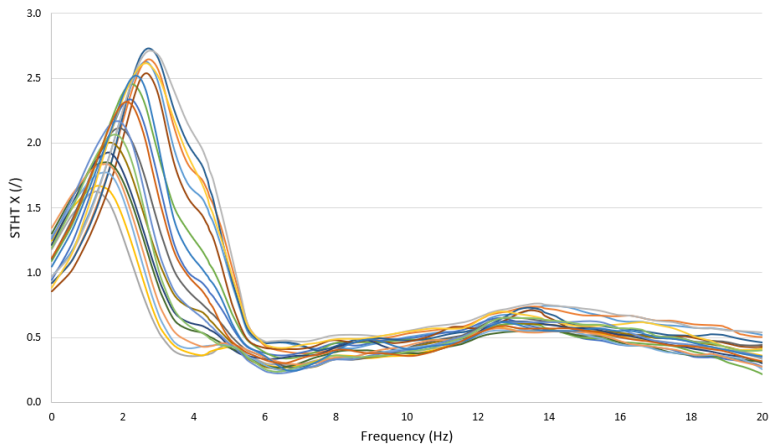


Fig. 3. STHT responses in the fore-and-aft direction for 20 subjects (excitation 1.1 m/s² r.m.s., angle of inclination of seat back 110°)

The highest resonant frequency of 2.66 Hz in the longitudinal direction was influenced by the excitation of 0.45 m/s² r.m.s. with a mean amplitude value of the STHT response of 1.96. For a seat backrest inclination angle of 110°, lower resonant frequencies of the STHT

response in the longitudinal direction were observed compared to a sitting angle of 90°. In the frequency range of 12 Hz - 14 Hz, there is a slight maximum, indicative of secondary resonance (Fig. 4).

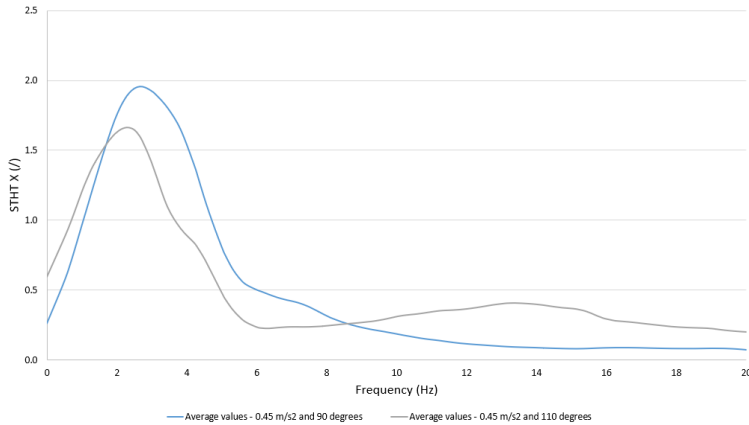


Fig. 4. Mean values of the STHT response in the fore-and-aft direction (excitation 0.45 m/s² r.m.s., angles of inclination of seat back 90° and 110°)

An excitation of 1.1 m/s² r.m.s. induced the highest resonant frequency of 2.35 Hz, with a mean amplitude value of the STHT response at 2.29 (Fig. 5). The obtained results demonstrate nonlinearity in the seat-driver system. Each increase in vibration amplitude leads to an increase in the amplitude of the STHT response and a decrease in the resonant frequency value. It can be concluded that, depending on the experimental conditions, the seat-driver system has the capability to dampen/amplify excitations.

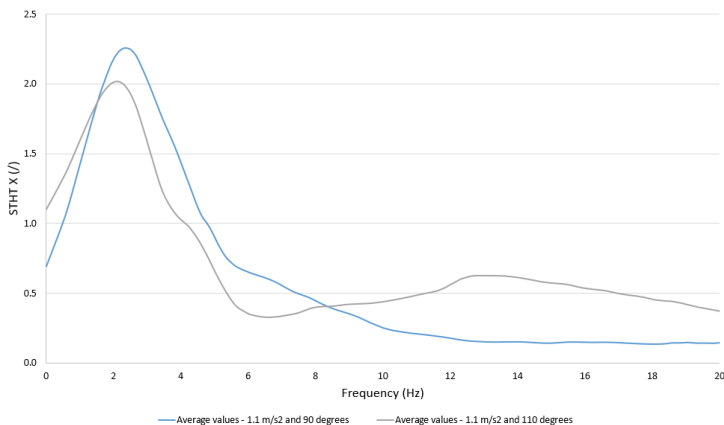


Fig. 5. Mean values of the STHT response in the fore-and-aft direction (excitation 1.1 m/s² r.m.s., angles of inclination of seat back 90° and 110°)

In the STHT response of the vertical direction, for an excitation of 0.45 m/s^2 , the appearance of a second maximum in the frequency range of 8 Hz - 10 Hz was observed. Additionally, the highest resonant frequency of 3.60 Hz was noted, with a mean amplitude value of the STHT response at 1.57. For a seat backrest inclination angle of 110° , lower resonant frequencies of the STHT response in the longitudinal direction were observed compared to other sitting angles of 90° . In the frequency range of 12 Hz - 14 Hz, there is a slight maximum, indicative of secondary resonance (Fig. 6).

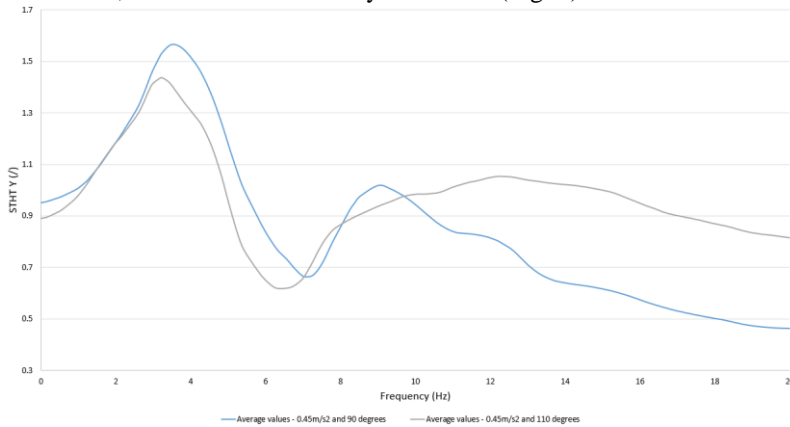


Fig. 6. Mean values of the STHT response in the vertical direction (excitation 0.45 m/s^2 r.m.s., angles of inclination of seat back 90° and 110°)

A resonant frequency of 2.98 Hz was observed under the influence of an excitation of 1.1 m/s^2 r.m.s. (seat back 90°), with a mean amplitude value of the STHT response at 1.74 (Fig. 7).

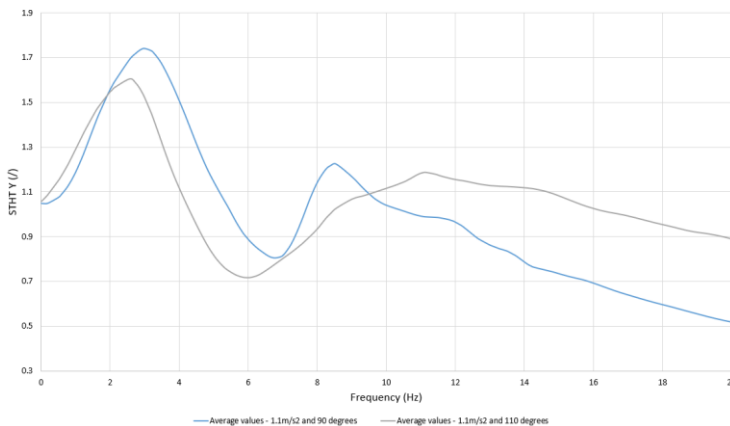


Fig. 7. Mean values of the STHT response in the vertical direction (excitation 1.1 m/s^2 r.m.s., angles of inclination of seat back 90° and 110°)

The lowest resonant frequency of 2.56 Hz and the highest mean amplitude value of the STHT response at 1.61 were observed under an excitation of 1.1 m/s² r.m.s. (seat back 110°) (Fig. 7).

Factor analysis was employed to determine the ranking of the influence of individual factors on the resonant frequency value of the STHT response. In the study, Analysis Of Variance (ANOVA) was applied. Five factors were analyzed, including height, weight, BMI, seated body height, and the age of the participants.

Table 1. Analysis of variance

Anthropometry	The mean value of the sum of squares	F ratio	Percentage share (%)
Height	0.12	1.16	3.71
Weight	0.23	6.3	19.55
BMI	0.32	17.68	37.18
Body height in a sitting position	0.27	15.54	29.4
Age	0.2	2.23	10.09

Analyses have shown that BMI is the most influential factor among the analyzed 20 male participants, with a contribution percentage of 37.18%. Another influential factor is body height in a sitting position with a share of 29.4%. Height and age have the least influence on body posture under the influence of vibrations.

3. CONCLUSION

The analysis of exposure to multi-axial vibrations (horizontal and vertical simultaneously) among male participants revealed an additional decrease in resonant frequencies of STHT responses in both observation directions. Resonant frequencies ranged from 2.85 Hz to 3.83 Hz for STHT response in the vertical direction, while for STHT response in the fore-and-aft direction, they ranged from 2.35 Hz to 2.97 Hz. The general conclusion is that ANOVA analysis of variance can aid in understanding the influence of individual factors on the function of the frequency response of STHT. This analysis showed that BMI has the greatest influence on the frequency response of a body exposed to multiaxial vibrations.

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HIBRIDNI ENERGETSKI SUSTAVI

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SAŽETAK:

Hibridni energetski sustav kombinira proizvodnju i/ili skladištenje energije korištenjem dva ili više izvora energije za pokretanje generatora. Njihova primjena omogućava lakši prijelaz s fosilnih goriva na alternativne izvore energije. To se očituje kroz istraživanje novih tehnologija kojima se integriraju obnovljivi izvori energije. Implementacijom hibridnih energetskih sustava koristeći postojeću energetsku infrastrukturu smanjeni su troškovi izgradnje novih postrojenja, utjecaj na okoliš i poremećaji sustava.

Planiranje hibridnog elektroenergetskog sustava, osim za potrebe tehnološkog razvoja, usmjerava se i na potrebe tržišta. Prioritet je konfigurirati kombinaciju energetskih tehnologija, koje će biti dostatne i pouzdane za potrebe krajnjih korisnika. Treba naglasiti kako se u hibridnim sustavima koristi barem jedan izvor goriva koji je obnovljiv. Sustav je dizajniran za potrebe povećanja pouzdanosti, ali i iskoristivosti obnovljivih izvora energije osiguravanjem kontinuirane proizvodnje energije. Dakle, potrebno je osigurati pohranu električne energije proizvedene iz obnovljivih izvora zbog njihove nestalnosti.

Implementacijom hibridnih energetskih sustava cilj je iskorištavanje obnovljivih izvora energije za potrebe proizvodnje električne energije prvenstveno s ekološkog aspekta smanjenja negativnog utjecaja na okoliš.

Ključne riječi: hibridni sustavi, obnovljivi izvori, elektroenergetski sustav, ekologija

1. UVOD

Obnovljivi izvori energije su krajnji cilj i krajnja sudbina energetske infrastrukture na zemlji.

Fosilna goriva, htjeli mi to ili ne, u konačnici bi mogla biti iscrpljena, pa je poželjno pripremiti se na taj trenutak dok je to relativno lako.

Međutim, u prijelaznom periodu, u kojem obnovljivi izvori nisu dostatni za cjelokupne energetske potrebe, a pogotovo dok nije razvidno koji će sustav objediniti sve izvore i koja će forma obnovljive energije prevladati, prisiljeni smo istraživati i tehnološki iznaći odgovarajuće prijelazno rješenje.

Također, većina obnovljivih izvora nema kontinuiranu dobavu. Iznimka su ne-fosilni sustavi, kao što je nuklearna energija.

2. POTREBA ZA HIBRIDNIM SUSTAVIMA

Solarni kolektori toplinske energije, solarni paneli imaju najveću proizvodnju u periodu od travnja do listopada, kada je sunce visoko na nebu, te je tada geometrijski gledano svjetlosni flux najveći. Istovremeno svjetlosno zračenje prolazi kroz kraću duljinu atmosfere te ne gubi određeni postotak energije apsorpcijom. Istovremeno, u tome periodu je količina naoblake najmanja (broj sunčanih sati najveći). Međutim, najveći potrošači energije smješteni su na visokim zemljopisnim širinama, gdje ljeti potrošnja znatno opada. U optimalnim uvjetima, solarni kolektori bilo koje vrste ne rade noću, pa je pitanje metode skladištenja energije za taj period još uvijek predmet istraživanja znanstvenika. Jedina alternativa skladištenju bi bila kada bi svijet bio u potpunosti umrežen, tako da oni dijelovi zemaljske kugle koji su trenutno u danu, napajaju one koji su u noći. Nažalost zbog političkih razloga to nije moguće, iako je tehnološki opravdano i moguće, ali o cijeni bi se dalo raspravljati.

Isto tako, zimi je situacija obrnuta kako s proizvodnjom, tako i s potrošnjom. Najveća količina energije, kako u kućanstvu tako i u javnim objektima, zimi se troši na zagrijavanje kada je proizvodnja iz sunčeve energije najmanja.

Situacija s energijom vjetra je slična. Iako varijacije imaju manji sezonski utjecaj. Iz iskustva proizlazi činjenica kako je nešto veća proizvodnja zimi. Međutim, statistička varijabilnost je dovoljna da zaključimo kako se ne možemo pouzdati niti u energiju vjetra za sve potrebe.

Svaki puta kada instalirana proizvodnja u nekom području ili nekom pogonu, zgradi, farmi, itd. ne podmiruje potrošnju, potrebno je pribjeći jednom od slijedećih sustava (slično vrijedi i za vozila, ali to je druga tema):

1. mreža (ako je dostupna)
2. dizel generator
3. generator s plinskom turbinom
4. mala hidroelektrana
5. bioplin/biomasa
6. goriva ćelija.

Za veća naselja, rješenje je svakako mreža, gdje za izvor energije u mreži vrijede ista pravila i pojavljuju se isti problemi. Postoje naravno i razlike, ali ovdje ćemo se više baviti autarkičnim sustavima.

Dakle, svi energetske sustavi gdje je za kontinuiranu dobavu (električne ili druge) energije potrebno imati dva različita izvora zovu se hibridni sustavi. Takvi sustavi imaju određene prednosti pred sustavima samo s jednim izvorom, čak i kada je taj izvor mreža.

Imaju također i mane. Najveća je ta da oba izvora moraju biti dimenzionirana da dobavljaju punu vršnu snagu potrošača, što je skupo.

3. ELEKTRIČNA I HIBRIDNA VOZILA

Električna vozila nemaju problema s vremenskim uvjetima i sezonama. Nitko ne očekuje da sva energija za pokretanje vozila dolazi od npr. solarnih ćelija na krovu. Međutim i u takvim slučajevima, solarni krov je koristan, jer može osigurati da vozilo koje je dugotrajno parkirano, ne isprazni baterije potpuno, što bi dovelo da njihovog oštećivanja.

Potrošnja električnog vozila može biti do tri puta manja od čistog ICE vozila, što je dobrim dijelom zasluga regenerativnog kočenja.

Većina potrošnje vozila u gradu nije trenje kretanja, već gubitak kinetičke energije tijekom kočenja u gradskoj vožnji (semafori, gužve, kretanje u koloni). Kod električnih vozila ta se energija (generatorskim režimom kočenja) vraća u bateriju. Ne računajući elektrokemijske gubitke baterije, regenerativno kočenje ima oko 2% gubitaka, a moguće je i manje.

Vozila s hibridnim pogonom imaju ICE i električni pogon (tablica 1). U gradu mogu koristiti samo bateriju, ili kombinaciju ICE i bateriju. Čak i kad bateriju ne dopunjavaju iz mreže, ukupna potrošnja je još uvijek manja nego kod ICE, upravo zbog spomenutog regenerativnog kočenja.

Tablica 1. Emisije CO₂ kod e-vozila (UK studija)

e-vozilo	emisija CO ₂ /km
ICE vozila	150-200g
Prius	122 g
Best hybrid	104 g
REWA NXR	50 g
EVI1999	50 g
Quick	63 g
Tesla road star	50 g

Kao što je vidljivo, hibridno vozilo smanjuje emisije za oko 30-50% dok e-vozilo čak do 75%. Glavni limitirajući faktor potpunog usvajanja e-pogona za vozila su cijena i masa baterija. Sve je ostalo na električnom vozilu isto ili čak jeftinije nego kod odgovarajućeg ICE vozila. Masa baterije najviše dolazi do izražaja kod dugih međugradskih vožnji jer je osim vozila, potrebno trošiti energiju i na transport "nositelja energije"- bateriju.

3.1. Vodik kao alternativni nositelj energije

Mada nije tema ovog članka, spomenut ćemo moguće rješenje problema transportiranja baterije. Kako smo već spomenuli, problem je transport nositelja energije - problem masene gustoće energije, koja je kod baterija (čak i litijeve) vrlo malena. Tako jedan kilogram nositelja energije (gorivo, baterija/akumulator) sadrži:

1. litijeva baterija - 0,26 kWh (!)
2. Dizel- 12kWh (4 kWh pri 30% ICE učinkovitosti)
3. Vodik 33kWh (19.8 kWh pri 60% iskorištenja gorive ćelije, pri kogeneraciji i više).

Vidljivo je kako je dizel gorivo kao nositelj energije skoro 20 puta "gušće" od litijeve baterije. Vodik je (maseno) znatno bolja alternativa, čak višestruko bolja od dizela. Problem kod vodika je niska masena gustoća, svega 30 kg/m³, ali to kod nekih vozila (brodovi) i nije toliki problem, jer prostor nije tako skućen. Možda i ostali međugradski promet (vlakovi, teški kamioni) mogu imati koristi od vodika.

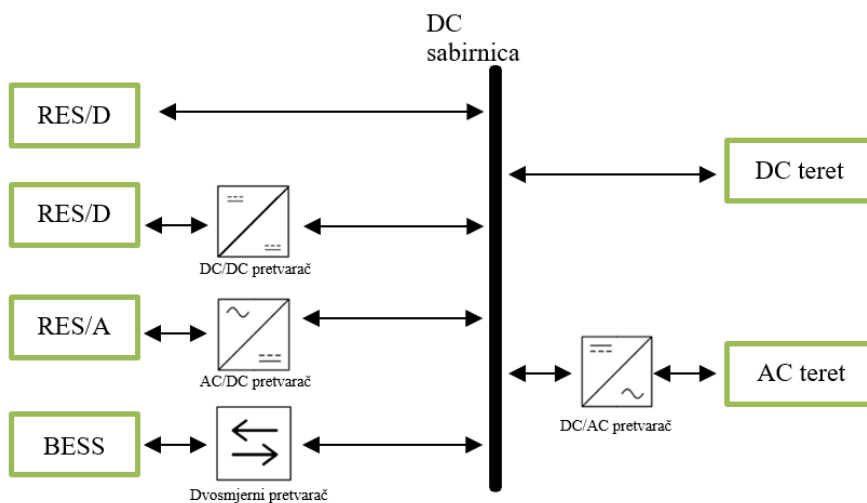
Dakle, iako vodik nije primarni izvor energije, već samo nositelj, tj. skladište energije, možemo ga uvjetno pridružiti hibridnim sustavima, istom logikom kao i npr. baterijsko skladištenje energije.

4. MOGUĆI SUSTAVI I NJIHOVA USPOREDBA

Prva je podjela vezana s tipom sabirnice, odnosno kako su resursi/izvori međusobno povezani te kako su povezani s potrošačima. Kako potrošača ima AC i DC, te izvora također AC i DC postoji nekoliko kombinacija.

1. Isključivo DC sabirnica prikazana je na slici 1. Svi AC izvori kao i svi AC potrošači trebaju AC/DC pretvarač.

Ovakva je konfiguracija odavno poznata u industrijskim pogonima (kranovi, teška vozila i slično). Česti napon DC sabirnice je 950V, dok se za priključenje mogu koristiti industrijski frekvencijski invertori. (Npr Siemens Erlangen, prosječni gubitci pri jednom stupnju pretvorbe oko 0.7%). Baterijski *backup* (BESS) može biti na nižoj ili višoj naponskoj razini, pretvorba ima još niže gubitke.

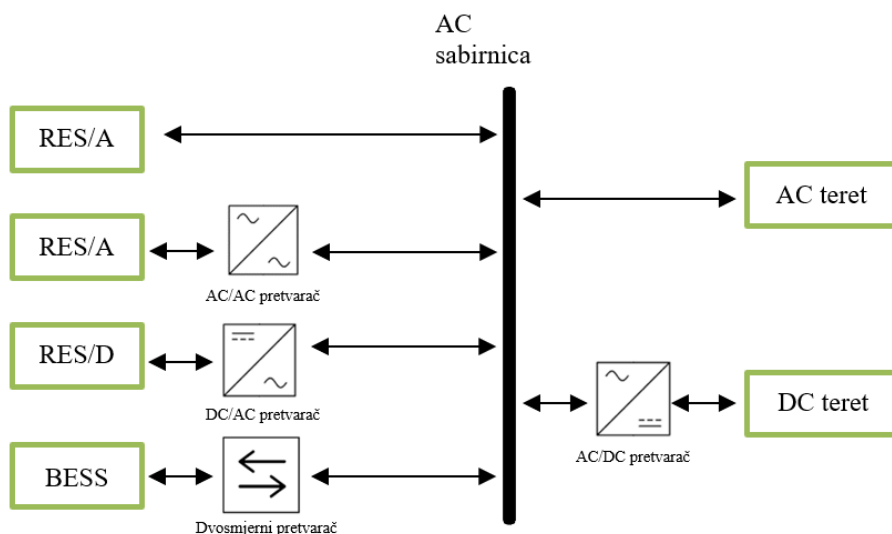


Slika 1. DC sabirnica [1]

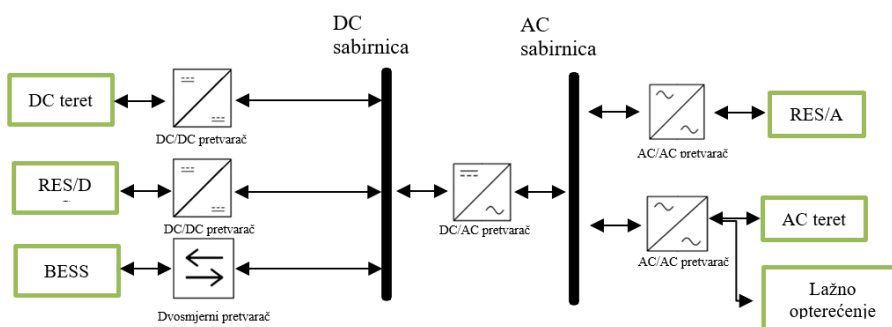
2. Isključivo AC sabirnica prikazana je na slici 2. Svi resursi i potrošači u ovoj konfiguraciji trebaju biti konvertirani na AC. Pozitivna strana je kako je prijenos na veće udaljenosti olakšan, postoje transformatori za bilo koju naponsku razinu, i svi dijelovi u slučaju potrebe mogu biti galvanski odvojeni. Loša je strana što svi izvori moraju biti sinhronizirani, što predstavlja odeređeni problem ako se radi o većim udaljenostima. AC bus može biti spojen i na mrežu, kada je mreža dostupna i operativna, a može se i odvojiti u izolirani otok ako mreža otkáže. Daleko najčešća konfiguracija za mikro instalacije.

3. Grupiranje izvora i potrošača na dvije sabirnice povezane jednim AC/DC pretvaračem prikazano je na slici 3. Kao što je vidljivo sa slike, postoji DC sabirnica na koju su povezani DC potrošači, DC izvori i baterijski *backup* s pripadajućim DC/DC pretvaračima. Isto tako

grupirani su AC izvori i potrošači na AC sabirnici. Oni mogu i ne moraju imati AC/AC pretvarače (ili samo transformator). Zavisno o razini snaga i naponskih razina, moguće su određene uštede, kako financijske, tako i na gubicima pretvorbe. Ova konfiguracija, kao i sve ostale koje ne mogu višak proizvodnje predati u mrežu, mora imati lažno opterećenje (*dummy load*) radi disipacije proizvedene energije za koju nema skladišnog kapaciteta.

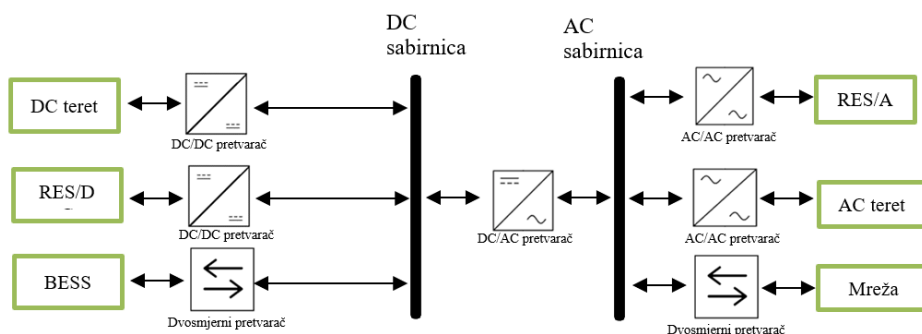


Slika 2. AC sabirnica [1]



Slika 3. Konfiguracija bez spoja na distribucijsku mrežu, koja se naziva "izolirana hibridna mreža". [1]

4. U slučaju da konfiguracija ima spoj na mrežu (slika 4), "Dummy load" nije više potreban, jer mreža uvijek može apsorbirati višak proizvodnje, Mreža je u takvim sustavima koji se onda zovu "povezani hibridni sustavi" obično povezana na AC sabirnicu jer je tako prirodnije za AC izvor, i opet cijeli sustav može biti galvanski izoliran.



Slika 4. Konfiguracija sa spojem na distribucijsku mrežu [1]

5. OBNOVLJIVI IZVORI U HIBRIDNIM SUSTAVIMA

Za razliku ranije spomenutih (*backup*) izvora, koji mogu ali i ne moraju biti obnovljivi, slijedeći su 100% obnovljivi i mogu se postavljati i koristiti na industrijskoj skali.

5.1 Vjetroturbine

Vjetroturbine su mehanički uređaji posebno dizajnirani za pretvaranje dijela kinetičke energije vjetra u mehaničku energiju.

Ako mehaničku energiju izravno koriste strojevi, poput pumpanja vode ili mljevenja kamenja, stroj se naziva vjetrenjača. Ako se mehanička energija zatim pretvara u električnu, stroj se naziva vjetrogenerator. [2]

Prema aerodinamičkim karakteristikama vjetroturbine, izlazna mehanička snaga može iznositi 3-4MW (60 m nacelle iznad zemlje). Mehanička snaga vjetroturbine, prema [3], može se izraziti kao:

$$P_m = \frac{1}{2} C_p \cdot \rho \cdot \pi \cdot R^2 \cdot v^3 \quad (1)$$

Gdje je: C_p = koeficijent snage vjetra,

R = radijus vjetroturbine,

ρ = gustoća zraka,

v = brzina vjetra.

Obično rotori turbina imaju učinkovitost koja varira između 40% i 50%. Učinkovitost mjenjača i generatora može se procijeniti na cca 80% do 90%. Učinkovitost turbine nije konstantna, već je funkcija brzine vjetra. Pri brzinama ispod dva m/s izlazna energija je nula, ne koristi se. [4]

Sasvim je jasno iz prirode izvora energije da vjetroturbina ima stupanj raspoloživosti ispod 100%, te da se za povećanje vremena kada je energija raspoloživa potrebno kombinirati

više vjetroturbina, što donekle pomaže (iako su uglavnom kolocirane). U nekim područjima je raspoloživost 60% (Sjever Europe s konstantnim oceanskim i polarnim vjetrovima).

U nekim područjima, kao što su neke lokacije u Dalmaciji raspoloživost može biti između 15 i 30%. Razlog nije manjak vjetra, već varijacije u brzini, koje dovode do gašenja turbine pri "refulima" s brzinom preko dozvoljenog sigurnosnog maksimuma. Iako reful traje kratko, nekad preopterećenje izaziva proces zaustavljanja i ponovnog pokretanja turbine koji traje par minuta.

5.2. Solarne ćelije

PV ćelije se sastoje od poluvodičkog materijala, kao što je silicij, koji je trenutno najčešće korišten element u industriji poluvodiča. U osnovi, kada svjetlost pogodi ćeliju, određeni dio se apsorbira unutar poluvodičkog materijala. Kada energija udari poluvodičke elektrone se oslobode, dopuštajući im da slobodno teku. PV ćelije imaju jedno ili više električnih polja koja djeluju tako da tjeraju elektrone koji su oslobođeni apsorpcijom svjetlosti da teku u određenom smjeru. Silicijevi fotonaponski paneli pretvaraju sunčevo zračenje u električnu energiju s učinkovitošću u rasponu od 5% do 20%, ovisno o vrsti ćelije. (Patel, 2006). Iako je stanje tehnike takvo da najnovije ćelije na osnovi Perovskitnih kristala imaju veću učinkovitost, većina instaliranih polja i dalje ima učinkovitost oko 20%. Ukupna instalirana snaga u svijetu je oko 1.3TW (<https://www.greenmatch.co.uk/solar-energy/solar-pv-statistics>).

Međutim osim učinkovitosti, moramo uzeti u obzir raspoloživost koja je za većinu instalacija ispod 20% (noć, loše vrijeme naoblaka). Prema tablici 2, za prosječno kućanstvo procijenjena snaga instalacije pri raspoloživosti 20% (zbroj W+PV) iznosi 4kW.

Tablica 2. Procijenjena veličina hibridnog sustava za prosječno kućanstvo iz realnih podataka (uz oprezno korištenje s obzirom na istvremenu upotrebu velikih potrošača)

Električni potrošač	Komada	Prosječna mjesečna potrošnja kWh
Hladnjak	1	182
Zamrzivač	1	180
Pećnica	1	104
Mikrovalna	1	16
Aparat za kavu	1	19
Pumpa za vodu (bunar)	1	90
Stereo sistem	1	5
Perilica za rublje	1 (dva pranja tjedno)	1
Osvjetljenje	4	40
Vanjsko svjetlo	2	150

Ukupno: 787
Vršna snaga: 5kW

3. ZAKLJUČAK

Iz gore izloženih podataka, vidljivo je da svaki sustav napajanja iz obnovljivih izvora zahtijeva *backup* sastavljen od bar dva obnovljiva izvora, te bar jednog skladišta energije, što SVAKI takav sustav čini “hibridnim sustavom”. Zbog stupnja raspoloživosti znatno manjeg od 100%, potrebno je da proizvodnja obnovljivog izvora bude otprilike pet puta veća od procjenjene potrošnje, ne računajući gubitke pri pohrani i pretvorbi.

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HYBRID ENERGY SYSTEMS

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ABSTRACT:

A hybrid energy system combines energy production and/or storage by using two or more energy sources to run a generator. Their application enables an easier transition from fossil fuels to alternative energy sources. This is manifested through the research of new technologies that integrate renewable energy sources. By implementing hybrid energy systems using the existing energy infrastructure, the costs of building new plants, the impact on the environment and system disruptions are reduced.

The planning of the hybrid power system, in addition to the needs of technological development, is also focused on the needs of the market. The priority is to configure a combination of energy technologies, which will be sufficient and reliable for the needs of end users. It should be emphasized that at least one renewable fuel source is used in hybrid systems. The system is designed for the needs of increasing the reliability and utilization of renewable energy sources by ensuring continuous energy production. Therefore, it is necessary to ensure the storage of electricity produced from renewable sources due to their volatility.

With the implementation of hybrid energy systems, the goal is to use renewable energy sources for electricity production, primarily from the ecological aspect of reducing the negative impact on the environment.

Keywords: *hybrid systems, renewable sources, electric power system, ecology*

ANALYSIS OF THE CORRUGATED STRUCTURE OF THE APATURA ILIA BUTTERFLY AS A BIOMIMETIC MODEL FOR THE POTENTIAL DESIGN OF NEW NANOSTRUCTURED MATERIALS

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ABSTRACT:

The structure of an Apatura ilia butterfly wing was examined. The corrugation of the structure provides a suitable surface for detection system materials. It was discovered that this is a partial ordering structure, and randomness in the recognized pattern was noticed. The key analysis parameter was particle density. The results demonstrated that the observed structure is perfectly consistent with the order of transparent materials. The surface density demonstrates the pattern's repeatability, which is vital for stimuli transfer because it functions as a type of actuator in its whole. When examined, the Apatura butterfly wing structure serves as a representative model for nanomaterials that could be used in many forms of sensing, medicinal, and military applications.

Keywords: *Apatura ilia butterfly, corrugated materials, structure analysis*

1. INTRODUCTION

The butterfly *Apatura ilia* [1] belongs to biophotonic structures. The wings of this butterfly support a herringbone nanostructure. [2] This is a huge number of entities grouped in a small area. Globally, a kind of ordering [3] can be observed within this structure. The almost parallel scales contain a large number of ridges (so-called herringbones) that exist in their primary locations. Considering the extremely small dimensions of their particles and the distances between them of the order of the mean free path of the molecules of the surrounding gas, this structure can be characterized as extremely dense. [4] This density structure can play a big role in materials of various applications. From a static point of view, corrugated materials have many advantages in mechanical sense such as advanced thermal and frictional behavior. [5]

On the other hand, from a dynamic point of view, this kind of condensed nanostructure is sensitive to the gentlest stimuli [6] and can become a cutting-edge technology for detection systems.

In this paper, the wing structure of the butterfly *Apatura ilia* was analyzed (Figure 1) and important factors in terms of particle density were emphasized.



Fig. 1. *Apatura ilia* butterfly

2. MATERIALS AND METHODS

The samples are characterized by using scanning electron microscope JEOL JSM 6610 LV (Japan) and represented in Figure 2. Main analysis is done by exploiting the optical methods for image analyzing such as ImageJ. ImageJ is an open source Java-written program created by Wayne Rasband. [7]

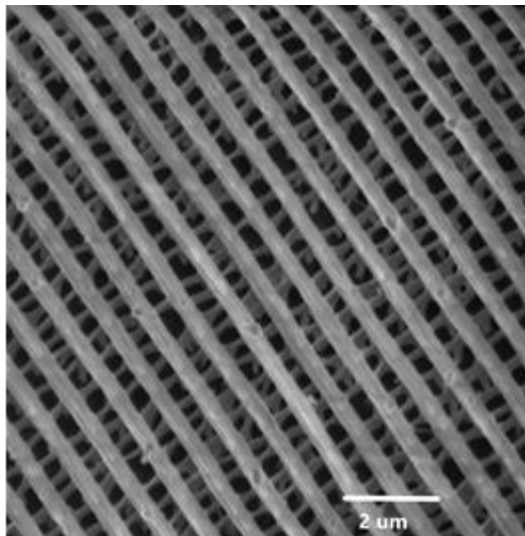


Fig. 2. SEM image of the *Apatura ilia* butterfly wing

3. MATERIALS AND METHODS

Figure 3 is a blueprint that roughly differentiates the parts of the structure from the cavities. [8, 9] It is observed that the parts called scales dominate (with a length of more than 100 μm and width of about 60 μm) [10], while the branched part of the herringbone structure, the ridge, is permeated with an interstructural space that is filled with the surrounding gas. These ridges are around 0.5 μm , as well as these interstructural distances between them. [10]

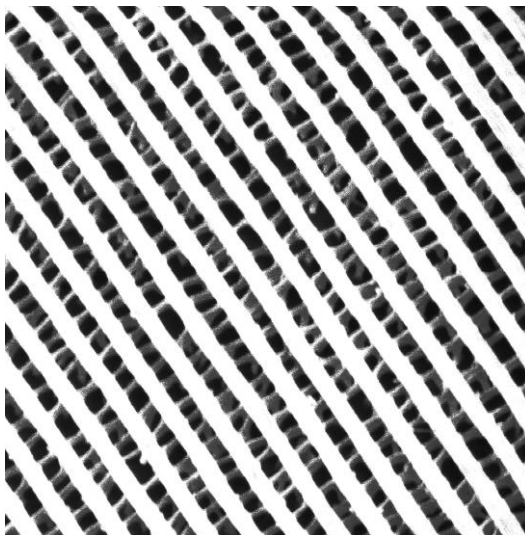


Fig. 3. Black and white representation of *Apatura ilia* wing structure

Figure 4A illustrates the region of a wing that is bounded on all sides by dividing ridges. The entire structure is depicted in this figure as a scheme of a type of complex ordering, however it excludes classic orderliness characterized by regularities. It could be taken as a kind of partial ordering structure. [11] Perhaps the best schematic representation of the complexity of the analyzed structure is given in Figure 4B. Here, the idea and sequence of structuring of the material can be observed, as well as randomness in terms of dimensions and repetition of patterns.

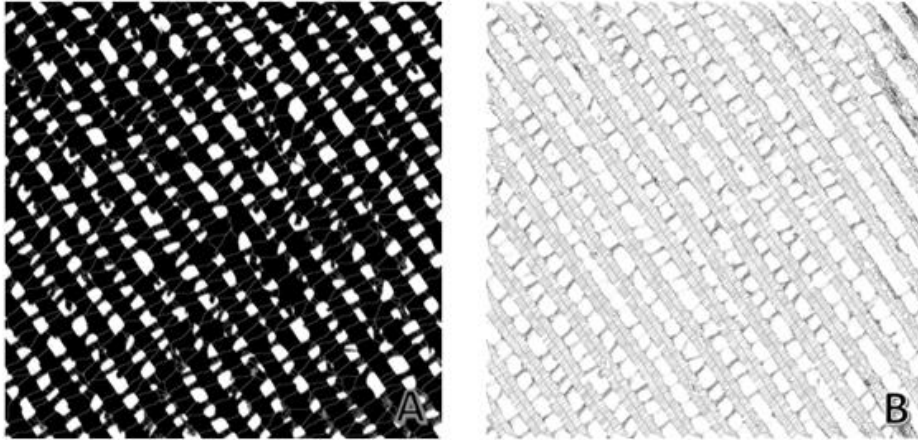


Fig. 4. Representation of the complexity of the structure recognized on *Apatura ilia* wing: simple (A) and detailed (B) one.

The next panel shows the distribution of the representation of the characteristic structure over the surface of the sample, depending on the persistence of the material (Figure 5A). Persistence is taken as a relative term that varies from the absence of structure through different transparent layers to the maximum opaque layer. Precisely, it is a property of a formation to behave as a cohesive whole in some dynamic conditions. [12] The obtained histogram confirms that the structure completely belongs to the order of transparent materials. [13]

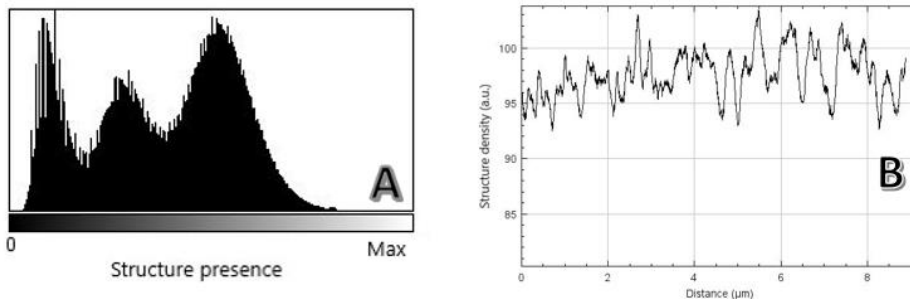


Fig. 5. SEM image of the *Apatura ilia* butterfly wing

As the most important parameter of this analysis, the density of the herringbone structure along the selected section line is graphically displayed (5B). [14] For this analysis, the classic formulation of density and its unit was not used, but a relative parameter that represents the ratio of the presence of voids in the structure, and then all other nuanced parts of it, from the most transparent to the most persistent. The specific parameter used for qualitative analysis refers to the ridge period, which is approximately from 1.2 to 1.5 ridges per micrometer. [10] This high relative density was observed and plotted in Figure 5B.

Finally, a 3D representation of the distribution of the complete structure on the analyzed surface is provided (Figure 6A). The z axis is completely unrealistic and hatched for better visual representation. A three-dimensional color representation is also given that refers to the representation of empty, interstructural space by surface, to absolute structural occupancy (Figure 6B). This spatial diagram shows a view from the angle of the smallest entities, i.e. parts of the herringbone called lamellae. [10] From this angle, it can be seen that despite the high density of particles, in the case of these smallest parts, the density of structure representation throughout the sample is much closer to the representation of the empty interstructural space.

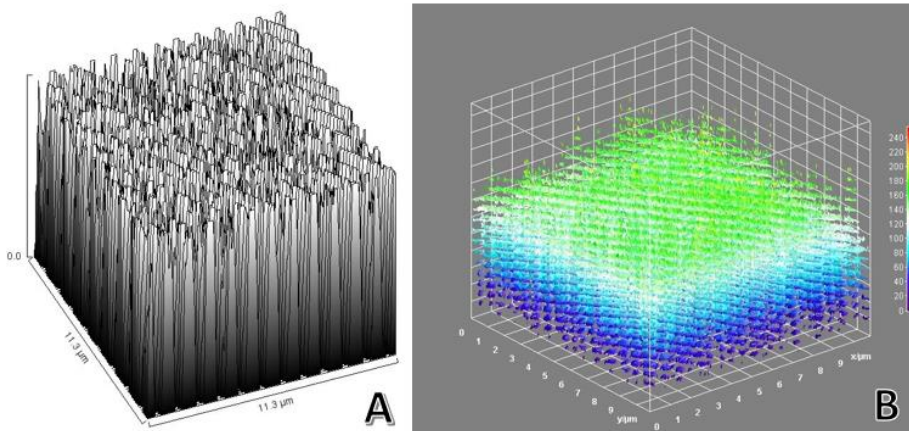


Fig. 6. Yyyyyyyy yyyyyyy

This discussion leads to the conclusion that with such a complex structure, the peculiarity is reduced to a high density, i.e. the main property lies down in many repeated entities of similar structure on a small surface. This reproducibility of the pattern on the surface (density) is crucial for the transfer of stimuli, because it acts as a kind of actuator as a whole. The alleged transparency of the structure refers to its sensitivity, that is, to the shifting of the boundaries in terms of the strength of the stimulus that needs to be detected. At the very end, specific distances between them do not play a role, it is more important that the order of the sizes of these distances coincides with the size of the entity of the structure. The example of an individual entity of the herringbone type of structure is given in the drawing (Figure 7). [15]

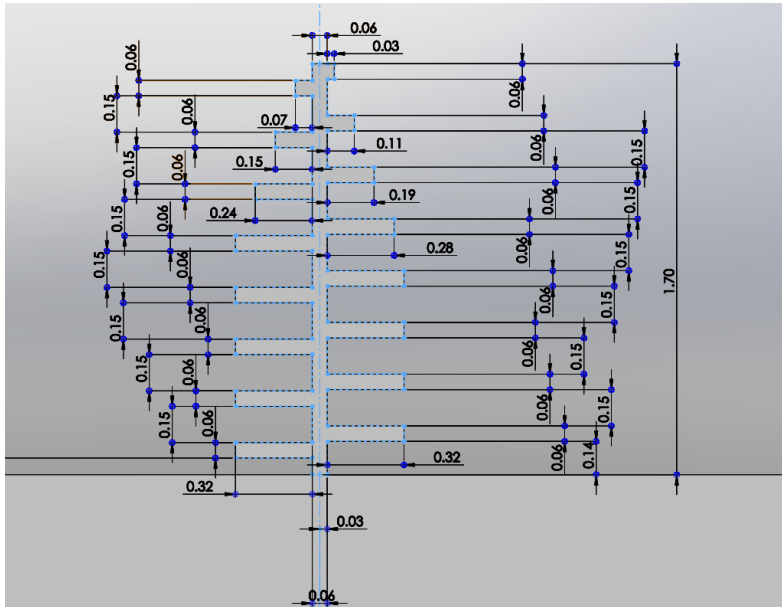


Fig. 7. Schematic representation of an individual entity of the herringbone type of structure. [15]

The biggest risk of this concept lies in the possibility of producing extremely sensitive nanoparticles as well as the technology of applying them to a specific substrate. Overcoming these problems could lead to very useful nanomaterials that could find their application in various fields [16], especially in all types of sensing [17], in medicine [18] and for military purposes. [15, 19]

3. CONCLUSION

The wing structure of the butterfly *Apatura ilia* was studied in this paper. Optical image analysis techniques were used in this case, mainly ImageJ. This method allowed the existence of solid entities as well as cavities in the structure to be compared. Also, the density of the structure was visualized. The parameters that are essential for the design of artificial biomimetic corrugated structures were also specified. Complex transparent materials have been proposed that can play a major role in various fields of sensing.

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FROM COAL TO NATURAL GAS: ANALYZING PM_{2.5} CONCENTRATION CHANGES CAUSED BY DISTRICT HEATING PLANT FUEL SWITCH

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ABSTRACT:

Kragujevac is one of the biggest industrial and educational centers in the Republic of Serbia with more than 150000 citizens. For many years this city has struggled with intensive air pollution caused by particle matter (PM), consequently influencing the environment, citizens' health, and life quality. One of the biggest sources of pollution in this city is the heating plant which was powered by coal until heating season 2022/2023, and from heating season 2022/2023 it operated using natural gas. By utilizing a machine learning approach, this study analyzes how the transition of the heating plant from coal to natural gas affected the PM_{2.5} pollution.

Keywords: air pollution, environment, human health, life quality

1. INTRODUCTION

Causing around 6.7 million deaths annually [1], air pollution is currently one of the biggest problems that people are facing. According to IQAir [2], the most dangerous pollutants are the particulate matter¹ (PM). Airborne particles (PM) can be divided into two groups based on their size: i) PM₁₀ – particles with a diameter under 10 μm and ii) PM_{2.5} – particles with a diameter under 2.5 μm. Because of their size, PM_{2.5} can easily enter the human bloodstream through the lungs, consequently causing respiratory and cardiovascular problems, and cancer [3]. It is estimated that this pollutant causes around 4 million premature deaths annually [4].

PM_{2.5} often originates from different emission sources, simultaneously varying in chemical composition. Overall, the process of combustion of gasoline, oil, diesel fuel, or wood is the main producer of PM_{2.5} [5]. Tessum et al. [6] analyzed sources of ambient PM_{2.5} in 96 global cities. The results show that in 46%, 27%, and 10% of cities, the biggest sources of PM_{2.5} were industry, energy transformation, and residential and commercial activities, respectively.

¹ Floating particles in polluted air which includes dirt, dust, smoke, and tiny drops of liquid

Kragujevac is one of the biggest administrative, educational, and industrial centers in the Republic of Serbia with more than 150000 citizens. Thus, this city was facing an air pollution crisis a few years in a row. The main sources of air pollution in the city of Kragujevac are:

- i. District heating plant;
- ii. Residential heating systems (mainly based on coal or solid biomass) in combination with low-efficiency buildings;
- iii. High-intensity traffic with an absence of ring roads;
- iv. Coal-powered power plants the closest of which is at a distance of 30 km;
- v. Highway A1 (Belgrade – Niš) and other regional roads.

In the heating season 2022/2023 the district heating plant in Kragujevac underwent a fuel switch. Until (and including) the heating season 2021/2022, the heating plant operated using coal as fuel, afterward the heating plant switched to natural gas. According to Zeng et al. [7] cities that have undergone similar fuel shifts have witnessed a significant drop in air pollution. Using a machine learning approach, this study analyzed how the coal-to-natural gas transition of the heating plant influenced the air quality in the city of Kragujevac.

2. MATERIAL AND METHODS

The observed citizen-installed PM_{2.5} sensor in Kragujevac measured 28 months of data (November 2021 – February 2024). Fig. 1 shows the location of the observed sensor and heating plant.



Fig. 1. Observed sensor and heating plant locations

The aforementioned sensor (SDS 011 Sensor developed by Nova Fitness, a spin-off of the University of Jinan, China) is part of a network of sensors installed by citizens united in efforts to improve air quality (the sensor can be accessed through <https://sensor.community/en/> website).

Measurements were divided into two datasets, DS1: November 2021 – March 2022, and DS2: April 2022 – February 2024. Dataset DS1 contains measurements for the heating season 2021/2022 when the heating plant was powered by coal, while dataset DS2 contains measurements for the heating seasons 2022/2023 and 2023/2024 when the heating plant was powered by natural gas. This study is based on the machine learning approach, the idea was to use the dataset DS2 to train a predictive model adjusted to the current scenario – a heating plant powered by natural gas. Afterward, the trained model was fed with parameters for the heating season 2021/2022 to estimate the hourly PM_{2.5} concentrations for the scenario that in the heating season 2021/2022 the heating plant operated on natural gas instead of coal. Finally, to analyze the effect of the heating plant transition from coal to natural gas, the actual and estimated hourly PM_{2.5} concentrations for the heating season 2021/2022 were compared. Fig. 2 shows the framework of this research.

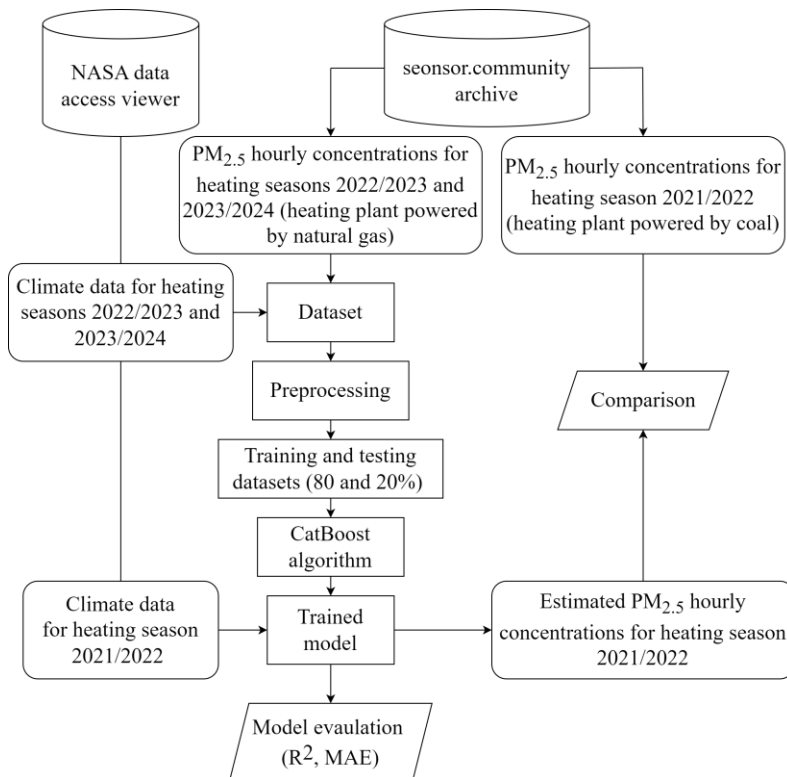


Fig. 2. The framework of the research

A variety of factors generally influence airborne PM_{2.5} concentrations. Hernandez et al. [8] analyzed the effect of outdoor temperature on PM_{2.5} concentrations and they induced that with lower temperatures the concentrations rise due to intense consumption of fuels needed for heating. Relative humidity is a factor that strongly correlates to PM_{2.5} concentrations [9]. According to X Li et al. [10] high atmospheric pressures cause downward airflow, consequently increasing particle concentrations. Wind speed is another climatic factor with a significant influence on airborne PM_{2.5} concentrations. Wang and Ogawa stated that the correlation between PM_{2.5} concentration and wind speed is negative when the wind speed is under 3 m/s, but positive when it is above 3 m/s [11]. Table 1 shows the content of observed datasets.

Table 1. Content of observed datasets

Data type	Parameter	Unit	Source
Dependent variable	PM _{2.5} concentration	µg/m ³	sensor.community archive [12]
Temporal data	Month	/	
	Hour	h	
Climate data	Outdoor temperature	°C	Nasa data access viewer [13]
	Relative humidity	%	
	Atmospheric pressure	kPa	
	Wind speed	m/s	

3. PREDICTIVE MODEL

According to the reviewed literature, the chosen parameters influencing the airborne PM_{2.5} concentrations are month, hour, outdoor temperature, relative humidity, wind speed, and atmospheric pressure. Graphical interpretation of the developed predictive model is shown in Fig. 3.

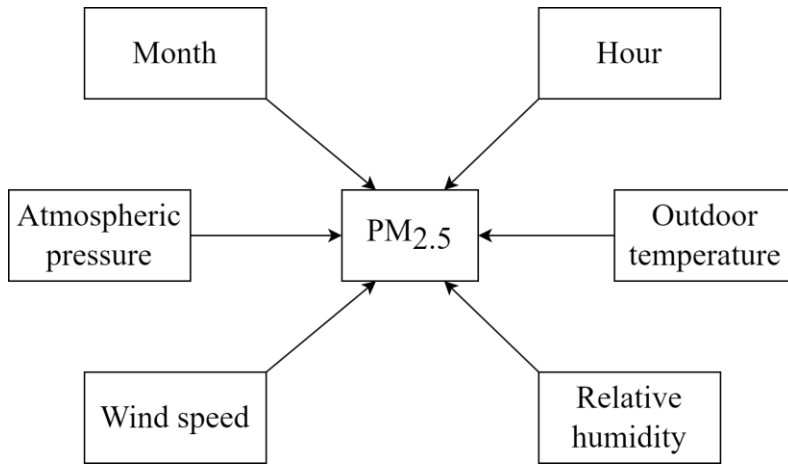


Fig. 3. Graphical interpretation of the developed predictive model

Before model training, the dataset was preprocessed. This includes filling in the missing data and synchronizing the concentration and climate data on an hourly level. Afterward, the preprocessed dataset was divided into a training dataset (80% of data) and a testing dataset (20% of data). The model was trained using the CatBoost algorithm. According to Hancock and Khoshgoftaar [14] CatBoost is a tree-based algorithm that can be used for regression and classification. Additionally, this algorithm showed good predictive performance in the case of PM_{2.5} concentration predictions [15][16].

In the case of this study, CatBoost performed well, resulting in an R² score of 0.817 and a mean absolute error (MAE) of 4.877 µg/m³. Fig. 4 represents an actual versus predicted scatter diagram.

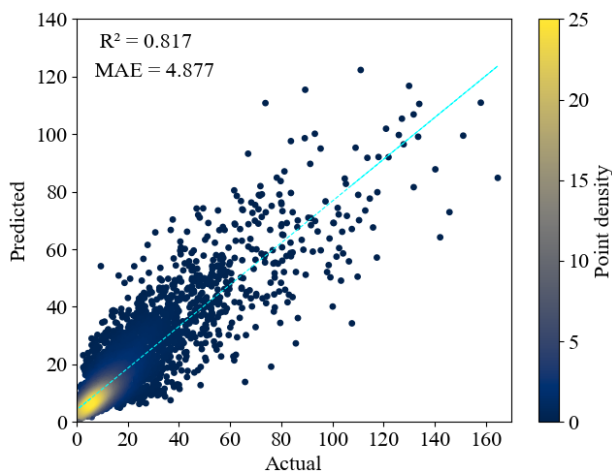


Fig. 4. Actual versus predicted scatter diagram

4. RESULTS

Fig. 5 contains hourly PM_{2.5} concentrations for the heating season 2021/2022.

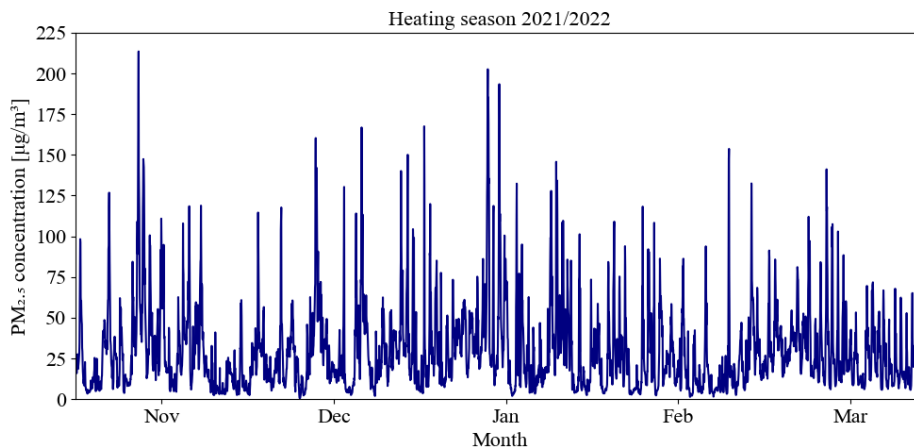


Fig. 5. Hourly PM_{2.5} concentrations for heating season 2021/2022

Based on the given figure it can be stated that:

- Citizens of Kragujevac were exposed to highly polluted air in the heating season 2021/2022;
- For around 668 hours the concentration of PM_{2.5} exceeded 45 µg/m³, for 96 hours it exceeded 100 µg/m³, and for 16 hours it exceeded 150 µg/m³.
- Average concentration of PM_{2.5} for heating season 2021/2022 was 29 µg/m³.

After training and evaluating the predictive model on dataset DS2 containing heating seasons 2022/2023 and 2023/2024 when the heating plant operated using natural gas, the model was fed with data containing influencing parameters (Fig. 3) for the heating season 2021/2022 to estimate the PM_{2.5} concentrations for the imaginary scenario if the heating plant worked on natural gas instead of coal. Estimated hourly concentrations for the heating season 2021/2022 are shown in Fig. 6.

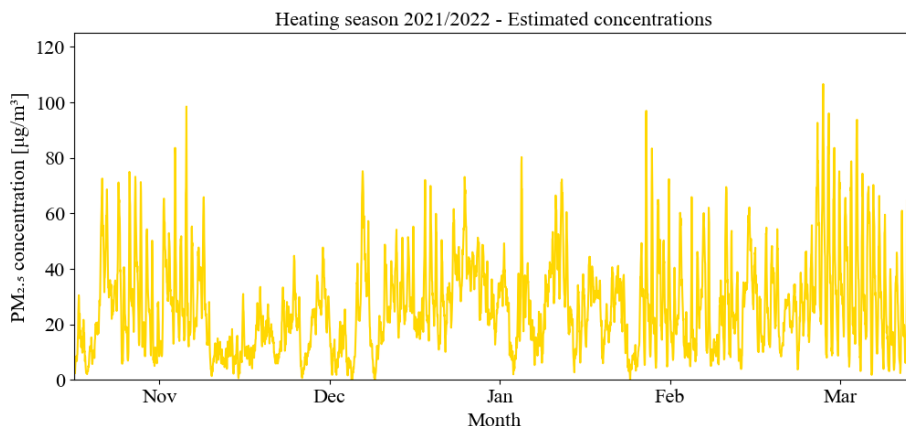


Fig. 6. Estimated hourly PM_{2.5} concentrations for heating season 2021/2022

According to Fig. 6, it can be stated that:

- Estimated values are indicating a significant increase in air quality;
- For around 474 hours the concentration of PM_{2.5} exceeded 45 µg/m³, for 2 hours only it exceeded 100 µg/m³, and there were no moments when the concentration exceeded 150 µg/m³.
- On average, PM_{2.5} concentrations are around 10% lower. Yet, during peak hours (when the concentrations are higher than 75 µg/m³) the estimated improvement in air quality is 50%.

To better understand the interdependence of the population's exposure to emissions in the city and the reading from the sensor, it is necessary to take into account the direction of the wind (whether it moves from the heating plant to the sensor or vice versa, or in some other direction). In this sense, we can say that the mentioned estimated progress in air quality of 10% is certainly lower than the one that was realistically achieved. The reason is the position and distance of the sensor from the heating plant. Furthermore, it is to be expected that the actual improvement of air quality is greater than that estimated in this study, and this especially refers to the improvement that will be experienced by citizens living in locations located within 2 km of the heating plant, i.e., those located closer to the heating plant than the location of the sensor (Figure 1). Overall, it can be concluded that the transition of the heating plant from coal to natural gas had a significant influence on air quality in the city of Kragujevac. The differences are noticeable through a lower number of highly polluted hours and lower seasonal average PM_{2.5} concentration. Fig. 7 shows the graphical comparison of actual and estimated hourly concentrations for the heating season 2021/2022.

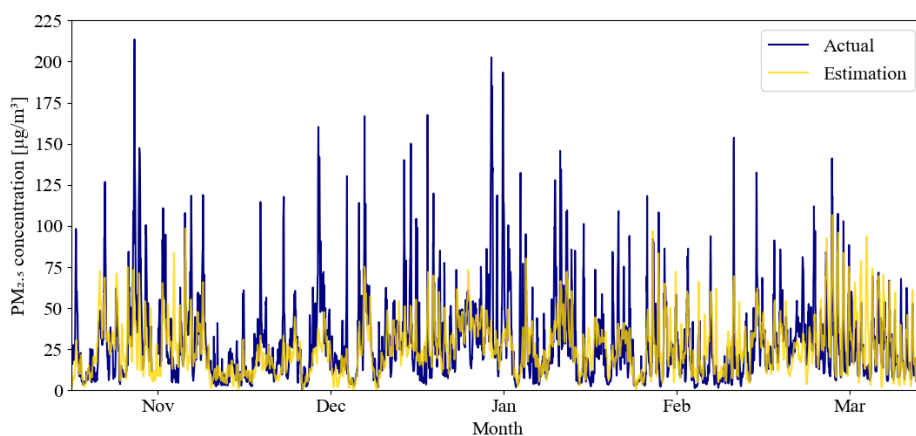


Fig. 7. Actual versus estimated hourly concentrations for the heating season 2021/2022

3. CONCLUSION

Kragujevac, one of the biggest cities in the Republic of Serbia, has been facing an air pollution problem for decades. In 2022, the heating plant in Kragujevac underwent a significant modification – a transition from coal to natural gas. Until (including) the heating season 2021/2022, the heating plant was powered by coal, afterward, it was powered by natural gas.

As shown in recent literature, a significant change in air quality happened in cities that have undergone similar transitions. This paper aimed to quantify the improvement in air quality in the city of Kragujevac that occurred after that fuel switch. To achieve this, the research utilized a machine-learning approach. Namely, the dataset combining $PM_{2.5}$ concentration and climate hourly information for the heating seasons 2022/2023 and 2023/2024 was used to train a predictive model based on the CatBoost regression algorithm. After training and evaluating the predictive model, it was fed with hourly climate data for the heating season 2021/2022 to estimate the hourly $PM_{2.5}$ concentrations for the imaginary scenario where the heating plant was powered by natural gas instead of coal. Afterward, actual and estimated hourly $PM_{2.5}$ concentrations were compared. The comparison showed that the coal-to-natural gas transition had significant effects on air quality. Namely, the number of hours exceeding the concentration of $45 \mu\text{g}/\text{m}^3$ decreased from 668 to 464, exceeding $100 \mu\text{g}/\text{m}^3$ decreased from 96 to 2, and there were no moments when the concentration exceeded $150 \mu\text{g}/\text{m}^3$ in comparison to 16 hours for the situation “before” the switch to natural gas. Additionally, the average $PM_{2.5}$ concentration decreased from 29 to $26 \mu\text{g}/\text{m}^3$.

4. ACKNOWLEDGMENT

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BEYOND SCREENS: ANALYZING SMARTPHONE USE AND LEARNING EFFECTIVENESS IN PROGRAMMING DISCIPLINES

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ABSTRACT:

Young people are increasingly using smartphones and less frequently computers. Modern education attempts to keep up with this trend through educational mobile applications and content adapted for use on phones. On the other hand, smartphones, with their limited display and input methods, cannot fully replace computers in acquiring software development skills. The question arises as to how habits of intensive use of mobile devices affect the learning performance of computer science students in disciplines involving programming. The habits and attitudes of computer science and information technology students at the Faculty of Technical Sciences in Čačak, as well as the teaching staff instructing programming, were analyzed. Quantitative methods (a questionnaire for students) and qualitative methods (interviews with teachers) were employed. The obtained results can be valuable for further research and immediate application in educational environments

Keywords: smartphones, higher education, computer science, programming

1. INTRODUCTION

Programming education, being a core aspect of computer science is relatively considered difficult since it is not an innate activity. It can be considered equal to learning to read and write a foreign language one will never get to hear [1]. Learning or building the skill of programming takes time and effort. Through the years, efforts have been made to ease the task of learning how to write computer programs [2]. Innovative teaching practices with the inclusion of mobile technologies can have the possibility to create more active learning experiences that improve student engagement, learning, and course retention [3]. Students from various computer science disciplines are eager to develop and even deploy their mobile applications on repositories like play store. The growth of mobile technologies associated with the decrease in the cost of smartphones made the latter an inevitable tool for students. In an educational setting, statistics show that 97% of students own a smartphone, and 95% of students bring that smartphone to class [4]. They are no longer merely voice communication devices, but rich computing environments [5].

However, consistent use of smartphones over time led to an ever-increasing dependency. Some students, prefer a smartphone over a laptop and personal computers because of the various functionalities, such as entertainment, online games, sending emails, chatting, agenda tracking, social media, and the ability to complete homework. Given the prevalence of smartphone addiction among students, it is crucial to explore the relationships between smartphone addiction and students' learning [6]. The question arises as to how habits of intensive use of mobile devices affect the learning performance of computer science students in disciplines involving programming. In the following sections, we presented the related work, the research methodology, results and discussion. We concluded the paper and provided ideas for future research.

2. RELATED WORK

Recent years have seen a steady growth in the volume of research devoted to the integration of smartphones into the educational system and the academic learning environment [7]. Numerous studies have examined the relationships between mobile phone use and academic achievements. Obtained results show mixed findings. On the one hand, there are studies whose results show that smartphone addiction negatively impacts students' learning and overall academic performance. On the other hand, there are studies whose results advocate the educational benefits of using smartphones for mobile learning, classroom engagement, etc. Some studies examined some other aspects of smartphone impact on education. Following are the some of representative studies and their findings.

Authors in [8] examine the effect of a smartphone's presence on learning and memory among undergraduates. One group of students were with their smartphones during the class and the others were not. As predicted, those without smartphones had higher recall accuracy compared to those with smartphones. Results showed a significant negative relationship between phone-conscious thought. The authors found that the presence of a smartphone and high phone-conscious thought affects one's memory learning and recall, indicating the negative effect of a smartphone's proximity to students' learning and memory [8]. Similar results were obtained in [4]. Students whose smartphones were physically removed during class had higher levels of course comprehension, lower levels of anxiety, and higher levels of mindfulness than the control group [4].

In [7], the authors examined the views of lecturers and students on the role of smartphones in the classroom. The study was conducted among lecturers and undergraduate students from seven academic institutions in Israel. Through an online questionnaire, respondents answered questions about their smartphone usage and perceptions regarding the legitimate use of smartphones in the classroom [7]. The result shows that both parties believe that the smartphone is a device that has potential to enrich lessons and expand knowledge [7].

The usage of smartphones also raises a number of privacy-related issues because they enable the gathering of data such as communications content, in-application activities,

etc., that can be pieced together to understand and influence users' behaviour [9]. This issue was also investigated in the University context. In [5] students' awareness level of information security using smartphones vs. computers was examined. The authors conducted a descriptive research design and an online survey method. Research findings showed that students were highly aware of some information security concepts. Moreover, the findings of this research have shown that most students believed the probability that their computer devices would become infected by malicious programs is higher than that is for their smartphones. A plausible explanation is that students hear about security incidents related to computers more than those targeting smartphones [5].

Findings in [6] accentuate benefits of smartphone use in education. Reducing the digital gap, completing homework, collaboration among peers, quick accessibility of information, and vocabulary enhancement are just some of them. These benefits have encouraged continuous dependence on smartphones among students [6]. Regarding these finding paper in [3] aimed to introduce an innovative approach of learning computer programming on a smartphone platform. The main goal was the introduction of a tailored module to teach Java programming language while developing applications for Android mobile platform. The proposed approach can be an appropriate alternative for the module 'Introduction to programming' of computer science curricula across the globe.

3. METHODS AND MATERIALS

The target group for our research was Information technology undergraduates at the Faculty of Technical Sciences in Čačak. We skipped freshmen, as they did not have many programming subjects and their feedback would not contribute to the study. The students were provided with a questionnaire – all questions were mandatory, except the last one, where students got the opportunity to freely enter their reflection. The second target group was teaching assistants who working on the programming subjects. They were interviewed directly and provided qualitative inputs to this research. The idea was to enlighten the issue of smartphone use from both sides. The 2-part questionnaire was developed and set on the Faculty Moodle platform. First part deals with features related to programming subjects and the second one with nomophobia (fear of detachment from the mobile phone) [10]. The full questionnaire is provided in the appendix.

Information collecting (both via questionnaire and interview) was conducted in March 2024. The questionnaire was anonymous and no personal data was collected. All students participating in this research did this voluntarily. A total of 155 students participated in the survey: 120 male, 34 female and one student who did not specify the gender. We used descriptive statistics and essential statistical tools from the SPSS package. One hundred and five students are 2nd year, 32 third year and 19 fourth (final) year.

4. RESULTS AND DISCUSSION

Most students' average grade in programming subjects was between 7 and 8 (34.2%), then above 9 (29%), between 8 and 9 (25.8%) and the least number of students got between 6 and 7 (11%). There are interesting findings about the frequency of taking smartphones during the programming sessions. Over 62% of students are reaching their smartphone during the programming class! And 9% are reaching the phone over 10 times a session. Once or less – 23.2% and constantly holding the phone – 5.2%. Although the results are concerning at the first look, one should approach this slightly reserved, because different students can complete programming exercises at varying times, leaving some spare time for checking the phone. However, these percentages are significant and should be taken as an indicator either of overuse of phones or of somewhat poor class organisation. Question number 7 explored the purpose of smartphone use – students graded from 1-5 the least to most used applications. The results are provided in table 1.

Table 1. Use of smartphones among students

	Gaming	Social Networks	Texting	Learning	Voice messages
1	53,5	1.9	1.9	14.2	28.4
2	20,6	8.4	6.5	31.6	32.9
3	9,7	16.8	22.6	29.7	21.3
4	7,1	25.2	41.9	16.1	9.7
5	9,0	47.7	27.1	8.4	7.7

Social networks are the most often used application: nearly half of students graded it with 5. Also, gaming is a rare activity on smartphones. Possible reasons are that the students have outgrown the games for mobile platforms and probably are gaming (if at all) on PC or dedicated platforms (Sony PS, Nintendo). We questioned students about their platform choice for composing e-mails. It turned out that over 56% of students write e-mails only on PC, and the rest do it solely on smartphones (16.8%) or mixed (27.1%). This result shows that e-mail is still considered something that requires a “full-fledged” device to be developed. This might be a firm indicator that students recognise certain operations as more demanding or more responsible, so the use of PC is required, e.g. to efficiently avoid typos, to attach specific files etc. Descriptive statistics for item 9 are provided in Table 2.

Table 2. Using PC and smartphone for learning programming (n=155)

	Q9_1	Q9_2	Q9_3	Q9_4	Q9_5	Q9_6
Mean	3.5032	1.9097	2.5032	2.5871	1.8774	4.0839
Std. Deviation	1.33082	1.08931	1.34055	1.55750	1.14152	1.14503

Minimum	1	1	1	1	1	1
Maximum	5	5	5	5	5	5

Although we suspected that due to students’ intensive use of mobile phones (and reduced, virtual keyboards) it was a challenge to enter the program code on PC, the Q9_6 indicated the opposite (“I have no problem entering code on the PC during programming exercises.”). However, this assertion from students should be cross-matched with what teachers said to get a more objective observation. Other answers also fit into a broader claim that students do intensively use PCs for programming. Still, we wanted to dive deeper into this matter.

When asked if they would prefer to learn and practice programming mostly on phone, if possible, we got almost three equal shares: yes (32.3%), no (36.1%) and maybe (31.6%). This may indicate that a significant share of students would prefer to somehow use a smartphone for learning programming, but also many of them are not sure what would that mean. The following item is: “I use educational software for learning programming on my phone.” A great majority (84.5%) do use such software. Coupled with the previous question, we can conclude that some kind of adaptation of programming courses would contribute to student success in programming. It is important to further explore what students actually use and how to make an intersection between programming class and appropriate smart phone apps. To play it safe, code snippets with brief quizzes could be a start.

The last corpus of questions is related to nomophobia – these are general questions contributing to understanding of person’s reactions regarding the limited access to the mobile phone. The descriptive statistics are given in Table 3.

Table 3. Nomophobia (n=155, Cronbach alpha = 0.85)

	Minimum	Max.	Mean	Std. Deviation
Q12_1	1	5	3.1613	1.27148
Q12_2	1	5	3.3161	1.31798
Q12_3	1	5	3.1355	1.27960
Q12_4	1	5	1.6581	1.27148
Q12_5	1	5	2.7806	1.31798
Q12_6	1	5	2.1484	1.27960
Q12_7	1	5	1.6000	1.27148
Q12_8	1	5	1.8645	1.31798
Q12_9	1	5	2.2516	1.27960
Q12_10	1	5	2.0581	1.27148

The correlation analysis is provided in Table 4.

Table 4. Correlation analysis (Pearson values)

	Reaching phone	Q9_1	Q9_2	Q9_3	Q9_4	Q9_5	Q9_6	Nomoph
Average grade	0.012	0.327**	-0.094	0.093	-0.043	-0.114	0.337**	-0.073
Reaching phone	1	0.020	0.028	-0.046	0.054	0.135	0.097	0.061
Q9_1		1	0.099	0.112	-0.037	-0.194*	0.279**	-0.004
Q9_2			1	0.378**	0.108	0.195*	-0.010	0.278**
Q9_3				1	0.131	0.278**	-0.011	0.040
Q9_4					1	0.172*	-0.101	0.002
Q9_5						1	0.068	0.123
Q9_6							1	0.061

A correlation analysis revealed moderate positive correlations between the average grade in programming subjects and items related to using a computer for practicing at home ($r=0.327$, $p<0.05$), as well as successful typing of code via keyboard during exercises ($r=0.337$, $p<0.05$). This finding suggests that as students achieve higher grades in programming, they tend to use computers more for home practice and have no issues typing code on computers during exercises.

The frequency of using phones in class is not associated with any item related to using mobile phones for learning programming, nor with the scale of nomophobia and the average programming grade. Nomophobia is positively correlated only with the item related to using phones to read parts of code ($r=0.278$, $p<0.05$), which is an expected finding. Regarding the interconnection of statements about using computers for practice at home, weak negative correlations were found with the item related to the rare use of computers for programming ($r=-0.194$, $p<0.05$) and positive correlations with the assessment of skills for typing code on computers during exercises ($r=0.278$, $p<0.05$).

Reading parts of code on a mobile phone is moderately positively related to watching tutorials on the phone ($r=0.378$, $p<0.05$), and weakly positively related to rare computer use ($r=0.194$, $p<0.05$). Watching tutorials on the phone is positively correlated with the item related to the rare use of computers for programming ($r=0.28$, $p<0.05$) while using a computer for parts of tasks that cannot be completed on the phone is positively associated with the same item ($r=0.17$, $p<0.05$).

Many students voluntarily answered the optional, last question, where they were allowed to freely reflect on the matter of using smartphones and learning programming. We selected several comments:

“A good app for learning programming would be of great use.”

“We can use mobile phones to test and develop mobile apps.”

“Bringing phones into the classroom should be banned both for students and professors”

“I believe programming on PC is more productive”.

“Learning programming via smartphone can be both good and bad.”

We interviewed several teaching assistants, to find out about their point of view. Here are their observations:

“Many students, although allowed to use any resource to solve the programming problem, reach their phone and use it to find the answer, maybe they use ChatGPT. I did not have a case of students using social networks in class.”

“There are two opposite groups of students: students trying and succeeding in every task and others who do not even try, using phones the whole time. As time passes by, more and more students reach their phones and play games, use social networks, etc.”

“Student with weak previous knowledge, usually reach their phone and do not show will to learn.”

5. CONCLUSION

The phone has evolved from a basic communicative functions device to a device used for web browsing, games, and instant communication on social media platforms [8]. With the rapid rise in the e-learning environment and increasing smartphone ownership, the integration of smartphones into the classroom has become an important issue. However, an agreement between instructors and students on smartphone usage has to be reached [8]. While teachers and parents are for or against smartphones in classrooms, empirical evidence showed that students who used their phones in class took fewer notes and had poorer overall academic performance, compared to those who did not [8]. Although use of smartphones should be encouraged in all educational settings, a distinction should be made between healthy use of smartphones and smartphone addictions that take away from life [11].

This research shows that students frequently use the smartphone, even during programming classes. They recognise that mobile phone is not fully convenient for programming (and students practicing on PC at home achieve greater success), however, they would like to use it for learning programming. The possible solution is to utilise apps for learning programming and to use more e-tests accessible via mobile devices. Regarding the intensive use of smartphones in class, for the students who are more efficient in completing tasks and then have too much spare time, additional tasks would make them further engage and use the time to learn new things.

It is a challenging (and perhaps impossible) task to transform the intensive use of smart phones among students into an assistive learning technology. The students are willing to somehow further utilise smartphones, but they are not sure how. It is up to teachers to specify the policy of phones use in class and to decide to what extent to use it as a learning tool. It further requires development of new teaching strategies.

For future research, it is important to more investigate what kind of learning software best fit in teaching programming and assess such tools in practice.

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APPENDIX – The questionnaire

1. What's your year of study?
2. Please specify your gender.
3. How many programming subjects you attended?
4. How many subjects you passed?
5. What is your average grade on programming subjects?
6. During programming classes in the computer lab, how often do you reach for your mobile phone during one session?
7. I use my mobile phone for: gaming, social media, texting, learning, voice calls. (5 item scale)
8. Do you usually compose your e-mails on computer or on smartphone?
9. Likert Scale (1-5) I often practice programming examples (test code samples, code projects, etc.) at home on the computer.
I usually read parts of code on my mobile phone at home.
I often watch programming tutorials on my phone.
I only use my computer (PC) for programming projects that cannot be completed on the phone.
I rarely feel the need to turn on my PC because I have everything I need on my phone.
I have no problem entering code on the PC during programming exercises.
10. If it was possible to adapt programming education so that a significant portion of programming is learned and performed on a smartphone, would you support such an approach?
11. I use educational software for learning programming on my phone. (For example, apps for learning Python, PHP, etc.)
12. Likert Scale (nomophobia)
I would feel uncomfortable without constant access to information through my smartphone.
I would be irritated if I couldn't look up information on my smartphone when I wanted to.
I would be annoyed if I couldn't use my smartphone and/or its features when I wanted to.
I would feel scared if my smartphone battery died.
I would feel the urge to check my smartphone after some time if I couldn't.
I would feel anxious if I didn't have my smartphone with me because it would cut off my constant connection with family and friends.
I would be nervous because I would be cut off from my online identity if I didn't have my smartphone with me.
I would feel uncomfortable because I wouldn't be able to stay updated with social media and online networks if I didn't have my smartphone with me.
I would feel anxious because I wouldn't be able to check my email/Viber/WhatsApp messages if I didn't have my smartphone with me.
I would feel weird because I wouldn't know what to do if I didn't have my smartphone with me.

ALGORITAM SIMULIRANOG KALJENJA ZA REŠAVANJE PROBLEMA PLANIRANJA POSLOVA U PARALELNOJ VEZI MAŠINA SA VREMENOM OBRADJE I VREMENOM PODEŠAVANJA

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SAŽETAK:

Ovaj rad se bavi problemom planiranja poslova u paralelnoj vezi mašina sa vremenima obrade poslova na mašinama i vremenima potrebnih za pripremu alata pri obavljanju poslova na mašinama. Planiranje poslova predstavlja ključnu oblast unutar planiranja i raspoređivanja resursa, posebno u dizajnu velikih, fleksibilnih sistema za upravljanje proizvodnjom i optimizacijom. Osnovni cilj ovog istraživanja je da se predstavi model paralelnog planiranja i raspoređivanja poslova i minimizira ukupno vreme funkcije cilja C_{max} . U uvodnom delu rada prikazana je sveobuhvatna analiza relevantne literature, opisana je metodologija i primena metaheurističkog algoritma za optimizaciju problema planiranja i raspoređivanja poslova. Naredni deo rada prikazuje rezultate optimizacije i efikasnost predloženog algoritma, utemeljenog na modelu paralelnog planiranja. Ulazni parametri za optimizaciju su izvedeni iz prethodnog rada autora, gde su istraživali sličan problem koristeći Genetski algoritam (GA). Osim toga, ovaj rad sprovedi detaljnu analizu i poređenje između SA i GA kao dva različita pristupa pri rešavanju istog problema. Ova saznanja doprinose dubljem razumevanju korišćenih algoritma i uvodjenje dodatnih ograničenja pri rešavanju budućih problema u kontekstu paralelnog raspoređivanja mašina. Rezultati ovog istraživanja pružaju vredan doprinos razvoju efikasnih strategija optimizacije resursa u industrijskim okruženjima

Ključne riječi: planiranje i raspoređivanje poslova, metaheuristika, vremena obrade poslova, vremena podešavanja mašina

1. UVOD

Planiranje proizvodnih resursa podrazumeva raspoređivanje poslova u pravo vreme, kako bi proces proizvodnje bio što efikasniji i produktivniji. Problem planiranja i raspoređivanja poslova u proizvodnji sastoji se od nekoliko faza i predstavlja sekvencijalni raspored poslova na mašinama, a sve u cilju minimiziranja funkcije cilja i veće produktivnosti proizvodnje [1]. Planiranje proizvodnje je jedna od osnovnih faza upravljanja proizvodnim sistemom gde se postavljaju osnovni ciljevi planiranja, strategije upravljanja i metodologije rada tako da sistem bude efikasan i dostiže početne kriterijume u vidu ciljeva preduzeća. Planiranje proizvodnje je veoma složen proces i spada u grupu

složenih i dinamičnih procesa koji su podeljeni u nekoliko faza: kratkoročno planiranje, srednjoročno planiranje i dugoročno planiranje. Sve faze planiranja zavise od procesa planiranja, ciljeva i strategije preduzeća [2]. U dosadašnjim istraživanjima u svetu planiranja u mnogim slučajevima se kao model uzima osnovni model, kada su sve mašine i poslovi dostupni za korišćenje u realnom vremenu. Međutim, u praksi se retko može naići na potpunu raspoloživost mašina bez određenih kvarova ili perioda nedostupnosti [3]. Ograničenja i dostupnost mašina mogu biti rezultat dostupnosti resursa, preventivnog i korektivnog održavanja mašina, kvarova mašina i mnogih drugih razloga koji mogu uticati na dostupnost mašina. Sve se to odražava kao posledica dinamičnog okruženja u svetu planiranja [4]. Da bi se sagledalo trenutno stanje proizvodnje i povećala produktivnost proizvodnje kao i nedostaci proizvodnog okruženja, potrebno je sagledati ceo proces proizvodnje. Simulacijom trenutnog stanja proizvodnje i detaljnom analizom, mogu se sagledati svi nedostaci posmatranog proizvodnog procesa kao što su: kritična područja uskih grla, nedostaci pri rukovanju obradivim materijalom, neadekvatan raspored mašina u proizvodnom okruženju, nedovoljno dobar raspored poslova, kašnjenje radnika, kašnjenje materijala i još mnogo toga što utiče na produktivnost proizvodnje.

Nakon temeljne analize, predlaže se odgovarajući matematički model kako bi se proizvodni proces optimizovao i otklonili proizvodni nedostaci. Identifikacija osnovnih uzroka i nedostataka modela na temelju istraživačke literature, praćena primenom naučno zasnovanih metoda, predstavlja naučni i sistematski pristup pri rešavanju problema planiranja i raspoređivanja poslova u proizvodnji [4]. Podrška operativnom planiranju proizvodnje je razrađena u više segmenata u ovom istraživanju, s osnovnom svrhom unapređenja stanja u proizvodnji i razvoja novih pristupa, metoda i tehnika za rešavanje problema planiranja proizvodnje. Planiranje je veoma važan proces upravljanja koji je osnova privrednog rasta samog preduzeća ukoliko postoje jasni ciljevi i strategije preduzeća [1]. Na osnovu toga, veoma je važno u proces planiranja uključiti metodologiju rada kako bi se ceo proces rada odvijao na osnovu definisanih pravila i na osnovu toga pratila efikasnost proizvodnje, što je jedan od najvažnijih parametara u procesu planiranja proizvodnog procesa [2]. Planiranje svih podprocesa podrazumeva strategiju i metodologiju za raspoređivanje svih poslova unutar proizvodnog okruženja. Sa razvojem informacionih i naprednih tehnologija, koje igraju ključnu ulogu u planiranju proizvodnje, koriste se različite metode u oblasti planiranja i raspoređivanja resursa. Najpoznatije metode u ovom kontekstu su: [3], [4]: Egzaktne metode: Osnovna karakteristika ovih metoda je precizno definisanje matematičkih funkcija kao i pronalaženje optimalnih rešenja u zavisnosti od veličine ispitivanih podataka. U ovoj grupi problema u okviru planiranja i raspoređivanja resursa, osnovne tehnike koje se koriste su tehnike nelinearnog, linearnog, dinamičnog, celobrojnog i nepovezanog programiranja. Heurističke metode: Ovakve metode pri traženju rešenja ne garantuju pronalaženje optimalnog rešenja, ali veoma efikasno pronalaze dovoljno dobro rešenje u realnom vremenu. Metaheurističke metode: Najpoznatiji algoritmi koji spadaju u grupu metaheurističkih metoda i koji se široko koriste za rešavanje problema planiranja i raspoređivanja resursa su: Genetski algoritam (GA), Optimizacija kolonije mrava (ACO), Simulirano kaljenje (SA), Tabu pretraga (TS) i mnogo drugi. Tehnike programiranja ograničenja mogu se primeniti na različite primere problema planiranja i raspoređivanja poslova, u zavisnosti od cilja optimizacije. Programiranje ograničenja sa ciljnom funkcijom odnosi se na određivanje vremena završetka poslednjeg obrađenog proizvoda, što se označava kao C_{max} i predstavlja

ukupnu vrednost kriterijuma funkcije. Metode simulacije: imaju veliku primenu i mogućnost predstavljanja složenih sistema u mnogo detalja, kao i mogućnost međusobnog komuniciranja između komponenti tokom procesa simulacije, što je jedna od glavnih prednosti u odnosu na druge metode. Takođe, metoda simulacije se koristi u različitim oblastima optimizacije, kao što su oblast planiranja i raspoređivanja resursa. Planiranje resursa zasnovano na simulacije ima veliku primenu u planiranju i kontroli sistema, a kao konačni izlaz dobija se detaljan plan rada.

Problem planiranja i raspoređivanja poslova ima široku primenu u proizvodnom okruženju. Predložena optimizacija problema, zasnovana na SA algoritmu, pruža optimalne rezultate. Analizom grafičkih rezultata optimizacije moguće je detaljno sagledati raspored posla, kao i ukupno trajanje proizvodnih procesa tokom proizvodnje. U daljem delu rada pružen je pregled literature o problemu raspoređivanja paralelnih mašina, dok nastavak rada posvećen je detaljnom prikazu metodologije rada i primeni predloženog matematičkog modela.

2. PREGLED LITERATURE

U ovom poglavlju dat je pregled literature zasnovan na pomenutom problemu. Jedan od prvih naučnika koji se bavio problemom planiranja i raspoređivanja resursa i koristio egzaktne metode za rešavanje takvih problema i bio je Harari [6] i njegovi saradnici 1957. godine. Kristof u svom radu [7] navodi da implementacija automatizovanih sistema u velikoj meri zavisi od efikasnog korišćenja resursa. Efikasni algoritmi i planiranje procesa mogu povećati i garantovati povraćaj investicije. Rad se bavi istraživanjem optimizacije rasporeda poslova u određeno vreme. Svaka operacija mora biti obrađena na mašini sa mogućom različitom efikasnošću, a time i vremenom obrade. Cilj je da se minimizira zbir vrednosti na kvadrat posla. Autor rada koristi metod Lagranževe relaksacije i pokazuje uspešnost metode na problemu rasporeda. U radu [8] predstavljeni su metaheuristički algoritmi simuliranog kaljenja i tabu pretraživanja za dobijanje približnih rešenja u različitim slučajevima i problemima tokom optimizacije. Rad predstavlja problem planiranja paralelnih mašina. Rezultati pokazuju efikasnost tokom procesa planiranja i raspoređivanja poslova. Autori u radu [9] predstavljaju problem identičnih mašina za paralelno planiranje. U ovom radu autori predstavljaju matematički model za raspoređivanje paralelnih mašina sa stohastičkim vremenom obrade. Da bi se rešio ovaj problem, predložen je algoritam Branch and Bound. Osnovni motiv autora rada je rešavanje robusnog problema paralelnih mašina sa stohastičkim vremenom obrade, koji ima za cilj maksimiziranje nivoa usluge korisnicima kao i minimiziranje vremena isporuke.

Autori u radu [10] predlažu heuristički pristup rešavanju problema planiranja i zakazivanja poslova. Osnovni cilj rada je zakazivanje n poslova na m paralelnih mašina sa minimalnim ukupnim radnim vremenom C_{max} . U ovom radu je predstavljen poznati problem paralelnog planiranja mašina sa podeljenim poslovima. Autori rešavaju prikazani problem pretpostavkom da se deo rada može obraditi na dve različite mašine istovremeno. U radu [11] autori razmatraju problem zakazivanja poslova na osnovu hibridnog genetskog algoritma. Autori koriste modifikovani genetski algoritam sa novim operatorima na osnovu vrednosti funkcije fitnesa. U radu je predstavljen i novi crossover operator zasnovan na mutaciji novog operatora na osnovu kritičnog rasporeda, kao i

lokalni pretraživač na osnovu kojeg se očekuje poboljšanje mogućnosti lokalnog pretraživanja. U radu [12] autori opisuju problem paralelnog raspoređivanja mašina sa više resursa, što pokazuje realniju sliku u procesu raspoređivanja. Cilj ovog rada je da se minimizira ciljna funkcija C_{max} , nedostupnost mašinskog sistema, nedostupnost kalupa u vidu resursa sa aspekta održavanja. U radu [13] predstavljena je primena stvarnog proizvodnog okruženja. Rad se bavi planiranjem i reprogramiranjem, uzimajući u obzir kvar mašina i bezbednost mašina u okruženju paralelnih mašina sa pododelom posla. Autori predlažu novi pristup rešavanju ove vrste problema. Predloženi pristup je predvidljivi algoritam za planiranje koji koristi umetanje u praznom hod u odnosu na podelu rada i zakazivanje. U radu [14] autori su ispitivali problem zakazivanja n nezavisnih poslova sa određenim datumima, rokovima kao i vremenom puštanja u rad nekoliko paralelnih mašina. U radu [15] autori predstavljaju genetski algoritam za rešavanje problema paralelnog uređenja mašina. Predložena metodologija se pokazala efikasnom za predloženi model. Autori na osnovu rezultata upoređuju genetski algoritam sa drugim metodologijama i zaključuju da predloženi metod u radu pokazuje odlične performanse. Autori rada [16] predstavljaju simulirani algoritam kaljenja na problemu raspoređivanja paralelnih mašina sa vremenom podešavanja. Predloženi algoritam uključuje ograničenu strategiju pretraživanja za smanjenje obima pretrage.

U radu [17] razmatraja se problem zakazivanja skupa poslova na dve paralelne mašine u cilju smanjenja ukupnog vremenskog domena u obliku ciljne funkcije. U radu [18] autori razmatraju problem postavljanja paralelnih mašina sa ograničenjima dostupnosti, što je drugačiji pristup. Za rešavanje ovog problema, autori predlažu i detaljno prikazuju u radu dinamički algoritam za programiranje vremena i potpuno polonomsku šemu za aproksimaciju vremena za zadatak sa dve mašine. U radu [19] autori razmatraju problem paralelnog mašinskog okruženja koji se često nalazi u mnogim praktičnim situacijama u proizvodnji. Cilj ovog rada je planiranje i raspored poslova kako bi se postiglo maksimalno vreme završetka svih poslova na mašini u najkraćem mogućem roku i povećala efikasnost proizvodnje. Autori u radu [20] razmatraju paralelno zakazivanje računara sa jednim zajedničkim serverom i obavljanje poslova. Autori u radu navode da čak i ako se radi o fiksnom broju mašina, to je veoma komplikovan slučaj za rešavanje. U radu se koristi metaheuristika za rešavanje ovog problema. U radu [21] se navodi da većina studija u oblasti planiranja resursa i raspoređivanja u okviru modela paralelnog mašinskog raspoređivanja smatra mašinu kao jedinstveni resurs. U proizvodnom okruženju za rad i obradu poslova potrebna su dodatna sredstva, što autori navode u radu i približavaju ovaj problem realnom problemu u praksi. Autori rada [22] razmatraju problem uniformnih mašina sa paralelnim rasporedom. Za ovaj problem autori predlažu razvijen model mešovitog celobrojnog programiranja čiji je cilj minimiziranje vremenskih intervala [23], [24], [5].

U prethodnom delu rada dat je detaljan opis metodologije i pregled literature kroz seriju radova na temu paralelnog planiranja i rasporeda mašina. Na osnovu sprovedenog istraživanja i metodologije korišćene u analiziranim radovima, za rešavanje problema paralelnog rasporeda mašina korišćen je metaheuristički algoritam: SA algoritam. U nastavku rada dat je detaljan opis korišćene metodologije, matematički model za definisani problem i studija slučaja zasnovana na predloženom modelu.

3. METODOLOGIJA

Metaheuristika predstavlja naprednu tehniku u optimizaciji čiji je cilj pronalaženje optimalnog rešenja ili dovoljno dobrog rešenja za dati problem optimizacije. Za razliku od konvencionalnih algoritama i iterativnih metoda, metaheuristika ne garantuje pronalaženje globalno optimalnog rešenja za problem koji se posmatra. Često se koristi stohastička optimizacija, što znači da pronađeno rešenje zavisi od skupa generisanih slučajnih promenljivih. U oblasti kombinatorne optimizacije, metaheuristike omogućavaju pronalaženje optimalnih rešenja sa manjim zahtevima za računarskom snagom u poređenju sa drugim algoritmima i metodama. Kao takve, one su korisne u rešavanju različitih problema optimizacije [25], [26], [4].

3.1. Algoritam simularnog kaljenja

Ovaj algoritam spada u grupu algoritama koji se sve više koriste u rešavanju teških NP problema zbog svoje efikasnosti u rešavanju. Osnovna karakteristika i princip SA algoritma je da temperatura materijala opada do dozvoljenog stanja koje odgovara najnižoj temperaturi, dok proces očvršćavanja materijala podrazumeva predefinisanje temperatura na kojima će materijal biti opterećen za određeno vreme. Neke od karakteristika ove metode naveo je Madić, a one su [29]: (1) kvalitet rešenja ne zavisi od početnog rešenja, ali ako nije definisano dobro početno rešenje, vreme potrebno za dobijanje konačno rešenje značajno raste, (2) biti takođe negativno, (3) može se primeniti za rešavanje različitih diskretnih i kontinualnih problema optimizacije. SA metodu je prvi put predložio 1983. poznati naučnik Kirkpatrick i njegovi saradnici [27]. Primena SA algoritma u rešavanju složenih problema optimizacije podstakla je i druge metaheurističke algoritme u razvoju i rešavanju sličnih problema, što se može videti u ovom radu. Pseudokod SA algoritma je predstavljen u Tabeli 1.

Tabela 1: Pseudo kod SA algoritma [28], [30], [4].

Pseudo kod simuliranog kaljenja

Ciljna funkcija $f(x)$, $x = (x_1, \dots, x_p)^T$

Inicijalizuj početnu temperaturu T_0 i početnu pretpostavku $x^{(0)}$

Postavi finalnu temperaturu T_f i maksimalni broj iteracija N

Definiši raspored hlađenja $T - \alpha T$, ($0 < \alpha < 1$)

While ($T > T_f$ and $n < N$)

Slučajno se pomeri na nove lokacije: $x_{n+1} = x_n + \text{rand}$

Izračunaj $\Delta f = f_{n+1}(x_{n+1}) - f_n(x_n)$

Prihvati novi rezultat ako je bolji

If Ako nije poboljšan

Generiši slučajan broj r

Prihvati ako je $p = \exp[-\Delta f/T] > r$

end if

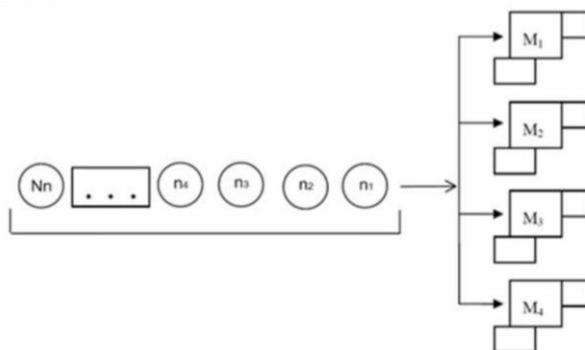
Ažuriraj najbolji x^* i f^*

$n = n + 1$

end while

4. MATEMATIČKA FORMULACIJA PROBLEMA

U nastavku rada u ovom poglavlju predstavljen je model raspoređivanja poslova na paralelnom skupu mašina. Ova vrsta primene može biti od velike koristi u proizvodnom sistemu tokom optimizacije procesa. U ovom slučaju, raspoređivanje se vrši na sličnom tipu mašine m gde se obrada n poslova na skupu mašina može obavljati istovremeno [4], [30]. Primer ovakvog tipa raspoređivanja poslova na paralelnom skupu mašina predstavljen je na Slici 1 [1]. U ovom slučaju, formulacija prikazanog problema paralelnog planiranja mašina sa vremenima izvođenja, može se definisati na sledeći način. Neka je $N = \{1, \dots, n\}$ skup poslova, a $M = \{1, \dots, m\}$ skup mašina. Ovaj problem se sastoji od raspoređivanja n poslova na m mašina sa određenim pravilima i ograničenjima tokom raspoređivanja [1], [4].



Slika 1. Grafički prikaz modela u paralelnoj vezi mašina [1]

U nastavku rada predstavljena je osnovna notacija matematičkog modela [1]:

- m – mašine,
- n – poslovi,
- p_j – vreme obrade,
- C_{max} - funkcija cilja: maksimalna produktivnost sa minimalnim vremenom,

Promenljiva:

$$x_{ij} \begin{cases} 1 & \text{if job } j \text{ is processed on machine } i \\ 0 & \text{else} \end{cases}$$

sa ograničenjem:

$$\begin{aligned} \sum_{j=1}^n x_{ij} p_j &\leq C_{max}, & i = 1, \dots, m \\ p_j &\leq C_{max} & j = 1, \dots, n \\ \sum_{i=1}^m x_{ij} &= 1 & j = 1, \dots, n \\ x_{ij} &\geq 0 & i = 1, \dots, m; j = 1, \dots, n \end{aligned} \quad (3)$$

Opisani problem se tumači kao problem raspoređivanja m mašina u paralelnu vezu, prilikom obrade poslova na mašinama, uspostavljen je siguran tok operacija na celoj liniji mašina. Kada se proces obrade prekine, postoji mogućnost obrade novog raspoloživog posla u tom trenutku, dok ciljna funkcija ima za cilj da minimizira sve poslove tokom vremena.

5. STUDIJA SLUČAJA

U ovom delu predstavljen je problem paralelnog mašinskog planiranja i rasporeda poslova u cilju postizanja maksimalne produktivnosti proizvodnje. SA algoritam je korišćen za optimizaciju rasporeda poslova, kako bi se postiglo što bolje raspoređivanje poslova na paralelnom skupu mašina i postigla maksimalna produktivnost. Matematička formulacija zadatka je detaljno prikazana u Poglavlju 4. U daljem delu rada su prikazani ulazni parametri algoritama. Treba napomenuti da su usvojena rešenja za svaki zadatak usvojena na osnovu najboljeg rezultata za definisani problem. U Tabeli 2 prikazana su vremena obrade poslova za sve mašine [1]. Vremena podešavanja poslova na mašinama prikazana su u Tabeli 3[1]. Ulazni parametri optimizacije izvedeni su iz prethodnog rada autora, koji je istraživao sličan problem korišćenjem genetskog algoritma (GA) [1].

Tabela 2: Vremena obrade poslova na mašinam M_1 i M_8

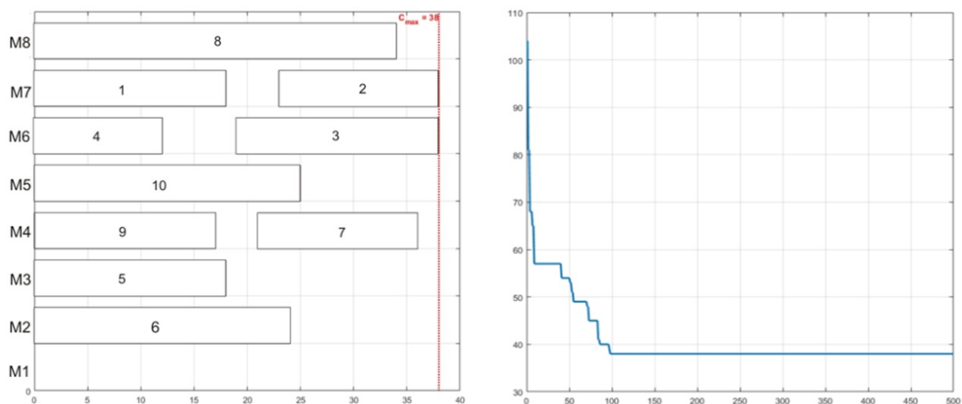
N	M1	M2	M3	M4	M5	M6	M7	M8
1	29	17	18	25	38	27	18	35
2	23	52	50	59	55	30	15	17
3	25	39	55	10	42	19	23	25
4	45	38	36	49	22	12	33	35
5	55	56	18	51	12	30	43	25
6	48	24	40	54	32	40	33	45
7	48	27	18	15	42	50	53	27
8	23	52	50	59	58	24	45	34
9	25	39	35	17	28	34	49	64
10	45	38	36	49	25	44	40	44

Tabela 3: Vremena podešavanja za izvršenje poslova na mašinama M_1 i M_8

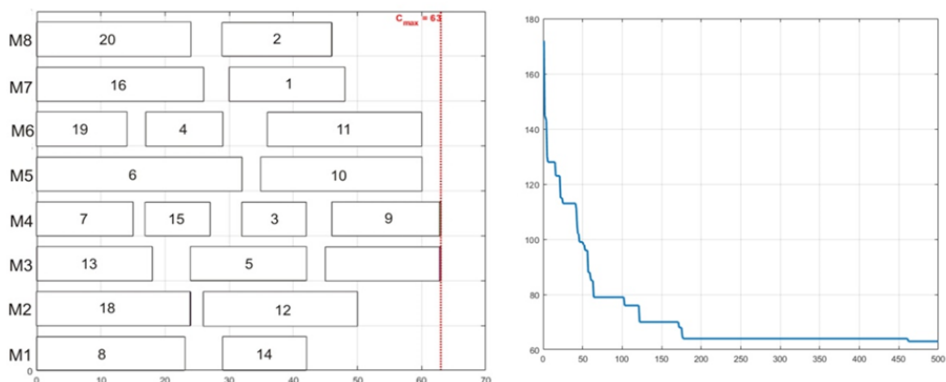
M1	1	2	...	6	7	8	9	10	M2	1	2	...	7	8	9	10
1	5	7	...	5	2	4	3	8	1	7	7	...	4	7	2	5
2	3	5	...	6	5	2	7	4	2	7	7	...	3	6	6	3
3	6	8	...	2	7	8	4	2	3	7	2	...	3	7	2	2
4	3	4	...	6	8	8	5	5	4	2	5	...	2	6	7	5
5	2	7	...	4	3	8	3	4	5	6	4	...	2	5	8	3
6	7	4	...	2	3	8	3	3	6	5	5	...	6	6	7	8
7	3	7	...	5	5	7	6	3	7	3	4	...	8	5	2	2
8	5	7	...	3	6	5	4	8	8	2	4	...	2	4	2	4
9	6	4	...	2	4	3	8	6	9	7	3	...	4	7	6	5
10	4	3	...	3	3	4	2	5	10	3	3	...	8	8	7	7

M3	1	2	...	6	7	8	9	10	M4	1	2	...	7	8	9	10
1	6	5	...	6	3	8	2	3	1	7	7	...	5	2	3	8
2	4	6	...	5	5	6	3	2	2	8	5	...	6	4	7	6
3	5	8	...	3	2	5	2	6	3	3	3	...	8	8	4	6
4	6	7	...	6	7	7	5	8	4	7	5	...	3	5	4	7
5	8	4	...	2	7	5	3	8	5	3	5	...	7	4	3	2
6	7	7	...	6	8	5	4	3	6	8	8	...	6	3	7	8
7	2	2	...	6	8	6	4	5	7	7	7	...	5	5	6	4
8	6	2	...	2	5	4	2	4	8	4	8	...	8	8	7	2
9	5	2	...	2	3	3	5	5	9	7	6	...	4	2	7	7
10	5	3	...	3	2	6	6	3	10	5	4	...	3	5	2	7
M5	1	2	...	6	7	8	9	10	M6	1	2	...	7	8	9	10
1	4	7	...	2	2	7	5	3	1	7	7	...	2	4	7	2
2	3	5	...	6	5	2	7	4	2	7	7	...	3	6	6	3
3	6	8	...	2	7	8	4	2	3	7	2	...	3	7	2	2
4	3	4	...	6	8	8	5	5	4	2	5	...	2	6	7	5
5	2	7	...	4	3	8	2	4	5	6	4	...	2	5	8	3
6	7	4	...	2	3	8	3	3	6	5	5	...	6	6	7	8
7	3	7	...	5	5	7	6	3	7	3	4	...	8	5	2	2
8	5	7	...	3	6	5	4	8	8	2	4	...	2	4	2	4
9	6	4	...	2	4	3	8	6	9	7	3	...	4	7	6	5
10	4	3	...	3	3	4	2	5	10	3	3	...	8	8	7	7
M7	1	2	...	6	7	8	9	10	M8	1	2	...	7	8	9	10
1	6	5	...	6	3	8	2	3	1	7	7	...	5	2	3	8
2	4	6	...	5	5	6	3	2	2	8	5	...	6	4	7	6
3	5	8	...	3	2	5	2	6	3	3	3	...	8	8	4	6
4	6	7	...	6	7	7	5	8	4	7	5	...	3	5	4	7
5	8	4	...	2	7	5	3	8	5	3	5	...	7	4	3	2
6	7	7	...	6	8	5	4	3	6	8	8	...	6	3	7	8
7	2	2	...	6	8	6	4	5	7	7	7	...	5	5	6	4
8	6	2	...	2	5	4	2	4	8	4	8	...	8	8	7	2
9	5	2	...	2	3	3	5	5	9	7	6	...	4	2	7	7
10	5	3	...	3	2	6	6	3	10	8	4	...	3	5	2	7

U Tabelama 2 i 3 prikazani su ulazni parametri za postavljeni matematički model, na osnovu Tabela može se zaključiti da razmatrani problem sa paralelnim rasporedom mašina se sastoji od $M = 8$ mašina i $N = 10$ poslova [1]. U nastavku rada prikazani su rezultati istraživanja na osnovu ulaznih parametara iz Tabele 2 i Tabele 3. Grafički rezultati u vidu rasporeda poslova na mašinama prikazani su grafički na Slikama 3 i 4. Na osnovu eksperimentalnih rezultata može se zaključiti da SA algoritam daje optimalne rezultate za dati problem, što je potvrđeno funkcijom cilja u modelu. Istraživanjem i optimizacijom zaključeno je da određeni ulazni parametri, kao što su temperatura i brzina hlađenja, igraju ključnu ulogu u uspehu algoritma.



Slika 3. Grafički rezultati zasnovani na SA algoritmu: zadatak 10 x 8



Slika 4. Grafički rezultati zasnovani na SA algoritmu: zadatak 20 x 8

6. ZAKLJUČAK I DISKUSIJA

Problem planiranja i raspoređivanja poslova je jedan od najtežih problema u kombinatornoj optimizaciji. Povećanje produktivnosti proizvodnje jedan je od ciljeva predstavljenog modela sa paralelnim mašinskim planiranjem. U ovoj studiji slučaja, SA algoritma je primenjena za rešavanje problema raspoređivanja paralelnih mašina sa vremenom obrade i vremenom podešavanja, koristeći ga za rešavanje specifičnog problema. U prvom delu rada prikazana je tema istraživanja i značaj ovog problema u današnjem svetu istraživanja. U drugom poglavlju je predstavljena relevantna literatura kako bi se steklo dublje razumevanje problema i kako se dosadašnja istraživanja odnose na ovaj rad. Poglavlje 3 detaljno opisuje metodologiju, posebno SA algoritam koji se koristi za optimizaciju u ovoj studiji slučaja. Četvrto poglavlje predstavlja matematički model koji je korišćen kao osnova za sprovedeni eksperiment. Ovaj model je bio ključan za definisanje cilja optimizacije i razumevanje kako SA algoritam funkcioniše u kontekstu problema. Peto poglavlje predstavlja rezultate eksperimenata, uključujući optimizovane

vrednosti i ponašanje SA algoritma u različitim uslovima. Na osnovu eksperimentalnih rezultata može se zaključiti da SA algoritam daje optimalne rezultate za dati problem, što je potvrđeno funkcijom cilja u modelu. Istraživanjem i optimizacijom zaključeno je da određeni ulazni parametri, kao što su temperatura i brzina hlađenja, igraju ključnu ulogu u uspehu algoritma. Ova istraživanja omogućavaju bolje razumevanje i ponašanje SA algoritma i kako optimalno konfigurisati algoritam za slične probleme u budućnosti. Pored toga, ovo istraživanje doprinosi razumevanju optimizacije putem metaheurističkih algoritama, posebno SA algoritama, i može se koristiti kao osnova za dalja istraživanja u ovoj oblasti. Takođe je značajno napomenuti da je u jednom od radova autora [1] istražen sličan model optimizacije korišćenjem GA, koji je takođe dao optimalne rezultate za ovaj problem. Komparativnom analizom GA i SA algoritama na osnovu dobijenih rezultata može se zaključiti uspešnost oba algoritma. Na osnovu prvog skupa ulaznih podataka i dobijenih rezultata, može se videti da GA algoritam i SA algoritam imaju kriterijumsku funkciju sa vrednošću od $C_{\max} = 63$ minuta, dok je GA algoritmu potrebno manje iteracija da bi se pronašlo optimalno rešenje. Takođe, na osnovu dobijenih rezultata mogu se videti rezultati zasnovani na kriterijumskoj funkciji GA algoritma gde je $C_{\max} = 37$ minuta i SA algoritma $C_{\max} = 38$ minuta. Može se reći da je potreban isti ili slučajan broj iteracija za pronalaženje optimalnog rešenja. Ovo istraživanje dalje potvrđuje da postoje različite metaheurističke metode koje mogu efikasno rešiti problem rasporeda poslova na paralelnim mašinama, dajući više mogućnosti da se izabere odgovarajući metod u zavisnosti od specifičnih potreba i resursa. Za buduće studije slučaja, plan je da se dodaju još metoda kao i da se model proširi u obliku ograničenja kako bi sam proces planiranja bio što realističniji u procesu proizvodnje u realnom vremenu.

ZAHVALNOST

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NUMERICAL ANALYSIS OF THE PIPE HEIGHT IMPACT ON STRUCTURAL LOADING CAUSED BY WIND PRESSURE

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ABSTRACT: *Wind load calculations are crucial in structural engineering, particularly in scenarios such as steel pipe installations where exposure to external forces is significant. To investigate the wind's effect on structures, data is collected on wind impacts at specific locations, and mathematical models describing wind effects are developed and enhanced. This study focuses on wind load determination for a steel pipe using local wind speed data following Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions. Through rigorous calculations based on equations provided by the standard, the peak wind velocity, turbulence intensity, and resulting wind pressure distribution on the pipe surface are determined. Additionally, a detailed analysis is conducted on the application of wind pressure via developed FEMAP API script, facilitating precise load definition on FEM shell elements, application of calculated force which represents wind pressure on FEM shell elements on half of the model, and application of FEMAP API script calculated force which represents wind pressure on FEM shell elements on half of the model. The results highlight the importance of accurate wind load assessment in ensuring structural integrity and safety.*

Keywords: *Wind Effects, FEM Analysis, FEMAP Application Programming Interface*

1. INTRODUCTION

Steel pipes play a crucial role in various industrial applications, including steel manufacturing plants. Understanding the effects of wind loads on structures is essential for ensuring their stability and resilience. The paper [1] introduces a comprehensive numerical model to predict the structural behavior of transmission towers which are part of the transmission line under high-intensity wind loads, such as downburst events, which are less understood despite extensive research on normal wind loads. Wind load is the predominant force acting on greenhouses. Customized greenhouse designs tailored to localized wind loads are essential, as demonstrated in [2] estimating wind loads for a double arch-type naturally ventilated greenhouse in India. Finite Element Method simulation in ANSYS 15.0 revealed potential failure zones, emphasizing the need for

precise structural design considerations in greenhouse construction to enhance structural stability. He et al. [3] proposed a computational modeling approach to assess the structural behavior of low-rise wood frame buildings under wind loads. The methodology utilizes a three-dimensional finite-element model validated through testing at the Wall of Wind Experimental Facility, providing insights into load paths and load-sharing mechanisms crucial for understanding the performance of vulnerable building components during windstorms.

The challenges posed by wind-induced motion in modern tall buildings, focusing on the complex coupled lateral and torsional effects arising from their irregular geometric shapes were investigated. By analyzing equivalent static wind loads and developing an optimal stiffness design technique, the aim of the study in paper [4] is to optimize the structural response of tall asymmetric buildings, ultimately reducing wind-induced loads and enhancing cost efficiency.

For numerical analysis in this study, FEMAP with NX Nastran solver [5] was used. This software is based on the Finite Element Method [6]. The numerical method performed in this paper is used to determine the stress state in the pipe [7]. In the next chapters the calculation of wind loads according to Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions [8] will be discussed. The developed Visual Basic script [9] which is used for the application of pressure on FEM shell elements will be explained. The FEM shell elements were used to model the pipe.

In this study, the process of wind load determination for a steel pipe by Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions were investigated. By analyzing local wind speed data and applying relevant equations from the standard, the impact of wind pressure on the pipe surface was assessed. Furthermore, this paper represents a comparative study of FEMAP API scripting, a calculated force that represents wind pressure and is applied on half of the model, and FEMAP API script calculated force that represents wind pressure and is applied on the half of the model utilization for the precise load definition, enhancing the accuracy of structural analysis.

2. CALCULATION OF WIND PRESSURE ACCORDING TO EUROCODE

Wind load is calculated based on local data on actual measured wind speed according to Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions [8]. For wind load determination, a fundamental value of basic wind velocity $v_{b,0}$ is used, which is given in the National Annex, and for the region near where the pipe will be placed. The value of $v_{b,0} = 25 \text{ m/s}$. The pipe will be placed on flat ground with regular vegetation classified as terrain category III according to Table 4.1 in standard [8]. The same table gives us the values of the roughness length $z_0 = 0.3 \text{ m}$ and the minimum height $z_{min} = 5 \text{ m}$ and $z_{max} = 200 \text{ m}$. Terrain factor k_r is calculated based on roughness length z_0 and reference roughness length $z_{0,II} = 0.05 \text{ m}$ for terrain category II:

$$k_r = 0.19 \cdot \left(\frac{z_0}{z_{0,II}} \right)^{0.07} = 0.215. \quad (1)$$

The terrain roughness factor c_r for $z_{min} \leq z \leq z_{max}$ is calculated using:

$$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right) \quad (2)$$

and $c_r(z) = c_r(z_{min})$ for $z \leq z_{min}$.

The value of the topography coefficient $c_o(z)$ is obtained from the National Annex. The value of the topography coefficient $c_o(z) = 1$ for flat terrain.

According to [8] the turbulence intensity for $z_{min} \leq z \leq z_{max}$ is:

$$I_v(z) = \frac{k_I}{c_o(z) \cdot \ln(z/z_0)}, \quad (3)$$

and $I_v(z) = I_v(z_{min})$ for $z \leq z_{min}$. Recommended value for turbulence factor k_I is 1.0, other values may be specified by the National Annex.

The mean wind velocity at height is given as:

$$v_m(z) = c_r(z) \cdot c_o(z) \cdot v_{b,0} \quad (4)$$

The peak velocity pressure $q_p(z)$ accounts for turbulence intensity $I_v(z)$ and the mean wind velocity $v_m(z)$ is:

$$q_p(z) = (1 + 7 \cdot I_v(z)) \cdot 0.5 \cdot \rho \cdot v_m(z)^2. \quad (5)$$

The recommended value of the air density according to the National Annex is $\rho = 1.25 \text{ kg/m}^3$.

Per [8] expression (4.1) basic velocity pressure is

$$q_b = 0.5 \cdot \rho \cdot v_{b,0}^2 = 390.63 \text{ N/m}^2. \quad (6)$$

According to expressions (5) and (6) the peak velocity pressure is

$$q_p(z) = (1 + 7 \cdot I_v(z)) \cdot c_r(z)^2 \cdot c_o(z)^2 \cdot q_b. \quad (7)$$

The peak velocity pressure value dependence on structure height according to equation (7) is shown in Fig. 1.

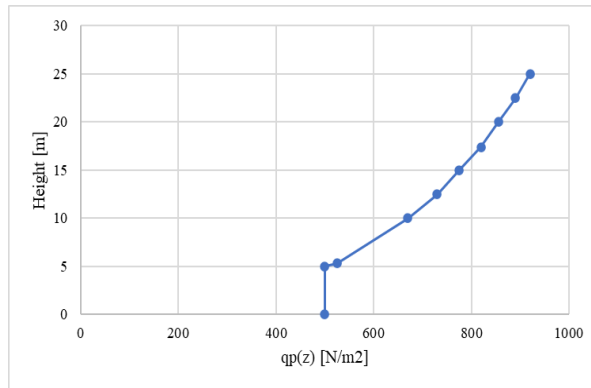


Fig. 1. Peak velocity pressure value dependence on structure height

For the reference height, the maximum height of the observed section $z_e = 25 \text{ m}$, [8] and it is used for the calculation of the peak wind velocity:

$$v(z_e) = \sqrt{\frac{2 \cdot q_p(z_e)}{\rho}} = 38.274 \text{ m/s}. \quad (8)$$

The peak wind velocity $v(z_e)$, kinematic viscosity of the air $\nu = 15 \cdot 10^{-6} \text{ m}^2/\text{s}$ and pipe diameter $b = 0.8 \text{ m}$ is used to calculate the Reynolds number:

$$R_e = \frac{b \cdot v(z_e)}{\nu} = 2.04 \cdot 10^7. \quad (9)$$

Reynolds number characterizes wind load distribution over a cylinder surface. The positions of the minimum pressure $\alpha_{min} = 75^\circ$ and the flow separation $\alpha_A = 105^\circ$ are obtained from Table 7.12 according to standard [8] for $R_e = 2.04 \cdot 10^7$. The distribution of load changes with the angle in regard to wind direction according to the end-effect factor $\psi_{\lambda\alpha}$ which is given by expression (7.18) in standard [8]. The indicative value of the end-effect factor (ψ_λ) in expression (7.18) [8] is determined from the diagram (7.36) in the standard [8] using the solidity ratio φ (which is for a cylinder equal to 1) and slenderness λ which can be found in the table (7.16) in [8]. Linear interpolation was used to calculate slenderness for $l = 25$ m:

$$\lambda = 28.57. \quad (10)$$

From the diagram (7.36) in standard [8] $\psi_{\lambda\alpha}$ is 0.81.

Wind pressure on external surfaces $w_e(z)$ is calculated as:

$$w_e(z) = q_p(z) \cdot c_{p,0} \cdot \psi_{\lambda\alpha}, \quad (11)$$

where $c_{p,0}$ is the external pressure coefficient without free-end flow, which is given in figure (7.27) [8] for various Reynolds numbers as a function of angle α .

$$w_e(z) = q_p(z) \cdot c_{p,0} \quad \text{for } 0^\circ \leq \alpha \leq 75^\circ$$

$$w_e(z) = q_p(z) \cdot c_{p,0} \cdot 0.154 \cdot \cos\left(\frac{\pi}{2} \cdot \left(\frac{\alpha - 75^\circ}{105^\circ - 75^\circ}\right)\right) \quad \text{for } 75^\circ \leq \alpha \leq 105^\circ \quad (12)$$

$$w_e(z) = q_p(z) \cdot c_{p,0} \cdot 0.81, \quad \text{for } 105^\circ \leq \alpha \leq 180^\circ,$$

The pressure distribution on the pipe according to equation (12) is shown in Fig. 2.

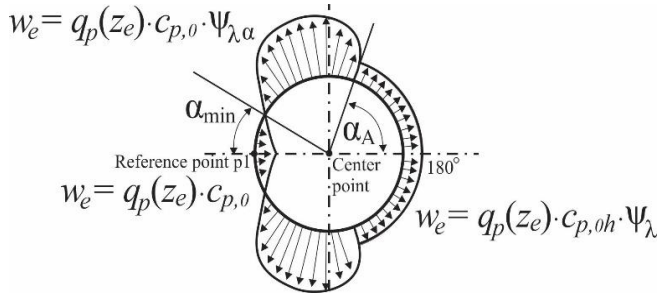


Fig. 2. Pressure distribution illustration

The reference area for the cylindrical structures is

$$A = l \cdot b = 25 \cdot 0.8 = 20 \text{ m}^2 \quad (13)$$

Then the resulting characteristic value of the wind-induced force on the foundation of the pipe is:

$$F_w = q_p(z_e) \cdot \psi_{\lambda\alpha} \cdot A = 915.56 \cdot 0.81 \cdot 20 = 14832 \text{ N}. \quad (14)$$

3. FEMAP API FOR LOAD DEFINITION

FEMAP is the most versatile software for pre-processing [5] i.e. FEM model preparation, which includes generation of finite element mesh and prescription of loads and boundary

conditions. To apply wind pressure on the pipe wall modeled with FEM shell elements and according to equation (12), and Fig. 2, the FEMAP API script is developed in Visual Basic (API stands for Application Programming Interface). More details on the FEMAP API script application are given in the paper [9].

All coefficients obtained from the Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions and previously given equation are declared. These coefficients are entered into an API-generated dialog box (Fig. 3.)

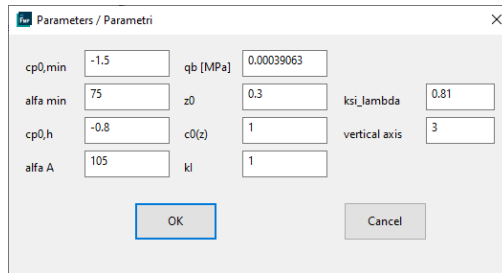


Fig. 3. FEMAP API dialog box for pressure coefficients

To select finite elements for wind load prescription a selection dialog box from the FEMAP API was created as shown in Fig. 4.

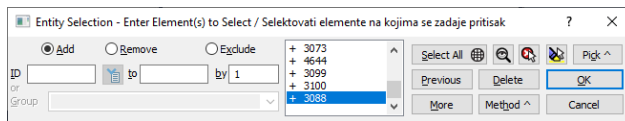


Fig. 4. FEMAP API dialog box for finite element selection

After the finite elements for pressure load are selected, API generates dialog boxes for the selection of the center and the reference point.

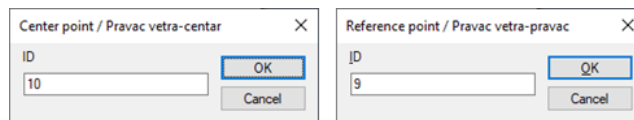


Fig. 5. FEMAP API dialog boxes for point selection

Initially, it is assumed that for every finite element on which pressure is applied, the external face is face number 2 and that the wind blows in the -x direction. The vertical axis (z, i.e. 3) is selected in the first dialog box (Fig. 3.) and stored as the vertical axis.

4. RESULTS AND DISCUSSION

The wind pressure distribution on the pipe is shown in Fig. 6. This distribution is obtained from previously shown equations and applied via the FEMAP API script. It can be seen the resemblance between Fig. 2 which is an illustration of different pressure zones and Fig. 6 which gives the real results. Fig. 6 shows the values of pressure on the lowest and highest rows of finite elements on the pipe.

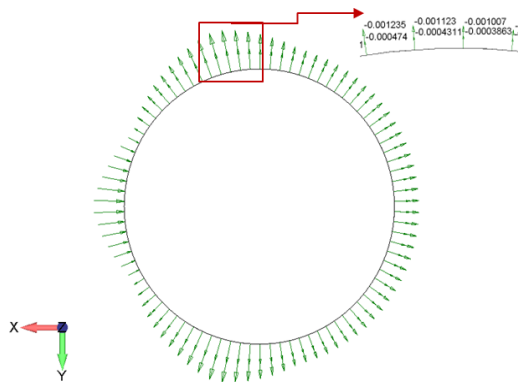


Fig. 6. Wind pressure distribution on pipe surface via API

The applying of wind pressure on cylindrical surfaces according to Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions are complicated in software where it is not possible to apply pressure via macros or code (API). An approximate method for applying wind impact on the structure involves applying pressure on half of the cylinder in the direction and orientation of the wind action (Fig. 7). In this approach, the area subjected to wind is equal to the product of the height and diameter of the pipe (dimensions of the cylindrical object under consideration). The total wind force applied in this case is equal to the force calculated by equation (14). The specified pressure is constant, i.e., it does not depend on the height of the object.

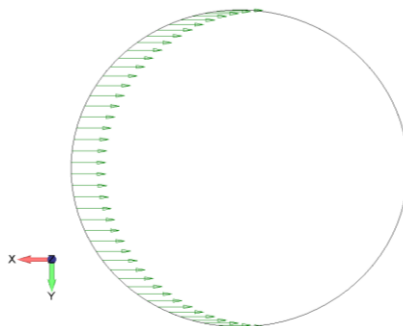


Fig. 7. Wind pressure distribution on pipe surface via analytical calculation

An examination has been conducted regarding the impact of wind load on the stresses on the pipe. The total wind force in the x-direction, specified according to Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions is 8230 N. The force obtained from equation (14) is calculated for the pressure at the top of the structure (pipe). Force (14) is relevant for the calculation of the structure's foundation. From the diagram, in Fig. 1, it can be observed that the pressure at the top of the structure is twice as high as the pressure at a height of 5 m. The ratio of the force obtained by API and the force in equation (14) is 0.554. In reality, the wind force is less than the force obtained from equation (14), so an analysis of the pipe was performed where the wind load is specified as a constant pressure on half of the model, resulting in a total force in the x-direction equal to 8899 N ($14832 \text{ N} * 0.6 = 8899 \text{ N}$).

In Fig. 8, the stress field on the pipe is shown for the load case where the wind is specified via the API by Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions. The maximal value of von Mises stress for this load case is 279.15 MPa.

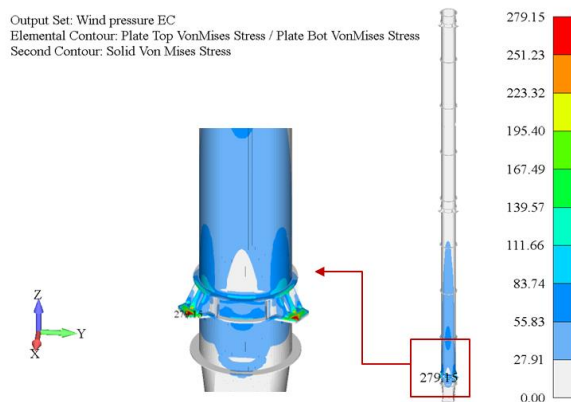


Fig. 8. Von Mises stress in the pipe: wind pressure according to Eurocode

In Fig. 9, the stress field on the pipe is shown for the load case where the wind load is applied as a constant pressure on half of the model, resulting in a total force equal to the force given by equation (14). The maximal value of von Mises stress for this load case is 438.37 MPa.

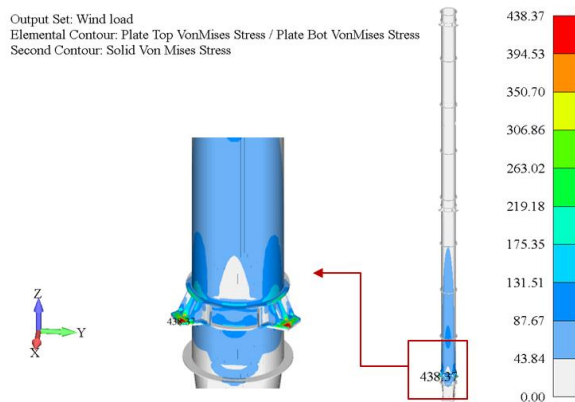


Fig. 9. Von Misses stress in the pipe: constant wind pressure

In Fig. 10, the stress field on the pipe is shown for the load case where the wind load is applied as a constant pressure on half of the model, resulting in a total force in the x-direction equal to 8899 N. The maximal value of von Misses stress for this load case is 261.64 MPa.

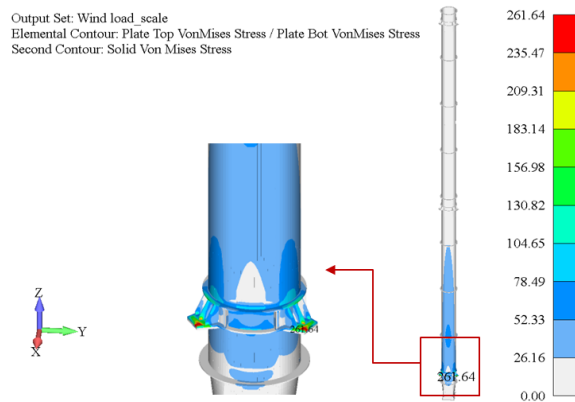


Fig. 10. Von Misses stress in the pipe: constant wind pressure (scale)

From Figures 8-10, it can be seen that the von Misses stress value is highest when the wind load is specified as a constant pressure, with the total force equal to 14832 N.

5. CONCLUSION

The analysis of wind load distribution on a steel pipe surface provides valuable insights into the structural behavior under external forces. By adhering to Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions, and employing advanced computational tools such as FEMAP API scripting, we ensure robust load definition and accurate assessment of structural response. The results indicate significant stress concentrations at specific locations on the pipe surface, emphasizing the importance of detailed wind load analysis in engineering design.

The maximal von Mises stress for the load case where wind load is applied via FEMAP API is 279.15 MPa. The maximal von Mises stress for the load case where wind load is applied with calculated force through equation (14) is 438.37 MPa. The maximal von Mises stress for the load case with the calculated force of 8899 N is 264.64 MPa. For the last two load cases, wind load was applied as a force on half of the model. As can be seen from the results in this paper, the last methodology can be used in finite element software where it is not possible to apply pressure via macros or code (API), and these efforts are warranted to enhance the reliability of numerical calculation results obtained by wind load in steel pipe installations.

ACKNOWLEDGEMENTS

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THERMAL ANALYSIS OF SOLAR WALL AIR HEATING SYSTEM

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ABSTRACT:

This study presents a thermal analysis of an air heating solar wall system featuring a modified Trombe wall design. The analyzed system comprises double glass glazing and a massive wall with an opening and central channel. The study aims to analyze the temperature distribution within the system to gain insights into its performance under varying constructive and operational parameters. Numerical simulations are used to assess dynamic temperature profiles within the system. The obtained results are analyzed to predict the effects of environmental parameter, such as solar radiation, ambient temperature, and wind velocity, on the surface temperatures of the solar wall. The proposed thermal analysis is important for determining the design parameters and operational conditions of the solar wall air system, thus advancing the development of sustainable and efficient passive solar heating solutions.

Keywords: solar wall, air heating, modified Trombe wall, temperature distribution

1. INTRODUCTION

Two distinct approaches have traditionally been employed for harnessing solar energy for building space heating: active systems, which utilize arrays of solar collectors, and passive systems, which capture solar energy through building design principles. Buildings have been identified as one of the most significant users of energy. Green building construction standards have received special attention in an effort to create more energy-efficient and sustainable buildings. Among passive methods, solar walls have gained prominence for their ability to transfer heat to indoor spaces via radiation and convection, operating at lower temperatures facilitated by their extensive surface area for heat exchange.

The solar wall air heating systems for various purposes are based on the utilization of massive solar walls. This heating concept involves the use of walls covered with transparent covers, whose irradiated surface exhibits good absorption characteristics, while the mass of the wall possesses significant thermal storage capacity. With its low cost, easy implementation geometry, and simplicity of operation, a Trombe wall is one of the most effective passive solar systems for heating, cooling, and ventilation of space, creating a comfortable and healthy interior environment. The performance of a Trombe wall is dependent not only on its construction, but also on external factors such as the ambient temperature and incident solar radiation [1].

Solar heating systems based on the use of solar walls must anticipate the construction of shading devices to prevent thermal overload of the heated space. Shading of the absorptive surface of the wall can be achieved through the use of awnings, movable blinds, or by planting deciduous trees on the southern side of the buildings. During the summer, the dense foliage of the trees casts shade on the absorptive surface of the wall, while in winter, the fallen leaves allow unhindered passage of solar radiation [2].

The solar walls have been the subject of numerous experiments and investigations. Many theoretical and experimental studies have shown that indoor comfort is improved due to well-designed solar walls. The literature generally describes the effects of design parameters on the efficiency of different types of Trombe wall [3-6]. This paper presents the effect of parameters, such as solar radiation, wind velocity, and ambient temperature, on the temperature distribution of the modified Trombe wall air heating system.

2. METODOLOGY

The construction of the modified Trombe wall with a central channel used for the analysis is shown in Figure 1. Such a design allows for faster and more efficient heat transfer from the receiving space, where intensive heat losses occur, to the central part of the wall, compared with a standard Trombe wall design. The central part of the wall can be made with or without fill material. The circulation of heated air from the receiving channel to the central channel of the wall can be either natural (thermosiphonic) or forced, necessitating the installation of fans in the wall opening [7].

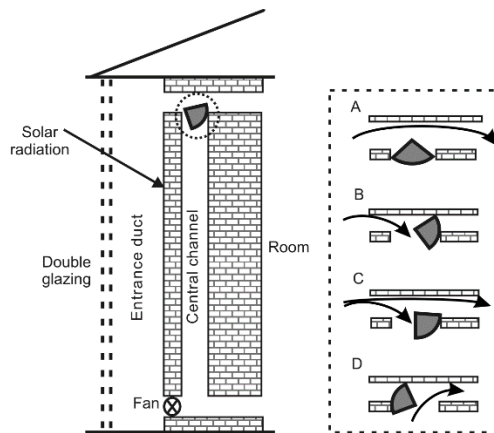


Fig. 1. Schematic representations of the active solar wall and regime of operation

Depending on the position of the valve, the wall has four different operating modes (A-D). Modes A, B, and C are used for heating and storing energy when the wall is exposed to the sun. Mode A is used for room heating by hot air circulation from the entrance duct, while mode B is used for intensive heat storage by direct absorption and conduction and by hot air circulation from the entrance duct into the inner channel space. Mode C is used for room heating and heat storage by simultaneous air circulation from

the entrance channel into the room and the inner channel space, and mode D is used for accumulated energy heating when the wall is not exposed to the sun. A fan is installed at the lower opening of the wall to facilitate forced air circulation.

Considered herein is a case in which an modified Trombe solar wall is exposed to solar radiation, resulting in a heat flux from the exterior side of the wall to the heated space. Figure 2 shows the outline of a solar wall for air heating and the main parameters involved in heat transfers: incident solar radiation (G), ambient temperature (T_{amb}), air inlet temperature in the entrance duct (T_{in}), air outlet temperature from the entrance duct (T_{out}), average temperature of absorbing surface of wall (T_1), average temperatures of glazing (T_2, T_3), external wall width (b), distance between glazing (b_1), receiving channel width (b_2), central channel width (b_3), internal wall width (b_4) and wall height (H).

Global solar radiation directed towards the external glass covering introduces the incident thermal flux to the solar wall system. When the air temperature in the heated space falls below the desired level, it necessitates the circulation of heated air from the receiving space to the heated room to achieve thermal comfort. In the proposed model of the solar air heating system, heat can accumulate in both the external and internal parts of the wall, which are of different thicknesses. Considering the thinness of the external part of the wall, it is assumed that it lacks significant heat accumulation capacity. Therefore, it is assumed that the heat that can be accumulated in the active solar wall accumulates only in its internal part, which is thicker than the external part, thus its accumulation capacity cannot be neglected.

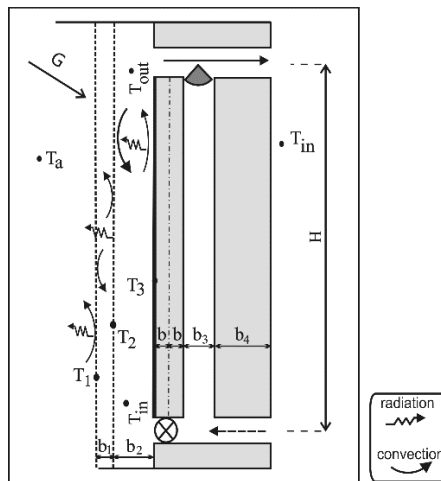


Fig 2. Definition of heat transfer modes and parameters of the wall

A portion of the air circulating from the receiving channel of the wall to the heated room returns through an opening at the lower part of the active solar wall to the receiving channel. To achieve thermal balance, it is assumed that the air temperature at the entrance to the receiving channel equals the air temperature in the heated room. The energy potential of the return airflow from the heated room is negligible compared to the potential of the airflow through the receiving channel between the absorptive surface of the wall

and the glass cover. Thus, the heat flux of the return airflow is disregarded in energy balances [8].

The constant parameters used to define the mathematical model of the analyzed solar wall used A portion of the air circulating from the receiving channel of the wall to the heated room returns through an opening at the lower part of the active solar wall to the receiving channel. To achieve thermal balance, it is assumed that the air temperature at the entrance to the receiving channel equals the air temperature in the heated room. The energy potential of the return airflow from the heated room is negligible compared to the potential of the airflow through the receiving channel, between the absorptive surface of the wall and the glass cover. Thus, the heat flux of the return airflow is disregarded in energy balances [8].

The constant parameters used in the simulation for heating a room with heated air flowing from the receiving zone to the heated room were set as follows:

- The azimuth angle of the south-facing wall was 0°
- Distance between glass covers $b_1 = 10$ cm
- Air velocity at the entrance of the receiving channel $v=1$ m/s
- Wall height $H = 3$ m and width $W = 2$ m
- Upper vent size $A = 0.3 \text{ m} \times 0.06 \text{ m} = 0.018 \text{ m}^2$
- Spacing of air vents, $h = 2.5$ m
- Glass covers: transmission $\tau = 0.85$, emissivity $\varepsilon_g = 0.95$
- Solar radiation absorption rate on the surface of the heat collecting wall $\alpha = 0.95$
- Solar radiation emit rate on the surface of the heat collecting wall $\varepsilon_1 = 0.95$
- Emission coefficient of the wall material $\varepsilon_w = 0.95$
- Fan efficiency $\eta = 0.95$.

3. RESULTS AND DISSCUSION

In numerical research, investigations were conducted to examine the effects of operational and constructive parameters on the temperature of the absorbing surface of the solar wall as well as on glass coverings. Figure 3 shows that the temperature of the absorbing surface of the wall increases with the increase in global solar radiation, for different values of the air temperature at the inlet the entrence channel of the wall. For a certain value of global solar radiation, the temperature of the absorbing surface of the wall is higher when the air temperature at the entrance of the receiving channel is higher, and vice versa. In the first simulation, it was assumed that wind speed $w=0$ m/s, $b_2=10$ cm and $t_{\text{amb}}=0$ °C.

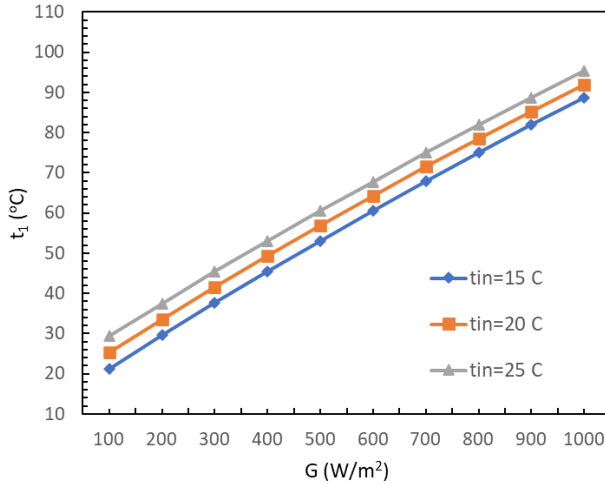


Fig. 3. Solar absorbing surface temperature t_1 as a function of global solar radiation G and air temperature at the entrance of the receiving channel t_{in}

Figure 4 shows the temperature change of the absorbing surface of the solar wall and glass covers for various levels of global solar radiation. The rise in global solar radiation correlates with an increase in the analyzed temperatures, showing a linear dependence.

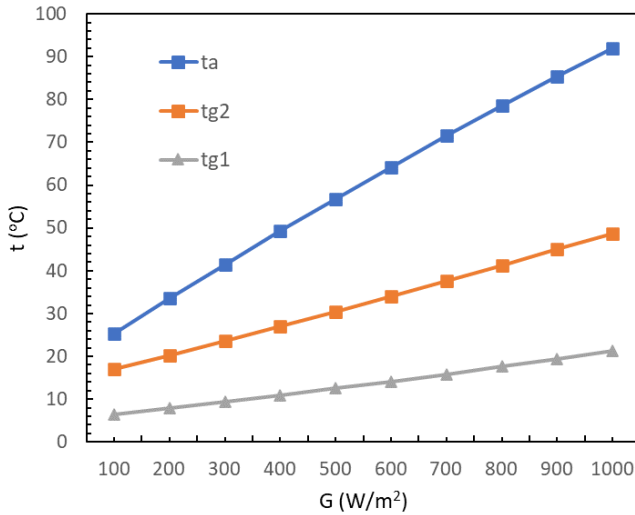


Fig. 4. Temperatures of solar absorbing surface t_1 and glass covers t_{g1} and t_{g2} as a function of global solar radiation G

The amount of energy obtained from installing low-emission double glazing depends on the kind of wall and thermal mass. The purpose of glazing in front of the wall is to both help absorb and prevent heat losses. For the Trombe wall system, using double glass increases passive cooling in the summer and decreases heat losses in the winter. The distance between the glass and the thermal mass i.e. receiving channel width is usually between 3-6 cm [9].

Figure 5 depicts that as the width of the receiving channel increases across a range of air temperature values at the entrance, the temperature of the wall's absorbing surface rises. Concurrently, the coefficient of heat transfer from the wall's absorbing surface to the air and from the air to the inner glass cover decreases with the widening of the receiving channel. When holding the receiving channel width constant, the temperature of the wall's absorbing surface correlates positively with the air temperature at the channel entrance. Conversely, a lower air temperature results in a lower temperature of the wall's absorbing surface. The width of the receiving channel emerges as an important factor in determining the temperature of the wall's absorbing surface, as revealed by the simulation outcomes. In this simulation, it was assumed that $G=1000 \text{ W/m}^2$, $w=0 \text{ m/s}$, $b_1=10 \text{ cm}$ and $t_{\text{amb}}=0 \text{ }^\circ\text{C}$.

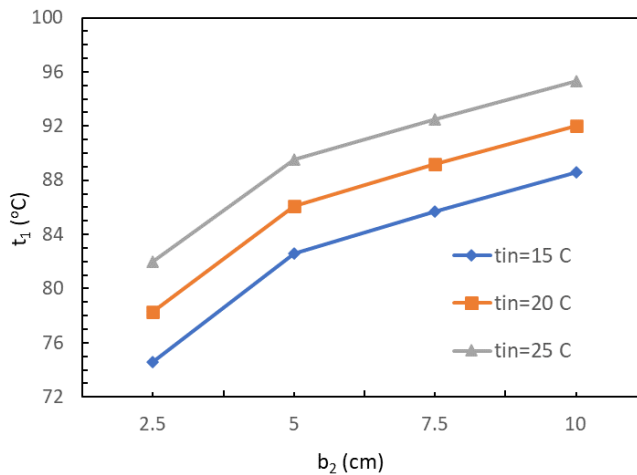


Fig. 5. Solar absorbing surface temperature t_1 as a function of receiving channel width b_2 and air temperature at the entrance of the receiving channel t_{in}

For different global solar radiation, a Figure 6 demonstrates that the temperature of the wall's absorbing surface t_1 rises slightly in response to an increase in the ambient air temperature t_{amb} . Nonetheless, when global solar radiation rises, the temperature of the wall's absorbing surface rises noticeably for a given air temperature in the surrounding area. In this simulation, it was assumed that $w=0 \text{ m/s}$, $b_2=10 \text{ cm}$ and $t_{in}=20 \text{ }^\circ\text{C}$.

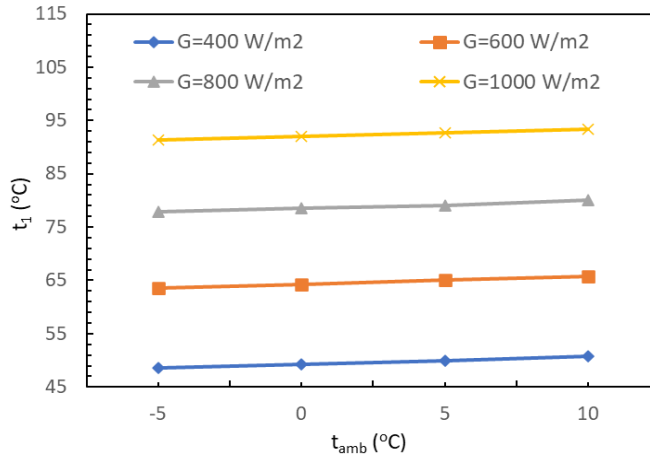


Fig. 6. Solar absorbing surface temperature t_1 as a function of ambient temperatures t_{amb} and global solar radiation G

Figure 7 shows that in addition to the temperature of the absorbing surface of the wall, the temperature of the glass covers also increases with the increase of the ambient temperature. The temperature of the outer glass cover has a faster increase, since it is in direct contact with the environment, and the influence of the surrounding temperature is greater. Due to the thermal effects that take place inside the receiving channel space of the wall, the influence of the surrounding temperature decreases, and with its increase, the temperature of the inner glass cover increases slightly.

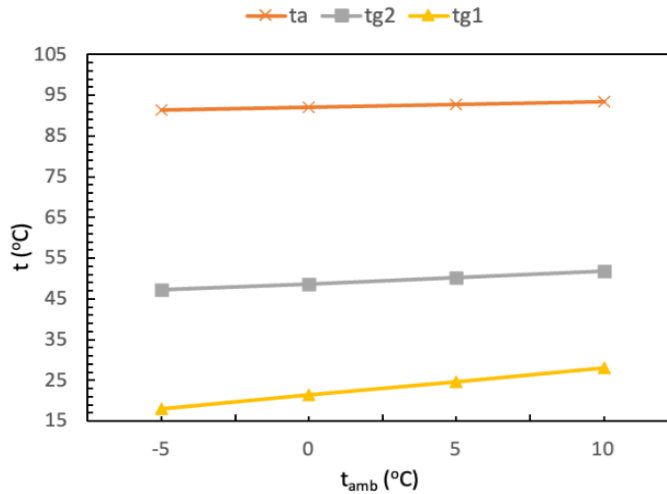


Fig. 7. Temperatures of solar absorbing surface t_1 and glass covers t_{g1} and t_{g2} as a function of ambient temperatures t_{amb} and global solar radiation G

4. CONCLUSION

Solar wall air heating systems offer an effective solution for today's energy needs, providing a renewable, cost-effective, and environmentally friendly alternative to traditional heating methods. Their versatility allows for integration into various building designs, while their low maintenance requirements enhance their appeal. With benefits including improved indoor air quality, and reduced carbon footprint, the adoption of solar wall air heating systems represents a smart choice for sustainable heating solutions in both new constructions and retrofitting existing buildings.

Analysing the temperature distribution within a solar wall air heating system is important for gaining insights into its performance under diverse constructive and operational parameters. The main results of the presented thermal analyses of an air-heating solar wall system with an opening and central channel are:

- During the colder period of the year, the absorbing surface temperature of the solar wall reaches approximately 50°C. Conversely, in the summer months, this temperature escalates to around 90°C. These results underscore the direct relationship between incident solar radiation and surface temperature, highlighting the solar wall's capacity to absorb and convert solar energy into heat;
- Widening the receiving channel in a solar wall system leads to increased temperature on the absorbing surface and higher thermal flux transferred to the air in the channel,

affecting heat gain in the room and losses to the environment. This temperature rise is most pronounced with channels up to 5 cm wide, highlighting the importance of channel width in optimizing system performance and energy efficiency;

- As ambient air temperature rises, energy losses from the outer glass cover to the environment decrease. Simultaneously, both the absorbent surface temperature of the wall and the temperatures of the glass coverings increase linearly;
- The impact of wind on solar absorbing surface temperature is negligible at low global solar radiation levels. However, for higher incident solar values, there is a discernible decrease in solar absorbing surface temperature by up to 4% with an increase in wind velocity. This finding underscores the influence of ambient conditions on the thermal dynamics of solar wall systems, highlighting the potential for optimizing energy efficiency by considering variations in environmental factors.

Understanding temperature variations across system components enables designers and engineers to optimize efficiency by identifying areas of heat loss or inefficiency. This analysis facilitates adjustments to design or operational parameters, improving overall performance of the solar wall air heating systems.

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BIOETHANOL PRODUCTION FROM SUGAR BEET MOLASSES REMAINED AFTER THE OSMOTIC DEHYDRATION OF RED CABBAGE

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ABSTRACT:

*Osmotic dehydration (OD) is a method to partially reduce the water content of fruits and vegetables, aiming to increase the shelf life of different food products. OD is usually a pre-treatment applied before the drying phase in food production. It is based on soaking fresh fruits or vegetables in a hypertonic solution, usually sucrose syrup. Recent investigations showed that sugar beet molasses is an excellent and low-cost hypertonic medium for OD of different foods. However, the main drawback of molasses application in industrial OD processes is the impossibility of regenerating diluted molasses remaining after OD, in difference to conventionally used sucrose syrup. This work is an investigation of the potential of applying sugar beet molasses that remained after the osmotic dehydration of red cabbage as feedstock for bioethanol production. Batch alcoholic fermentations of media with different initial sugar concentrations of 100-200 g/L using *Saccharomyces cerevisiae* were investigated. The highest ethanol yield of 71.17 g/L was obtained by fermentation of media with an initial sugar concentration of 150 g/L. According to the results, molasses remaining after OD of red cabbage can be used as a convenient substrate for bioethanol production offering savings in process water and energy for mixing. Hence, efficient utilization of sugar beet molasses as a low-cost substrate for the osmotic dehydration of red cabbage with the further application as feedstock for bioethanol production is feasible.*

Keywords: *bioethanol, fermentation, molasses, osmotic dehydration, red cabbage*

1. INTRODUCTION

Over the past two decades, the production of green energy sources such as bioethanol, received significant attention worldwide. Bioethanol as an alternative to fossil fuels is offering improvement in urban air quality accompanied by reductions in the emission of greenhouse gases, nitrogen oxides, and hydrocarbons. Besides, bioethanol is also widely used as a chemical in medicine, and as a raw material in the food and feed industry, pharmaceutical and chemical industry [1]. Bioethanol has been conventionally

manufactured through fermentation by yeast *Saccharomyces cerevisiae*, using sugary raw materials such as molasses from sugar beet processing because of its cost-effectiveness and feasibility [2]. The commercial production of sugar crop-derived biofuels may increase in the coming years, owing to the surplus of sugar on the World Market and ongoing EU policy changes. In Europe, bioethanol production employs primarily wheat and sugar beet, while sugar beet molasses is the most utilized sucrose-containing feedstock [3]. Combined production of sugar and ethanol enables increased profitability and fuel efficiency in sugar beet processing by using intermediate or byproducts for ethanol production [2]. In Serbia, beet molasses is the most utilized sucrose-containing feedstock [4].

Besides its application for bioethanol production, beet molasses can be used as a hyperosmotic medium for the osmotic dehydration (OD) of different foods. Wide prospects for osmotic dehydration (OD), defined as dewatering impregnation by soaking fresh food in a hypertonic solution, usually sucrose syrup, have arisen recently as a pre-treatment technique in food processing. Osmotic dehydration (OD) is a method to partially reduce food water content, aiming to increase the shelf life or as a pre-treatment in the processing of different dried products, or for ingredients to be included in complex foods. Recently, sugar beet molasses was found to be an excellent hypertonic medium for the osmotic dehydration (OD) of different foods. It is a low-cost alternative to conventionally used sucrose syrup, due to the high dry matter content (up to 85%) and specific nutrient composition. The application of molasses as a medium for OD enables the enrichment of the different food materials in minerals and vitamins, which penetrate from molasses to the plant tissue [5,6,7]. At the same time, during OD water and some dissolved substances diffuse from fruit particles to molasses leading to its dilution and some changes in the chemical composition. Sugar beet molasses is a particularly convenient substrate for OD of red cabbage. Red cabbage after osmotic dehydration in sugar beet molasses may be used in the baking industry for the production of a nutritionally valuable food [7]. The main drawback for molasses application in industrial processes is the impossibility of regenerating diluted molasses which remains after OD, in difference to the traditionally used sucrose syrup [5,6]. This diluted molasses that remained after OD of fruit may potentially be used as a substrate for bioethanol production since molasses dilution is a necessary step before alcoholic fermentation. However, the effect of diffusion of small amounts of food constituents into molasses and its influence on fermentation efficiency by *S. cerevisiae* remains to be investigated.

The present work investigates the potential of bioethanol production from sugar beet molasses which was previously used for the OD of red cabbage by batch ethanol fermentation using *Saccharomyces cerevisiae*. The main goal of this research is the valorization of diluted molasses remaining after OD of red cabbage as feedstock for further industrial bioethanol production. The potential of integrated production of osmotically dehydrated red cabbage and bioethanol using beet molasses as the substrate is experimentally investigated in this work with the final goal to be applied in the industrial-scale production process.

2. MATERIALS AND METHODS

2.1. Raw material and fermentation media

Sugar beet molasses used as a hypertonic solution for OD was obtained from the sugar factory Sunoko D. O. O. Serbia. The red cabbage was purchased at a local market in Novi Sad, Serbia, and stored at 4 °C. The red cabbage was cut into cubes dimensions 1x1 cm. Osmotic dehydration was conducted under atmospheric pressure at 45 °C by continuous recirculation of molasses (initial dry matter content of 83 %) over the red cabbage cubes placed in a perforated cylinder vessel. The red cabbage to molasses ratio was 1:4 (w/w). The immersion was conducted for 5 h which was necessary to reach equilibrium moisture content in molasses. Finally, the cabbage pieces were removed, and the remaining molasses was used to prepare the fermentation medium. The chemical quality analysis of molasses included estimation of dry mass, total sugars, ash, total nitrogen, crude protein, free-amino nitrogen, and pH value according to AOAC methods [8].

The molasses that remained after OD of red cabbage was diluted with tap water to obtain different initial sugar content (100, 125, 150, 175, and 200 g/L) of the fermentation substrate. The pH value of each medium was set at 5.5 by adding 10% H₂SO₄. Further, 500 mL of each medium was transferred in 1 L Erlenmeyer flasks, and sterilized by autoclaving at 121 °C for 30 min. Media were cooled at a fermentation temperature of 30 °C before inoculation.

2.2. Producing microorganism

Saccharomyces cerevisiae (DTN) strain was stored at 4 °C. For inoculum preparation, loopful slant cultures were transferred to 250 mL Erlenmeyer flask containing 100 mL sterilized medium (glucose 20 g/L, peptone 10 g/L, yeast extract 10 g/L; pH 4.5) and cultured for 24 h at 30 °C in a thermostat on the rotary shaker (GFL, Germany, Type 3015) at shaking frequency 120 rpm and shaking diameter 30 mm. Yeast cells were separated by centrifugation (3000 rpm, 10 min), and suspended in sterilized 0.9 % NaCl, again separated by centrifugation and suspended to form suspension. For inoculation, the aliquot of yeast suspension containing 0.6 g of yeast dry mass was transferred into a fermentation substrate prewarmed at 30 °C.

2.3. Fermentation

Afterward, Erlenmeyer flasks with fermentation medium were sealed with a fermentation airlock filled with sterile parafine. Fermentation experiments in triplicate were carried out at 30 °C in a thermostat. Fermentation was monitored by measuring the weight of the fermentation system and produced CO₂ during the batch. At the end of each batch, the fermented liquid was centrifuged at 3000 rpm for 15 min. For residual sugar content determination, the supernatant was hydrolyzed in 33 % HCl at 100 °C for 10 min and neutralized with NaOH solution, and sugar concentration was then determined using the

3,5-dinitrosalicylic acid (DNS) [9]. The ethanol concentration of the alcohol distillate was determined by the pycnometer, based on the density at 20 °C [8].

2.4. Fermentation parameters

Utilized sugar (S_u , g/L) was calculated as the difference between initial (S_o , g/L) and residual sugar concentration (S_r , g/L) in fermentation media. Sugar utilization (Y_s , %) was calculated as the percentage content of utilized sugar (S_u , g/L) to the initial sugar (S_o , g/L). The ethanol yield in fermented media (P , g/L) represents the mass of produced ethanol per volume unit of fermented media. Ethanol yield (Y , L/100 kg) is calculated as the volume of produced ethanol per mass unit of used molasses and molasses dry mass.

2.4. Statistical analysis

One-way analysis of variance (ANOVA) is used to statistically evaluate data using software Microsoft Office Excel 2010 for Windows. A 5 % probability level ($p=0.05$) was regarded as statistically significant.

2. RESULTS AND DISCUSSION

The chemical composition of molasses, especially the content of fermentable sugar, nitrogen, phosphorus, mineral ions, and vitamins are crucial factors influencing the growth, cell viability, and fermentation performance of *Saccharomyces cerevisiae* and consequently the final ethanol yield and profitability of bioethanol production [2]. The physical-chemical parameters of the quality of molasses remaining after OD of red cabbage are summarized and presented in Table 1.

Table 1. The quality of beet molasses remained after the osmotic dehydration of red cabbage

Parameter	Value
Dry matter (%)	72.3±0.7
Total sugar (%)	48.4±1.7
Ash (%)	8.3±0.1
Total nitrogen (%)	1.7±0.1
Protein (Kjeldahl N×6.25) (%)	10.6±0.6
Free amino nitrogen (FAN) (%)	0.2±0.1

As shown in Table 1, the content of dry matter of molasses that remained after OD of red cabbage was about 72%, which is about 10% less than the dry matter content of standard beet molasses [2]. Consequently, the water content of this molasses is about 10% higher enabling savings of process water for media preparation and energy for mixing during molasses dilution. Taking into account the fact that spoiling osmophilic microorganisms show vital activity at 75% of dry matter or less [10] it may be concluded that this molasses should not be stored for a long period due to the risk of microbial contamination, and

should be used for the fermentation soon as possible. This requires synchronization of the production of osmotically dehydrated cabbage and bioethanol production or its integration in a manner that the remaining molasses after OD of cabbage is completely utilized for bioethanol production daily.

The content of fermentable sugars of molasses as a substrate for ethanol fermentation is the main quality parameter since the sugar is directly converted to ethanol, while the content of non-sugar compounds like vitamins, minerals, betaine, amino acids, lactic acid, phenolic compounds, and color compounds may also influence the yeast metabolism [11]. The total sugar content in samples of molasses was $48.4 \pm 1.7\%$ implying that this raw material has a high potential as a sugar-rich substrate for bioethanol production similar to conventional molasses. Investigated molasses contained $8.3 \pm 0.1\%$ ash, providing certain mineral compounds that are nutrients for yeast that contribute to yeast fermentation activity. The total nitrogen content in the investigated molasses was about 1.7%, implying a total crude protein content ($N \times 6.25$) of 10.6%. Nitrogenous compounds of molasses do not consist of protein, betaine, amino acids, amides, peptones, and nitrates. However, yeast can use only ammonium ions or degraded amino acids from molasses for cell biosynthesis [10]. Hence, the free amino nitrogen (FAN) content represents a more significant quality parameter from a bioethanol production point of view. FAN content of investigated molasses was only about 0.2% implying that the supplementation of nitrogen sources through the addition of ammonia salts, yeast extract, spent brewer's yeast, or hydrolyzed soybean residues is necessary to achieve efficient fermentation.

From a bioethanol production point of view efficient exploitation of raw materials for ethanol production is one of the main goals. Therefore it is crucial to convert as much sugar as possible from molasses to ethanol. Hence the influence of initial sugar content in the range 100-200 g/L on the amount of utilized sugar (S_u) and sugar utilization degree (Y_s) is analyzed and presented in Figure 1.

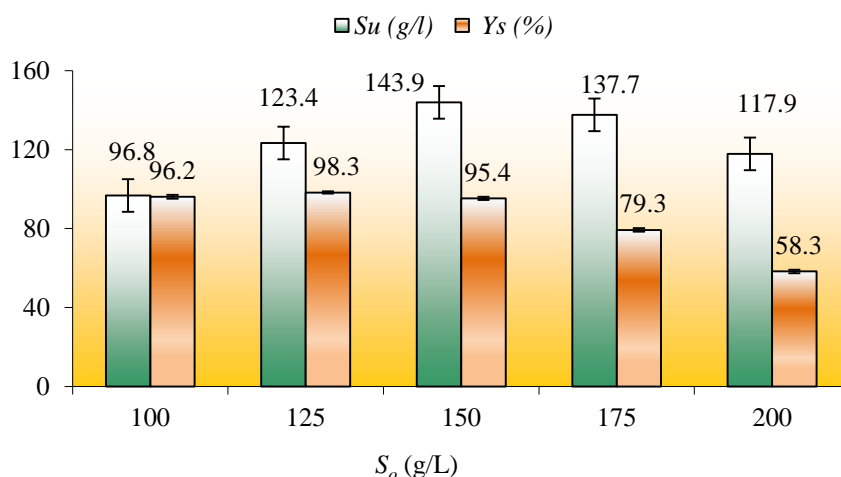


Fig. 1. Utilized sugar (S_u) and sugar utilization (Y_s), obtained after fermentation of molasses remained after osmotic dehydration of red cabbage with initial sugar concentration (S_o)

As shown in Figure 1., both the amount of used sugar (S_u) and sugar utilization (Y_s , %) are dependent on the initial sugar content (S_o) of substrates. It is noticeable that the amount of used sugar (S_u) from media by yeast increased from 96.8 ± 1.9 g/L for the initial sugar content of 100 g/L to 143.9 ± 2.5 g/L for the initial sugar content of 150 g/L, and then decreased up to 117.9 ± 3.6 g/L for the initial sugar content of 200 g/L. These results suggest that 150 g/L might be the best environment for utilizing sugar. Results of the sugar utilization degree (Y_s) suggest that for initial sugar in the range 100-150 g/L in media almost complete present sugar is utilized by yeast (95.4-98.3%). The maximal Y_s of 98.3% was obtained for an initial sugar content of 125 g/L. However, a further increase of S_o led to a significant lowering of sugar utilization to 58.3%. This implies that the initial sugar content over 150 g/L is not convenient for ethanol production using investigated molasses, since there is a large content of residual sugar which if not used by yeast remains in vinasse effluent after distillation, which requires a high cost of wastewater treatment.

Obtaining high ethanol content in fermented media is the main prerequisite to enable high energy savings during the phase of mash distillation. Also, gaining insight into the yield of ethanol that can be produced in media with different sugar content, and yield per molasses and its dry matter under certain production conditions is of crucial importance. The results of some main fermentation parameters including obtained ethanol yield in fermented media (P), ethanol yield per used molasses mass (Y), and ethanol yield per molasses dry matter (Y_{dm}) are presented in Figure 2.

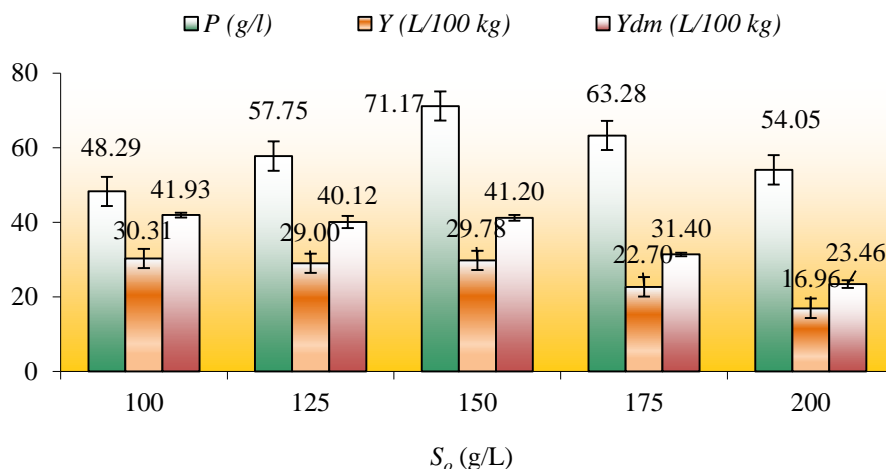


Fig. 1. Ethanol yield in fermented media (P), ethanol yield per molasses (Y), and ethanol yield per dry matter (Y_{dm}) of molasses remained after osmotic dehydration of red cabbage

According to the presented results, it may be noticed that the ethanol yield in the fermented medium (P) follows the results of the amount of utilized sugar (S_u), implying that the initial sugar content in fermentative media does not influence the fermentative activity of yeast and that ethanol yield was dependent on the ability of yeast to utilize sugar. Ethanol yield in fermented media ranged from 48.3 ± 0.73 g/L for an initial sugar content of 100 g/L to 71.17 ± 1.27 g/L for an initial sugar content of 150 g/L.

Ethanol yield obtained per mass of molasses (Y) and molasses dry mass (Y_{dm}) was 30 L/kg and 41 L/kg, respectively, and didn't differ significantly for initial sugar concentrations of 100 g/L, 125 g/L, and 150 g/L. Further increase of initial sugar concentration to 175 g/L and 200 g/L lead to decrease of ethanol yield to 23 L/kg and 17 L/kg, respectively. Ethanol content in fermented media is one of the most significant factors influencing energy savings during distillation and rectification as most energy-requiring production phases [12]. In this contest, the initial sugar content of fermentation media based on beet molasses remaining after OD of red cabbage should be set at 150 g/L to obtain the highest ethanol yield and energy savings during ethanol distillation which contributes to the whole process economy.

3. CONCLUSION

Molasses remaining after OD of red cabbage is an excellent raw material for bioethanol production yielding up to 30 L per 100 kg molasses, and 41 L per 100 kg of its dry matter. A maximal ethanol yield of 71.17 g/L is obtained from media with an initial sugar content of 150 g/L. In comparison to standard beet molasses, the utilization of molasses remaining after OD of red cabbage as a substrate for bioethanol production enables savings in process water and energy for molasses dilution for fermentation medium preparation. However, the long-term storage of this molasses is not recommended due to the high risk of microbial contamination, and therefore the synchronization of the red cabbage OD process with the bioethanol production capacity is necessary for industrial production. Anyway, the utilization of beet molasses firstly as a substrate for OD of red cabbage, and further utilization of remaining molasses for bioethanol production is a highly efficient method for obtaining savings in this integrated production process.

4. ACKNOWLEDGMENTS

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PHYSICO-CHEMICAL PROPERTIES OF HOTEL'S SWIMMING POOLS WATER IN COASTAL AREA OF MONTENEGRO

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ABSTRACT:

The swimming pools are very popular during the summer touristic season in Montenegro, but also they are identified as a potential source of human health risk for users, due to either chemical or microbiological contamination. Thus, the aim of this paper was monitoring of physical and chemical characteristic of swimming pools water, indoor and outdoor, in a coastal area of Montenegro during the summer season. The results of investigation generally indicated very good quality of swimming pools water. Conductivity, pH, turbidity, temperature and oxidability complied with the Montenegrin standards. Only residual chlorine content in indoor swimming pools water was slightly above the maximum allowed concentrations, while this parameter for outdoor swimming pools water complied with prescribed value.

Keywords: *swimming pool waters, outdoor pools, indoor pools, physico-chemical parameter*

1. INTRODUCTION

Swimming is an important recreational activity, which promotes good physical, mental and cardiovascular health. Thus the quality of swimming pool water is of great importance for human health and prevention of water born diseases. Swimming pool water can potentially contain numerous microorganisms and dissolved chemicals which may originate from several sources. Many inappropriate pollutants can be found in pool water, such as: skin cells, urine, sweat, saliva, ammonia, secretions from the nose and throat, and residues of cosmetic products. The most important is the presence of urine and sweat which is associated with fecal contamination of water. Therefore, swimming pool water must be regularly controlled and free of any pathogens, such as bacteria and viruses. Swimming pool water has to meet quality standards, same as drinking water: it should be transparent, odorless, tasteless, with a freezing point of 0 °C and a boiling point of 100 °C [1-3]. The most important physico-chemical characteristics of water are pH value, salinity, temperature, conductivity, dissolved oxygen and alkalinity. The mentioned properties

provide a useful information about water quality allowing to assess the ability of bacteria to grow in water.

Optimal pH value of swimming pool water is between 7.2 and 7.8 (if chlorine is used for disinfection), between 7.2 and 7.6 (in a case of bromine or other non-chlorine disinfection processes). The value of pH above or below this limits lead to the decrease of efficiency of chlorine disinfection (more chlorination needed) or negatively effect the pool structure (corrosion of metal parts) and swimmers comfort (discomfort in the eyes, drying of the skin). Thus, continuous monitoring of pH value is desirable [3,4,5].

Temperature greatly influences the chemical composition of pool water. An increase in temperature leads to a lower solubility of calcium salts, which makes the so-called spa pools more susceptible to scale formation and leads to eventual damage to pool equipment. Also, increased temperature has the effect of reducing the effectiveness of chlorine-based disinfectants [4,6].

Electrical conductivity of water is result of presence of inorganic solids dissolved in water, such as: chloride, nitrate, carbonate salts of calcium, magnesium and iron.

Conductivity also correlates to the temperature of water. An increase in temperature accelerate the ions mobility thus affecting the increase in conductivity. Another key factor affecting conductivity is atmospheric carbon dioxide. The conductivity of pure water, without impurities, is generally $<0.1 \mu\text{S}/\text{cm}$ at 25°C . However, due to exposure to atmospheric carbon dioxide, the conductivity increases to values higher than $2 \mu\text{S}/\text{cm}$ [3,5,7].

Total alkalinity refers to the ability of the pool water to resist a change in pH. The key purpose of total alkalinity serves to help in managing or controlling the pH in the pool [8]. Presence of dissolved alkaline salts (carbonates, bicarbonates, hydroxides, borates, silicates and phosphates) influence the alkalinity of swimming pool water.

Turbidity of water refers the presence of organic matter. Turbidity does not necessarily represent a direct health risk, but potentially indicates the possible presence of hazardous contaminants and a lower efficiency of pool water circulation systems [9,10].

The aim of this study was to assess the physico-chemical properties of hotel's swimming pool water in a coastal area of Montenegro.

2. MATERIALS AND METHODS

Quality of swimming pool water was investigated on 13 km^2 coastal area of Montenegro which included 6 touristic places (Ulcinj, Bar, Budva, Tivat, Herceg Novi and Kotor). The 73 water samples from outdoor swimming pools and 23 samples from indoor swimming pool were collected during the period of March-October in 2022. year. Physico-chemical properties of swimming pool water were determined on site or in a laboratory of Institute of Public Health of Montenegro. Residual chlorine, pH and temperature of water samples were recorded on-site at the time of sampling while turbidity, oxidability and electrical conductivity were determined in the Laboratories of the Institute of Public Health Montenegro.

3. RESULTS AND DISCUSSION

The quality parameters of investigated swimming pool water are given in table 1 and 2. The average values of the water temperature of the indoor pools (28.78 °C) and the water of the outdoor pools (25.40 °C) were within the limits prescribed by Montenegrin legislative [11].

The average value of pH for indoor swimming pools water was 7.12 (and 7.07 for outdoor swimming pools water. These are optimal pH values, which are in accordance with the prescribed value, range from 6.50 to 7.60. However, in several tested samples, pH values were below or above the prescribed limits. Lower pH values are associated with the occurrence of corrosion on the metal parts of the pool, but also with certain health problems to swimmers, while high pH values are associated with weaker disinfection characteristics, which can also lead to an increased health risk to swimmers [12].

Table 1. *Physico-chemical parametars of indoor swimming pool water samples*

Parameter	Average	Maximum	Minimum	Referent value [11]
Temperature, (°C)	28.78	25.70	34.10	25-32
Electrical conductivity, (µS/cm na 20°C)	1022.87	400	2730	<2500
pH	7.12	5.70	7.90	6.50 -7.60
Turbidity, (NTU)	0.33	0.10	0.66	< 1
Residual chlorine, (mg/L)	1.04	<0.01	2.20	0.20 -1.00
Oxidability, (mg/L)	5.21	1.28	15.36	< 8

Table 1. *Physico-chemical parametars of outdoor swimming pool water samples*

Parameter	Average	Maximum	Minimum	Referent value [11]
Temperature, (°C)	25.40	16.40	31.00	25-32
Electrical conductivity, (µS/cm na 20°C)	1797.88	346	12940	<2500
pH	7.07	3.36	7.88	6.50 -7.60
Turbidity, (NTU)	0.78	0.02	35.00	< 1
Residual chlorine, (mg/L)	0.97	0.23	2.20	0.20 -1.00
Oxidability, (mg/L)	6.15	0.64	31.36	< 8

The average value of electrical conductivity of the analyzed water samples, of both, indoor and outdoor pools were also in accordance with the prescribed values, but the average value of conductivity for outdoor pools was significantly higher (1798 $\mu\text{S}/\text{cm}$ at 20°C) compared to indoor pools (1023 $\mu\text{S}/\text{cm}$ at 20°C). Increased values of this parameter are usually associated with increased concentration of chemicals for maintaining the quality of pool water (disinfectants, pH regulators, etc.), but also with increased capacity of pool use and insufficiently frequency of pool water changes [12].

The average value of water turbidity for indoor pools (0.68NTU) and outdoor pools (0.78NTU) was below the prescribed maximum value (1NTU).

However, the average value of residual chlorine (1.04 mg/L) in indoor pools water was slightly above the permitted limit (1.0 mg/L), while for outdoor pools water residual chlorine content (0.97 mg/L) was acceptable.

Oxidability, expressed as a KMnO_4 consumption, refers to the content of organic matter in pool water. Oxidability is another important parameter for swimming pool water, because its high value is associated with the presence of organic substances (including microbial contamination) and easily oxidability inorganic substances in water [13]. The mean value were in compliance with acceptable limit for both, indoor and outdoor pools, 5.21 and 6.15 mg/l, respectively. However, in several samples, the values obtained were higher than the allowed value (8 mg/L). High values of this parameter suggest an increased content of organic matter in the pool water, which may be the result of several factors: insufficient or inappropriate water disinfection (or generally inadequate pool maintenance), increased number of swimmers, etc.

3. CONCLUSION

The average values of the physical and chemical parameters of water (temperature, pH, electrical conductivity, oxidizability, turbidity) were in accordance with the referent values prescribed by Montenegrin legislation. Only the average value of residual chlorine in indoor swimming pool waters was slightly above the prescribed value, while for outdoor pool waters was within acceptable limits. The increased value of residual chlorine may influence the increase of products of pools water desinfection (trihalometanes) and the continual monitoring of their content is necessary.

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MEHATRONIČKA RUKA KAO POMOĆ PRI RAZVOJU KOGNITIVNIH SPOSOBNOSTI DECE

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SAŽETAK:

U sklopu ovog rada razvijena je mehatronička ruka koja korišćenjem medicinskih injektora omogućava različite načine rukovanja materijalom. Jedan od primera je i izuzimanje plastičnih čaša iz vertikalno postavljenog gravitacionog magacina, što je posebno analizirano u samom radu. Osnovna ideja za razvoj jednog ovakvog sistema proistekla je iz potrebe da se pomogne pri razvoju kognitivnih sposobnosti dece, odnosno da se omogući da deca na što lakši i jednostavniji način shvate prostornu orijentaciju, a zatim nauče osnovne principe rada različitih manipulatora. Pomenuta mehatronička ruka realizovana je tako da ima pet stepeni slobode, odnosno sačinjena je od tri osnovna segmenta sa pripadajućim zglobovima koji su rotacioni (kao kod minimalne antropomorfne konfiguracije industrijskog robota) i dva dodatna segmenta koji čine hvataljku, sa pripadajućim zglobovima koji su i rotacioni i linearni. Testiranjem u realnim uslovima rada potvrđena je funkcionalnost razvijene ruke i uočene sve prednosti i nedostaci razvijenog rešenja.

Ključne reči: mehatronička ruka, antropomorfna konfiguracija, hvataljka, medicinski injektori, mehatronika za decu

1. UVOD

Savremena mehatronika se danas, pored značajne primene u industriji, itekako sreće i u svakodnevnom životu, kako u domenu robotike [1-3], tako i u domenu automatizacije [4,5]. Posebno interesantna mehatronika može biti u ustanovama za edukaciju, i to predškolskog i ranog školskog uzrasta. Naime, u tom uzrastu deca savladavaju osnovne veštine koje koriste za razmišljanje, pamćenje, obraćanje pažnje oko sebe, orijentaciju u prostoru i slično, odnosno razvijaju svoje kognitivne sposobnosti a razni oblici interaktivnih mehatroničkih sistema mogu pomoći u razvoju istih [6-8].

U tom cilju, u sklopu ovog rada razvijena je mehatronička ruka koja korišćenjem medicinskih injektora omogućava različite načine rukovanja izabranim predmetima rada [9]. Rukovanje materijalom se sreće veoma često u svakodnevnom životu jer je potrebno izvršiti premeštanje predmeta rada sa jednog na drugo mesto, skladištiti predmete rada na odgovarajuće pozicije, omogućiti čekanje u redovima, i slično. U tim slučajevima neophodno je dobro se orijentisati u prostoru, te isplanirati i napraviti tačan redosled aktivnosti za uspešno izvršenje postavljenog zadatka.

Dakle, korišćenjem jednog ovakvog sistema deca treba da prošire svest o prostornoj orijentaciji, uvide kompleksnost upravljanja sistemima ovog tipa razmišljajući o tome na

koji način izvršiti postavljene zadatke, te naposljetku nauče nešto o postupcima rukovanja materijalom i primeni raznih vrsta manipulatora, i sve to praktično kroz igru. Ovakvi sistemi već postoje i na tržištu [10,11] ali su uglavnom realizovani pomoću kartona i/ili drveta, dok su u ovom slučaju za fizičku realizaciju razvijene mehatroničke ruke korišćene tehnike 3D štampe.

Rad je organizovan na sledeći način: u odeljku 2 detaljno je prikazan postupak razvoja celokupnog sistema, od projektovanja 3D modela, preko fizičke realizacije do testiranja u realnim uslovima rada. Nakon toga, u odeljku 3 data je diskusija o razvijenom sistemu i postignutim rezultatima. Na kraju rada, u odeljku 4, izvedeni su najvažniji zaključci i dati su pravci daljih istraživanja.

2. PROJEKTOVANJE I IZRADA MEHATRONIČKE RUKE

Kao što je već prethodno rečeno, u sklopu ovog rada razvijena je mehatronička ruka koja korišćenjem medicinskih injektora omogućava različite načine rukovanja materijalom.

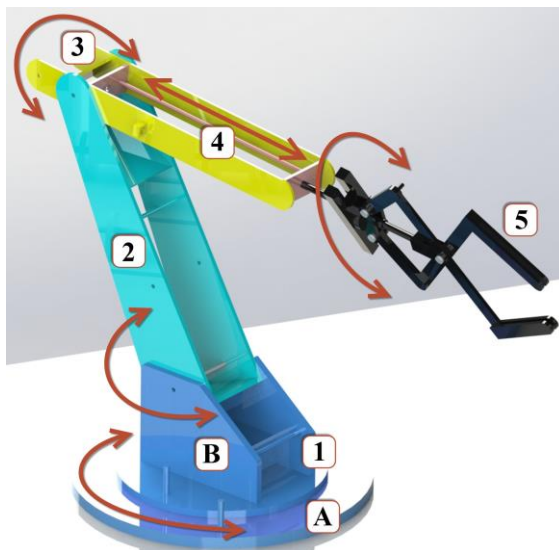
Razvojni put podrazumevao je tri faze:

- projektovanje, odnosno izradu 3D modela ruke i neophodnih dodatnih elemenata;
- izradu pojedinih segmenata korišćenjem postupaka 3D štampe;
- fizičku montažu kompletnog sistema i testiranje u realnim uslovima rada.

2.1. Idejno rešenje i razvoj 3D modela

Kako je osnovna ideja da se mehatronička ruka koristi u edukativne svrhe, prilikom projektovanja je vođeno računa o tome da ne bude velikih gabaritnih dimenzija kako bi bila lako prenosiva i da, ni u kom slučaju, ne može da dovede do povrede deteta koje je koristi [9]. Projektovanje 3D modela ruke (slika 1) urađeno je korišćenjem softverskog okruženja Inventor Professional 2022.

Razvijena mehatronička ruka sastavljena je od pet segmenata. Tri osnovna segmenta realizovana su sa pripadajućim rotacionim zglobovima (slično antropomorfnj konfiguraciji industrijskog robota) dok preostala dva segmenta čine hvataljku i realizovani su sa pripadajućim translacionim i rotacionim zglobovima. Na ovaj način dobijen je sistem sa pet stepeni slobode. Adekvatnim izborom uglova minimalne konfiguracije hvataljke se pozicionira u željenu tačku radnog prostora a njenim rotacionim zglobovima se obezbeđuje odgovarajuća orijentacija. Pomoću translacionog zgloba hvataljke omogućava se zatvaranje/otvaranje hvataljke, odnosno hvatanje/otpuštanje predmeta rada.



Slika 1. 3D model mehatroničke ruke

Prvi segment ove konfiguracije (slika 1, pozicija 1) sa pripadajućim zglibom (slika 1, pozicija B) obezbeđuje rotaciono kretanje (u levu ili desnu stranu) oko nepokretne osnove (slika 1, pozicija A), čime je dobijen prvi stepen slobode razvijene ruke. Rotaciono kretanje je moguće u onolikoj meri koju dozvoljava hod klipnjače izabranog medicinskog injektora a u ovom slučaju iznosi približno 90°. Dakle, kretanje je omogućeno pomoću medicinskih injektora, od kojih je prvi fizički vezan za segment mehatroničke ruke a drugi za upravljački sistem, pri čemu su injektori međusobno povezani pneumatskim crevom. Pokretanje klipnjače prvog injektora (a ujedno i kretanje definisanog segmenta) omogućeno je ručnim aktiviranjem drugog injektora na način da se voda koja se nalazi unutar tog drugog injektora prenosi u prvi. Istovetno je rešen problem kretanja svih segmenata razvijene ruke.

Drugi segment razvijene konfiguracije (slika 1, pozicija 2) zahvaljujući pripadajućem zglibu takođe može da rotira (prema gore ili prema dole), čime je dobijen drugi stepen slobode. Pomenuto kretanje je omogućeno na isti način kao i u prethodnom slučaju, s tim što ugao rotacije u ovom slučaju može dostići maksimalno oko 60°. Potrebno je napomenuti i to da je kretanje ovog segmenta nešto zahtevnije jer je neophodno iskombinovati i ujednačiti kretanja prethodnog, baznog i narednog segmenta sa ovim.

Treći segment (slika 1, pozicija 3) sa pripadajućim zglibom ponovo omogućava rotaciono kretanje (prema gore ili prema dole), čime je dobijen treći stepen slobode i to na isti način kao kod antropomorfne konfiguracije industrijskih robota, sa prva tri rotaciona zgliba. Ovaj segment predstavlja vezu osnovnog dela razvijene mehatroničke ruke sa alatom koji dalje izvršava postavljeni zadatak. Kao i u prethodnim slučajevima, u zavisnosti od hoda klipnjače medicinskog injektora ograničena je rotacija i ovog segmenta i to na približno 60°.

Preostala dva stepena slobode vezana su za alat, odnosno hvataljku. Zahvaljujući prvom segmentu hvataljke koji je fizički pozicioniran unutar trećeg segmenta osnovnog dela ruke (slika 1, pozicija 4), pomoću dva paralelno postavljena medicinska injektora omogućeno je translatorno kretanje (prema napred ili nazad). Time je dalje omogućeno zatvaranje odnosno otvaranje hvataljke, te hvatanje i otpuštanje predmeta rada, respektivno. Na taj način dobijen je četvrti stepen slobode. Dužina hoda medicinskih injektora direktno definiše stepen zatvorenosti/otvorenosti hvataljke i veličinu predmeta rada kojima je moguće manipulirati korišćenjem razvijene mehatroničke ruke.

Na samom kraju, zahvaljujući drugom segmentu hvataljke (slika 1, pozicija 5) omogućeno je i rotaciono kretanje hvataljke koje može iznositi maksimalno oko 90° a što je opet posledica ograničenja izabranog medicinskog injektora. Rotacija klipnjače pomenutog medicinskog injektora vrši se unutar trećeg segmenta osnovnog dela razvijene mehatroničke ruke, pri čemu injektor klizi preko dve vođice unutar tog segmenta. Na taj način omogućava se rotacija hvataljke u željenom smeru.

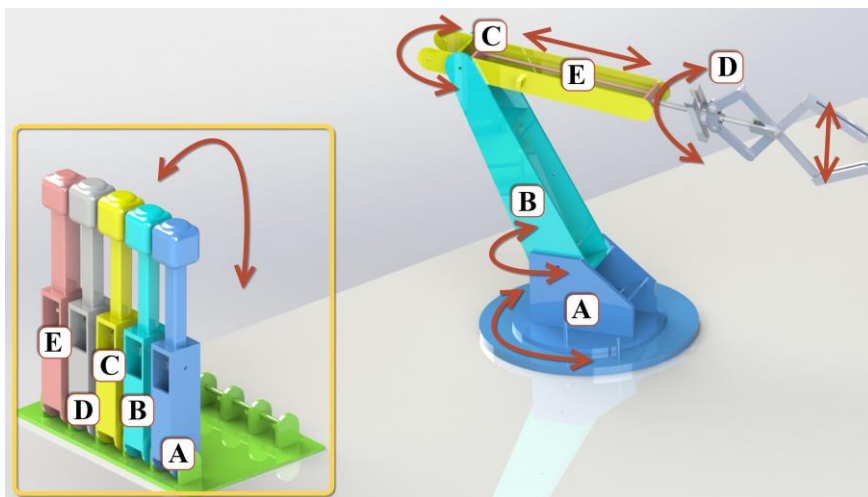
2.2. Ručno upravljani pokretački sistem

Kao što je već prethodno rečeno, razvijena mehatronička ruka koristi se za različite oblike rukovanja materijalom i radi na principu pravilnog hvatanja predmeta rada, pozicioniranja u tačan položaj uz ispravnu orijentaciju i odlaganja predmeta rada na predviđenu poziciju (*engl. Pick and Place*). Pokretanje segmenta ruke omogućeno je pomoću ručno upravljaniog pokretačkog sistema koji je sastavljen od pet upravljačkih palica, odnosno džojstika (slika 2), shodno broju stepeni slobode [9].

Za svaki od džojstika povezan je jedan ili dva medicinska injektora i to na taj način da se spuštanjem džojstika iz krajnjeg vertikalnog položaja (slika 2) voda iz injektora povezanih sa džojsticima istiskuje i preusmerava u injektore povezane sa segmentima mehatroničke ruke, čime se ostvaruje odgovarajuće kretanje. Sa druge strane, podizanjem džojstika iz spuštenog ka krajnjem vertikalnom položaju, voda se istiskuje iz injektora povezanih sa segmentima mehatroničke ruke i preusmerava u injektore koji se povezani sa džojsticima, te se na taj način ostvaruje kretanje u suprotnom smeru od prethodno opisanog.

Uopšteno, kompletno upravljanje razvijenom mehatroničkom rukom može se predstaviti na sledeći način:

- povlačenjem prvog džojstika prema dole ili gore omogućava se rotacija baze (prvog segmenta) u desnu ili levu stranu, respektivno (slika 2, pozicija A);
- povlačenjem drugog džojstika prema dole ili gore omogućava se rotacija drugog segmenta prema gore ili dole, respektivno (slika 2, pozicija B);
- povlačenjem trećeg džojstika prema dole ili gore omogućava se rotacija trećeg segmenta prema dole ili gore, respektivno (slika 2, pozicija C);
- povlačenjem četvrtog džojstika prema dole ili gore omogućava se rotacija hvataljke u desnu ili levu stranu, respektivno (slika 2, pozicija D);
- povlačenjem petog džojstika prema gore ili dole omogućava se translatorno pomeranje prvog segmenta hvataljke prema nazad ili napred čime se dalje vrši zatvaranje ili otvaranje hvataljke, odnosno hvatanje ili otpuštanje predmeta rada, respektivno (slika 2, pozicija E).



Slika 2. Ručno upravljani pokretački sistem

Radi lakše orijentacije i razumevanja načina rada razvijene mehatroničke ruke, voda koja se nalazi unutar medicinskih injektora obojena je u različite boje. Pomenuta boja vizuelno olakšava detetu da prepozna koji džojstik se koristi za upravljanje kojim segmentom same ruke. Nakon toga je neophodno da shvati pravilan način orijentacije segmenata i da tačno pozicionira predmet rada.

2.3. Fizička realizacija mehatroničke ruke

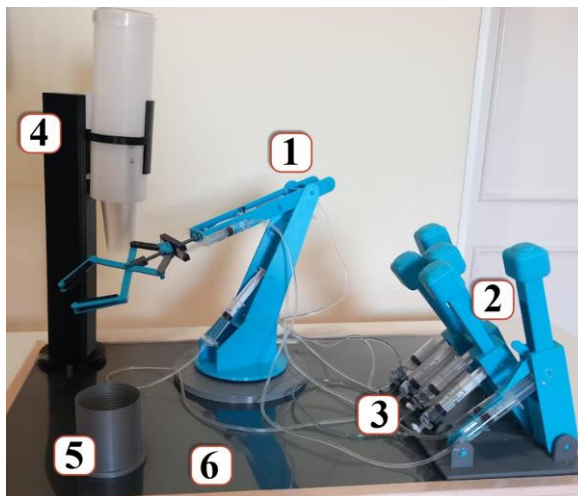
Svi segmenti mehatroničke ruke, kao i ručno upravljani pokretački sistem izrađeni su putem 3D štampe, korišćenjem PETG filameta a međusobno su povezani korišćenjem vijčanih veza. Glavni razlog za izbor 3D štampe bio je da se smanji mogućnost od povređivanja pri korišćenju jer je razvijena ruka prvenstveno namenjena deci preškolskog i ranog školskog uzrasta.

Izbor materijala za izradu ruke značajno je uticao i na nosivost celog sistema. U skladu sa tim, radi testiranja funkcionalnosti napravljen je jedan gravitacioni magacin sa plastičnim čašama iz koga je potrebno izuzeti jednu čašu i postaviti je na predviđeno mesto, u namenski napravljen držač [9]. Gravitacioni magacin i držač za čaše izrađeni su takođe putem 3D štampe, korišćenjem PETG filameta.

Radi lakšeg razumevanja, na slici 3 je prikazan kompletan realizovan sistem:

- fizički izrađena mehatronička ruka (slika 3, pozicija 1);
- ručno upravljani pokretački sistem (slika 3, pozicija 2);
- medicinski injektori (bez ulivene vode) kojima se ostvaruje veza između ruke i pokretačkog sistema (slika 3, pozicija 3);
- gravitacioni magacin sa plastičnim čašama (slika 3, pozicija 4);
- držač u koji je potrebno odložiti čašu izuzetu iz magacina (slika 3, pozicija 5);

- osnovna ploča na koju su postavljeni svi prethodno definisani elementi (slika 3, pozicija 6).

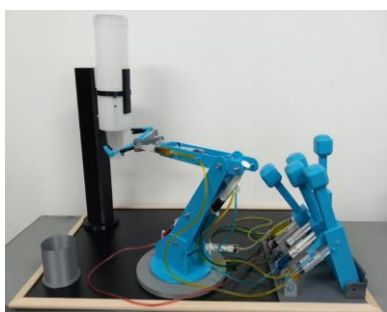


Slika 3. Fizički realizovana mehatronička ruka sa svim dodatnim elementima

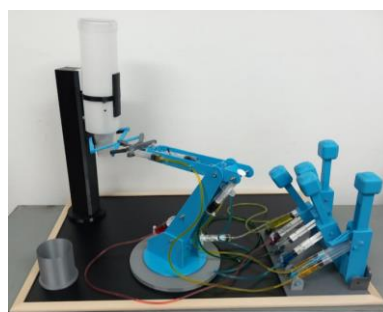
Nakon izrade svih potrebnih elemenata i sklapanja celokupnog sistema, izvršeno je testiranje u realnim uslovima rada (kao što je već prethodno rečeno, za zadatak izuzimanja plastičnih čaša iz gravitacionog magacina i pozicioniranje istih na tačno definisano mesto), koje je prikazano „korak po korak“ u nastavku:

- **Korak 1:** U prvom koraku bilo je potrebno pravilno pozicionirati hvataljku ispod gravitacionog magacina sa čašama (slika 4a), odnosno prevesti je iz inicijalnog položaja (onog u kome se hvataljka nalazila na početku rada) u položaj za hvatanje;
- **Korak 2:** Nakon pozicioniranja hvataljke, bilo je neophodno zatvoriti istu (slika 4b) da bi se obezbedilo izuzimanje čaše iz magacina;
- **Korak 3:** U nastavku rada bilo je potrebno obezbediti takav položaj segmenta (slika 4c) da se omogući uspešno izuzimanje čaše iz magacina i dalji prenos iste ka mestu za odlaganje;
- **Korak 4:** U ovom koraku bilo je neophodno usmeriti mehatroničku ruku ka držaču za čaše, vodeći računa o tome da hvataljka mora biti zatvorena tokom celokupnog kretanja (slika 4d);
- **Korak 5:** Nakon kretanja bilo je potrebno pravilno pozicionirati i dobro orijentisati hvataljku iznad držača za čaše, kako je prikazano na slici 4e;
- **Korak 6:** Po dostizanju željenog položaja direktno iznad držača, bilo je potrebno čašu spustiti vertikalno naniže u držač, kako je prikazano na slici 4f;

- **Korak 7:** U nastavku rada bilo je neophodno otvoriti hvataljku (slika 4g) i odložiti čašu u držač;
- **Korak 8:** Na samom kraju, bilo je potrebno hvataljku vratiti u unapred definisani inicijalni položaj, poznat korisniku, kao što je i prikazano na slici 4h.



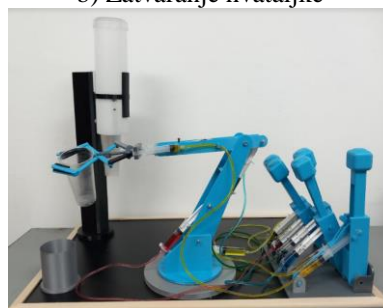
a) Pozicioniranje hvataljke



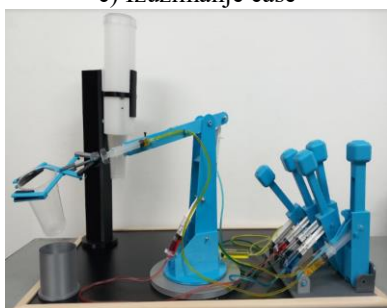
b) Zatvaranje hvataljke



c) Izuzimanje čaše



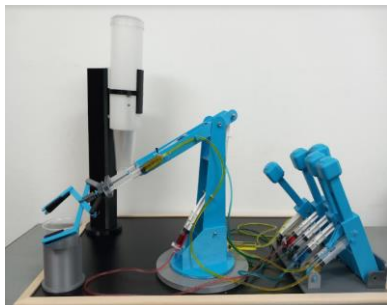
d) Kretanje od magacina do držača



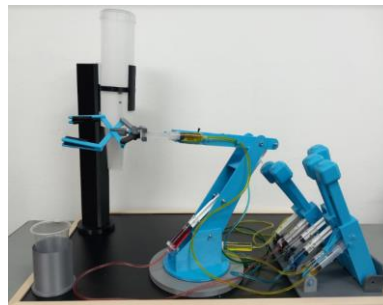
e) Pozicioniranje iznad držača



f) Spuštanje čaše u držač



g) Otvaranje hvataljke



h) Povratak u inicijalni položaj

Slika 4. Realizacija postavljenog zadatka po koracima [9]

3. DISKUSIJA

Tržište danas nudi široku i raznovrsnu ponudu raznih oblika mehanizama i robota namenjenih deci. Razne igračke u vidu humanoidnih robota, robota životinja i slično ostvaraju neki vid interakcije se detetom i podstiču ga na kreativno razmišljanje, pomažu u razvoju motoričkih veština itd.

Kao doprinos oblasti razvoja kognitivnih sposobnosti dece u sklopu ovog rada razvijena je mehatronička ruka za rukovanje predmetima rada. Korišćenjem razvijene ruke dete se podstiče na razmišljanje o pravilnoj orijentaciji u prostoru, načinima za kretanje u prostoru sa preprekama itd. a istovremeno se uvodi u svet tehnike i nauke i to kroz edukativnu igru. Testiranjem mehatroničke ruke u realnim uslovima rada potvrđena je njena funkcionalnost na primeru izuzimanja čaša iz gravitacionog magacina i odlaganja istih na predviđeno mesto. Kao takvu, razvijenu ruku moguće je koristiti i za druge zadatke. Na primer, da dete složi kocke sa slovima u položaj tako da prikazuju njegovo ime ili kocke sa brojevima u položaj tako da prikazuju njegov datum rođenja. Na taj način, opet kroz igru, dete može da nauči i slova i brojeve. Ono što je neophodno obezbediti u tim slučajevima jesu odgovarajući predmeti rada i postolja za njihovo odlaganje. Dodatno, bilo bi potrebno razviti i neku korisničku aplikaciju pomoću koje bi dete videlo tačne pozicije slova ili brojeva, tj. šta treba da uradi, a koju bi pokretao edukator.

Sa druge strane, kao negativna strana postojećeg rešenja izdvaja se mala nosivost što ograničava dimenzije i masu predmeta rada kojima se rukuje. Naime, debljina segmenata mehatroničke ruke je mala (od 3 mm do 5 mm) a i izabrani medicinski injektori su malih zapremina (od 5 ml do 20 ml). To je urađeno iz razloga što je reč o testnoj varijanti i glavni cilj je bio da se dokaže funkcionalnost mehatroničke ruke.

Međutim, pomenuti problem je relativno lako rešiv. Potrebno je samo promeniti dimenzije u projektovanom 3D modelu i pripremiti nove fajlove za izradu, i to na taj način da se iste usklade sa novoizabranim predmetima rada i novodefinisanim zadatkom.

4. ZAKLJUČAK

Jedna od važnijih stvari u razvoju deteta jeste razvoj njegovih kognitivnih sposobnosti koje podrazumevaju sposobnosti opažanja, orijentacije, pamćenja, učenja, snalaženja itd. Savremeni interaktivni mehatronički sistemi mogu pomoći u razvoju pomenutih sposobnosti i često se koriste.

Jedan od primera takvog sistema predstavljen je i u ovom radu i podrazumeva mehatroničku ruku za rukovanje materijalom kojom se upravlja korišćenjem namenski napravljenih džojstika. Funkcionalnost razvijene ruke potvrđena je u realnim uslovima rada na način da je ispitana mogućnost izuzimanja plastičnih čaša iz gravitacionog magacina i njihovog odlaganja u odgovarajući držač. Na osnovu uspešnog obavljenog testiranja, uzimajući u obzir sva ograničenja vezana za nosivost, zaključuje se da se mehatronička ruka može primeniti i za realizaciju drugih zadataka interesantnih deci i da može pomoći u razvoju njihovih kognitivnih sposobnosti.

Buduća istraživanja biće vezana za razvoj nove verzije mehatroničke ruke i dodatnih elemenata potrebnih za realizaciju drugih zadataka.

ZAHVALNICA

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A MECHATRONIC ARM AS AN AID FOR THE DEVELOPMENT OF CHILDREN'S COGNITIVE ABILITIES

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ABSTRACT:

In this paper a mechatronic arm, which enables different ways of material handling by using medical injectors, was developed. One of the examples is the removal of plastic cups from a vertically placed gravity storage. It was analyzed separately in the paper. The basic idea for the development of such a system stemmed from the need to help in development of children's cognitive abilities, that is, to enable children to understand spatial orientation as easily and simply as possible, and then learn the basic principles of different manipulators operation. The mechatronic arm is realized in such a way that has five degrees of freedom. It is made up of three basic segments with associated rotational joints (as in the case of Articulated Robots) and two additional segments that make up a gripper, with associated rotational and linear joints. The functionality of the developed mechatronic arm was confirmed by testing in real working conditions. All the advantages and disadvantages of the developed solution were observed.

Keywords: *mechatronic arm, Articulated Robots, gripper, medical injectors, mechatronics for kids*

PRIMJENA 3D TEHNOLOGIJA U EDUKACIJI STUDENATA IZ OBLASTI MAŠINSKIH ELEMENATA

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SAŽETAK:

U cilju unapređenja nastave u oblasti mašinskih elemenata na Mašinskom fakultetu Univerziteta Crne Gore je uvedena primjena inovativnih metoda u vidu 3D tehnologija koje su implementirane u praktični dio nastave. Upotreba 3D tehnologija, u vidu 3D modeliranja i štampanja mašinskih djelova, omogućava studentima da steknu dublje razumijevanje mašinskih elemenata kroz interaktivno i vizuelno iskustvo. Osim što je studentima na ovaj način omogućeno da stvore realistične modele mašinskih elemenata, 3D tehnologije takođe pružaju mogućnost simuliranja različitih radnih uslova i testiranja konstruktivnih rješenja mašinskih elemenata u virtualnom okruženju. Ovo je posebno korisno jer studenti mogu kombinovati različite materijale, oblike i dimenzije mašinskih elemenata, a nakon toga izvoditi eksperimente i istraživati njihov uticaj na ponašanje mašinskih elemenata u različitim radnim uslovima. Takođe, ova interaktivna metoda učenja podstiče kreativnost, timski rad kao i vještine za rješavanje različitih problema, što studente priprema za složene projekte i izazove koje će susresti u svojoj budućoj karijeri.

***Ključne riječi:** 3D model, 3D štampa, mašinski elementi*

1. UVOD

3D tehnologije su sveprisutne i neprekidno se razvijaju, otvarajući nove mogućnosti i pružajući inspiraciju za kreativne projekte i inovacije. Ove tehnologije imaju široku primjenu u različitim oblastima tako da se sve više koriste u industrijama kao što su medicina [1,2], inženjering, arhitektura, dizajn, obrazovanje i mnoge druge. Jedna od najpopularnijih tehnologija jeste 3D štampanje, pored njega postoje i 3D modeliranje, 3D skeniranje, 3D animacija, virtuelna realnost i druge. Studenti sve više iskazuju želju za praktičnim radom da bi upotrijebili svoje teorijski stečeno znanje, kako bi im to omogućili u okviru kursa iz oblasti mašinskih elemenata uvedena je primjena 3D tehnologija. Ovo istraživanje je bazirano na primjeni 3D modeliranja i 3D štampanja i uticaju istih na kvalitet nastave i razumijevanju materije. Obzirom na to da Mašinski fakultet Univerziteta Crne Gore posjeduje svu neophodnu opremu ove aktivnosti je bilo moguće realizovati.

Hirpa G. Lemu i Ove Mikkelsen su kroz svoje istraživanje studentima dali pristup 3D štampanim elementima čiji je 3D model trebalo odraditi, pored toga imali su mogućnost da svoje ideje pretvore u fizički objekat pomoću 3D štampe. U svom radu su prikazali rezultate koje su dobili anketiranjem studenta nakon odrađenih zadataka. Rezultati pokazuju da se više od 80% studenata, koji su učestvovali u anketi, izjasnilo da im je upotreba 3D štampanih djelova doprinijela boljem razumijevanju i podržavaju ovaj način rada. [3]

Uvođenjem 3D modeliranja u praktični dio nastave Guangdong i dr. su omogućili studentima da razumiju strukturu opreme i odnos komponenti u sklopu. Ispunili su ciljeve obuke pomoćnog motora i motivisali učenike za samostalan rad. [4]

2. METODOLOGIJA

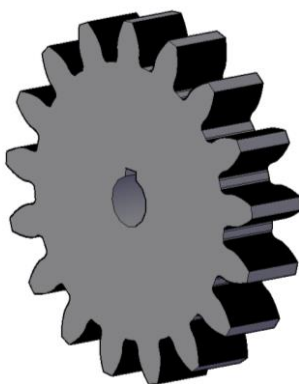
Kroz nastavu u okviru kursa Mašinski elemenati studenti stiču teorijsko znanje za proračun različitih mašinskih elemenata kao što su: zupčanic, vratila, zavrtnjevi, ležajevi i drugi. Nakon odrađenog teorijskog dijela koji se odnosio na cilindrične zupčanike studenti su dobili zadatak da odrade kompletan proračun koji im je neophodan kako bi nacrtali 3D model cilindričnog zupčanika sa pravim zupcima. Pored cilindričnog zupčanika odrađen je proračun vratila i klina bez nagiba. Poslije proračuna svih elemenata i dobijenih neophodnih podataka za dalji rad nacrtani su 3D modeli i pušteni na štampu. Elementi dobijeni štampom su na kraju sklopljeni u jednu cjelinu kako bi se dobio model prenosnika sa tri cilindrična zupčanika.



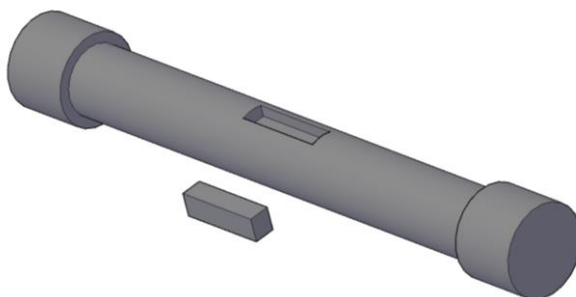
Slika 1. Proces dobijanja 3D štampanog elementa

2.1. 3D modeliranje

3D modeliranje je jedna od 3D tehnologija koja omogućava kreiranje trodimenzionalnih elemenata pomoću specijalizovanih softverskih alata. Proračunom cilindričnog zupčanika sa pravim zupcima i ostalih elemenata planiranih za štampu dobijeni su podaci koji su neophodni za kreiranje 3D modela. Model je odrađen u okviru softverskog paketa AutoCAD 2018. AutoCAD-ov softver ima mogućnost 2D crtanja kao i kreiranje 3D modela. Na Slici 2. je prikazan model zupčanika koji ima 17 zubaca i modul zupčanika 6 mm. Vratilo prečnika 15.3 mm i odgovarajući klin su prikazani na Slici 3.



Slika 2. Model zupčanika



Slika 3. Model vratila i klina bez nagiba

2.2. 3D štampa

Nakon dobijenog 3D modela fajl je eksportovan u .stl formatu kako bi se odradila dodatna podešavanja prije puštanja u štampu. 3D štampanje omogućava kreiranje trodimenzionalnih objekata dodavanjem slojeva određenog materijala. Materijal koji je upotrijebljen za izradu elemenata u ovom radu jeste Poly Lactic Acid (PLA). Neposredno prije puštanja štampača u rad neophodno je podesiti dodatne parametre kao što je debljina slojeva štampanja, gustina ispunjenosti kojom je ispunjen element, debljina zida i druge. Vrijednosti podešenih parametar su prikazani u Tabeli 1.

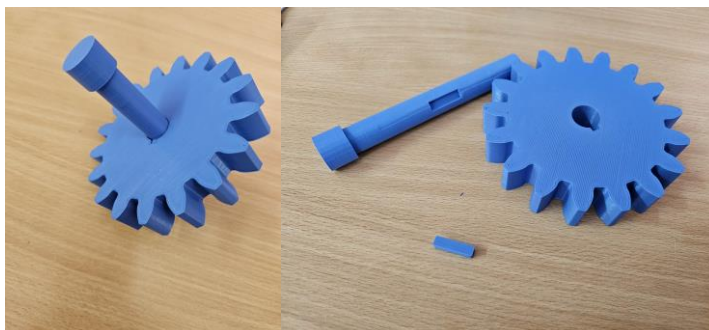
Tabela 1. Parametri za štampanje

Debljina sloja	0.2 mm
Gustina ispunjenosti	25 %
Debljina zida	0.8 mm

Mašinski elementi su štampani na štampaču Snapmaker, koji je prikazan na Slici 4. Pomoću softvera Luban generisan je G-kod i elementi su pušteni u proces štampanja. Na Slici 5. su prikazani elementi dobijeni 3D štampom, a na Slici 6. je prikazan konačan model prenosnik sa cilindričnim zupčanicima sa pravim zupcima.



Slika 4. 3D štampač [5]



Slika 5. Elementi dobijeni 3D štampom



Slika 6. Prenosnik sa cilindričnim zupčanicima

3. ZAKLJUČAK

Upotreba 3D tehnologija u nastavnom procesu je doprinijela boljem angažovanju studenata jer im je pružila uzbudljivo iskustvo u učenju iz oblasti mašinskih elemenata. Kroz interaktivne 3D modele imali su mogućnost bolje vizualizacije i razumijevanja kompleksnih koncepata. Rezultat ovoga je kvalitetno učenje što će doprinijeti boljem pripremanju studenata za praktični rad. Pored učenja studenti su dodatno razvili vještine za timski rad, kritičko razmišljanje i rješavanje problema koje su jedne od ključnih kompetencija za buduće inženjere. Sve u svemu, integracija 3D tehnologija u obrazovnom procesu može značajno unaprijediti kvalitet obrazovanja i usvajanja novih znanja, kako iz oblasti mašinskih elemenata tako i drugih oblasti gdje je moguće primijeniti ovaj metod.

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APPLICATION OF 3D TECHNOLOGY IN THE EDUCATION OF STUDENTS IN FIELD OF MACHINE ELEMENTS

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ABSTRACT:

In order to improve teaching in the field of machine elements, the Faculty of Mechanical Engineering of the University of Montenegro introduced the application of innovative methods in the form of 3D technologies that were implemented in the practical part of the teaching. The use of 3D technologies, in the form of 3D modeling and printing of machine parts, allows students to gain a deeper understanding of machine elements through an interactive and visual experience. In addition to enabling students to create realistic models of machine elements in this way, 3D technologies also provide the possibility of simulating different working conditions and testing constructive solutions of machine elements in a virtual environment. This is particularly useful because students can combine different materials, shapes and dimensions of machine elements, and then perform experiments and investigate their influence on the behavior of machine elements in different working conditions. Also, this interactive learning method encourages creativity, teamwork, and problem-solving skills, which prepares students for the complex projects and challenges they will meet in their future careers.

Keywords: 3D model, 3D printing, machine elements

THE INFLUENCE OF THE LASER BEAM ON THE QUALITY OF THE SURFACE WHEN THE PARAMETERS ARE CHANGED

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ABSTRACT:

Laser cutting and engraving machines are widely used in various industrial, commercial and creative contexts. This process is used for precision carving and creating detailed engravings or reliefs on various materials, including metal, plastic, wood, glass and textiles. Laser cutting of materials has emerged as a key technology in modern manufacturing processes due to its precision, efficiency and versatility. The advantages of laser cutting include a precise result, a reduction of the thermally affected zone, a regular cut profile, smooth and straight edges, minimal or almost no deformation of the processed material, and the ability to work at high speeds. One of the leading problems is the quality of the cut, which can depend on the manufacturing parameters, the quality of the material, the thickness of the material, and the focal length. This paper presents an analysis of the quality of the cut in relation to the change in manufacturing parameters on plywood with a thickness of 5 mm. During the analysis, the most important processing parameters, the minimum and maximum power of the laser beam, and the cutting speed will be varied.

Keywords: *laser, cutting, parameters, material*

1. INTRODUCTION

Laser processing is a technology for engraving, drilling, welding and cutting materials, which enables the production of even the most demanding surfaces. Thanks to its high precision, this process enables the engraving and cutting of the smallest parts and exceptional accuracy in shaping different geometries [1]. Laser cutting of materials has emerged as a key technology in modern manufacturing processes due to its precision, efficiency and versatility. The process of laser cutting and engraving is used to create engravings and reliefs on the surface of various materials such as ceramics, plastic, wood, leather, paper, glass, metal and others.

The advantage of laser processing compared to conventional methods of processing is that there is no direct contact between the tool and the object of processing, which means that there is no physical contact, and thus there is no tool wear. A high precision and cut quality is achieved up to 0.025 mm, which requires a shorter production time [2]. Laser processing is one of the most economical techniques with proper optimization of parameters; in

addition, there is no waste material due to the removal of material by evaporation during processing. It is suitable for individual and serial pieces; in addition, it is not necessary to tighten the material but to position it well on the work surface.

Disadvantages of laser processing are high initial equipment costs and materials with large dimensions in terms of thickness, which can be a challenge for laser processing. The most important disadvantage is the high level of gas evaporation during the melting of the material, which leads to the emission of dangerous gases that hurt the environment.

In addition to the mentioned disadvantages, it is difficult to determine the parameters depending on the density of the wood, because it is a heterogeneous material, which is a problem for determining the power and speed of cutting, as a result of inadequate parameters, it can cause burning of the cutting edges. Adrian Petra presented this problem in his work, where he presented which type of laser is optimal for cutting, engraving and burning. Based on the research, he concluded that wood such as beech, chipboard, etc., is suitable for cutting ash, white pine etc. suitable for lighting, and walnut, chestnut, oak, etc., for engraving [1].

Increasing the power increases the cutting speed and air pressure while the focal length decreases. The observed parameters are cutting speed, power during laser processing, focal length and air pressure. HA Eltawahni and others showed the influence of the mentioned parameters in their paper by cutting plywood of different thicknesses, 4 mm, 6 mm, and 9 mm [3].

This paper presents an analysis of the quality of the cut and the change in manufacturing parameters on plywood with a thickness of 5 mm. During the analysis, the most important processing parameters, the minimum and maximum power of the laser beam, and the cutting speed will be varied.

2. CNC Laser

The most precise and modern material processing is laser processing. There are several types of lasers for processing such as CO₂ lasers, fiber lasers, Nd:YAG lasers and disc lasers.

In this work, CO₂ laser SR 7050 was used during the experiment.

Table 1 shows the basic technical characteristics of the CNC laser.

Table 1. Technical characteristics of CO₂ laser SR 7050

Characteristics	Dimensions	Units
Dimensions (LxWxH)	1300 x 900 x 1000	mm
Laser power	100	W
Working area	700 x 500	mm
Guides-linear	15	mm
Engraving speed	0-1000	mm/s
Cutting speed	0-200	mm/s
Precision	0.001	mm

Maximum material thickness	30	mm
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CO2 CNC laser is a molecular laser, the main gas is carbon dioxide, and the auxiliary gas is nitrogen, xenon and hydrogen. The core of the machine uses the transition between the vibration level and the rotational energy of the CO2 molecule to create a laser beam [4]. This technique relies on using an intense light beam that is focused on the material, causing local heating to the point of melting or vaporization. During this process, parts of the solid material melt or evaporate simultaneously. Thanks to the laser beam's precision and the auxiliary gas's purity, the resulting cuts are extremely clean, smooth, shiny and geometrically precise. This process achieves a narrow heat-affected zone (HAZ), improving the processing quality [5]. The CO2 laser can process all materials, except metal.

The CO2 laser consists of a tube that is filled with gas or a mixture of gases under a certain pressure; at the end of the tube, two parallel mirrors reflect the laser beam and thus form a resonator, where the high voltage produces a lot of fast electrons in the tube, which transfer energy to molecules through their collisions gas. The laser beam is reflected from the first mirror to the second, and the second laser beam is reflected to the third mirror where at an angle of 90 degrees, the laser beam falls on the focus lens, which focuses the beam on the work surface. Figure 1 shows a schematic view of the CO2 laser [6].

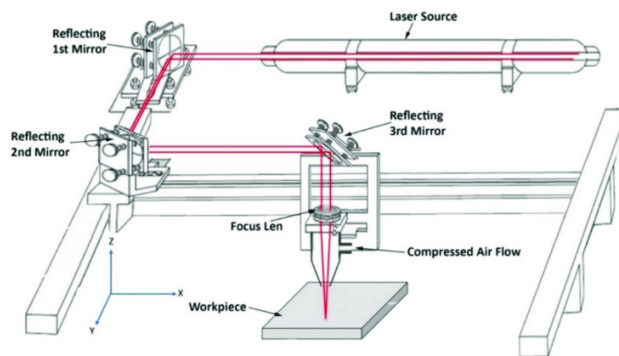


Fig. 1. Schematic view of CO2 laser [6]

When making a certain product on a CNC machine, it is necessary to prepare it in virtual form. Various software is used for product preparation such as CorelDraw, Pagemaker, Adobe Illustrator, and variants of CAD programs. RDWorks software was used for the SR 7050 CNC machine. The program recognizes files in a vector format such as .dxf, .ai, .cdr and others.

3. ANALYSIS OF THE RESULTS OBTAINED

Experimental research aimed to determine the influence of processing parameters on the quality of the cut in laser cutting; the tests were performed on a laser machine.

The 2D model was created in the AutoCAD software package, where the original format was obtained in .dwg format; to perform the necessary processing, it must be converted to .dxf format. Figure 2 shows the openings and contours made in AutoCAD.

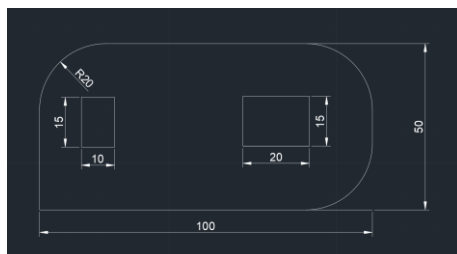


Fig. 2. Preparation of openings and contours in AutoCad

The exported .dxf file is imported into the specialized RDWorks software, which offers a wide range of parameter settings such as minimum and maximum power, cutting speed, and number of repetitions. In the program, defining which processing we need for a specific contour using color palettes is necessary. Based on the selected color, we set the Scan or Cut command so that the laser recognizes the desired function.

Figure 3 shows the specialized software RDWorks with an imported .dxf file.

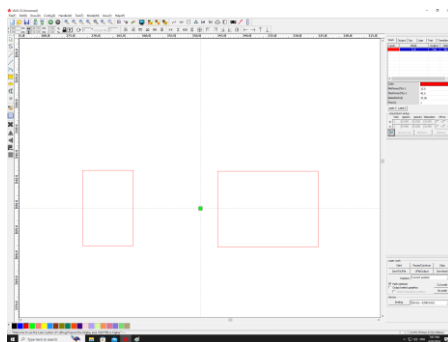


Fig. 3. RDWorks software environment

The material of the processing object is plywood with a thickness of 5 mm, manufactured by Agacija Furniture; it consists of cross-glued layers of veneer, which gives it excellent technical properties. Its application is most prevalent in the construction industry, the

furniture industry, the production of decorative interior items, the packaging and pallet industry, the production of models and models, and many other areas [7].

The research aims to determine the parameters based on which the best quality of the cut will be obtained, such as the roughness and width of the cut. Three samples were made for each experiment using the given parameters. During the experiment, the constant parameters are material thickness - 5mm and focal length - 10mm. Depending on the type and thickness of the material, the focal length is determined, and the laser beam is focused. It must be constantly positioned exactly about the surface of the workpiece so that the cutting effect is complete [8].

3.1. Experiment I

The power of the laser is 100 W, and when setting the parameter, the power is displayed as a percentage.

During this experiment, a minimum power of 10%, a maximum power of 20%, and a cutting speed of 30 mm/s were used, where the number of repetitions was 40.

Figure 4 shows the created contours based on the given parameters.



Fig. 4. Experiment I

Based on the image, it can be seen that the given parameters need to be more adequate because the expected result is not met, and the contours are not cut. All three samples did not cut off the contour.

3.2. Experiment II

Based on the previous experiment, where the contour remained on the material itself, the parameters were varied to increase the strength. The minimum power used in this experiment is 15%, the maximum power is 40%, the cutting speed is 30 mm/s, and the number of repetitions is 15. Figure 5 shows the contour based on the given parameters.



Fig. 5. Experiment II

Table 2. Presentation of the obtained results based on the given parameters

Smoke (mm)	Sample I (mm)		Width of cut (mm)	Sample II (mm)		Width of cut (mm)	Sample III (mm)		Width of cut (mm)
	Work piece	The core of the piece		Work piece	The core of the piece		Work piece	The core of the piece	
axb (10x15)	10.29x15.23	9.56x14.46	0.73x0.77	10.28x15.32	9.22x14.19	1.06x1.13	10.30x15.25	9.72x14.62	0.58x0.63
cxd (20x15)	20.29x15.39	19.50x14.35	0.79x1.04	20.38x15.64	19.42x14.40	0.96x1.24	20.43x15.29	19.44x14.37	0.99x0.92
mxn (100x50)	100.16x50.21	99.54x49.89	0.62x0.32	100.24x50.30	99.52x49.85	0.72x0.45	100.17x50.25	99.66x49.91	0.51x0.34

The results presented in Table 2 were obtained by measuring with the help of a Mitutoyo digital beak measuring device, where the maximum measuring range is 150 mm, and the accuracy is 0.01 mm [9]. Based on the obtained results, it is noticeable that with smaller contours, there are larger deviations from the optimal values, where the maximum deviation is 0.64 mm. In addition, there is a greater burning of the material, which causes black spots on the surface due to ignition and a high level of harmful gas. Smaller deviations from the optimal value are observed when cutting a larger contour, where the maximum deviation is 0.3 mm. By subtracting the value of the opening of the workpiece and the core of the piece, the results of the width of the cut were presented, where it was observed that the minimum width of the cut was 0.32 mm at the largest opening.

3.3. Experiment III

In this experiment, the minimum power used was 15%, the maximum power was 40%, the cutting speed was 60 mm/s, and the number of repetitions was 15. Based on experiment II, it was observed that the cutting speed should be increased to avoid significantly burning the material. Figures 6 and 7 show the contour based on the given parameters.

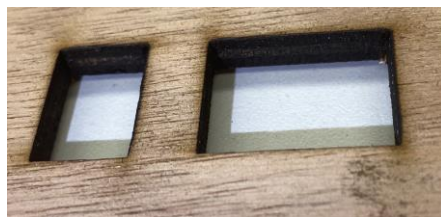


Fig. 6. Experiment III – smaller contours



Fig. 7. Experiment III – larger contour

Table 3. Presentation of the obtained results based on the given parameters

Smoke (mm)	Sample I (mm)		Width of cut (mm)	Sample II (mm)		Width of cut (mm)	Sample III (mm)		Width of cut (mm)
	Work piece	The core of the piece		Work piece	The core of the piece		Work piece	The core of the piece	
axb (10x15)	10.33x15.03	9.83x14.81	0.50x0.22	10.26x15.08	9.85x14.86	0.41x0.22	10.14x15.06	9.87x14.84	0.30x0.22
cxd (20x15)	20.05x15.26	19.83x14.78	0.22x0.48	20.10x15.12	19.80x14.89	0.30x0.23	20.03x15.09	19.75x14.74	0.28x0.35
mxn (100x50)	100.0x50.12	99.83x49.91	0.19x0.21	100.0x50.17	99.75x49.88	0.31x0.29	100.0x50.15	99.77x49.90	0.28x0.25

The results presented in Table 3 were obtained by measuring with the help of a digital beak measuring device. Based on the results, a maximum deviation of 0.33 mm was observed for the smaller contour compared to the optimal values. In comparison, the maximum deviation for the larger contour was 0.17 mm. By subtracting the value of the opening of the workpiece and the core of the piece, the results of the width of the cut were presented, where it was observed that the minimum width of the cut was 0.19 mm at the largest opening.

4. CONCLUSION

Laser cutting of materials has emerged as a key technology in modern manufacturing processes due to its precision, efficiency, and versatility. In addition to laser cutting, engraving can be used with minimal operator intervention, where no additional processing is required. Many factors influence the quality of the obtained surfaces, such as the width of the cut and the roughness of the surface.

Laser processing of plywood darkens the color of the cut surface from light brown to black when burning the plywood. Color varies depending on focal length, laser power, cutting speed, and number of passes. Dark surfaces created during processing can be removed with the help of pressurized air or by wiping the surface, after which the surfaces turn brown.

After the analysis, it was observed in experiment I that the laser's power significantly affects the cut's quality. In contrast, a higher power effectively achieved the desired results. The minimum deviation for the 10x15 mm opening is 0.22 mm in experiment III, while the maximum deviation is 1.13 mm in experiment II. The minimum deviation for the 100x50 mm opening is 0.19 mm in experiment III, while the maximum is 0.72 mm in experiment II. Based on these results, it can be observed that by increasing the cutting speed, the ignition of the material is reduced, as well as the width of the cut. For smaller contours, deviations from optimal values are larger than larger ones, suggesting that additional care is needed when setting parameters for smaller slices. Parameters such as minimum, maximum power range, and cutting speed should be carefully adjusted to achieve optimal cut quality with minimal deviation from the desired values. Further research should include a larger range of parameters such as material thickness and type, focal length variation, and a larger power range.

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INVESTIGATION OF THE STABILITY OF SILYBUM MARIANUM PLANT EXTRACTS DEPENDING ON THE STORAGE AND PRESERVATION CONDITIONS

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ABSTRACT:

Silybum marianum contains secondary metabolites such as phenols and flavonoids, and other active substances that show antioxidant activity. In addition, it shows other significant properties such as antimicrobial, anti-inflammatory, hepatoprotective, antidiabetic and cardio protective properties, and therefore their extracts are used as herbal medicines.

In order for the extract to retain the herbal medicine properties with preserved biologically active substances as well as their activity, it is important to investigate their stability, which will remain throughout the product's shelf life. Biologically active substances can be thermolabile or volatile, and therefore subjected to changes under the influence of environmental factors such as temperature, humidity, light, oxygen, and others. Testing the stability of herbal products is complicated, because the whole plant is considered an active substance, so it is possible to monitor stability through selected individual components and/or changes in the capacity of extracts biological activity. In this direction, changes in the content of total polyphenols and antioxidant activity were investigated depending on the exposure time, the effect of light and the storage temperature regime. Three temperature regimes were chosen: +4°C (refridgerated), 25°C (room temperature), and 40°C (extreme conditions). The samples were kept in light and dark bottles. Changes in the content of total phenols, and antioxidative activity with time of exposure were monitored. The effects of certain environmental parameters on the stability of plant extracts were determined and quantified. The research results can serve as an important tool in studies of the plant extracts stability and storage conditions.

Keywords: *Silybum marianum*, stability, antioxidant activity, polyphenol

1. INTRODUCTION

Silybum marianum belongs to the family Asteraceae [1]. The foliage, blossoms, fresh shoots, and buds of the plant are commonly consumed in culinary dishes like soups and salads [2;3], while its seeds and fruit have been utilized as a traditional herbal solution for liver and biliary ailments for over two millennia in certain regions [4]. Extracts obtained

from the dried seeds of *Silybum marianum* typically contain around 60% silymarin, the principal active component constituting approximately 4% of the dried seeds or aerial parts of the plant [5]. Originally discovered in regions across the Mediterranean mountains, North Africa, and Asia, cultivation of *Silybum marianum* has since expanded globally [7].

The silymarin complex comprises various flavonolignans, notably silybin (50%-60%), silychristin (20%), silydianin (10%), and isosilibine (5%), along with the flavonoid taxifolin [8]. This intricate combination exhibits a range of beneficial effects, including antioxidant, anti-inflammatory, anti-fibrotic, anti-lipid peroxidative, immune-stimulating, and hepatocellular stabilizing properties [9]. Moreover, betaine, trimethylglycine, and essential fatty acids present in *Silybum marianum* seeds contribute to enhancing the hepatoprotective and anti-inflammatory effects of the silymarin complex [10].

However, the high instability of phenolic compounds in herbal plants limits their application despite their considerable potential. Polyphenols, characterized by unsaturated bonds and a robust antioxidant capacity, are sensitive to factors such as heat, pH variations, light exposure, enzymatic activities, and the presence of metal ions and oxygen [11]. Moreover, these compounds exhibit instability during prolonged storage periods [12]. Because of these factors, the stability of phenolic compounds depends not only on their chemical characteristics but also on the overall composition of the extract.

Therefore, in this study, variations not only in the levels of total polyphenols but also in antioxidant activity were examined based on exposure duration, light exposure, and storage temperature conditions. Three temperature conditions were selected: +4°C (refrigerated), 25°C (room temperature), and 40°C (extreme conditions). Samples were stored in both transparent and opaque containers. Alterations in total phenol and flavonoid content, as well as antioxidative activity over time, were observed. The impact of specific environmental factors on the stability of plant extracts was analyzed and quantified. These research findings could serve as valuable resources for investigating the stability and appropriate storage conditions of plant extracts [13].

2. MATERIAL AND METHODS

Milk thistle seeds were ground into a fine powder with a particle diameter of 0.4 mm using a blender. The extraction process was conducted in two steps, starting with defatting. The ground sample was weighed and extracted with n-hexane for 4 hours at room temperature, using a sample-to-solvent ratio of 20 grams of sample to 200 mL of petroleum ether. The samples were then filtered and dried to remove any remaining petroleum ether.

As a sample, an extract of the *Silybum marianum* was used. New samples were made after degreasing, UV extraction was performed for 30 minutes at 50°C, after which 10 g of sample and 100 mL of ethanol solvent were taken. After extraction, the solvent was removed using a rotary evaporator (BUCHI Rotavapor R-215) under the following conditions: bath temperature 60°C, boiling point 40°C and cooling water temperature 20°C. The extract was then dried at 40°C to constant weight. The extract is dissolved in the solvent in which the extraction was carried out, and after the initial concentrations have been determined, it is transferred to bottles for storage.

Three temperature conditions for storage were selected: +4°C (in the refrigerator), 25°C (room temperature) and 40°C (extreme conditions). The samples were stored in

transparent and opaque containers. Changes in the total content of phenols and antioxidant activity over time, were monitored.

For the determination of total phenols, Folin–Ciocalteu colorimetric method in alkaline medium was used [14], and for the measurements of the antioxidative value, the DPPH method was used [15].

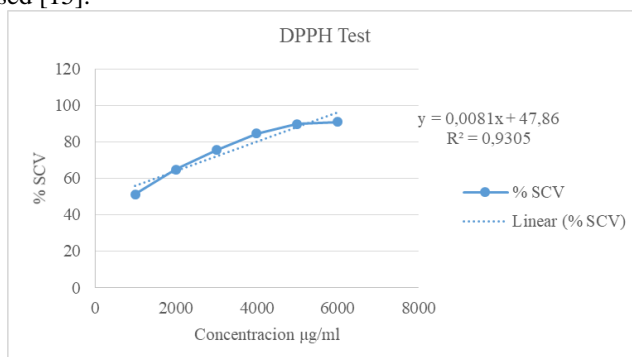


Figure 1. Measurement of radical scavenging activity and calculation of IC₅₀ DPPH analysis

3. RESULTS AND DISCUSSION

Although the degradation of bioactive compounds can take place in the earlier stages of plant material processing, including dried and scalded plant material, then in the processes of isolation of biological active substances such as different types of extraction [15], in this paper we focused on degradation during scalding and storage of extracts. The average concentration of total phenols in the roots after extraction is 115.11 mg/g of dry sample, and it decreases with further scalding under different treatment conditions. The most pronounced drop in the concentration of total phenols was observed during treatment at 40 °C and storage in light bottles, where the concentration decreased 51.36%, i.e. the average concentration of total phenols after 40 days was 59.79 mg/g.

Table 1. The content of total polyphenols depending on the time of treatment (storage), temperature and transparency of the packaging, mg/g of dry extract

TIME/ DAYS	5 °C, OC	5 °C, TC	25 °C, OC	25 °C, TC	40 °C, OC	40 °C, TC
0	115,11	115,11	115,11	115,11	115,11	115,11
10	111,05	105,54	97,24	93,31	83,07	79,25
20	109,50	102,27	97,45	90,35	80,68	78,40
30	105,37	101,45	95,41	90,27	71,42	66,44
40	104,58	101,27	93,65	88,89	65,57	59,32

*TC = transparent containers, OC = opaque containers

Comparing the results of total polyphenols under the same conditions in dark and light bottles indicates that the degradation is less pronounced in dark bottles.

The stability of the bioactive compounds present in *Silybum marianum* plant extract decreases in all tested holding treatments as their antioxidant potential. Values of antioxidant capacity depending on scalding conditions are shown in Table 2.

Table 2. Values of the antioxidative capacity of the extract depending on the content, IC₅₀ µg/ml DPPH test

TIME/ DAYS	5°C, OC	5°C, TC	25°C, OC	25°C, TC	40°C, OC	40°C, TC
0	115,11	115,11	115,11	115,11	115,11	115,11
10	111,05	105,54	97,24	93,31	83,07	79,20
20	109,50	102,27	97,45	90,35	80,68	78,40
30	105,37	101,45	95,41	90,27	71,42	66,44
40	104,58	101,27	93,65	88,89	65,57	59,32

*TC = transparent containers, OC = opaque containers

The best stability was observed at 5 °C in dark conditions which retained 80.03% of DPPH• antioxidant activity after 40 days of storage as expressed by the IC 50 value. In fact, both storage conditions of 5 °C (light) and 25 °C (darkness) retained quite high DPPH• antioxidant activity. It was found that during scalding, the degradation of polyphenolic components occurs, and thus the antioxidant value of the extracts decreases. The results obtained in this work are in line with earlier publications where Zamora and other authors Research on antioxidants after 3-month storage at different temperatures showed that up to 50% of the total antioxidant capacity can be lost [16]. Similar results were also shown by studies by the authors of Gião and coworkers, on the antioxidant stability of plants used to obtain infusions during their storage and shelf life [17] [18]. These studies are also useful for recommending storage conditions and predicting shelf life. As stability testing involves testing the quality and capability of the product at appropriate time intervals and is conducted over a period corresponding to the normal time the product is likely to remain in storage or in use, the effects of environmental storage factors are also taken into account.

The paper showed that temperature increases the rate of decomposition of active ingredients due to an increase in their kinetic energy, which results in an increase in the proportion of molecules that collide. Sunlight as a form of energy also facilitates decomposition and affects the stability of extracts, which is in line with earlier published results [19].

4. CONCLUSION

The stability of extracts is affected by numerous physical factors such as temperature, moisture and light, and chemical factors such as hydrolysis, oxidation, polymerization and isomerization.

Based on the measurement results, it was determined that storage temperature and light are the main obstacles when it comes to the stability of phenolic compounds, as well as their corresponding antioxidant activity of *Silybum marianum* plant extracts.

In addition, as with the scalding of herbal extracts, it is very important to take care of the storage time and temperatures when it is consumed for antioxidant purposes. In this sense, the combined analysis of antioxidant capacity and phenolic content allow to reveal the effects of storage conditions on the antioxidant profile of the plant. Therefore, in subsequent research, each plant should be investigated in more detail separately with more storage time and temperature in order to obtain a reliable model for the stability of plant extracts before creating a new extract, a dietary supplement or medicinal formulation.

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APPLICATION OF FDM TECHNOLOGY IN PRODUCT DEVELOPMENT PROCESS: AN EXAMPLE OF CARRIER FOR CENTRIFUGAL FAN FOR NESPI 4 CASE

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ABSTRACT:

This paper presents application of FDM technology in design and manufacturing process of the carrier for centrifugal fans for the NESPI 4 CASE. Two centrifugal fans were selected as heat removal devices for the case. During the design process of the fan carrier, an analysis of the possibility of using the free space of the case was performed, considering the way of use of the device. The design process of the fan carrier included creating 3D models of all device components. The carrier was manufactured using FDM 3D printing technology. During the assembly process, an operating and functionality check was performed, which showed that there was no incompatibility between the carrier and the other components of the device. Furthermore, temperature and noise tests showed that using a previously developed cooling system in cooperation with the ventilation system caused a decrease in computers' operating temperature by almost 50%, while noise levels were within the allowed range for human health.

Keywords: *product development, 3D model, FDM technology, heat, fan*

1. INTRODUCTION

Permanent technological development has significantly influenced all aspects of human life. Nowadays, humans in medium- or high-developed countries use many devices on the job, during trips and at home to learn, raise efficiency, or even increase life quality in general. This is especially reflected in the fact that different types of computers are becoming an integral part of any process, from business activities to leisure.

Furthermore, the strong development of the industry caused the development of new technologies that provide a fast and accurate product development process. Additive technologies made a great contribution to the product development process by providing possibilities for rapid prototyping [1, 2]. However, the development and accessibility of those technologies, as well as the use of different materials, led to manufacturers being able to produce final products using additive technologies, such as 3D printing [1, 2].

Efficiency of processes performed by computer can depend on its environment, especially on air temperature and humidity. However, the computer generates a certain heat during its operation, so it is recommended that it has a cooling system, in particular if it is in case. In the absence of an adequate cooling system, the computer may experience overheating, resulting in diminished performance and potentially permanent damage to its components, ultimately leading to system failure. Raspberry Pi 4 is a small-sized computer that does not have own case, as well as a factory integrated cooling system [3]. However, it can generate high temperatures during the operation that can reach over 100°C. Furthermore, NESPI 4 CASE, as a case developed for the Raspberry Pi 4, does not have a high efficient active cooling system [4]. Considering that there was no cooling system for Raspberry Pi 4 that is compatible with NESPI 4 CASE, it was developed and manufactured, consisting of a passive component (aluminum cooler) and an active component (axial fan). Temperature tests showed that utilization of this cooling system decreased temperature up to 30% [4]. Although there was a decrease in temperature on the computer, there was a requirement to ventilate the hot air from the case.

In this paper, the application of additive technologies in the product development process of the carriers for centrifugal fans is presented. Two centrifugal fans with their carrier form a ventilation system for NESPI 4 CASE. Considering that fans without applicable carrier are available on the market, carrier must be designed according to requirements, as well as the way of use of the device. The carrier for centrifugal fans is designed in SolidWorks software, while 3D models of all device components were created in order to check for incompatibilities. The final product of the carrier is manufactured using FDM 3D printing technology. During the assembly process, the compatibilities of all components and parts were confirmed. According to the main goal to decrease the temperature inside of the case and by certain procedure, temperature and noise tests of the whole assembly are performed.

2. ANALYSIS OF POSSIBILITIES FOR IMPROVEMENT OF NESPI 4 CASE

NESPI 4 CASE is made of plastic and is especially designed for Raspberry Pi 4 computers. However, the design of the case reminds on a well-known console Nintendo Entertainment System, produced in 1980s. Retro design of the case makes it very popular for the fans of those times and consoles. NESPI 4 CASE has cover of SSD memory drawer, two USB ports, a start and reset button, and an indicator LED. Also, the case has USB-C, LAN, two micro HDMI and audio ports that provide comfort during use with Raspberry Pi 4 computer [5].

In order to provide adequate cooling of internal components, the case has lattice openings on the top of the cover. This place for openings was chosen because the Raspberry Pi 4 computer is placed inside of the case, and according to its component, openings are positioned. The process of improvement of the whole assembly, i.e., NESPI 4 CASE and Raspberry Pi 4 computer, was started because of the necessity to provide heat dissipation in order to achieve at least the optimal temperature inside the computer and prevent damage. The first phase was to design and manufacture an active and passive cooling system for the Raspberry Pi 4 computer [4], while the second phase was to improve the NESPI 4 CASE by importing a ventilation system.

In the second phase, the possibilities of removing parts of the case that are not in use were considered, in order to free up space for mounting the ventilation system. Considering the purpose of the device, it was concluded that the drawer and connector for SSD memory can be removed because microSD memory is used (Fig. 1.). This activity should free up space of 87x81x11 mm, which is connected to the hole under the cover of the upper part of the case.

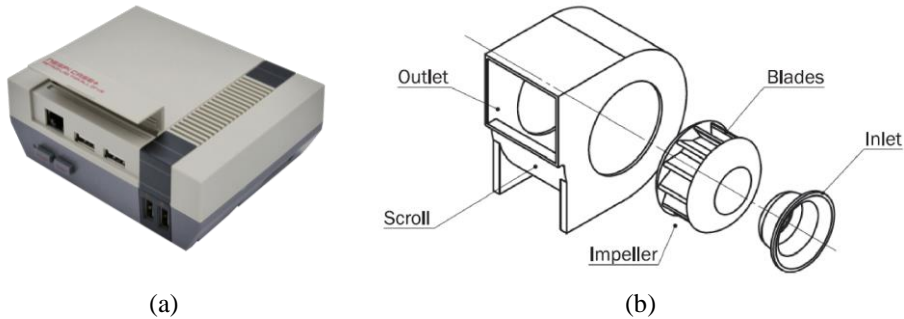


Fig. 1. (a) NESPI 4 CASE [5], (b) Centrifugal fan with scroll enclosure [6]

Furthermore, that provides the possibility of using centrifugal fans as an active component of the ventilation system. Centrifugal fan has a spirally shaped impeller in a housing. The air from the environment enters the impeller in an axial direction and is discharged at the impeller's outer periphery, moving along the centrifugal direction. Centrifugal fans can generate relatively high air pressures and, because of that, are suitable for high-pressure applications compared with axial flow fans [6]. Since the operating DC voltage of the computer and the case is 5V, it is necessary to choose a centrifugal fan whose motor has the same operating voltage in order to eliminate the need for additional components. According to the dimensions of the centrifugal fans available on the market, there are two variants that correspond - one centrifugal fan with dimensions of 80x80x10 mm or two centrifugal fans with dimensions of 40x40x10 mm. In this phase of analysis, two centrifugal fans with dimensions of 40x40x10 mm were chosen (Fig. 2.) due to the lower price on the market and optimal use of space in the case.

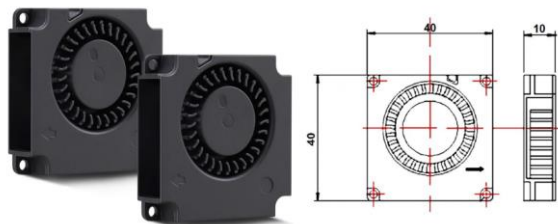


Fig. 2. Two centrifugal fans for ventilation system [7]

However, it is not possible for centrifugal fans to stand inside the upper part of the case. Furthermore, one of the goals was to avoid changing the appearance and function of the case, so the use of screws that would destroy the case was rejected. Therefore, it was necessary to design and manufacture a carrier for two centrifugal fans, while a carrier with fans must be as assembly mounted on the existing case, i.e., the upper part of the case.

2. DESIGN OF CARRIER FOR CENTRIFUGAL FANS

In the framework of the design process of the carrier for centrifugal fans, besides known dimensions of centrifugal fans as well as building measures, it was necessary to check the compatibility of the carrier and all other components of the whole assembly. In order to decrease the total costs of the design, manufacturing and testing process, compatibility analysis was performed in a virtual environment. In accordance with that, 3D models of all components of NESPI 4 CASE were created in the SolidWorks software package based on measurements of physical products (Fig. 3), while the 3D model of the Raspberry Pi 4 computer was downloaded from the CAD model sharing website. A 3D model of the centrifugal fan (Fig. 3.) was created based on measures given by the manufacturer (Fig. 2.)

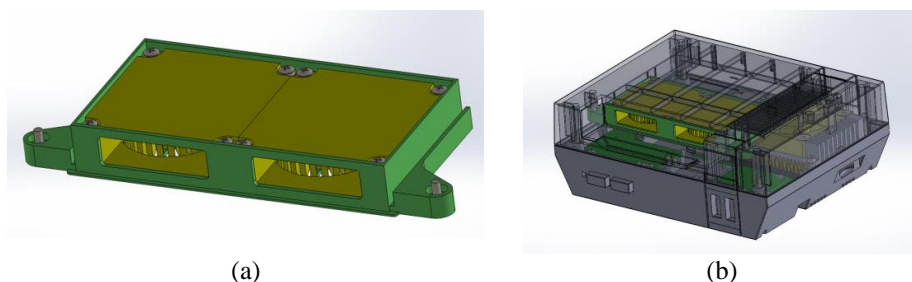


Fig. 3. (a) 3D model of assembly of carrier and centrifugal fans, (b) 3D model of whole assembly [8]

During the design process of the centrifugal fan carrier, its function was considered, as well as the need to be mounted without disturbing the shape of the case. Therefore, it means the carrier must be mounted inside the case and on its upper part. Also, it was not possible to remove additional elements of the case, as well as to drill additional holes in order to mount the carrier. In addition, through analysis of the whole assembly, as well as the dimensions and position of the fans and the contact surfaces between the parts, it was considered which elements of the parts should be separated in order to function safely, at which points should be performed connection of carrier and upper part of the case, as well as functionality, i.e., the possibility of easy assembly and disassembly of the carrier and fans.

Based on that, the carrier was designed in the form of a console in which the fans were mounted and attached to it with screws (Fig. 3.). The holes on the fans already existed, so there was no need to drill additional holes. Since the impeller of centrifugal fans was very close to the cables inside the case, a physical barrier on the carrier was designed so that

the cables would not reach the impeller. The idea was to mount the entire carrier (with fans) in place of the drawer support and connect it to the upper part of the case with screws using existing holes. The connection points will be the same as the connection points of the drawer support and the upper part of the case, so there will be no need to drill additional holes in the case, which fulfils one of the limitations.

The carrier was designed to have two openings on the bottom side, each for one fan with a protective grid. The openings have the same dimensions as the impeller of the fan and are placed in such a way as to obtain the maximum utilization of the airflow. On the front side, there are two openings, each for one fan. These openings do not have a protective grid, considering only the construction of centrifugal fans (Fig. 3.). The places for mounting the centrifugal fans inside the support were designed to match the external shape of the fans in order to make maximum use of the space, but also to position the fans next to each other. According to the construction of centrifugal fans and design of the carrier, it was intended that hot air from the NESPI 4 CASE is sucked in through openings with a protective grid and expelled through openings on the front side of the carrier that does not have a protective grid.

The whole assembly consists of NESPI 4 CASE, Raspberry Pi 4 computer, a previously manufactured cooling system for the computer [4], and the carrier with centrifugal fans, screws, and cables. However, during the design process of the carrier, its position must be predicted in such a way as to ensure the smooth operation of parts of the assembly. It is necessary that the carrier is connected with the upper side of the case only at certain points, and there must be no contact with other parts of the assembly. Also, the connection of the carrier and the fans must be done in such a way that the carrier has certain rigidity and stability so that there are no vibrations during the operation of the fans or destruction of the carrier during assembly or disassembly. During the design process, a gap of 0.32 mm between the support and the cooler was achieved, so free space was used as much as possible while all the parts of the assembly could perform their full function (Fig. 3.). For connections of parts of the whole assembly screws in different standard dimensions were planned: M2x5mm, M2x6mm, M2x20mm, M2.5x12mm, M2.5x16mm, M4x12mm and M2x5mm, and 3D model of screws were taken from the base of standard parts of the SolidWorks software. At the end of the design process, a 3D model of the whole assembly was tested for compatibility, especially through interference detection, and showed satisfactory results.

3. MANUFACTURING OF CARRIER FOR CENTRIFUGAL FANS

The final product of the carrier for centrifugal fans was manufactured using 3D printing technology as one of the most common additive technologies. Based on the creation of a physical model of the product "layer by layer", additive technologies enable relatively fast production of prototypes and final products with almost no limitations in the shape of the product. This allows mounting and testing of parts and assemblies in a relatively short period of time. However, one of the possible limitations of additive technologies is that they are not applicable for serial and mass production of products, as well as depending on the used technology, some parts require additional processing.

The selected technology for manufacturing the carrier for centrifugal fans was FDM technology (Fused Deposition Modeling) because of its simplicity and low cost of

manufacturing. FDM technology is based on the deposition of previously melted material (mostly thermoplastics) on a hot surface [9]. The selected material for manufacturing the carrier is PLA material (polylactic acid). This material is a biodegradable thermoplastic produced from renewable plant resources, and according to its mechanical characteristics and low price, it is suitable for the production of simpler functional products [2, 9]. Although PLA is not thermally stable above a temperature of $\sim 60^{\circ}\text{C}$, considering the operating conditions of the carrier and the constant flow of hot air whose temperature does not exceed that temperature, the PLA material is suitable for the production of the final product [2, 9].

During preparation for manufacturing, the 3D CAD model of the carrier was converted into the STL file format and then imported into the software 3DWOX (Figure 4 (a)). This software was used to set the parameters of 3D printing and generate the G-code. The orientation of the model was optimally selected to achieve a minimum thin region, minimum area of overhanging surface and minimum amount of support. The final product carrier was made on a 3D printer manufactured by Sindoh, type DP200, in the Laboratory of Advanced Technologies in The Academy of Applied Technical and Preschool Studies in Niš, Serbia.

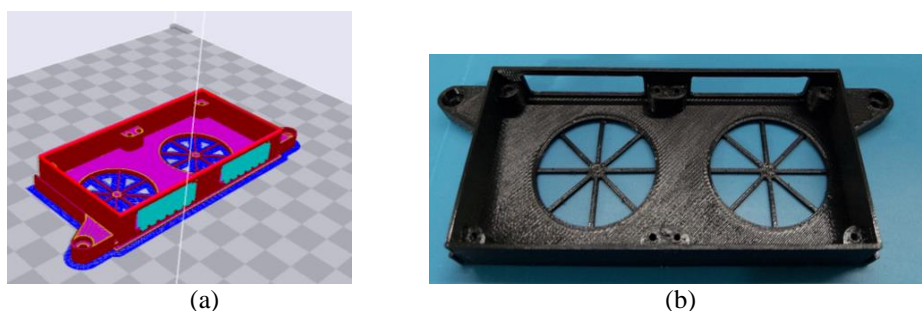


Fig. 4. (a) Setting up parameters for manufacturing [8], (b) 3D printed carrier [8]

The manufacturing time for the carrier was 2 hours and 20 minutes, with a consumption of 15.7 grams of PLA material. Post-processing for the carrier was necessary to remove support structures, clean the final product, and last 10 minutes (Fig. 4. (b)). According to the used material, time for manufacturing and post-processing, and depreciation costs of the machine, the total manufacturing cost is around € 2. However, design, assembly and mounting costs were not included.

3. ASSEMBLING AND FUNCTIONAL TESTING

In the process of assembly, the first step was to check the compatibility of the carrier with fans and carrier with case by visual inspection. Considering that there were no unwanted gaps between the components, fans were mounted into the carrier and connected with screws (Fig. 5 (a)). Then, the assembly was mounted into the upper side of NESPI 4 CASE and also connected with screws (Fig. 5 (b)).

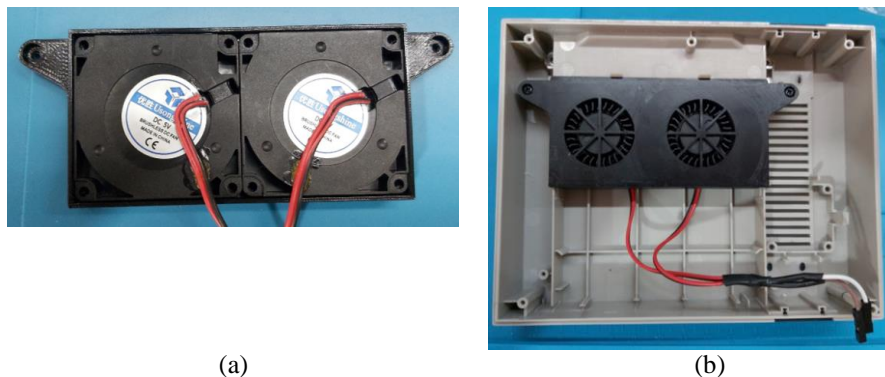


Fig. 5. (a) Checking compatibility of carrier with fans [7], (b) Mounting carrier with centrifugal fans into upper side of NESPI 4 CASE [7]

All components of the assembly were connected, and a compatibility test was started. During three-day functional testing in different operating modes of device, all parts and components of assembly were in designed position and ratio. In addition, there was no contact between the rotating and fixed parts in the whole assembly. Also, considering that the carrier is in the form of a console, functional tests showed that there was no vibration of the carrier due to the operation of the fans.

4. TEMPERATURE AND NOISE TESTING

4.1 Temperature testing

The main goal was to reduce the operating temperature of the Raspberry Pi 4 computers' components, so temperature testing was started by measuring the computers' temperature in various assemblies with previously developed cooling [4] and ventilation systems. However, because the same testing conditions were provided for all assemblies, testing was performed at a constant ambient temperature, and the test procedure for all assemblies was the same. Before starting the test, the ambient temperature was measured to check its value, the computer was started, and the operating temperature without load was measured, which should be between 30°C and 35°C. For all measures, the ambient temperature was 26 °C. Then, the computer started to realize given tasks, with an anticipation that this action would prompt its heating. The first measurement was taken three minutes after task execution commenced, and each subsequent measurement was at three-minute intervals until five consecutive measured results were obtained. Testing was performed using the Raspberry Pi OS operating system and the Command Line Pi program to read and record the current temperature [4]. The testing plan is shown in Table 1, while measurement results are shown in Table 2.

Table 1. Testing plan

<i>Measurement No.</i>	<i>Cooling system</i>		<i>Ventilation system</i>
	<i>Passive cooler</i>	<i>Fan</i>	
1	No	No	No
2	Yes	No	No
3	Yes	Yes	No
4	Yes	No	Yes
5	Yes	Yes	Yes

Table 2. Measurement results for operating temperature

<i>The first test</i>						
<i>Measurement No.</i>	1	2	3	4	5	<i>Average</i>
<i>Measurement result [°C]</i>	67.6	82.3	83.7	83.2	84.2	80.2
<i>The second test</i>						
<i>Measurement No.</i>	1	2	3	4	5	<i>Average</i>
<i>Measurement result [°C]</i>	55.5	61.3	61.8	69.6	72	64.04
<i>The third test</i>						
<i>Measurement No.</i>	1	2	3	4	5	<i>Average</i>
<i>Measurement result [°C]</i>	47.7	49.6	53	54.5	56.4	52.24
<i>The fourth test</i>						
<i>Measurement No.</i>	1	2	3	4	5	<i>Average</i>
<i>Measurement result [°C]</i>	44.8	45.7	47.2	46.2	46.2	46.02
<i>The fifth test</i>						
<i>Measurement No.</i>	1	2	3	4	5	<i>Average</i>
<i>Measurement result [°C]</i>	42.8	37.4	39.9	38.4	42.8	40.26

Test results showed that the operating temperature of the computer has a tendency to increase. However, in the case where only the passive cooler was in assembly, there were

certainly decreases in average temperature, as well as in the case with the passive cooler and fan, which makes a cooling system. Furthermore, in the case with the passive cooler and ventilation system, there was great difference in average temperature compared to the first test. The last test with cooling and ventilation systems showed that the operating temperature of the computer was almost twice smaller than in the first test without any kind of cooling and ventilation. In summary, the test showed that there was a tendency for rising temperatures, which can lead to possible damaging computers' components, and some kind of cooling is necessary. However, tests showed that it is not enough to install a cooling system based on passive and active components because heat accumulates inside the housing and leads to a slow but gradual rise in temperature. Considering all test results, it can be concluded that both systems – cooling and ventilation contribute to the decreasing of operation temperature of Raspberry Pi 4 computer, and those its proper operation.

4.2 Noise testing

It is well-known that any kind of motor can generate some level of noise. Even small motors for ventilators on computers can generate different levels of noise, dependent on computer load, state of ventilators, etc. That can lead to the potential discomfort in using the complete device at home. Because of that, during tests of cooling and ventilation systems, the noise generated by the fans was measured and analyzed.

The noise measurement was performed in a room where there was partial silence (not a deaf room) at distances of 0.1 m and 2 m [4]. Tests were realized based on the plan shown in Table 3, with four measurements in different assemblies of cooling and ventilation systems. Noise measurements were done with an Extech HD 450 sound level meter, and the expected level of noise was in the range of 50 to 60 dB, which represents the level of noise generated by personal computers. It is well known that exposure to noise greater than 70 dB for a long period of time can cause damage to the human body [4].

Table 3. Noise testing results

Measurement No.	Cooling system	Ventilation system	Distance [m] / Noise [dB]	
			0.1	2
1	No	No	30.9	30.9
2	Yes	No	51	36.7
3	No	Yes	57.6	43.9
4	Yes	Yes	57.9	45.4

Test results showed that without colling nor ventilation system, there was noise of 30.9 dB, and that noise was generated by surroundings. With the installed cooling system, generated noise was 51 dB in the close vicinity of the device, i.e., at a distance of 0.1 m, and 36.7 dB at a distance of 2 m. However, with installed cooling and ventilation systems, the generated noise was 57.9 dB and 45.4 dB, respectively. Results showed that the NESPI

4 CASE housing with a Raspberry Pi 4 computer generates noise that is in range as any other device with the same purpose, as well as home devices. Considering that noise at this level is not dangerous for humans, this device with cooling and ventilation systems is safe for long and continuous use.

5. CONCLUSION

This paper presents the application of additive technologies in the development and manufacturing process of a ventilation system for the NESPI 4 CASE. The design of the carrier of the system was done in accordance with the requirements and limitations of the case, as well as the Raspberry Pi 4 computer and previously developed and manufactured cooling system. The carrier was manufactured using FDM 3D printing technology, material PLA. During the assembly process, by visual inspection and functional testing, it was concluded that there was no inconsistency between the carrier and other components. Also, during the operation of the device there was no contact between the carrier and the computer components, which was one of the goals in the design process. Temperature tests showed that the ventilation system and cooling system have a significant contribution in decreasing of operation temperature of Raspberry Pi 4 computer, almost 50% of decreasing of temperature. Furthermore, noise tests showed that this device with a cooling and ventilation system generates noise that is not dangerous for humans, so it is safe for use.

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MEASURING INSTRUMENT AND FAULT DIAGNOSIS SYSTEM

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ABSTRACT:

With the advancement of information and microprocessor technologies, vibration analysis has become one of the more reliable and important methods of technical diagnostics. The paper presents the development of a new device for vibrodiagnostics of machine plants. Experimental results demonstrate that studying and analyzing vibrations of machines using LabVIEW programming is simpler, more effective, and visually comprehensible compared to other text-based languages. Additionally, this vibration testing system not only enables real-time data acquisition of multiple channels but also offers excellent expandability and high speed. Data analysis is conducted on the records collected with high-sensitivity piezoelectric sensors. Furthermore, the paper showcases measurement results obtained with the developed Micro Mon Rotech device in industrial environments.

Keywords: *Data Acquisition System, Vibro-diagnostics, Condition Monitoring, LabVIEW.*

1. INTRODUCTION

Diagnostic and monitoring equipment relies on the use of computers with significant software and hardware resources. During the development phase of new vibrodiagnostic devices, computers and hardware components for data collection enable simulation and analysis of vibrodiagnostic phenomena in laboratory conditions, greatly facilitating the development of new devices.

Technical diagnostics represent activities performed to assess the condition of a system within a specific time period. Available algorithms, rules, and models are used to determine the system's condition for timely prediction of malfunctions. This increases the reliability, availability, and effectiveness of the installations. Predictions and identification of failure causes are carried out during the operation of the installations or during downtime and maintenance periods. It is optimal for the production system to perform checks during operation to avoid production halts, or to constantly monitor through Real-Time control systems [1,8].

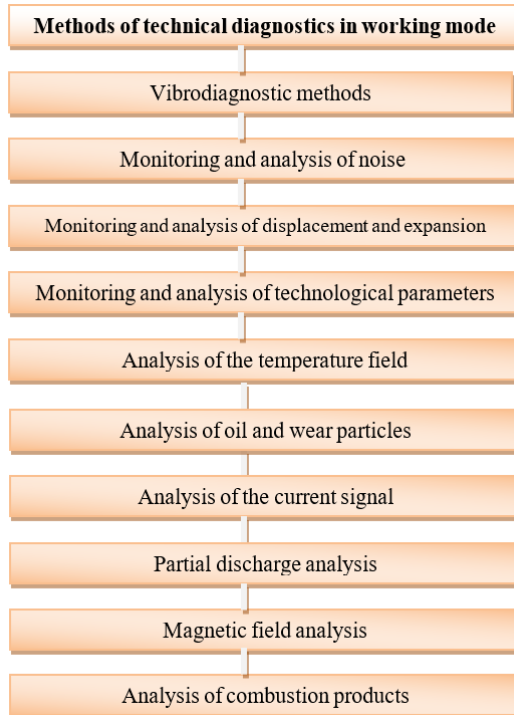


Fig. 1. Methods of technical diagnostics in working mode [1]

To ensure reliability in the operation of increasingly complex technical systems, appropriate diagnostic devices and systems are being developed. The development of instrumentation for testing, measurement, and automation is driven by the increasing use of computers in the concept of virtual instrumentation, which provides significant benefits to engineers requiring increased productivity, accuracy, and performance [5-7].

This paper presents measurement results obtained with the developed instrument for technical diagnostics, which was tested on both laboratory models and industrial plants. The software of this measurement system for data collection and vibration analysis has been developed in the LabVIEW environment. This system provides the capability to record relevant measurements, analyze them, store, and display the results.

2. DEVELOPMENT OF THE MEASUREMENT SYSTEM

The equipment used in the experimental and development phases, as presented in this paper, consists of a vibration system with sensors and a signal amplifier, as well as a data acquisition and processing system. Testing of the data acquisition and processing system, preceding actual measurements, was conducted using a signal generator.

Figures 2 and 3 depict block diagrams of the testing system for the acquisition block with a signal generator and the diagram of the measurement system in the developmental phase with a model of a three-phase AC motor with an overhang disk [1].

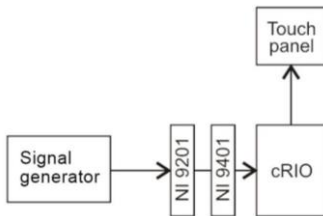


Fig. 2. Block diagram of the test system with a signal generator

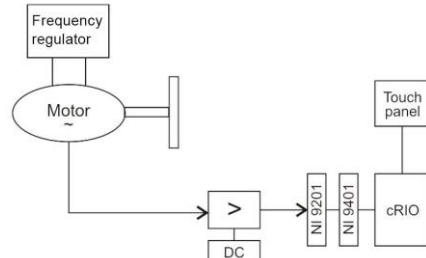


Fig. 3. Block diagram of the measurement system with a three-phase AC motor with an overhang disk

The experimental testing and system verification were conducted on a model of a three-phase AC motor with an overhang disk, as shown in Figures 3 and 4.



Fig. 4. Vibration measurement and simulation system



Fig. 5. Motor with an overhang disk



Fig. 6. NI 9201 acquisition card



Fig. 7. NI 9401 acquisition card



Fig. 8. NI cRIO 9004

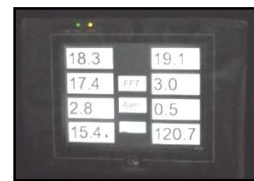


Fig. 9. Touch panel EasyView

The basic components of the experimental equipment, as shown in figures 4-9 [1, 2], are:

1. Three-phase AC motor with an overhang disk and piezoelectric sensor SKF CMCP-1100
2. Signal amplification module for the accelerometer
3. Acquisition cards - NI9201, NI9401
4. Real-Time controller - NI cRIO-9004
5. Touch panel
6. Signal generator

For data acquisition, NI 9201 and NI 9401 acquisition cards were used. The NI 9201, shown in Figure 6, is a 12-bit card with 8 analog inputs, a $\pm 10V$ input measurement range, a total sampling rate of 500 kS/s, 12-bit resolution, D-Sub connectors, and performs analog-to-digital signal conversion. The NI 9401, depicted in Figure 7, is a card with 8 digital TTL/CMOS inputs/outputs.

The Real-Time programmable logic controller NI cRIO-9004, shown in Figure 8, serves for communication with other devices within the system and is used for closed-loop control. The Touch panel EasyView, depicted in Figure 9, which is touch-sensitive in the developed system, is used for monitoring, controlling the PLC device, and displaying measured results [9].

The software component of this device is a vibration monitoring and analysis application developed in the LabVIEW environment, as shown in Figure 10. The main purpose of this application is data acquisition, processing, and presentation. Data processing includes calculation of required physical quantities, analysis in the time and frequency domains, and many other functions. Key elements of the LabVIEW application include an interface to the system driver of the acquisition cards and RIO controller, functions for signal manipulation and processing, and the user interface. The interface to the system driver passes the application unprocessed signals obtained from the acquisition of real physical quantities [2].

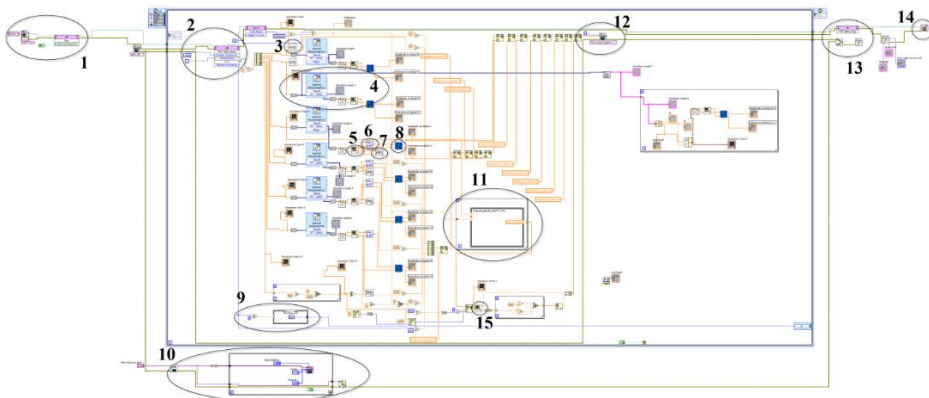


Fig. 10. Block diagram of the program for monitoring and analyzing vibrations [8]

3. VIBRATION MEASUREMENT WITHIN INDUSTRIAL ENVIRONMENT

In accordance with current standards and technical norms, the Micro Mon - Rotech measurement system has been tested on a real system in parallel with measurement and analytical devices from leading global companies. The paper presents parallel results with the Microlog CMVA65 - SKF device. Depending on the characteristics of the measurement sensor, vibration displacement, vibration velocity, or vibration acceleration can be measured during vibration measurements.

Evaluation of equipment was done according to ISO 10816-2:1996 standard “Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts“ - Large land-based steam turbine generator sets in excess of 50 MW, under the “dynamic condition” criteria, Fig. 11.

Velocity mm/s (RMS)	Speed(RPM)	
	1500	3000
11.8	Damage Occurs	
10		
8.5	Restricted operation	
7.5		
5.3	Unrestricted operation	
3.8		
2.8	Newly Commissioned	

Fig. 11. ISO 10816-2 Steam Turbine and Generators

Vibration measurement was performed at turbine plants in Blocks 1 and 2 of the TENT "B" Obrenovac under the following conditions [4]:

Measuring equipment: Micro Mon – Rotech (Fig. 12) and Microlog CMVA65 – SKF (Fig. 13)

Measured quantity: vibration acceleration

Derivate quantity: vibration velocity (RMS*)

Principal measuring axis: horizontal H; vertical V; axial A.

Selected measuring points: L₁-L₉ (Fig. 14)



Fig. 12. Measuring equipment MicroMon Rotech



Fig. 13. Microlog CMVA65 SKF

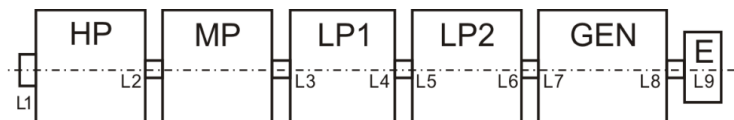


Fig. 14. Measurement point deposition at the turbine plant in Block 1 TENT „B“ Obrenovac (HP-turbine; MP-turbine; LP1,2-turbine; GEN-generator; E-exciter; L1-L9-bearing) [8]

Results of vibro severity measurement on Block 1 are shown in (Table 1,2. and Fig. 15, 16) (Microlog) and results obtained with Micro Mon (Fig. 17, 18). Outcome of the results comparison apparently shows that developed measuring device Micro Mon meets the appropriate standards.

Table 1. Results of vibration velocity measurement on bearings 1-5 in Block 1

AXIS	RMS (mm/s)									
	L ₁		L ₂		L ₃		L ₄		L ₅	
	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i
H	1.8	1.7 (1X)	1.2	0.8 (1X)	4.2	4.1 (1X)	3.0	2.9 (1X)	3.2	3.1 (1X)
						0.8 (2X)		0.6 (2X)		0.9 (2X)
V	0.7		0.8	0.6 (1X)	4.5	4.5 (1X)	3.8	3.7 (1X)	3.5	3.4 (1X)
								0.4 (2X)		
A	1.0	0.8 (1X)	2.7	2.6 (1X)	1.6	1.5 (1X)	1.4	1.0 (1X)	0.5	
								0.8 (2X)		

Table 2. Results of vibration velocity measurement on bearings 6-9 in Block 1

AXIS	RMS (mm/s)									
	L ₆		L ₇		L ₈		L ₉			
	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i	V _{RMS}	V _i /n _i		
H	5.6	5.6 (1X)	2.7	2.0 (1X)	1.0	1.0 (1X)	0.6			
				1.9 (2X)						
V	1.4	1.3 (1X)	3.0	2.1 (1X)	2.3	1.3 (1X)	1.4	0.9 (1X)		
				2.2 (2X)				1.9 (2X)	1.0 (2X)	
A	5.2	5.1 (1X)	2.0	1.8 (1X)	2.7	1.2 (1X)	1.1			
				0.7 (2X)				2.4 (2X)		

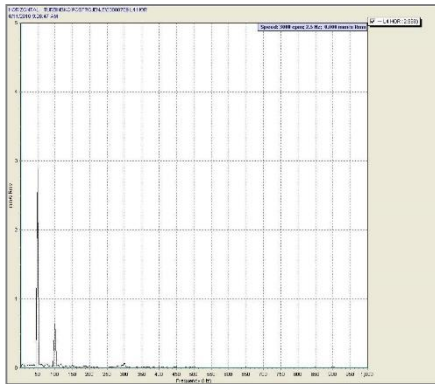


Fig. 15. FFT Spectral analysis (Microlog) (L₄/H)

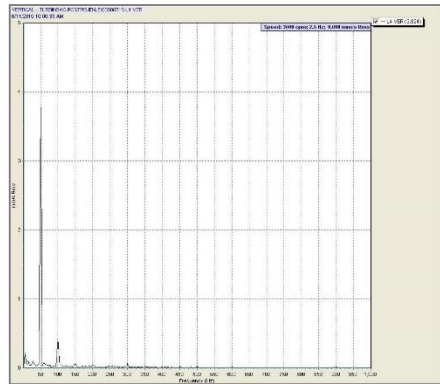


Fig. 16. FFT Spectral analysis (Microlog) (L₄/V)

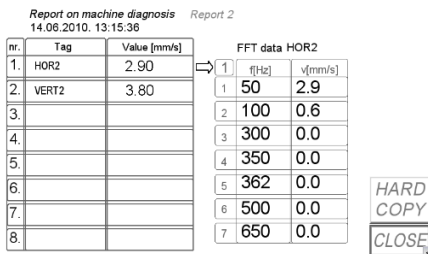


Fig. 17. Vibration at L₄, H axis (Micro Mon Rotech)

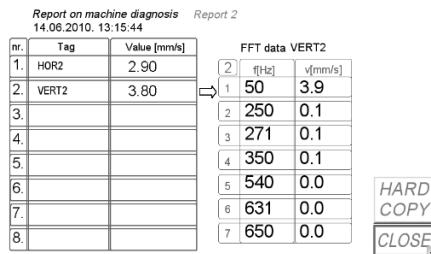


Fig. 18. Vibration at L₄, V axis (Micro Mon Rotech)

From the spectral displays of vibration velocity on bearing no. 4, as shown in figures 15 and 16, and the MicroMon Rotech report, as shown in figures 17 and 18, it can be seen that the vibration level on bearing L₄ is satisfactory and that the RMS values do not exceed the allowable limits according to ISO 10816-2.

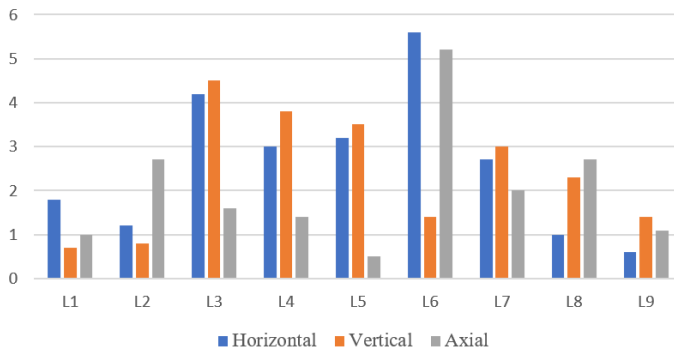


Fig. 19. Vibration at turbine bearings L1-L9 on Block 1 (RMS (mm/s))

Based on the total measurement, the conclusion is that the Block 1 vibration level is within the permissible level. On bearings L1, L2, L4, L5, L7, L8, L9 the level of vibration was within the ISO standard recommendation.

On L3 and L6 higher level of vibration was detected. L6 – on H and A axis. Primary cause: bad alignment of LP turbine axis and GEN turbine. Secondary cause: residual vibrations.

In Block 2, from the measured results, significantly increased vibrations in the axial direction are evident on bearing no. 6 (16.5 mm/s) and bearing no. 3 (12 mm/s), attributed to rotor unbalance of the LP turbine and shaft misalignment in the area of bearings no. 6 and 3. The generator rotor exhibits minor unbalance of low intensity on bearings no. 7 and 8, with accompanying elevated axial vibrations.

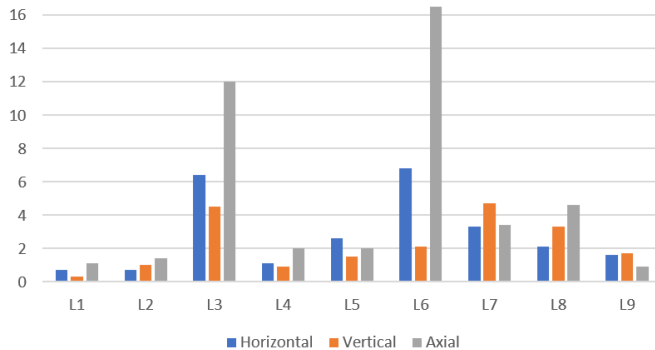


Fig. 20. Vibration at turbine bearings L1-L9 on Block 2 (RMS (mm/s))

By comparing the measured results with the Microlog and Micro Mon devices, it can be observed that the measured results are consistent, with very little deviation, as shown in figures 21 and 22.

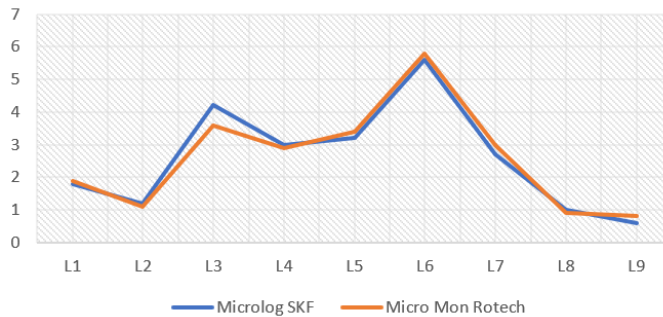


Fig. 21. Comparative display of measured results on Microlog SKF and Micro Mon Rotech devices in the horizontal direction

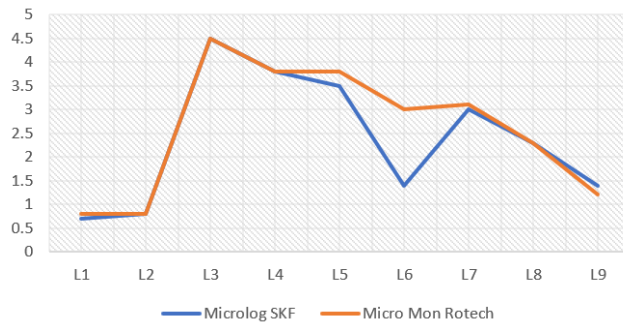


Fig. 22. Comparative display of measured results on Microlog SKF and Micro Mon Rotech devices in the vertical direction

Micro Mon is a portable, multi-channel, modular device for field measurements and monitoring of diagnostic parameters in industrial plants [3].

Application areas:

- vibration measurements and balancing;
- stress/strain measurements;
- deflection, inclination or displacement measurements;
- temperature, load, fluid pressure measurements;

Range of application:

- site condition monitoring;
- spectrum analysis;
- start up, coast down measurements;
- trend records;
- on site balancing;
- steel structure measurements;
- proactive machinery protection;
- on line fault detection.

Micro Mon is currently installed at the TENT A Obrenovac plant in operation for flue gas desulfurization and performs continuous monitoring of key parameters. The following images show the reports displayed by this system (Figures 23, 24), demonstrating that all monitored parameters at this plant are within normal range and compliant with the standard.

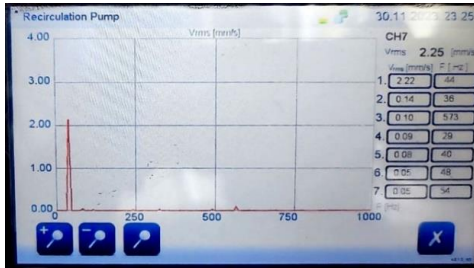


Fig. 23. Vibration spectrum measured using Micro Mon Rotech on the recirculation pump at TENT A

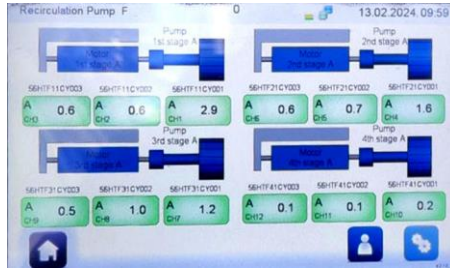


Fig. 24. Micro Mon report, displaying vibrations on the 4 recirculation pumps at TENT A, flue gas desulfurization plant

4. CONCLUSION

This paper presents research results on the improvement and development of vibration diagnostic devices. The results demonstrate that LabVIEW is a highly suitable environment for modern computer instrumentation and vibration diagnostic systems.

In the experimental part of the study, vibration measurements on a physical model "Motor with an overhang disk" were conducted at different frequencies as one of the testing phases of the diagnostic device itself.

The developed Micro Mon Rotech measurement instrument was verified under real conditions at a turbine plant, and the results showed that the device is as efficient as other devices from well-known companies. It was discovered that the majority of bearings at the tested plant were in satisfactory condition.

Finally, the paper presents results from Micro Mon, which is currently installed at the TENT A Obrenovac plant as a Real-Time system, continuously monitoring critical system parameters, thus providing workers with constant insight into the plant's condition.

In conclusion, continuous work on modification and improvement of the diagnostic devices is necessary for their development, especially for those installed as Real-Time control systems, as each plant is different and has its specific needs.

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TOPOLOGICAL AND GEOMETRIC DESCRIPTORS USED FOR CLASSIFYING DIGITAL OBJECTS

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ABSTRACT:

The description and classification of object shapes is a classical problem stemming from various problems in industry, medicine and applied sciences. We combine approaches from digital image processing, topology and machine learning to address such problems. After initially preprocessing the images (to decrease the contrast and the illumination differences), we binarize the images using increasing threshold values. We form the corresponding filtration and compute its persistent diagram, from which we derive several topological object descriptors, which we use for classifying digital objects. We also calculate some geometric classifiers, related to area, perimeter and elongation. For each value, topological and geometric, we discuss its applicability, and compare new and existing classifiers.

Keywords: *classification, shape analysis, image processing*

1. INTRODUCTION

Real-world data, coming from various areas of industry, medicine and applied sciences, can be correlated or exhibit an underlying dependence which is not immediately perceptible. In multidimensional problems, a classical approach is to assume that the data is generated from an unknown underlying low-dimensional manifold, and to apply algorithms of manifold learning and dimension reduction in order to isolate the features that are essential, and either discard or aggregate the non-essential ones (see [1] for an overview of these algorithms). However, dimension reduction introduces difficulties with the discovery and particularly the preservation of higher-dimensional topological structures in the manifold (such as tunnels and voids, see [2]), which may play a crucial role in differentiating between either two or more classes in a number of classification problems.

To address these issues, algorithms of persistent homology (PH) were developed, with the explicit intention of calculating and observing changes in topological invariants, such as

Betti numbers. These algorithms usually start with a nested family of simplicial complexes (a filtration) which are generated from the point cloud data in question. These are used to track the appearance, disappearance and persistence (length of existence) of topological invariants, with respect to a parameter. The features whose topological invariants are the most persistent are considered to be the most important, and the ones with the least persistent invariants are considered topological noise, and can be removed in order to perform a topological simplification (see [3]), consequently leading to a reduction in required memory resources.

This topological approach also enabled a number of interesting conclusions related to human motion [4], variations in human face shape due to weight gain [5], emotion recognition [6], geometric alignment for protein docking [7], the topology of the cosmic web [8], and the local behavior of natural images [2, 9] to name just a few.

Similarly, many classical problems of digital image processing are of a topological nature, and problems such as digital segmentation (which are usually approached with non-topological methods) have been addressed and are constantly being improved upon (see, for instance, [10, 11]). Such approaches are proving to be quite important, especially bearing in mind the number of image modalities and standards that are being used in various applications.

In this paper we combine methods and best practices from digital image processing, topology and machine learning in order to derive conclusions related to the problem of classification of digital objects in a general framework. The objective is not to perform a comparison with state-of-the-art classifiers already used in literature, but rather to investigate the influence of both geometric and topological classifiers, especially in a more general setting, discuss their applicability, compare them, with regards to a larger class of image analysis problems.

The paper is organized in four sections. In Section 2, we give an overview and a brief reminder of the concepts that were used for the problems of classification. In Section 3, we discuss the used methodology and give an experimental validation of the results, and in Section 4, we summarize our conclusions.

2. PRELIMINARIES

We give here a short, less formal description of some key concepts and algorithms which can be used in order to perform the required classification. We rely on a number of methods from digital image processing, topology and machine learning, but will, for simplicity, largely use classical methods from these areas. The interested reader is directed towards [12, 13] for an overview of algorithms related to image processing and image analysis, [14] for the basics of algebraic topology, [15,16] for classical algorithms used in machine learning, and to [17,18] for an introduction to persistent homology.

We begin with an overview of the geometric classifiers used in this paper.

Definition 1. A binary digital object is a finite set O of (black or foreground) pixels inside a rectangular subset of the square grid. Two pixels p and q are (8-)neighbors if they have a non-empty intersection, and are (8-)connected if there is a sequence of neighboring pixels in O connecting p and q .

Definition 2. [19] Let O be a digital object. The area A is defined as the number of pixels in O , and the centroid (x_c, y_c) of O as:

$$(x_c, y_c) = \left(\frac{1}{A} \sum_{(x,y) \in O} x, \frac{1}{A} \sum_{(x,y) \in O} y \right), \quad (1)$$

where (x, y) represents the coordinates of a given pixel.

Definition 3. A boundary edge is incident to both a pixel in O , and in O^C . The (black) pixel incident to a boundary edge is called a boundary pixel. The perimeter (or perimeter length) of an object O is the number of its boundary pixels.

In this paper we also mention elongation (or circularity), defined as follows.

Definition 4. [19] Let O be the set of pixels (x, y) in O , and (x_c, y_c) the centroid of O . The elongation measure e is given as the ratio μ_o/σ_o , where μ_o is the mean of the distances from the centroid of O to its boundary pixels, and σ_o their standard deviation.

We now turn our attention to the topological classifiers, which are (in this paper) notions taken from persistent homology. Informally, PH aids in evaluating homological features (of an object) given by the number of n -dimensional holes, which are called the n -th Betti numbers β_n . For example, with 2D digital images (see below), we typically think of β_0 as the number of (8-)connected components, and β_1 as the number of holes.

However, in order to track the evolution (appearance and disappearance) of homological features via Betti numbers, we first need to define an abstract simplicial complex and filtration for a given finite non-empty set S :

Definition 5. [18] An abstract simplicial complex is a non-empty subset K of the power set of S , such that if $\alpha \in K$ and $\beta \subseteq \alpha$, then we also have $\beta \in K$. The sets (of cardinality $k+1$) in K are called its (k) -simplices.

Definition 6. [18] Let K be a simplicial complex, and f a map from each simplex in K to a real number, which is monotonic in the sense that it takes larger values on a simplex than on its subsimplices. Then there are only finitely many distinct subcomplexes K_i , defined as the sublevel sets $K_i = f^{-1}(-\infty, i]$ for $i = 0, 1, 2, \dots, n$, and the finite increasing sequence of simplicial complexes:

$$\emptyset = K_0 \subset K_1 \subset K_2 \subset \dots \subset K_n = K, \quad (2)$$

is called a filtration.

By construction, there exist induced homomorphisms from the homology groups of a simplicial complex K_i to K_j if $i \leq j$, and their ranks are exactly the Betti numbers mentioned above. The collection of Betti numbers is often visualized as a pair of birth-death coordinates (a_i, a_j) , where the notation implies that the observed p -dimensional homological class (feature) was 'born' at K_i and 'died' entering K_j . The set of all such points (with multiplicity) for a given dimension p is called the p -th persistence diagram of the filtration, denoted as $Dgm_p(f)$. Figure 1 (left) shows an example of a persistence diagram. The persistence barcode (shown right on Figure 1) shows the same information, albeit in a perhaps more streamlined manner. Both figures correspond to the same image from the database, and were made with the GUDHI library.

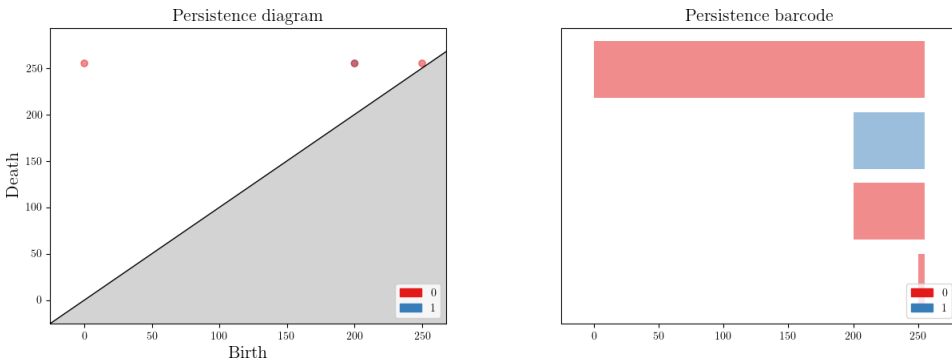


Fig. 1. Left: The 0-dimensional and 1-dimensional persistence diagram (shown overlaid). Right: their corresponding persistence barcode. In both pictures, the color red corresponds to the case $p = 0$ and blue to the case $p = 1$.

As the death coordinates of a point are larger than its birth coordinates, all points lie above the diagonal, and their vertical distance from the diagonal is called its persistence. In the following, we use $pers(P) = pers(a_i, a_j)$ to denote the persistence of the hole or component represented by a point P on the diagram.

Definition 7. [10] Let $Dgm_p(f)$ be the p -th persistence diagram of a filtration. The q -th norm of the p -th persistence diagram is given by:

$$N_q = \left(\sum_{P \in Dgm_p(f)} pers(P)^q \right)^{\frac{1}{q}}, \quad (3)$$

and, the first and second moments of the p -th persistence diagram, m_1 and m_2 , as the mean and variance, respectively, of the sum of birth and death coordinates $a_i + a_j$ of all points in the diagram.

In our classification problems, we used the zeroth, first and second norm, as well as the first and second moments of the first persistence diagram.

3. METHODOLOGY AND RESULTS

Here we outline in short the basic methodology used in order to help with the classification of digital objects, illustrate our results, and compare approaches. Our approach was implemented in Python 3.10.6 (using the NumPy 1.23.4, GUDHI 3.7.0 and scikit-learn 1.2.0 libraries), and executed on a PC with an Intel i7-11390H CPU at 5GHz with 8GB of RAM, running Linux.

Our data consisted of the Columbia Object Image Library (COIL-100) database [20] which contains color images of 100 objects (in PNG format, of size 128×128). Due to the fact that 72 images were made of each object, we selected a subset of images to use in order to avoid overfitting. Firstly, 17 among the first 20 objects were selected at random, and then for each such object 18 images (corresponding to angular poses divisible by 20) were chosen to be training images, and 2 (corresponding to angular poses not divisible by 20) were randomly selected as testing images. Thus in total, we used 306 images for training and 34 for testing.

Each image was converted to grayscale, and we used the convention of setting each pixel value to be in the range [0, 255], where 0 implies a black pixel, an 255 a white one. Each image in the database was preprocessed beforehand, so as to better emphasize regions that are meaningful and easy to recognize using human perception. We used the classical algorithm for removing specular reflection (setting the maximal saturation value to be 51, and the minimal brightness value per pixel to be 230), altered the contrast (to 75%), and applied the median filter two times (the window size was chosen to be 3×3). These values were reached after extensive empirical experimentation with the dataset, and have, for our application, been able to emphasize the most notable features of the images. The median filter did influence the sharpness of the image, but we found that the classification accuracy did not significantly change when using only topological descriptors. The same preprocessing was then applied to the original image inverted.

After such preprocessing was done, we binarized each image and its corresponding inverted image, using values 0, 10, 25, 50, 75, 100, 125, 150, 175, 200, 225, and 250 as threshold values. This gave two sets of images with more and more black pixels, and we applied the standard approach, described in [21], to form two filtered simplicial complexes using these threshold values as filtration values, see Figure 2.

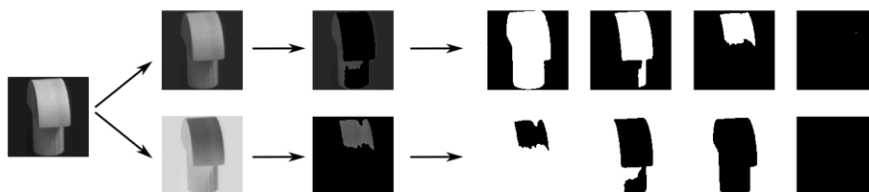


Fig. 2. The original image and its inverted image are preprocessed, and then binarized using the threshold values as filtration values for the two simplicial complexes.

This enabled us to calculate persistences and the persistence diagrams, and we calculated both for the original preprocessed image and its inverse:

- the first and second moment of the first persistence diagram, then its zeroth, first and second norm, as well as the filtration (threshold) values for which the maximal first Betti number is first attained; these represent the topological classifiers used in order to form a feature vector in our topological pipeline (denoted here with T),
- areas, perimeters and elongations of each binarized image; these represent the geometric classifiers used in order to form a feature vector in our geometric pipeline (denoted here with G).

If both sets of classifiers were used, we denoted that in this paper as T+G.

After finally normalizing the feature vector (using *StandardScaler* from *scikit-learn*), we performed two experiments: in the first one, only the topological and geometric classifiers of the original, non-inverted (but preprocessed) images were used. In the second, we used the corresponding values of both the (preprocessed) original and (preprocessed) inverted images.

In each experiment, we used four machine learning algorithms to perform the final classification: one based on a random forest classifier and three *k*-nearest neighbors algorithm classifiers (for $k = 1$), which take as input either the whole set of feature vectors (of size 59, if considering the T+G pipeline for the second experiment), or its PCA projection into a two- and five-dimensional space. This is a classical approach meant to alleviate issues that may arise as a consequence of the fact that with the increase in dimensionality, the amount of required data often increases significantly.

In the following tables, RF stands for the random forest classifier, *k*-NN for the classical *k*-nearest neighbors algorithm classifier (for $k = 1$), and PCA2 for and PCA5 for the same *k*-nearest neighbors algorithm, but which was initialized based on a (two-component and five-component, respectively) PCA projection of the initial data.

Table 1. The accuracy and Rand index values of our classifications, performed only on the noninverted images. T indicates that the feature vector consisted of values of topological classifiers, G of geometric ones, and T+G of both. Maximal values are shown in bold.

		RF	k-NN	PCA2	PCA5
T	Accuracy	0.323	0.529	0.147	0.176
	Rand index	0.861	0.951	0.916	0.898
G	Accuracy	0.882	0.971	0.176	0.235

	Rand index	0.979	0.995	0.918	0.930
T+G	Accuracy	0.882	0.912	0.059	0.147
	Rand index	0.979	0.982	0.889	0.920

Table 2. The accuracy and Rand index values of our classifications, performed on both the original and inverted images. T, G, and T+G have the same meaning as before. Maximal values are shown in bold.

		RF	k-NN	PCA2	PCA5
T	Accuracy	0.323	0.441	0.147	0.059
	Rand index	0.904	0.943	0.881	0.916
G	Accuracy	0.882	1.0	0.265	0.353
	Rand index	0.980	1.0	0.914	0.930
T+G	Accuracy	0.882	0.912	0.382	0.441
	Rand index	0.980	0.982	0.927	0.948

We note that the highest recognition rate was achieved when using geometric classifiers of both the original and inverted image.

4. CONCLUSION

In this paper, we have addressed a problem in digital object recognition by working with both topological (such as moments and norms of p -th diagrams) and geometric classifiers (such as area and elongation). We showed that, on the tested images of real-life objects, using geometric classifiers shows most promise, regardless of whether they are calculated for the original image only, or together with the inverted one.

For this dataset, the inclusion of additional topological classifiers does not in general lead to an increase in classification accuracy. This is likely due to the fact that the digital objects considered had highly clustered values for geometric values of area, perimeter and elongation, which is reasonable to assume as they are images of the same object taken under different angular poses.

Additionally, most of the images, when binarized, usually had one or two connected components and one hole, if any, which led to difficulties in distinguishing the objects based on topological properties. We also see that in the accuracy percentage when using only topological classifiers: it is about half as successful as when using the geometric ones (when not using PCA).

It is also interesting to note that the introduction of PCA did not, in our setup, lead to an increase in accuracy, and that using this method of projecting initial data into a smaller-dimensional space did not aid classification.

Further research could be oriented towards utilizing alternative methods of mathematical morphology for preprocessing, or varying the geometric and topological classifiers used, which might introduce classifiers related to the zeroth persistence diagram.

Also, alternative metrics (other than the Euclidean/Minkowski) could be used for the k -nearest neighbors algorithm classifier, and the influence of the value of k (neighbors) on classification could be examined. Alternatively, it may be of some use to consider adding weights to points in each neighborhood, and finding a natural and efficient assignment of weights.

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CHOQUET-TYPE PSEUDO-INTEGRALS FOR FACE RECOGNITION

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ABSTRACT:

Pseudo-integrals are integrals based on fuzzy measures. Choquet and Sugeno integrals are among the most famous. The Choquet integral and its generalizations based on the Sugeno measure are especially interesting for applications. In the paper, one such integral is defined, but based on the so-called c -credibility measure. The construction of that measure on the final set based on singletons is given. Face recognition plays an important role, for example, in border control and verification of personal documents (passports, identity cards, driver's licenses, etc.), and can be solved, for example, by using different local descriptors. Each part of the face shown in the digital image can be compared with the corresponding part of another image, and from all these comparisons a conclusion should be drawn about the coincidence-overlapping of the two faces. Aggregation functions play an important role, especially Choquet-type integrals, which is also presented in this paper.

Keywords: *aggregation function, face recognition, fuzzy measure, pseudo-integral*

1. INTRODUCTION

A large number of common situations in modern society inspire new applications of many concepts coming from mathematics and informatics. One such application is shape recognition, especially face recognition (in problems such as flow control at border crossings, control of traffic participants, in various mobile applications, devices, etc.)

Classical methods, which are used in face recognition, include, e.g., principal component analysis [2,17], descriptors [1,5,17,18], and others. More recently, contemporary methods include promising approaches based on artificial intelligence.

One of the new approaches to this problem, which is presented in this paper, is based on the use of aggregation functions, integrals based on non-additive measures, i.e., the so-called pseudo-integrals.

Success was assessed using appropriate descriptors for the recognition of each part of the face (parts considered: eyebrows, eyes, left and right cheek, nose and mouth), separately.

This paper is organized into five sections. In Section 2, an overview of some functions, whose arguments and values are from interval $[0, 1]$, is given. Fuzzy measures and integrals based on them, as well as some illustrative examples used in applications, are presented in Section 3. In the Section 4, the application of pseudo-integrals in face image classification is demonstrated. Section 5 summarizes our conclusions.

2. OPERATIONS ON $[0,1]$

Information aggregation occupies an important place in various fields of research, where the aggregation of data or values is required. Thus, it can be stated that aggregation uses different pieces of information, usually from different sources, in order to reach a conclusion or decision. We will review the definitions (see [7]) of some basic operations whose arguments are from the interval $[0,1]$.

Definition 1. An aggregation function is defined as a function $\kappa: [0, 1]^n \rightarrow [0, 1]$, $n \in \mathbb{N}$ such that:

h1) $\kappa(0, \dots, 0) = 0$ and $\kappa(1, \dots, 1) = 1$,

h2) $\kappa(t_1, \dots, t_n) \leq \kappa(s_1, \dots, s_n)$ such that $t_i \leq s_i$, $i = 1, \dots, n$

h3) $\kappa(t) = t$ for all $t \in [0, 1]$.

One special class of aggregation operations are t-norms.

Definition 2. The function $T: [0, 1] \rightarrow [0, 1]$ such that:

t1) $T(t, s) = T(s, t)$, t2) $T(T(t, s), r) = T(t, T(s, r))$,

t3) $t_1 \leq t_2 \Rightarrow T(t_1, s) \leq T(t_2, s)$, t4) $T(t, 1) = t$,

is called a triangular norm (shortly t-norm).

Example 1. The minimum and product are the best known examples t-norm. Many other examples can be found in [7] such as Hamacher's t-norm $T_H(t, s) = \frac{ts}{t + s - ts}$, or

Schweizer-Sklar's t-norm $T_{SS}(t, s) = (\max(t^{-\alpha} + s^{-\alpha} - 1, 0))^{-1/\alpha}$, $\alpha \neq 0$.

Definition 3. The function $c: [0, 1] \rightarrow [0, 1]$ is a fuzzy complement if the following conditions are satisfied:

c1) $c(0)=1, c(1)=0$, c2) $(\forall t, s \in [0, 1]) t \leq s \Rightarrow c(t) \geq c(s)$.

If $c(c(t)) = t$ holds for every $t \in [0, 1]$, then the complement c is involutive. If c is a continuous function, then we say that c is a continuous fuzzy complement. The equilibrium of fuzzy complement c is an element $\varepsilon \in (0, 1)$ for which $c(\varepsilon) = \varepsilon$.

Example 2. The standard, Sugeno, and Yager fuzzy complements are examples of continuous involutive fuzzy complements:

1) $c(t) = 1 - t$, $\varepsilon = \frac{1}{2}$;

$$2) c_\lambda(t) = \frac{1-t}{1+\lambda t}, \quad \lambda > -1, \quad \varepsilon = \frac{\sqrt{1+\lambda}-1}{\lambda}, \quad (\lambda \neq 0), \quad \varepsilon = \frac{1}{2}, \quad (\lambda = 0);$$

$$3) c_\lambda(t) = (1-t^\lambda)^{1/\lambda}, \quad \lambda > 0, \quad \varepsilon = \left(\frac{1}{2}\right)^{1/\lambda}.$$

3. FUZZY MEASURES AND INTEGRALS

In this Section, we conceptually discuss fuzzy measures, give an overview, and list some examples, such as the Sugeno's λ -fuzzy measures and credibility fuzzy measures.

Also, examples are given of the construction of those measures on a set of objects, that are relevant to the Section on applications of aggregation operators in face recognition.

3.1. Fuzzy measures

Definition 4. A fuzzy measure on X is a set function measure $m: E \rightarrow [0, 1]$, where $E \subseteq P(X)$, $\emptyset, X \in E$, such that: $m(\emptyset) = 0$; $(\forall A, B \in E) A \subset B \Rightarrow m(A) \leq m(B)$.

One of the earliest examples of fuzzy measure is Sugeno's λ -fuzzy measure.

Definition 5. The set function $g: P(X) \rightarrow [0, 1]$, is called λ -fuzzy measure, $\lambda > -1$ if $g(\emptyset) = 0$, $g(X) = 1$, and the following is valid:

$$(\forall A, B \subset X) g(A \cup B) = g(A) + g(B) + \lambda g(A)g(B).$$

If $X = \{x_1, \dots, x_n\}$ and $\lambda \neq 0$, then λ can be determined from the following [15]:

$$1 + \lambda = \prod_{k=1}^n (1 + \lambda g_k),$$

where the values $g_k = g(x_k)$ are fixed. By denoting $A_k = \{x_1, \dots, x_k\}$ the above implies:

$$g(A_{k+1}) = g(A_k) + g_{k+1} + \lambda g(A_k)g_{k+1},$$

where $g(A_1) = g_1$.

From papers [12] and [14], as an example of a fuzzy measure that we use in the construction of pseudo-integrals (and further application in face recognition), we give the definition of the c -credibility measure and its construction on a concrete example.

Definition 6. Let $c: [0, 1] \rightarrow [0, 1]$ be the involutive fuzzy complement, whose equilibrium is ε . The c -credibility measure on X is a set function $cr: P(X) \rightarrow [0, 1]$ such that:

$$cr1) cr(\emptyset) = 0,$$

$$cr2) (\forall A, B \in P(X)) A \subset B \Rightarrow cr(A) \leq cr(B),$$

$$\text{cr3) } (\forall A \in P(X)) \text{ cr}(\bar{A}) = c(\text{cr}(A)),$$

$$\text{cr4) } \text{cr}\left(\bigcup_{j \in J} A_j\right) = \sup_{j \in J} \text{cr}(A_j),$$

for arbitrary sets $A_j \in P(X)$, $j \in J$, for which $\sup_{j \in J} \text{cr}(A_j) < \varepsilon$, where J is an arbitrary

index set. The ordered triple $(X, P(X), \text{cr})$ is said to be a c -credibility space. Credibility is a regular fuzzy measure, i.e. $\text{cr}(X) = 1$, and the extension theorem is very important for this measure.

If $X \neq \emptyset$ and $\text{cr} : P(X) \rightarrow [0, 1]$ is a c -credibility measure, then the so-called extension conditions are valid:

$$(1) \sup_{\omega \in X} \text{cr}(\{\omega\}) \geq \varepsilon \quad (2) \text{cr}(\{\omega^*\}) \geq \varepsilon \Rightarrow \sup_{\omega \neq \omega^*} \text{cr}(\{\omega\}) = c\left(\text{cr}(\{\omega^*\})\right).$$

Example 3. We will construct a measure of credibility $\text{cr} : P(X) \rightarrow [0, 1]$, on the set

$X = \{x_1, x_2, \dots, x_7\}$, whose elements are parts of the face (see Section 4). Of course, it stands that $\text{cr}(\emptyset) = 0$, $\text{cr}(X) = 1$, and that the monotonicity must be satisfied, i.e. a larger set will be given more credibility. In order to apply the credibility extension theorem, it would be necessary to specify singleton credibility measures. For ease of presentation, the elements x_i , $i = 1, \dots, 7$ of the set X we will mark with ω_j , $j = 1, \dots, 7$ it with so that this is true, i.e. that $\text{cr}(\{\omega_1\}) \leq \text{cr}(\{\omega_2\}) \leq \dots \leq \text{cr}(\{\omega_7\})$. That is, we will assume that we have: $\text{cr}(\{\omega_1\}) = g_3 = 0.131$, $\text{cr}(\{\omega_2\}) = g_2 = 0.133$, $\text{cr}(\{\omega_3\}) = g_5 = 0.139$, $\text{cr}(\{\omega_4\}) = g_7 = 0.139$, $\text{cr}(\{\omega_5\}) = g_4 = 0.141$, $\text{cr}(\{\omega_6\}) = g_6 = 0.155$, $\text{cr}(\{\omega_7\}) = g_1 = 0.348$.

Only one singleton (in our case $\{\omega_7\}$) can have credibility greater than or equal to some $\varepsilon < 1$, while the others ($\{\omega_1\}, \dots, \{\omega_6\}$) must have a credibility less than ε . The set

$A = \{\omega_{i_1}, \omega_{i_2}, \dots, \omega_{i_r}\} \subset \{\omega_1, \omega_2, \dots, \omega_6\}$, $i_1 < i_2 < \dots < i_r$, has the same credibility as the singleton with the highest credibility, i.e. $\text{cr}(A) = \text{cr}(\{\omega_{i_r}\})$. E.g.

$\text{cr}(\{\omega_1, \omega_2\}) = \max(\text{cr}(\{\omega_1\}), \text{cr}(\{\omega_2\})) = 0.133$. If $\omega_7 \in A$, then, among the elements from \bar{A} , we choose the one whose singleton has the highest credibility and the complement of that credibility is the credibility of A . Also, the second condition of the extension theorem must be satisfied, which means that the largest of all the credibility values of the singletons $\{\omega_1\}, \dots, \{\omega_6\}$ must be equal to the complement of the credibility of $\{\omega_7\}$. If Sugeno's fuzzy complement is taken, then we have:

$$0.155 = \text{cr}(\{\omega_6\}) = c_\lambda(\text{cr}(\{\omega_7\})) = \frac{1 - 0.348}{1 + 0.348\lambda}, \text{ that is, } \lambda = 9.214.$$

Thus, we take the Sugeno's complement $c_\lambda(t) = \frac{1-t}{1+9.214t}$, whose equilibrium is

$$\varepsilon = \frac{\sqrt{1+9.214} - 1}{9.214} = 0.238 < cr(\{\omega_7\}).$$

With this Sugeno's fuzzy complement selected, its equilibrium is smaller than the highest credibility.

If $\omega_7 \in A = \{\omega_{i_1}, \omega_{i_2}, \dots, \omega_{i_r}\}$, $i_1 < i_2 < \dots < i_r$, then $cr(A) = c\left(\sup_{\omega \in A} cr(\{\omega\})\right)$.

For

example:

$$cr(\{\omega_1, \omega_2, \omega_3, \omega_7\}) = c(\max(cr(\{\omega_4\}), cr(\{\omega_5\}), cr(\{\omega_6\}))) = \frac{1-0.155}{1+9.214 \cdot 0.155} = 0.348.$$

The c-credibility measure is appropriate here, as we chose the fuzzy complement and its equilibrium ourselves.

3.2. Pseudo-integrals

We list here some of the most famous integrals which are based on fuzzy measures, such as Sugeno [15], Choquet [3] and the generalized Choquet integrals [9].

Definition 7. Let Σ be a σ -algebra of subset of X and m be a positive monotone set function on Σ . Let f be a non-negative extended real-valued measurable function on (X, Σ, m) and $A \in \Sigma$, the Sugeno fuzzy integral of f on A with respect to m is defined by

$$(S) \int_A f \, dm = \inf_{\alpha \in [0, \infty]} \sup(\alpha \wedge m(A \cap F_\alpha)),$$

where $F_\alpha = \{x \mid f(x) \geq \alpha\}$ is called the α -cut, $\alpha \in [0, \infty]$, and \wedge the minimum, infimum in the field of real numbers or the meet operations in lattices.

Definition 8. The Choquet integral of $f: X \rightarrow [0, 1]$, based on a given λ -fuzzy measure g , is defined as:

$$CH \int f \circ g = \sum_{k=1}^n [f(x_k) - f(x_{k+1})] g(A_k),$$

where $X = \{x_1, \dots, x_n\}$ and $f(x_{n+1}) = 0$. The values $f(x_k)$ are ordered in a non-increasing order (i.e. $f(x_k) \geq f(x_{k+1})$, for $k = 1, \dots, n$).

Definition 9. The generalized Choquet integral was defined in [9] as:

$$GCH \int f \circ g(M) = \sum_{k=1}^n M(f(x_k) - f(x_{k+1}), g(A_k)),$$

where, as before, $X = \{x_1, \dots, x_n\}$ and $f(x_{n+1}) = 0$, and M is a $(1,0)$ -increasing function $M : [0,1]^2 \rightarrow [0,1]$, which satisfies $M(x, y) \leq x, M(x, 1) = 1, M(0, y) = 0$. It is customary to take the t-norm as the function M .

Definition 10. The generalized Choquet integral based on c-credibility measure is defined as:

$$\int f \circ cr = \sum_{k=1}^n M(f(x_k) - f(x_{k+1}), cr(A_k)),$$

where, as before, $X = \{x_1, \dots, x_n\}$ and $f(x_{n+1}) = 0$, and M is a $(1,0)$ -increasing function $M : [0,1]^2 \rightarrow [0,1]$, which satisfies $M(x, y) \leq x, M(x, 1) = 1, M(0, y) = 0$.

4. FACE RECOGNITION

In this Section, the previous research published in [12] is extended with certain changes being made in the parameters that were used.

The results of performing facial image classification of $n=15$ persons are illustrated. For each person we have $m=11$ images, which individually differ by different lighting conditions and angles, expressed feelings, facial expressions, etc.

Out of several classifiers which could be considered (such as the global (entire) image, eyes, eyebrows, mouth, nose, left and right cheek, forehead and chin), we considered seven in total.

The database used, consisting of $N=165$ grayscale images, is partitioned in 150 images for the training set and 15 for the testing set.

All grayscale images, which were part of the original AT&T image database, were converted to PNG format (for greater compatibility), and used in conjunction with the global classifier.

Several face regions were extracted from each image by cropping the original images and storing them in appropriate folders. These regions are, in the authors' opinion, a natural choice, they represent prominent features, and are easily recognizable by ordinary human perception. These were used in conjunction with all classifiers other than the global classifier.

After all required images (and subimages depicting prominent face features) are obtained, a test image can be classified in a number of ways. An interesting approach to classification is to use pseudo-integrals, such as the ones mentioned in Subsection 3.2. The main idea is to begin with a function g representing, for example, a λ -fuzzy measure. It

is first evaluated on singletons, which represent the face features (classifiers) mentioned above, and each obtained value is related to the measure of the importance of its corresponding classifier.



Fig. 1 Face regions extracted from the AT&T database, and further preprocessed.

After this is done, another function f is defined, and is highly dependent on the test image observed. For each classification class, its pseudo-integrals are calculated (with regards to g). The final classification is then done by assigning the test image to the class for which the maximal value of the pseudo-integral is obtained.

One such approach was used in [12]. The functions f , related to an observed test image, were calculated similarly as in [8]. However, in this paper we are interested primarily in the calculations of value of the fuzzy measure g associated with each classifier.

In [12], the authors performed a preprocessing step, in a manner which is dependent on the classifier which was considered. For each classifier, the preprocessing step included the binarization of the image and the application of morphological operations which tended to emphasize the facial features in a manner which was, in their opinion, recognizable to human perception.

Table 1. The results of applying classification using each individual classifier, along with the percentage of the classification accuracy.

Index	Classifiers	Accuracy
1	global image	58%
2	eyes	33.33%
3	eyebrows	32.67%
4	mouth	35.33%
5	noise	34.67%
6	left cheek	38.67%
7	right cheek	34.67%

After preprocessing, a number of classical image moments invariants was calculated for each image, such as the first, second, third and fourth Hu moment invariants, or disconnectedness and anisotropy, for which we refer the interested reader to [14, 18]. A series of Leave-One-Out validation techniques were performed in order to obtain which image moment invariants (or which collection of these) gave the largest classification accuracy for all 165 considered images, per classifier. The largest obtained classification accuracy was then used as the basis for the calculation of the function g , see Table 1.

Namely, following [8], the classification accuracy which related to the global image classifier was multiplied with 0.6, and the rest accuracies with 0.4. This gave the values for the fuzzy measure of singletons as follows:

$$(g_1, g_2, g_3, g_4, g_5, g_6, g_7) = (0.348, 0.133, 0.131, 0.141, 0.139, 0.155, 0.139)$$

where the indices used refer to the same classifiers as in Table 1 above. For each of the 15 persons, we calculate the generalized Choquet integral based on c -credibility measure. The largest of all 15 calculated values indicates which class the tested image should be classified as. Thus, for the first image, we have the calculated values of the function f for each part of the image x_1, \dots, x_7 (global image, ..., right cheek) 0.34, 0.52, 0.4, 0.46, 0.99, 0.42, 0.39.

Sorting these values, we have

$$f_1 = 0.99, f_2 = 0.52, f_3 = 0.46, f_4 = 0.42, f_5 = 0.4, f_6 = 0.39, f_7 = 0.34.$$

Now the renumbering is performed according to the function values, i.e.

x_1 =noise, x_2 =eyes, x_3 = mouth, x_4 = left cheek, x_5 =eyebrows, x_6 =right cheek, x_7 =global image. We now have:

$$cr(\{x_1\}) = 0.139, cr(\{x_2\}) = 0.133, cr(\{x_3\}) = 0.141, cr(\{x_4\}) = 0.155,$$

$$cr(\{x_5\}) = 0.131, cr(\{x_6\}) = 0.139, cr(\{x_7\}) = 0.348,$$

Therefore:

$$cr(A_1) = cr(\{x_1\}) = 0.139, cr(A_2) = cr(\{x_1, x_2\}) = 0.139, cr(A_3) = cr(\{x_1, x_2, x_3\}) = 0.141,$$

$$cr(A_4) = cr(\{x_1, x_2, x_3, x_4\}) = cr(A_5) = cr(\{x_1, x_2, x_3, x_4, x_5\}) = 0.155,$$

$$cr(A_6) = cr(\{x_1, x_2, x_3, x_4, x_5, x_6\}) = 0.155, cr(A_7) = cr(\{x_1, x_2, x_3, x_4, x_5, x_6, x_7\}) = 1.$$

$$\int f \circ cr = \sum_{k=1}^n (f(x_k) - f(x_{k+1})) cr(A_k)$$

$$= (0.99 - 0.52) \cdot 0.139 + (0.52 - 0.46) \cdot 0.139 + (0.46 - 0.42) \cdot 0.141 + (0.42 - 0.4) \cdot 0.155 + (0.4 - 0.39) \cdot 0.155 + (0.39 - 0.34) \cdot 0.155 + (0.34 - 0) \cdot 1 = 0.43171.$$

In [12], it was shown that for this particular approach, using the classical Choquet integral led to better results than using the generalized Choquet integral defined with four different t-norms. The authors have since then observed that, even when using additional variants of the generalized Choquet integral (i.e., using new t-norms), the results were not able to

outperform the best obtained in [12]. Also, varying the distances which were used did not lead to a significant increase in classification accuracy.

5. CONCLUSION

This paper presents a class of aggregation operators called pseudo-integrals based on fuzzy measures. Those integrals have proven themselves to be better than other aggregation functions in shape recognition problems, especially face recognition. They are used in face recognition for classification, by providing a unified answer to the question of whether the classification is well performed, as well as the degree of its success.

For this purpose, classifiers representing different parts of the face and their descriptors are considered. We give here the results for descriptors based on image moment invariants. Further investigations will include other interesting descriptors, and alternative distances (such as the Mahalanobis distance, etc.) which are used.

Apart from the generalized Choquet integrals mentioned above, other classes of the generalized Choquet integral, Sugeno's integrals, as well as other pseudo-integrals (such as the one based on the measure of credibility) will be reviewed.

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APPLICATION OF FUZZY METRIC SPACES IN IMAGE PROCESSING AND FIXED POINT RESULTS

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ABSTRACT:

The study of fixed point theory in metric spaces and its generalizations plays a crucial role in nonlinear analysis. This paper focuses on fixed point theory in the context of fuzzy metric spaces, introducing a novel class of contractive mappings and establishing a fixed point theorem for this class. An illustrative example is presented to validate the theoretical results, with implications for image processing using appropriate fuzzy metrics.

Keywords: *fixed point, contractive mapping, Cauchy sequence, image processing.*

1. INTRODUCTION AND PRELIMINARIES

The beginning of the development of the fixed point theory was related to the use of successive approximations in order to ensure the existence and uniqueness of solutions, primarily differential and integral equations. Fixed point theory is applied in various fields such as economics, physics, chemistry, differential and integral equations, partial differential equations, numerical analysis, image processing and many others.

Banach's contraction principle in metric spaces is one of the most important results in the fixed point theory and nonlinear analysis in general. Ever since 1922, when Stefan Banach formulated the concept of contraction and proved his well-known theorem ([1]), scientists around the world published new results that are related to the generalization of metric space or to the generalization of the contractive condition. In addition to the generalization of the Banach contractive condition, attention is paid to the generalization of the metric space.

Theorem 1.1. ([1]) *Let (X,d) be a complete metric space and $f:X \rightarrow X$ q -contraction i.e. there exists $q \in (0,1)$ such that*

$$d(fx, fy) \leq qd(x, y) \tag{1.1}$$

for all $x, y \in X$. Then there exists a unique fixed point of the mapping f .

In the field of mathematics and engineering, the concept of fuzzy sets introduced by Zadeh in 1965 has revolutionized the way we model and analyze uncertain and vague phenomena. Fuzzy logic has found applications in various fields such as artificial intelligence, decision theory, and image processing.

In 1975, Kramosil and Mihalek [6] introduced the concept of fuzzy metric spaces, which further extended the applications of fuzzy sets in mathematical analysis.

In 1997, in order to define the Hausdorff topology, A. George and P. Veeramani [2] modified the definition of fuzzy metric spaces by Kramosil and Mihalek [6].

Below we list the definitions and theorems needed for the original part of the paper.

Definition 1.1. ([5]) *A binary operation $T : [0, 1] \times [0, 1] \rightarrow [0, 1]$ is a continuous triangular norm if it satisfies the following conditions:*

- (t1) *T is associative and commutative,*
- (t2) *T is continuous,*
- (t3) *$T(a, 1) = a$, for all $a \in [0, 1]$,*
- (t4) *$T(a, b) \geq T(c, d)$ whenever $a \geq c$ and $b \geq d$, for each $a, b, c, d \in [0, 1]$.*

Example 1.1. *Basic examples of a continuous t-norm are*
 $T_M(p, q) = \min\{p, q\}$, $T_P(p, q) = p \cdot q$, $T_L(p, q) = \max\{p + q - 1, 0\}$.

Remark 1.1. Minimum t-norm T_M is the strongest t-norm, i.e. for every t-norm T the following is satisfied: $T \leq T_M$.

Definition 1.2. ([2]) *A 3-tuple (X, M, T) is called a fuzzy metric space if X is an arbitrary (non-empty) set, T is a continuous t-norm and M is a fuzzy set on $X^2 \times (0, +\infty)$, satisfying the following conditions for each $x, y, z \in X$ and $t, s > 0$*

- (Fm-1) *$M(x, y, t) > 0$,*
- (Fm-2) *$M(x, y, t) = 1$ if and only if $x = y$,*
- (Fm-3) *$M(x, y, t) = M(y, x, t)$,*
- (Fm-4) *$M(x, z, t+s) \geq T(M(x, y, t), M(y, z, s))$,*
- (Fm-5) *$M(x, y, \cdot) : (0, +\infty) \rightarrow [0, 1]$ is continuous.*

Definition 1.3. ([2]) *The sequence $\{x_n\}$ in a fuzzy metric space (X, M, T) converges to $x \in X$ if $\lim_{n \rightarrow \infty} M(x_n, x, t) = 1$ for every $t > 0$.*

Definition 1.4. ([2]) *The sequence $\{x_n\}$ in a fuzzy metric space (X, M, T) is a Cauchy sequence if for all $\varepsilon \in (0, 1)$ and $t > 0$ there exists $n_0 = n_0(\varepsilon, t) \in \mathbb{N}$ such that $M(x_n, x_m, t) > 1 - \varepsilon$ for every $n, m \geq n_0$.*

Remark 1.2. Grabiec in [3] introduced stronger definition of a Cauchy sequence in the following way: sequence $\{x_n\}$ in a fuzzy metric space (X, M, T) is a Cauchy sequence if $\lim_{n \rightarrow \infty} M(x_n, x_{n+p}, t) = 1$ for every $p > 0$.

In [2] authors noted that with the Grabiec definition of Cauchy sequence, set of real number R fails to be complete.

Fuzzy metric spaces in which the sequence is Cauchy in the sense of Grabiec's definition are called G fuzzy metric spaces.

Lemma 1.1. ([3]) *If for two points $x, y \in X$ and a positive number $k < 1$, it holds $M(x, y, kt) \geq M(x, y, t)$, then $x = y$.*

First generalization of Banach contraction principle in the frame of fuzzy metric space was given in the paper of Sehgal and Bharucha-Reid [10].

Theorem 1.2. ([10]) *Let (X, M, T_M) be a complete fuzzy metric space such that $\lim_{t \rightarrow \infty} M(x, y, t) = 1$ for every $x, y \in X$ and $f: X \rightarrow X$. If there exists $q \in (0, 1)$ such that for all $x, y \in X$ and $t > 0$*

$$M(fx, fy, t) \geq M(x, y, \frac{t}{q}). \quad (1.2)$$

Then there exists a unique fixed point of the mapping f .

Remark 1.3. The requirement that a t-norm is T_M is a stringent condition, and further studying is warranted to determine which additional conditions for either the t-norm itself, or the space, is needed. Alternatively, it may be beneficial to consider a modified form of the contractive condition to ensure the validity of the theorem across a wider class of triangular norms. Further research in this area could lead to valuable results and their applications in various mathematical frame.

2. FIXED POINT THEOREM

Theorem 2.3. ([3]) *Let (X, M, T) be a G complete fuzzy metric space such that $\lim_{t \rightarrow +\infty} M(x, y, t) = 1$ for every $x, y \in X$ and $f: X \rightarrow X$ be such that (1.2) is satisfied then there exists a unique fixed point of the mapping f .*

Theorem 2.4. ([12]) *Let (X, M, T) be a complete fuzzy metric space such that $\lim_{t \rightarrow +\infty} M(x, y, t) = 1$ for every $x, y \in X$ and $f: X \rightarrow X$ be such that (1.2) holds. If $\lim_{t \rightarrow +\infty} T_{i=1}^{\infty} M(x_0, fx_0, \frac{1}{\sigma_0^i}) = 1$, for some $\sigma_0 \in (0, 1)$ and some $x_0 \in X$, then f has a unique fixed point.*

Lemma 2.2. ([4]) *Let (X, M, T) be a fuzzy metric space and let $\{x_n\}$ be a sequence in X such that*

$$\lim_{t \rightarrow 0^+} M(x_n, x_{n+1}, t) > 0, n \in N \text{ and } \lim_{t \rightarrow +\infty} M(x_n, x_{n+1}, t) = 1, t > 0.$$

If $\{x_n\}$ is not a Cauchy sequence in (X, M, T) , then there exist $\varepsilon \in (0, 1)$, $t_0 > 0$, and sequences of positive integers $\{n_k\}, \{m_k\}$, $n_k > m_k > k$, $k \in N$, such that the following sequences: $\{M(x_{m_k}, x_{n_k}, t_0)\}$, $\{M(x_{m_k}, x_{n_k-1}, t_0)\}$, $\{M(x_{m_k-1}, x_{n_k}, t_0)\}$, $\{M(x_{m_k-1}, x_{n_k+1}, t_0)\}$, $\{M(x_{m_k+1}, x_{n_k+1}, t_0)\}$ tend to $1 - \varepsilon$, as $k \rightarrow +\infty$.

Theorem 2.5. Let (X, M, T) be a complete fuzzy metric space such that $\lim_{t \rightarrow 0} M(x, y, t) > 0$ for every $x, y \in X$ and $f: X \rightarrow X$. If there exists $q \in (0, 1)$ such that for all $x, y \in X$ and $t > 0$

$$M(fx, fy, t) \geq (M(x, y, t))^q \tag{1.3}$$

then f has a unique fixed point.

Proof. Let $x_0 \in X$ and $fx_n = x_{n+1}$. Suppose that $x_n \neq x_{n+1}$ for all $n \in \mathbb{N}$. Otherwise, x_n is a fixed point. Then using (1.3) for $x = x_{n-1}$ and $y = x_n$ we have

$$M(x_n, x_{n+1}, t) \geq (M(x_{n-1}, x_n, t))^q \geq \dots \geq (M(x_0, x_1, t))^{q^n} \tag{1.4}$$

Letting $n \rightarrow +\infty$ and since $q^n \rightarrow 0$ we obtain that

$$\lim_{n \rightarrow +\infty} M(x_n, x_{n+1}, t) = 1. \tag{1.5}$$

It remains to prove that the sequence $\{x_n\}$ is a Cauchy sequence. Suppose contrary. Then using (1.3) for $x = x_{n_k}$ and $y = x_{m_k}$ and Lemma 2.2. we obtain the following

$$M(fx_{n_k}, fx_{m_k}, t_0) = M(x_{n_k+1}, x_{m_k+1}, t_0) \geq (M(x_{n_k}, x_{m_k}, t_0))^q. \tag{1.6}$$

Letting $k \rightarrow +\infty$ in (1.6) we have that

$$1 - \varepsilon \geq (1 - \varepsilon)^q > 1 - \varepsilon.$$

Contradiction. So the sequence $\{x_n\}$ is a Cauchy sequence and since the space is complete there exists $x \in X$ such that

$$\lim_{n \rightarrow +\infty} M(x_n, x, t) = 1, t > 0.$$

It should be shown that $x = fx$. Suppose contrary, that $x \neq fx$. Then using (1.3) for $y = x_{n-1}$ we get

$$M(fx, fx_{n-1}, t) = M(fx, x_n, t) \geq (M(x, x_{n-1}, t))^q \tag{1.7}$$

Based on (Fm-2) and letting $n \rightarrow +\infty$ in (1.7) we obtain that $M(fx, x, t) \geq (M(x, x, t))^q = 1$ and so $x = fx$, which is contradiction with our assumption. It remains to prove that the fixed point is unique. Let's assume the opposite, i.e. that there exist $x, y \in X$, $x \neq y$, and $x = fx$, $y = fy$. Then by (1.3) we have that

$$M(x, y, t) = M(fx, fy, t) \geq (M(x, y, t))^q > M(x, y, t).$$

A contradiction has been obtained, and the proof is completed.

Example 2.1. Let $X = [0, 1]$ and $M(x, y, t) = \frac{e^{-|x-y|}}{t+1}$ and $T = T_p$. Then (X, M, T) is a complete fuzzy metric space. Let $fx = \frac{x}{3}$. Then

$$M(fx, fy, t) = \frac{e^{-|x-y|}}{3(t+1)} \geq \frac{e^{-|x-y|}}{2(t+1)} = (M(x, y, t))^{\frac{1}{2}}.$$

So, all conditions of Theorem 2.5. are satisfied for $q = \frac{1}{2}$ and $x = 0$ is a unique fixed point.

Example 2.2. Let $X = [0, 1]$ and $M(x, y, t) = \frac{1}{1+(t+3)^{|x-y|}}$ and $T = T_p$. Then (X, M, T) is a complete fuzzy metric space. Let $fx = x/(t+3)$. Then

$$M(fx, fy, t) = \frac{1}{1+|x-y|} \geq (M(x, y, t))^{\frac{1}{2}}.$$

All conditions of Theorem 2.5. are satisfied for $q = \frac{1}{2}$ and $x=0$ is a unique fixed point.

3. EXPERIMENTAL RESULTS

One of the fundamental techniques employed in image processing is filtering, which plays a crucial role in enhancing the quality of images. In this study, we focus on color image filtering, specifically image noise removal. Rather than utilizing classical distance metrics, we propose the use of fuzzy metrics, which defined in the previous section. To perform image filtering with the aim of noise reduction we will use a fuzzy algorithm defined in [8] by authors N. M. Ralević, D. Karaklić, and N. Pištinjat, The efficacy of this approach will be evaluated and discussed in detail.

Each pixel in an image (i, J_i) ("position", "color") can be described by its spatial coordinates of pixel i_1, i_2 (points $i = (i_1, i_2) \in I \times I, I = \{0, 1, \dots, n-1\}$ from the screen), and by vector $J_i = (J_i^1, J_i^2, J_i^3)$. The first component of the vector represents the amount of red color, the second component represents the amount of green color, and the third component represents the amount of blue color, these color components being red, green, blue (RGB), respectively.

When filtering an image, it is extremely important to establish the criterion by which a noisy pixel is replaced with another one without noise. This is done by replacing the central pixel in window $W = \{(i, J_i) | i \in I_1 \times I_2\}$, $(\bar{i} = (\bar{i}_1, \bar{i}_2) \in I_1 \times I_2$,

with the pixel that is most similar in color and spatial distance to all other pixels in W .

The fuzzy image filtering algorithm operates by selecting a replacement pixel for a suspected pixel in a defined window W . This selection is dependent on the choice of a suitable fuzzy metric denoted as c . Using the metric c will induce an ordering relation that will be used to compare the pixels ("position", "color") of the image and to select the pixel that is the least different from all other pixels in the window, i.e. the most similar to all other pixels in W (in terms of color and distance). Consequently, the central pixel within the window W is substituted with the selected pixel determined by the algorithm applied to each sliding window.

In the algorithm for filtering the image we use fuzzy metric $c : W \times W \rightarrow R$ defined with:

$$c((i, J_i), (j, J_j)) = M_1(J_i, J_j) \cdot M_2(i, j). \quad (3.1)$$

Fuzzy metric which is used in order to measure similarity in colors among pixels is marked with M_1 . It is defined in the following way:

$$M_1(J_i, J_j) = M_{1,1}(J_i^1, J_j^1) \cdot M_{1,2}(J_i^2, J_j^2) \cdot M_{1,3}(J_i^3, J_j^3). \quad (3.2)$$

For the metrics $M_{1,i}, i = 1, 2, 3$ will be use are the fuzzy metrics defined over $X = [0, 1]^2$, with

$$M_1(J_i, J_j) = e^{-\frac{|J_i^1 - J_j^1| + |J_i^2 - J_j^2| + |J_i^3 - J_j^3|}{K+1}}. \quad (3.3)$$

Fuzzy metric that considers spatial distance between pixels is marked with M_2 . It is defined in the following way:

$$M_2(i, j) = \frac{1}{1 + m \cdot \max(|i_1 - j_1|, |i_2 - j_2|)}. \quad (3.4)$$

In the following example, the picture pills.jpg is given in jpg format. To test the quality of that image, we will use the image quality index UIQI, defined in the paper of Z. Wang and A.C. Bovik [13]. For measuring sharpness, we have used the image quality metrics introduced in the paper [7] of N.D. Narvekar and L.J. Karam.

As it can be seen, the filtered image given below is contaminated with 1% salt and pepper noise. The chosen size of window is 5. The metric c which is defined with (12), where M_1 and M_2 are defined by (3.1) and (3.2), respectively. The tested values of the parameters appearing in those metrics ranged from 125 to 2500 with a step of 125 for K , while m took the values $1/n$, $n=1, \dots, 100$. The values of metric for the image quality UIQI for each color for the filtered image by applying the method proposed in paper [8] are equal to:

$$\text{UIQI: } [0.79764, 0.861399, 0.822604].$$

The best result was obtained for $K=2500$ and $m=1/26$

The sharpness for image filtered by our metric is 0.5006.

The values of metric of image quality UIQI for each color for filtered image by median filter are equal to:

$$\text{UIQI: } [0.844410, 0.909726, 0.865253].$$

The sharpness for image filtered by VMF is 0.2622.



Figure 1. Pills, Original image in jpg format

The result was that our image has slightly lower values for corresponding UIQI image quality, but much higher sharpness. This will enhance the understanding of the intricate relationship between quality and sharpness. And this is very important in cases in which the details of the image itself are essential.

In the articles [8] and [9], denoising was investigated on digital images of Lena and Baboon, using fuzzy metrics. In both cases, greater sharpness of the image was shown for the selected parameter values, and in the first case better UIQI.

5. CONCLUSION

In this paper, the theorem on the fixed point for the fuzzy metric spaces was proved, as well as new examples of those spaces, which would enable a wider scope of application of such metrics. One of these applications is image filtering with appropriate selection of fuzzy distances, which we considered, and by varying their parameters, we determine the best possible solution for our problem. In the already existing algorithm based on fuzzy metrics on the example of one image, an example of fading with 1% salt and pepper noise is illustrated.

Future research endeavors will focus on exploring alternative types of sums and adjusting their respective parameters within the framework of fuzzy metrics. By utilizing the algorithm discussed in this paper, further investigations can be conducted to evaluate the performance of different types of sums in overcoming various challenges in image processing.

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MECHANICAL ANALYSIS AND SIMULATION OF ABB IRB 120 ROBOT OPERATION USING MATLAB

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ABSTRACT:

This paper deals with the mechanics calculation and simulation of ABB IRB 120 robot operation using MATLAB. Industrial robots are crucial for improving efficiency and quality in manufacturing, but they require precise motion modeling. Kinematics analyzes the geometry and motion of the robot, while dynamics studies the effects of forces and moments. By using MATLAB and Robotic Toolbox, this paper models the kinematics and dynamics of robot motion, using DH parameters and dynamic parameters obtained from 3D models. Simulations in MATLAB and Simulink enable performance analysis and optimization of robot motion, which is essential for integration into manufacturing processes.

Keywords: *robot, simulation, kinematics, dynamics*

1. INTRODUCTION

Industrial robots are essential components of many production settings in the modern world, allowing for more productivity, lower costs, and better product quality. However, it is essential to comprehend and precisely model robot motion in order to properly integrate them into production lines and enable them to carry out tasks with a high degree of precision. In order to design control algorithms and optimize performance, it is necessary to calculate the kinematics and dynamics of robots. [1][2]

Kinematics deals with geometric structure and motion of the robot, i.e., how different parts of the robot move in space. This includes analyzing the position, velocity, and acceleration of joints or other points on the robot. On the other hand, dynamics focuses on analyzing the motion of the robot under the influence of forces and moments, taking into account factors such as inertia and gravity. Understanding and calculating these parameters is crucial for the development of control algorithms that enable precise and efficient robot control.[3][4]

This work focuses on using MATLAB, one of the most advanced software for numerical analysis and simulation, to calculate the kinematics and dynamics of robot motion. For the design, control, and optimization of robot motion systems, exact modelling and analysis of robot motion in a variety of scenarios are made possible by the combination of MATLAB and Robotic Toolbox.

The aim of this work is to analyze an example of MATLAB application in calculating the kinematics and dynamics, as well as simulating the motion of the ABB IRB 120 robot. For

this analysis, it is necessary to define the geometric model by determining the Denavit-Hartenberg (DH) parameters. Subsequently, transformation matrices will be defined, along with dynamic parameters taken from the 3D model of the robot. These examples involve simulations of robotic manipulators, performance analysis of control algorithms, and optimization of robot motion paths. The paper will provide a detailed demonstration of robot modeling in MATLAB, description of the functions used for kinematics and dynamics calculations, as well as graphical representation of simulations and calculations.

2. SYSTEM MODELING

Finding the DH parameters is a crucial stage in modelling and analysing the kinematics of manipulators. A robotic manipulator's geometry and kinematics are described by a collection of parameters called DH parameters, which make it possible to precisely simulate the kinematic properties of the device. Determining rotational and translational axes, creating coordinate systems for each manipulator joint, and figuring out the geometric connections between successive joints are all the steps in the process of computing DH parameters.[5]

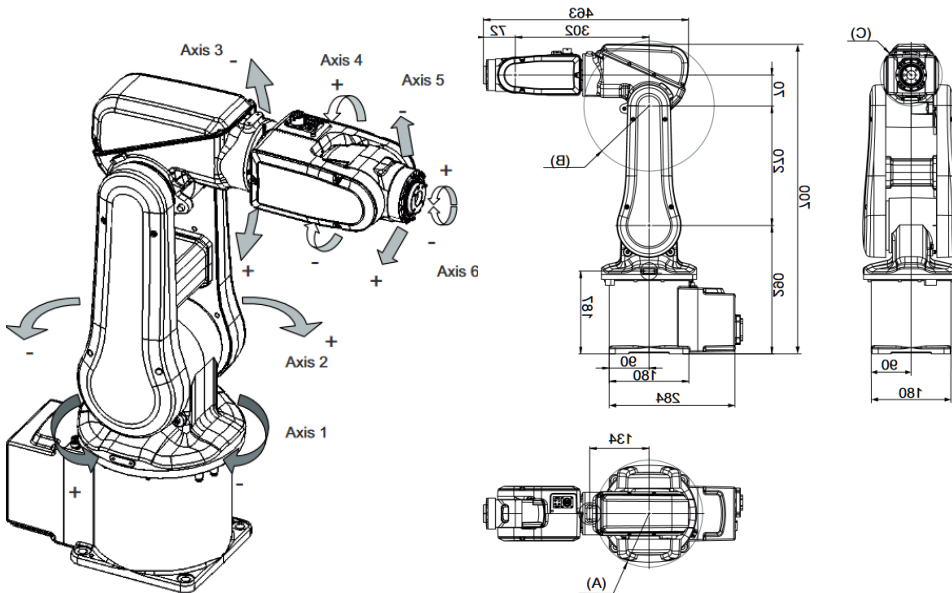


Fig 1. Six axes of the ABB IRB120 robot and joint dimensions [6]

During this process, physical characteristics of the manipulator itself are taken into account, such as joint lengths, displacements of coordinate systems, and joint orientations. Calculating DH parameters requires precise and careful analysis to ensure accuracy in modeling the manipulator's kinematics.

$${}^0\mathbf{A}_n = {}^0\mathbf{A}_1 \cdot {}^1\mathbf{A}_2 \cdot \dots \cdot {}^{n-1}\mathbf{A}_n = \prod_{i=1}^n {}^{i-1}\mathbf{A}_i = \begin{bmatrix} {}^0\mathbf{R}_n & {}^0\mathbf{p}_n \\ \mathbf{0} & 1 \end{bmatrix} \quad (1)$$

The equation represents the DH homogeneous transformation matrix for converting coordinates from the end-effector coordinate system to the base coordinate system of the manipulator, where rotational matrices, position vectors, and DH parameters are individually represented.

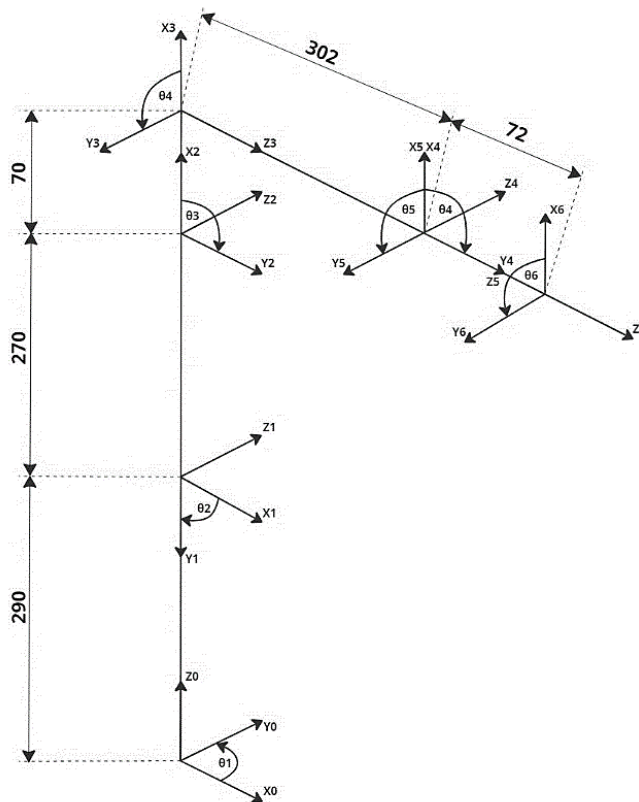


Fig 2. Definition of joint coordinate systems and DH parameters for the IRB120 [7]

Physical parameters from the robot's 3D model are required for the investigation of its dynamics. These parameters are generated using 3D modelling software like *AutoDesk Inventor* using separate robot segments.

The integrated Robotic Toolbox, a specialized tool for the study and simulation of industrial robotics, is used to calculate the kinematics and dynamics of robot movements. Numerous features are included in this toolkit, such as path development, dynamics, kinematics, and robot motion simulations.

Initially, a MATLAB script including all of the previously specified manipulator settings must be created to generate a robot model. This script creates an IRB120 robot object, which is then used to simulate the

```
L1 = Link('d',0.29, 'a',0, 'alpha',-pi/2, 'm',8.281, 'r',[0 0.238 0],  
'I',[0.038 0.028 0.039 0 0 0]);  
L2 = Link('d',0, 'a',0.27, 'alpha',0, 'offset',-pi/2, 'm',10.554, 'r',[0.001  
-0.169 -0.056], 'I',[0.163 0.07 0.112 0 -0.001 0]);  
L3 = Link('d',0, 'a',0.07, 'alpha',-pi/2, 'm',7.948, 'r',[-0.049 0.124 -  
0.001], 'I',[0.023 0.034 0.045 -0.004 0 0]);  
L4 = Link('d',0.302, 'a',0, 'alpha',pi/2, 'm',3.908, 'r',[-0.076 0 0.005],  
'I',[0.009 0.016 0.012 0 0 0]);  
L5 = Link('d',0, 'a',0, 'alpha',-pi/2, 'm',1.476, 'r',[0.301 0.630 0],  
'I',[0.001 0.002 0.002 0 0 0]);  
L6 = Link('d',0.072, 'a',0, 'alpha',0, 'm',0.037, 'r',[0 0 0.006], 'I',[0 0  
0 0 0 0]);  
IRB120 = SerialLink([L1 L2 L3 L4 L5 L6], 'name','IRB120');
```

The motion and appearance of the manipulator can be graphically represented using the plot function, as well as through the plot3d function, which allows the display of the robot with CAD models of segments, as shown in the image.

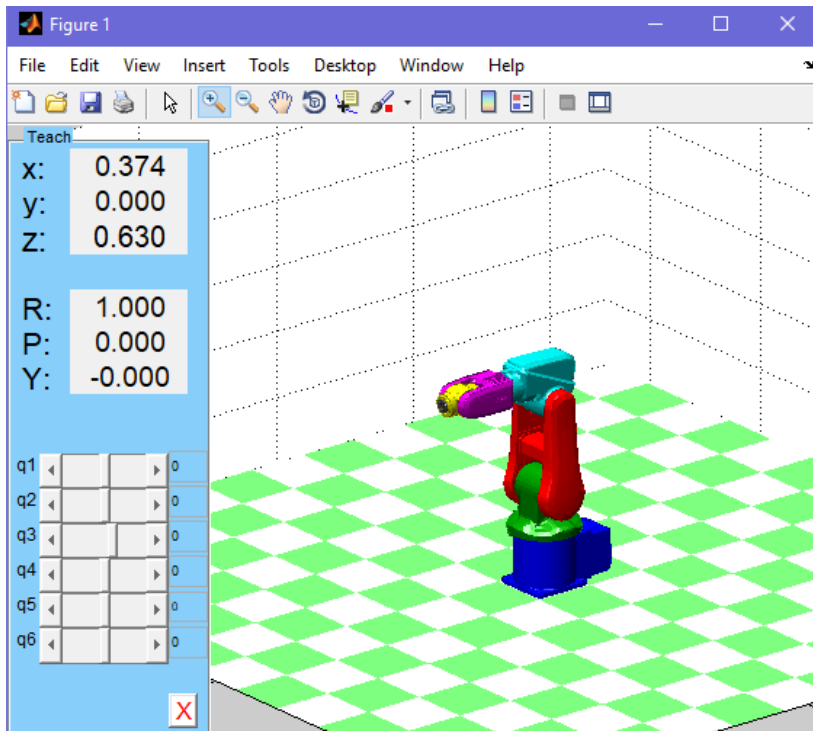


Fig 3. 3D representation of the robot

2. CALCULATION AND SIMULATION OF MOTION

To calculate the mechanics of the industrial robot ABB IRB 120, a Simulink model of the robot is created, as seen in the picture.

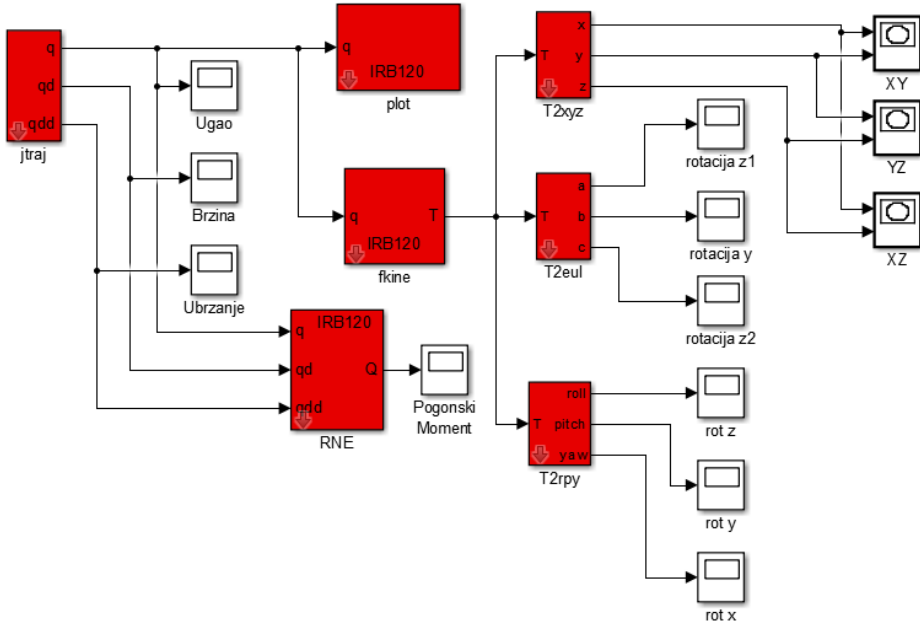


Fig 4. Simulink model block diagram in MATLAB

Where:

In order to generate a trajectory between two places, the **Jtraj** block first generates a matrix of internal coordinates for each joint, from the starting to the finishing point in space. The block specifies the start and end positions as well as the length of the simulation. This block allows the rotation angles (Fig 5), angular acceleration (Fig 7), and angular velocity (Fig 6) to be shown for every robot joint.

Every internal coordinate is calculated for forward kinematics by the **Fkine** block, which also produces homogeneous transformation matrices for every point on the robot's end-effector (gripper) trajectory.

To show the values of **X**, **Y**, and **Z** in the homogeneous transformation matrix over time, utilize the functions **T2xzy**, **T2eul**, and **T2rpy**. They represent successive transformation matrices around a fixed coordinate system with rotations around the X, Y, and Z axes, respectively, and three successive Euler rotational transformations for a variable coordinate system around the X, Y, and Z axes.

The Newton-Euler recursive approach is used by the **RNE** block to calculate the inverse dynamics. This block makes possible to see the robot's torque at each joint (Fig 8).

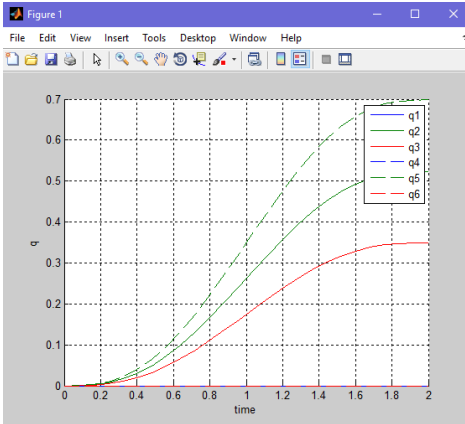


Fig 5. Diagram showing how the robot's joint angles vary for a given motion trajectory.

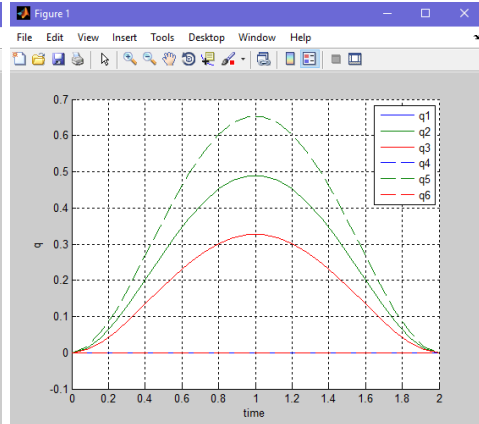


Fig 6. Diagram showing how the robot's joints' angular velocities vary for a given motion trajectory.

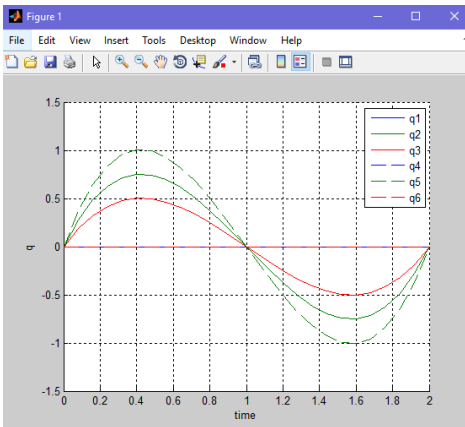


Fig 7. Diagram showing how the robot's joints' angular acceleration changes for a certain motion trajectory.

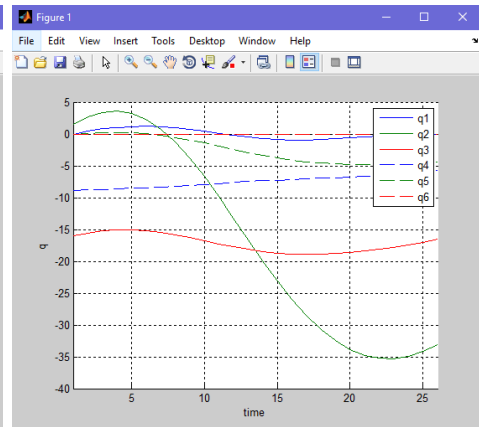


Fig 8. A diagram showing how the robot's joints' torque changes for a certain motion trajectory.

After the calculations are performed, it is possible to simulate the movement of the robot using the plot block. The simulation of the robot's movement is shown in Fig 9.

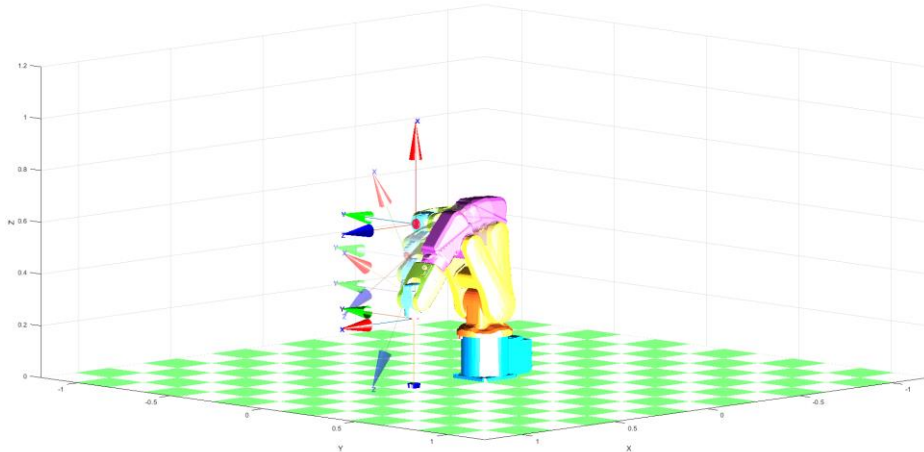


Fig 9. Simulation of the robot's movement at several characteristic points.

3. CONCLUSION

Industrial robots have become indispensable elements in modern manufacturing environments, providing the ability to increase efficiency, reduce costs, and enhance product quality. However, successful integration of robots into production lines and the execution of tasks with high precision require a detailed understanding and accurate modeling of their movements. This includes the calculation of robot kinematics and dynamics, which is crucial for the development of control algorithms and optimization of such systems.

Kinematics focuses on studying the geometric structure and movements of the robot, analyzing the position, velocity, and acceleration of joints or other points on the robot. On the other hand, dynamics deals with analyzing the movement of the robot under the influence of forces and moments, taking into account factors such as inertia and gravity. Understanding and calculating these parameters are essential for the development of control algorithms that enable precise and efficient robot control.

The paper presents an example of the application of MATLAB in the calculation of kinematics and dynamics, as well as the simulation of the movement of the ABB IRB120 robot. This analysis included determining the mechanical model through the definition of DH parameters, as well as transformation matrices and dynamic parameters obtained from the 3D model of the robot. After determining the robot parameters, a MATLAB script and a robot model in Simulink were created, where the appropriate calculations of robot mechanics and simulation of its movement were performed.

Further research in this area will be focused on implementing the simulated movement trajectory on a real system to serve some of the machining tools.

ACKNOWLEDGEMENT

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PRECISION TECHNOLOGY FOR SUSTAINABLE OLIVE CULTIVATION FOR INNOVATIONS IN OLIVE OIL PRODUCTION VALUE CHAIN

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ABSTRACT:

Paper is based on pilot project implemented in Bar Municipality (Montenegro) that focuses on precision technology for sustainable olive cultivation implemented by Business Start Center in Bar and Barska uljara with support of PhD researchers. In particular, project focuses on using UAV (Unmanned Aerial Vehicle or drone) and sensor-stations to monitor cultivation of autochthonous olives type "žutica". The goal of the project is to propose precision technology that will modernize olive cultivation and create competitive value chain for sustainable and resilient autochthonous olive cultivation. Precision technology is used to monitor the complete annual process of olive cultivation, during all the stages of both vegetative and reproductive organs growth and development. Four pilot areas are selected and we have set in place soil sensors which collect real time data. UAVs and the sensors provide high-resolution imagery and real-time data about crop health, pests and irrigation requirements. Gathering information about olive plantations will lead to optimization of inputs and to real time response to changes in climate conditions or other type of risks.

Keywords: smart agriculture, precision agriculture, value chain, economic valorisation

1. INTRODUCTION

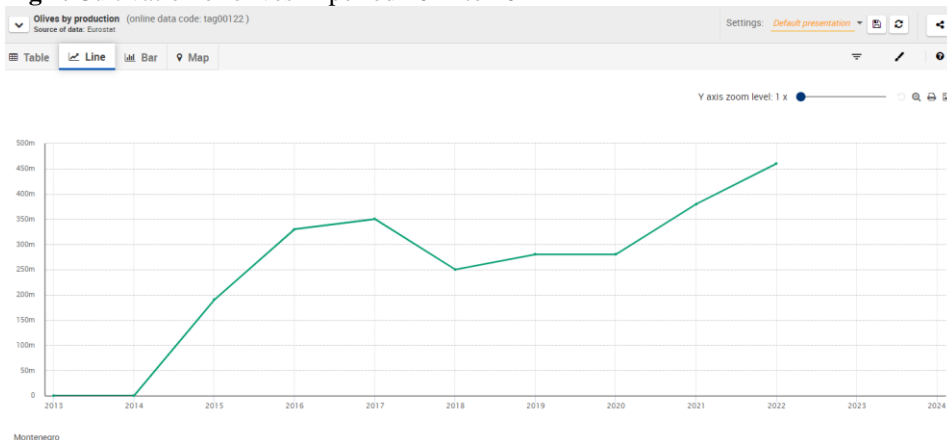
Montenegro is well known for olive cultivation, which is an ingrained traditional practice longer than 2500 years. Autochthonous olive varieties like «Zutica» are being cultivated from the ancient times are representatives of this long-term practice. Favourable environmental conditions prevailing on the Montenegrin seaside enabled olive cultivation in the coastal area. Montenegro is very rich in agricultural genetic resources, considering the small area covered. There are the oldest exemplars of the old trees in the region and beyond, such as the 'Old Olive' in area of Bar, estimated to be more than 2,000 years old. According to the official scientific data, there are about 450,000 productive olive trees in Montenegro, spreading on around 3,200 ha. Currently, the production of olive oil is relatively low (below 500t), making Montenegro importing country for additional 300t per year, even though the capacities are much stronger. In Smart specialization strategy of Montenegro, olive oil production is identified as emerging area with high growth potential.

Table 1. Olive cultivation in Montenegro Accordint to Monstat

Production Year/Fruits and olives	Production in t overall				Cultivated production in t			
	2017(p)	2018(p)	2019(p)	2020(p)	2017(p)	2018(p)	2019(p)	2020(p)
Plums	9888.1	11835.8	9636.7	11260.3	1044.5	1378.6	721.8	842.5
Apples	5371.8	7583.4	6344.1	7340.6	1346.8	1687.5	1486.8	1402.1
Oranges	2753.8	3645.4	3376.4	3142.4	2347.2	3092.9	2830.8	2697.1
Pears	2063.1	2298.0	1892.6	2207.9	389.1	400.2	333.1	359.5
Peaches	1279.7	1291.6	1036.3	1254.2	1235.7	1241.3	984.2	1192.4
Olives	758.6	521.3	574.1	550.2	417.1	279.1	307.5	294.9

Cultivation of olives is presented on EUROSTAT website and databases. Based on preliminary data we can see that cultivation of olives is increasing every year and in most cases olives are cultivated to be used in production of olive oil.

Fig 1. Cultivation of olives in period 2014 to 2022



When it comes to situation in Montenegro olive trees are prone to alternate bearing, therefore the quantity of raw material (olive fruit) is uncertain each year. Olive farmers for that reason experience economically unstable business. It is very important to do analysis that would explore economic valorization of this agricultural product. Olive oil made from *autochthonous olives type «žutica»* creates unique value proposition of Montenegro and therefore the olive industry sector needs to undergo value chain analysis with goal of economic valorisation and commercialization.

Olive oil production is important sector in Montenegro as well as in other Mediterranean regions. Environmental and economic sustainability of agricultural cultivation of olives is one of the most interesting areas of discussion in the current academic debate (1).

In our project we planned to use precision technology to monitor the complete annual process of olive cultivation, during all the stages of both vegetative and reproductive organs growth and development. UAV technology or more familiar name for this is drone technology is used for three-dimensional (3D) monitoring of hundreds of olive trees. Drone imagery in combination of sensor-stations are used just to monitor canopy characteristics in order to determine the need for irrigation and fertilization.

2. METHODOLOGY

We have focused our attention of olive pruning practice in Montenegro and the fact that olives in our agroecosystems have traditionally been cultivated in areas with no irrigation. Pruning at those areas which are difficult to reach with mechanization is labour intensive costly practice with important implications for crop harvest and nutrition. This is important for our analysis because pruning affects soil protection, fertilization needs and irrigation strategies. Currently in Montenegro pruning is conducted in traditional manner which involves on-ground measurements of the primary canopy dimensions, which also might generate inconsistent results due to the irregular geometry of the trees, especially old and millennial olive trees, characteristic for Montenegrin olive growing. This requires very intensive field work that is very costly and time consuming.

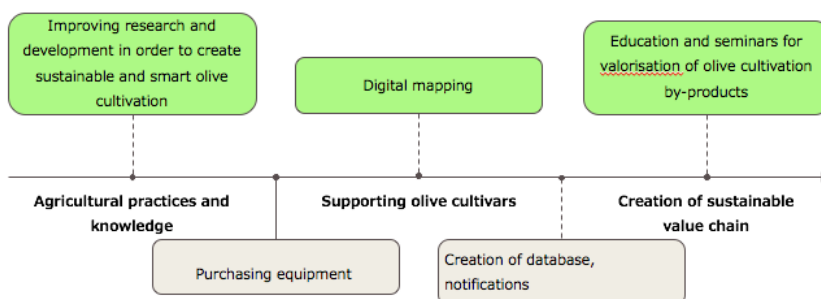
Our methodology is based on results of research of alternatives for traditional practice that are used in many olive growing countries, particularly in Italy, Spain and Greece. In those countries precision agriculture is increasingly being applied in olive cultivation. It uses as new method to manage cultivation with the goal to provide information that can be used to calculate right amount of irrigation and fertilization and to limit waste or excess (2).

In addition to this research that was previously conducted shows that heavy fertilization results in losses and quality decline [3,4]. In addition to this, Álamo [5] observed significant savings in fertilizer use by coupling precision agriculture and leaf analysis. Based on these researches and published studies, our methodology proposes the use of UAV technology or more familiar name for this is drone technology for three-dimensional (3D) monitoring of hundreds of olive trees. Drone imagery will enable us to monitor olive farming at hard to reach areas. We propose to use this technology in combination with sensor-stations to monitor canopy characteristics from the pruning point of view, to monitor information about olive tree plantation needs, harvesting methods, overall health status of the orchard – providing inputs for observing nutrient deficiencies.

Four pilot areas are selected at the territory of Bar - and we have set in place meteorological stations with sensors which collect real time data.

UAVs and the sensors provide high-resolution imagery and real-time data about crop health, fertilization and irrigation requirements. Gathering information about olive plantations will lead to optimization of inputs and to real time response to changes in climate conditions or other type of risks.

Fig. 2. Methodology for using high precision technology for creation of sustainable value chain as proposed in project



With outputs from research we intend to support the identification and elimination of mutual problems regarding the autochthonous olive growing and processing in Montenegro, such as: improper, inadequate or even non-existing fertilization, irrigation, pruning, pest and disease protection etc.; low olive and olive oil yield, poor trade and marketing skills, non-existent valorisation of numerous olive-by (secondary) products; non-existing usage of precision agriculture with support of ICT in olive farming. Olive growers are not familiar with digital and contemporary solutions that would make their production easier and more predictive. Therefore, all of these weaknesses leave strong negative impact on the national olive farming and therefore there is a strong need for connecting farmers with business support experts and scientists in order to enlarge the olive-product offer on the national market and to ensure better sustainability and resilience of the one of the most important agricultural branches of Montenegro.

3. RESULTS AND DISCUSSION

High Technology Farming is a broad concept which refers to usage of wide range of new tools (Robotics, ICT, Big Data, Earth Observation, etc.) in agriculture. The synergic use of these instruments across EU allows the shifting to the new paradigm of Sustainable Precision Agriculture (SPF).

Currently, S3 HIGH TECH FARMING Partnership has aggregated more than 20 Regional and National Administrations in EU with a strong priority related to innovation and adoption of new technologies in the agricultural sectors. Montenegro is currently the area of interest for this initiative. With this project we are contributing to protected cultivations with EYE and Touch monitor which is specific thematic area of his initiative.

Specific objective of our research is supporting creation of the first Montenegrin renewable Agri-Food product in sustainable food supply chain that directly contributes to

development of more sustainable and resilient autochthonous olive cultivation with support of ICT technologies.

Fig. 3. Image of sensor station



We have placed sensor stations at 4 locations: Mandarici, Bartula, Stari Bar and Dobre Vode as shown in Figure 3

Four sensor stations contain:

- High Precision Digital Temperature Barometric Pressure Sensor Module
- Rainfall Rainfall Measure Rain Gauge
- Portable High Accuracy Wind Speed Sensor Transmitter 485 Anemometer 10~30V DC
- Portable High Accuracy Wind Speed Sensor Transmitter 485 Anemometer 10~30V DC
- Solar Outdoor Weather Transmitter Radiation Detector
- Soil protection temperature and humidity sensor

Sensor stations are equipped with software for monitoring conditions in pilot areas with early warning system mechanism (sending data to phones) so that owners can identify deficiencies and malfunctions in the olive groves. We have implemented the system during period from November 2023 to April 2024 and it will be used to monitor the complete annual process of olive cultivation.

Research shows that excessive fertilization and irrigation affects the quality of groundwater and the economy of the farmer (1), but also affects negatively the quality of olive oil produced from those olives. Based on the research of Fernández-Escobar et al., 2002 this reduction of quality is due to a decline in the content of polyphenols. With

Precision agriculture, we can access when the needs for additional irrigation happen; and monitoring the leafs and trees with drone and image technology the need for fertilization can be accessed too. Similar research and sensor-stations are set up in Italy, Spain and Greece contributing to more production of olive oil, employment generation and growth of wealth in those regions.

After monitoring quantitative and qualitative outputs of usage of precision technology in 5 years we will be able to use economic indicators to access growth of olive cultivation-olive oil production. Previous research shows that from an economic point of view, no irrigation and no fertilization could be considered more convenient than treatments that are based on full or partial fertilization and/or irrigation (1,5, 6,7,8 and 9).

Olive cultivars and olive oil produces sometimes have lower total output value because of higher input costs that their businesses have to face in setting up irrigation system at those hard to reach areas (5). In some cases, excess fertilization could too lead to less quality of olive oil (7, 8). We have also conducted further studies researching the cost of olive cultivation and olive oil production in Montenegro trying to develop efficient value chain that would reflect economic and environmental sustainability of olive production leading to better net value to olive cultivars and attracting more farmers to this business.

4. CONCLUSION

Implementation of High Technology Olive Farming – olive cultivation monitoring with drone-imagery that is implemented in the pilot groves and that enables individual olive trees as well as whole groves to be mapped in order to obtain the images that provide information about olive tree plantation mechanism, pruning practices, harvesting methods, overall health status of the tree. Data will be used as inputs for nutrient deficiencies and similar. However precise data will be collected in time period of three to five years. Thanks to Precision Agriculture, and as has been found in the results obtained in this work, there can be a saving in the application of fertilizers, with the resulting economic benefit to growers and environmental improvement for the whole of society. More investigation is needed to evaluate the profitability of using Precision Agriculture in other olive farms, even smaller ones if they are part of associations (cooperatives), communities of irrigators, etc

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VODIKOVE GORIVNE ĆELIJE KAO ALTERNATIVNO GORIVO

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SAŽETAK:

Vodik (H) je kemijski element, koji je u molekularnom stanju bez boje okusa i mirisa. U atomskom stanju izrazito je reaktivan te se u prirodi ne nalazi samostalno. Glavni je sastojak vode te anorganskih tvari a čini 75% mase Sunca.

S obzirom na dostupnost vodika u spojevima poput vode (H₂O), metana (CH₄), fosilnih ugljikovodika te biomase, potrebno je riješiti probleme njegova izdvajanja iz tih spojeva, skladištenja, distribucije te korištenja kao potencijalnog goriva budućnosti.

Cilj je objasniti navedene probleme, ali i navesti prednosti vodika u odnosu na klasična goriva. Vodik je sve zastupljeniji u primjeni kao alternativno gorivo u svim aspektima moguće primjene. Naglasak je na njegovoj prednosti zbog težnji smanjenja stakleničkih plinova.

Ključne riječi: vodik, vodikove gorivne ćelije, gorivo, promet

1. UVOD

U posljednjih nekoliko desetljeća, potraga za održivim izvorima energije postala je prioritet u globalnoj borbi protiv klimatskih promjena i iscrpljivanja fosilnih goriva. Jedna od najperspektivnijih tehnologija u tom području su vodikove gorivne ćelije, koje nude ne samo čistu i učinkovitu alternativu, već i širok spektar primjena u transportu, industriji i energetici.

Vodikove gorivne ćelije predstavljaju tehnologiju koja pretvara vodik i kisik u električnu energiju, s vodom kao jedinim nusproduktom. Ova tehnologija nudi značajne prednosti u usporedbi s konvencionalnim fosilnim gorivima, uključujući niže emisije CO₂ i veću energetske učinkovitost.

Gorivne ćelije mogu se klasificirati prema vrsti elektrolita koje koriste i prema načinu temperaturnog režima. Prema vrsti elektrolita razlikujemo:

- alkalne gorivne ćelije (AFC)
- gorivne ćelije s protonskom izmjenom (PEMFC)
- gorivne ćelije s fosfornom kiselinom (PAFC)
- gorivne ćelije s otopljenim karbonatom (MCFC)
- gorivne ćelije sa čvrstim oksidom (SOFC).

Cilj je istražiti mogućnosti primjene gorivnih ćelija, posebice u cestovnom i zračnom prometu ponajprije s ekološkog aspekta. Postupak skladištenja vodika uz respektabilan pristup sigurnosti bitan je jer je vodik lako zapaljiv u tekućem stanju. Svakako je potrebno naglasiti sve aspekte sigurnosti primjene vodika kao goriva te cjelokupnu održivost globalnog energetskeg sustava.

Zbog ograničenih zaliha fosilnih goriva, odnosno nafte i prirodnog plina, te zbog što većeg zagađivanja koja nastaju zbog istih, nužan će biti prijelaz na energetski sustav koji se temelji na čistom okolišu. Takav energetski sustav mogao bi biti sustav temeljen na vodiku. Vodik predstavlja vjerojatniji oblik nosioca energije budućnosti jer se može proizvesti iz bilo kojeg izvora a da pritom ne emitira stakleničke plinove i slične nečistoće. Tehnologije za njegovu proizvodnju, skladištenje i distribuciju naveliko su već razvijene no ipak nisu toliko „popularne“. Stoga će biti potrebno još neko vrijeme kako bi se takvi procesi dodatno istražili, naglasivši sve vodikove prednosti ali i mane koje svako konvencionalno gorivo ima.

Potencijalni rizici pri upotrebi vodika kao goriva su curenje (mala viskoznost, visoka difuznost i velik uzgon), sklonost paljenju te naposljetku brzo razvijanje plamena.

2. PROIZVODNJA VODIKA

Vodik se uglavnom proizvodi iz fosilnih goriva, prirodnog plina, nafte i ugljena. Tehnologija proizvodnje vodika iz fosilnih goriva uključuje reformiranje parom, djelomičnu oksidaciju i rasplinjavanje. Vodik se proizvodi termokemijskim i biološkim procesima te pomoću fotoelektrokemijskog sustava.

Kako bi proizvodnja bila relativno održiva treba je povezati sa skladištenjem nastalog nusprodukta CO₂. Trenutno se cca 18% proizvedenog vodika na svjetskoj razini dobiva rasplinjavanjem ugljena u velikim središnjim postrojenjima. Potencijala za napredak ima, a odnosi se na: inovativne membrane za odvajanje zraka, napredak u konfiguraciji rasplinjača, sustave za pročišćavanje vrućeg plina, nova otapala i membranske reaktore za odvajanje vodika i ostalo. Trenutno manje korištene tehnologije ili one u razvoju su: termičko ili katalitičko kreiranje metana koje transformira metan u vodik i ugljik bez proizvodnje CO₂; proces reakcije poboljšanog upijanja koji u istom reaktoru kombinira reakcije reformiranja parom i pomaka sekvenciranjem CO₂ (kroz apsorpciju u prikladnijim materijalima); reformiranje solarne pare gdje se koncentrirana sunčeva energija koristi kao izvor topline za reakciju reformiranja. [1]

Elektroliza, proces razdvajanja vode na vodik i kisik, uz pomoć električne energije je nešto skuplji od onoga proizvodnje vodika iz fosilnih goriva i zahvaća manji udio svjetske proizvodnje (cca 4%). Proces se uglavnom koristi za dobivanje vodika visoke čistoće. Dvije su vrste elektrolizatora: alkalni koji koriste vodenu otopinu kalijeveg hidroksida (KOH) i čvrsti polimer (obično za manje kapacitete) čiji je elektrolit polimerna membrana (isto kao u gorivnim ćelijama s polimernim elektrolitom). Prednosti čvrstih polimernih elektrolizatora su odsutnost korozivnih tekućina, veća gustoća struje i radnih tlakova, a nedostaci se kriju u izdržljivosti. Održivost opisanog procesa ovisi o prvom izvoru korištenom za proizvodnju električne energije.

Proizvodnja vodika iz biomase temelji se na termokemijskim i biološkim procesima. Voda se cijepa na vodik i kisik zbog termokemijskih ciklusa kroz niz kemijskih reakcija, koje uključuju međuspojeve koji se u potpunosti recikliraju na kraju procesa. Takvi ciklusi rade

na temperaturama $T > 2000^{\circ}\text{C}$ teoretski, bez električne energije. Toplina se može dobiti iz solarnih ili nuklearnih izvora, a efikasnost se procjenjuje 40-50% većom od elektrolize vode, ako prihvati učinkovitost proizvodnje električne energije. Nedostaci ovog procesa su odvajanje proizvedenog vodika i problem korozije povezan s kemikalijama. Zbog svoje kompleksnosti, termokemijski proces se razmatra za centraliziranu proizvodnju vodika, skupa s postrojenjima za nuklearnu energiju IV. generacije ili koncentriranim solarnim sustavima. Razvoj tehnologije iziskuje velik istraživački napor, a prve komercijalne sustave možemo očekivati od 2030. pa nadalje. [1]

Fotoelektrokemijski sustav koristi poluvodiču, uronjen u vodenu otopinu i izravno pretvara sunčevu svjetlost u kemijsku energiju. Proces se pokazao ekonomičniji i učinkovitiji od procesa fotonaponske elektrolize. [1]

Ostale tehnologije za proizvodnju vodika odnose se na proizvodnju iz vode pomoću sunčeve svjetlosti i fotosintetskih mikroorganizama.

3. USPOREDBA VODIKA S KONVENCIONALNIM GORIVIMA

Uspoređujući vodik s ostalim konvencionalnim gorivima koji se koriste u pomorstvu (metan, benzin) dolazi se do slijedećih spoznaja. Vodik ima brzi razvoj opasnosti od požara u slučaju izlivanja, za razliku od benzina koji ima spori razvoj. U slučaju nastanka požara isti traje najkraće, ali je gašenje klasificirano kao teško. Najduže trajanje požara ima benzin. Kod svih goriva koja se koriste u pomorstvu temperatura plamena je ista. Vodik ima najnižu energiju eksplozije po volumenu dok benzin ima najvišu. Temperatura samozapaljenja vodika veća u odnosu na metan i benzin. Međutim, vodik ima najnižu toplinu zračenja te najmanju vidljivost plamena.

3.1. Sigurnosni aspekti vodika kao goriva

Bez opreznog rukovanja i kontrole, vodik, kao i ostala goriva, predstavlja potencijalni rizik. U odnosu na ostala goriva, vodik je istovremeno opasniji i sigurniji. Zbog svojstava poput gustoće, viskoznosti i koeficijenta difuzije, curenje vodika je od 1,26 do 2,8 puta brže, nego li curenje prirodnog plina. Brzina plamena vodika sedam puta je brža nego ona prirodnog plina ili benzina, što bi značilo da ukoliko bi došlo do eksplozije, vodik ima 22 puta manju eksplozivnu energiju, od one karakteristične za benzin. S obzirom na to da je vodikov plamen nevidljiv ljudskom oku potrebno je riješiti dodavanje kemikalija koje emitiraju svjetlost. Isparavanje benzinske vatre puno je opasnije od isparavanja vodikove vatre zbog toga što požar vodika proizvodi samo vodenu paru.

Kvar spremnika vodika odnosi se na sljedeće [1]:

- katastrofalno puknuće zbog greške proizvodnje spremnika,
- kvara zbog nestručnog rukovanja spremnikom,
- probijanja istog oštrim predmetom ili požarom,
- curenje zbog neispravnog uređaja za rasterećenje tlaka ili kemijski induciranog kvara na stijenci spremnika.

Provedene studije dovele su do zaključka da je puknuće malo vjerojatan događaj. Prethodno navedeni problemi mogu se smanjiti upotrebljavanjem sljedećih mjera [2]:

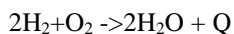
- sprječavanje propuštanja kroz dizajn sustava,

- odabir odgovarajuće opreme, otpornosti na udarce i vibracije,
- detektiranje ventilacijskog otvora uređaja za rasterećenje tlaka,
- protekcija visokotlačnih vodova,
- implementacija normalno zatvorenog solenoidnog ventila na svaki dovodni vod spremnika, itd.

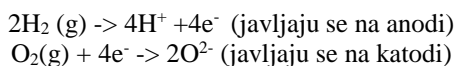
4. VODIKOVE GORIVNE ČELIJE

Gorivne ćelije mogu se podijeliti prema vrsti elektrolita koji koriste te prema temperaturnom režimu rada. Prema vrsti elektrolita razlikujemo: alkalne gorivne ćelije (AFC), gorivne ćelije sa polimernom elektrolitskom membranom (PEMFC), gorivne ćelije sa fosfornom kiselinom (PAFC), gorivne ćelije s otopljenim karbonatom (MCFC) te gorivne ćelije sa čvrstim oksidom (SOFC). Kada govorimo o temperaturnim režimima rada, gorivne ćelije se dijele na: niskotemperaturne (gdje spadaju PEM, AFC te PAFC gorivne ćelije) te visokotemperaturne (MCFC te SOFC gorivne ćelije).

Princip rada gorivne ćelije može se objasniti na sustavu s vodikom kao gorivom i kisikom kao oksidansom. Ako se vodik i kisik u plinovitom stanju dovedu u kontakt oni se spajaju u vodu i oslobađaju energiju bez direktnog izgaranja prema relaciji:



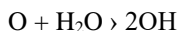
Reakcijski koraci oksidacije H_2 i redukcije O_2 odvijaju se na odvojenim površinama elektroda u dvije prostorno odvojene polureakcije:



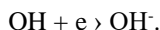
Redukcija kisika je složena, višestruka reakcija, čiji mehanizam ovisi o materijalu elektrode. Ukupna reakcija ima nekoliko podreakcija. Procesom disocijacije atomski kisik se adsorbira na površini metalne elektrode:



Reakcijom s vodom nastaju hidroksilne grupe adsorbirane kao hidroksid na površini metala:



Nadalje procesom elektronacije nastale hidroksilne skupine se reduciraju u ione:



Za dobivanje višeg napona pojedinačne gorivne ćelije se spajaju u „snop“ gorivnih ćelija, a snop gorivnih ćelija se dobiva tako da se svaka ćelija spaja na slijedeću. Kako bi se međusobno povezale ćelije koristi se bipolarna ploča. Rad snopa gorivne ćelije zahtijeva

učinkovito upravljanje toplinom, zrakom, vodikom i vodom omogućeno zahvaljujući dodatnoj opremi kao što su pumpe, puhala i kontrole. [2]

5. PRIMJENA GORIVNIH ČELIJA

Napretkom tehnologije gorive ćelije sve se više primjenjuju glede tehničkih specifikacija i ekonomskog aspekta. Primjenjuju se u svim oblicima prometa s tim da će se u ovom radu objasniti prednosti njihove uporabe u cestovnom i zračnom prometu. S aspekta primjene u svakako je naglasak na osobnim vozilima.

5.1. Primjena u cestovnom prometu

U cestovnom prometu koncept primjene gorivnih ćelija predstavlja izazov suvremenom društvu kako kod osobnih vozila (automobila) tako i u javnom prijevozu. Uglavnom su veliki proizvođači automobila predstavili svoj prototip vozila na gorivne ćelije, a neki od njih i proizveli manje serije vozila na gorivne ćelije i nagovijestili planove za proizvodnju i komercijalizaciju u skorijoj budućnosti. Natjecanje za razvoj održivog vozila na gorivne ćelije i njegovo plasiranje na tržište počelo je 90-ih godina 20-og stoljeća i nastavljeno je u 21. stoljeću. Nastojanja i želje za razvojem tehnologije automobilskih gorivnih ćelija su učinkovitost vozila, niske ili nulte emisije i gorivo koje bi se moglo proizvoditi iz autohtonih izvora. Problemi za uvođenje nastaju kod cijena gorivnih ćelija, te cijena i dostupnosti vodika. [3]

Potreba za snagom i učinkovitošću (ušteda goriva) svakako je bitna stavka posebice s točke smanjenja stakleničkih plinova. Snaga automobilskog motora ovisi o kriterijima, kao što su: masa vozila, površina prednjeg poprečnog presjeka, koeficijent otpora, koeficijent otpora kotrljanja i učinkovitost pogonskog sklopa, a modificira se brzinom vozila, ubrzanjem i nagibom ceste. Učinkovitost automobilskog motora uglavnom je izražena kao specifična potrošnja goriva [g kWh⁻¹]:

$$f_c = \frac{3.6 \cdot 10^6}{\eta_{sys} \cdot H_{LHV}}$$

gdje je:

H_{LHV} – niža ogrjevnost goriva (kJ/kg)

η_{sys} – učinkovitost vozila. [3]

Specifična potrošnja goriva za benzinski motor s unutarnjim izgaranjem približno iznosi 240 g kWh⁻¹, što je učinkovitost od 34%, dok je za dizelske motore učinkovitost oko 40%. Specifična potrošnja goriva za motor na gorivne ćelije je ispod 60 g kWh⁻¹, što bi u efikasnosti iznosilo iznad 50%. Benzinski motor s unutarnjim izgaranjem i sustav gorivnih ćelija u principu se razlikuju s obzirom da prvi ima maksimalnu efikasnost u vrijednosti svoje maksimalne snage, dok drugi istu ima pri djelomičnom opterećenju. Učinkovitost sustava gorivnih ćelija može biti duplo veća od motora s unutarnjim izgaranjem, jer motor većinu vremena radi pri djelomičnom opterećenju. [3]

Sustav automobilskih gorivnih ćelija ovisi o izboru goriva. Potencijalna goriva za vozila na gorivne ćelije su vodik, benzin ili metanol, a svaki ima prednosti i nedostatke. [1]

Odabir goriva ovisi o sljedećim čimbenicima:

- infrastruktura za opskrbu gorivom i trošak izgradnje,
- trošak goriva po energetske sadržaju ili po milji,
- posljedice na okoliš,
- kompleksnost i troškovi skladištenja i obrade na vozilu,
- sigurnost,
- nacionalna sigurnost i energetska politika. [3]

Prosječan rad sati vozila je u rasponu 3000-5000 h, a isto se očekuje za vozila na gorivne ćelije. Ono što bi moglo utjecati na vijek vozila je rad s promjenjivom snagom, učestala paljenja i gašenja, nečistoća u gorivu i zraku, te rad u različitim uvjetima. Veličina i težina automobila s pogonom na vodikove gorivne ćelije mora biti slična onome na pogon s unutarnjim izgaranjem.

Od 90-ih godina 20-og stoljeća, svjetski giganti automobilske industrije, kao što su Ford i Chrysler, radili su na raznim verzijama vodikovih gorivnih ćelija. Također, Daimler, Toyota i Honda, započeli su programe u matičnim državama. [4]

Gorivne ćelije prvo su podvrgnute testiranju na korisnim vozilima (slika 1), poput industrijskih vozila za rukovanje materijalima, vozila za vuču u zračnoj luci, vozila za selidbu ljudi u zračnoj luci, kolica za golf, vozila za održavanje travnjaka i ostala. Takva vozila nemaju zahtjeve kao što imaju autobusi ili automobili. [3]



Slika 1. Prototip viličara s pogonom na vodik [1]

Još jedna uporaba gorivnih ćelija u cestovnom prometu odnosi se na skutere i bicikle. Za razliku od automobila, snaga potrebna za skutere je oko 3 kW, te nekoliko stotina vata za bicikle. No, i dalje se vuče problem skladištenja vodika, makar je domet skutera mnogo manji i ne zahtijeva veliki spremnik za skladištenje vodika. Takav problem se može riješiti uporabom kućnih uređaja za punjenje goriva, poput elektrolizera ili distribucijom metalnih hidridnih spremnika. [3]

5.2. Primjena u zračnom prometu

Potencijalna goriva za upotrebu u zrakoplovima su: sintetički zrakoplovni kerozin (*Synjet*), tekući metan LCH_4 i tekući vodik LH_2 .

Neki autori navode kao moguće kandidate goriva etilni alkohol, metilni alkohol i amonijak, no takva goriva nisu energetska. To znači da je njihova toplina izgaranja toliko niska da bi težina goriva bila dva puta veća nego kod konvencionalnih goriva koja se sada upotrebljavaju u zrakoplovima. To predstavlja problem zbog veličine skladištenja, a time i veličine zrakoplova, pa bi se takva tekuća goriva eventualno mogla koristiti u automobilima. [2]

Niži omjer uzgona i otpora (L/D – *left to drag*) i manje opterećenje krila karakteriziraju zrakoplove s pogonom na vodik, a oni su posljedica niske gustoće goriva. Kako bi se smanjio omjer površine i volumena spremnika mjesto za skladištenje vodika u zrakoplovima je trup u odnosu na skladištenje konvencionalnih goriva gdje se mlazno gorivo skladišti na krilima. Tako će zrakoplovi na pogon vodika imati veće trupove nego što to inače biva. S obzirom na malu težinu goriva uzlijetanje će biti lakše, a time i površina krila manja kako bi mogao djelovati s piste. Veliki trup i mala krila dovode do nižeg omjera uzgona i otpora. Nisko opterećenje dolazi iz činjenice male težine goriva koja se troši tijekom leta. Budući da je vodik kriogen, to je njegova prednost i nedostatak. Prednost se krije u tome da ima visoku specifičnu toplinu i nisku temperaturu skladištenja ($-423^{\circ}F$), a to znači da služi kao hladnjak za problematične elemente motora i strukture vozila. Mana koja proizlazi iz svojstva niske temperature skladištenja je to što zahtijeva izoliranje spremnika za gorivo i pripadajući vodovod, da bi se smanjilo curenje topline u gorivo.

Da bi se spriječilo ukapljivanje ili zamrzavanje zraka, radi se na izolaciji koja sprječava kontakt zraka s bilo kojim površinama koje su prehladne. Vijek trajanja aviona jest 15 do 20 godina, a u tom periodu trebao bi izdržati udare i naprezanja slijetanja i polijetanja. Također bi u tom razdoblju trebao biti podvrgnut inspekciji, održavanju i zamjeni. [2]

Tekući vodik u podzvučnim i nadzvučnim zrakoplovima nudi ove prednosti: čisti okoliš, poboljšana sigurnost, poboljšane performanse zrakoplova, manje energije potrebno iz resursa, niži izravni operativni troškovi, univerzalna dostupnost te povoljan ekonomski učinak. [2]

5.3. Primjena u pomorstvu

U pomorskom prometu, vodik se kao gorivo upotrebljava u gorivnim člancima (najčešća verzija uporabe) te u motorima na unutarnje izgaranje. Gorivni članci (gorivne ćelije) su elektrokemijski uređaji koji pretvaraju električnu energiju goriva u istosmjernu električnu struju. Brodski sustav pogonjen gorivnim člancima treba osigurati skladištenje, pretvarače (DC/DC, odnosno DC/AC), inverter te elektromotore u cilju njegovog korištenja kao potencijalnog goriva budućnosti. Posebice zbog njegovoj prednosti u cilju smanjenja stakleničkih plinova.

Prva primjena gorivne ćelije u pomorstvu odnosi se na jahtu „Yacht No 1.“. Jahta je duljine 12 metara te se sastoji od tri spremnika gdje je moguće pohraniti šest kilograma vodika pod tlakom od tristo bara. Koristi PEMFC gorivne članke snage 1.2 kW. Nešto sličnijih karakteristika jest i brod „Ross Barlow“ (slika 2), koji također koristi PEMFC gorivne članke, nešto veće snage, 5 kW.

Propulzijski sustav s nultom emisijom zamijenio je postojeći dizel motor te je središnji dio broda pretvoren u natkriveni demonstracijski prostor. Kao medij za pohranu koristi metalni hidrid (opisan ranije) kojeg je razvila grupa stručnjaka u Zürichu. Moguće je pohraniti veliku količinu vodika na sobnoj temperaturi pri tlaku od deset bara.

Sljedeća primjena PEMFC gorivnih ćelija u pomorstvu jest na brodu Nemo H2 prikazan na slici 3. On posjeduje 6 spremnika koji mogu pohraniti 24 kg vodika pod tlakom od 350 bara. Kao rezervu posjeduje i olovne baterije čime je moguće poboljšati performanse gorivnih članaka.



Slika 2. Brod Ross Barlow



Slika 3. Brod Nemo H2

Prvi brod koji je koristio MCFC gorivne ćelije jest brod „Viking Lady“ (slika 4) sagrađen 2009. Brod posjeduje 500 snopova gorivnih ćelija čije je očekivano vrijeme rada cca 24 000 sati. Gorivna ćelija proizvodi električnu snagu od 330 kW i uspješno je radila više od 18.500 sati te je samim time jedan od ekološki najprihvatljivijih brodova na svijetu. Nadogradnjom, u brod su dodane i litij – ionske baterije kako bi se nadomjestilo sporo reagiranje gorivnih članaka s obzirom na česta pokretanja i dinamička opterećenja.

2021. godine u Pariz je stigao prvi teretni brod pogonjen vodikom (slika 5), a projekt je financiran sredstvima Europske unije. Projekt je prvih 18 mjeseci radio kao demo verzija. Njime se preko rijeke Seine prevozio teret namijenjen gradovima. U projektu se koristio komprimirani vodik dobiven procesom elektrolize čime bi se dobila snaga od 1 MW.



Slika 4. Viking Lady



Slika 5. Prototip broda na rijeci Seine

Toyota svojom tehnologijom vodikovih gorivnih ćelija oprema katamaran Energy Observer (slika 6) za put oko svijeta. U ovoj kompaniji vjeruju da vodik doprinosi proizvodnji energije bez negativnih emisija ugljika, i da će osvajanje modularne tehnologije gorivnih članaka ubrzati njenu primjenu na brojnim područjima primjene. Toyotin Fuel Cell System je razvijen kao modularno rešenje koje se može primijeniti i u pomorstvu na primjeru broda koji proizvodi i troši vodik. Tijekom šestogodišnje priče, započete 2017. godine, posada Energy Observera je plovila svjetskim morima i oceanima

prvim brodom koji autonomno proizvodi vodik. Ovo elektro-plovilo budućnosti koristi više obnovljivih izvora energije, kao i sustav za proizvodnju vodika iz morske vode, bez emitiranja štetne emisije ugljika. Dakle, Energy Observer predstavlja ekološku i energetska prekretnicu, unapređujući energetska rješenja budućnosti, čineći ih efikasnim i primjenjivima u mnogim primjerima. Modul sa gorivnim člancima je testiran na plovilu u brodogradilištu i pod punim opterećenjem na moru. Nakon tri naporene godine i gotovo 20.000 nautičkih milja dokazano je kako je sustav proizvodnje i skladištenja energije na Energy Observeru (slika 7) veoma pouzdan. [8]



Slika 6. *Energy Observer* [8]



Slika 7. Sustav ugrađen u plovilo [8]

6. ZAKLJUČAK

Zbog ograničenih zaliha fosilnih goriva, odnosno nafte i prirodnog plina, te zbog što većeg zagađivanja koja nastaju zbog istih, nužan će biti prijelaz na energetska rješenja koja se temelje na čistom okolišu. Vodik predstavlja najvjerojatniji oblik nosioca energije budućnosti jer se može proizvesti iz bilo kojeg izvora a da pritom ne emitira stakleničke plinove i slične nečistoće.

Tehnologije za njegovu proizvodnju, skladištenje i distribuciju naveliko su već razvijene no ipak nisu toliko „popularne“. Stoga će biti potrebno još neko vrijeme kako bi se takvi procesi dodatno predstavili naglasivši vodikove prednosti, ali dakako i mane koje svako konvencionalno gorivo ima.

Kako bi se vodik kao gorivo što više koristio potrebno je uspostaviti odgovarajuću infrastrukturu koja uključuje proizvodnju, distribuciju i opskrbu vodikom.

Problem skladištenja vodika zbog njegovih kemijskih i fizikalnih svojstava predstavlja najveću prepreku za sektor prometa. Vodik zahtijeva veće spremnike zbog svoje visoke gravimetrijske gustoće energije. Kako bi brod na vodik imalo slične performanse kao onaj na konvencionalna goriva potrebno je zadovoljiti tehničke, ekonomske i sigurnosne zahtjeve. Ovisno o primjeni i veličini skladištenja razlikujemo sljedeće vrste skladištenja vodika: stacionarni mali i veliki sustavi za pohranu, te mobilni skladišni sustavi za transport i distribuciju.

Sustavi za skladištenje trebaju zadovoljiti kriterije poput visoke gustoće energije, visoke gustoće snage, niskih gubitaka u slučaju ključanja tekućeg vodika, malenog utjecaja na okoliš i sigurnog rukovanja na stanicama za punjenje vodikom. S obzirom na agregatno stanje vodika[4] potrebno je odabrati adekvatno vrste skladištenje vodika na plovilima.

Zaključuje se, vodik je siguran, ali isto toliko i nesiguran kao gorivo. Navedene mane navedene u prethodnim razmatranjima ne umanjuju njegovu vrijednost kao zamjenskog goriva, dapače zbog čiste prirode okoliša u kojem vodik radi, vodikove gorive ćelije mogle bi naveliko zamijeniti postojeća goriva no uz jednu pretpostavku a to je da njegova

proizvodnja a samim time i korištenje postane masivno. Takva politika mogla bi se postići uz neke promocije provedene od strane države, ali time i susjednih država koje su već počele s uvođenjem vozila odnosno zrakoplova na vodikov pogon.

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HYDROGEN FUEL CELLS AN ALTERNATIVE FUEL IN TRANSPORT

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ABSTRACT:

Hydrogen (H) is a chemical element, which in its molecular state is colorless, tasteless, and odorless. In its atomic state, it is highly reactive and is not found independently in nature. It is a major component of water and inorganic substances, constituting 75% of the mass of the Sun.

Given the availability of hydrogen in compounds such as water (H₂O), methane (CH₄), fossil hydrocarbons, and biomass, it is necessary to address the challenges of its separation from these compounds, storage, distribution, and utilization as a potential fuel of the future.

The aim is to elucidate these challenges, as well as to outline the advantages of hydrogen compared to conventional fuels. Hydrogen is increasingly being utilized as an alternative fuel in various applications. Emphasis is placed on its advantage due to efforts to reduce greenhouse gas emissions.

Keywords: *hydrogen, hydrogen fuel cells, fuel, transport*

TEHNIČKA REŠENJA U PROJEKTOVANJU KAMINA KAO INOVIRANOG EKOLOŠKI PRIHVATLJIVOG PROIZVODA

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SAŽETAK:

Sagledavanjem međusobne zavisnosti ekonomije, društva i životne sredine, glavni izazov u razvoju savremenih proizvoda predstavljaju ne samo zahtevi tržišta, već i uticaj proizvoda na životnu okolinu, koji je iz koncepta prevencije zagađenja prerastao u koncept održivog razvoja. Ovaj rad će ukratko pokazati inovacije i invencije koje su doprinele razvoju kamina kao ekološkoj prihvatljivog proizvoda. Ostvarene inovacije doprinose smanjenoj upotrebi resursa, odnosno smanjenoj upotrebi energenata. Takođe, savremeni materijali koji se koriste u izradi ovog kamina ne samo da odgovaraju propisima energetske efikasnosti, već su i po svojoj strukturi ekološki prihvatljiviji.

Ključne riječi: Tehnička rešenja, Kamin, Inoviranje proizvoda, Ekološki prihvatljiv proizvod.

1. UVOD

Krajem sedamdesetih godina prošlog veka, nastao je koncept prevencije zagađenja, kao pokušaj da se deluje na uzroke i činioce a ne na posledicu [1]. Pri tom je fokus bio preusmeren ka razvoju tehnologija orijentisanih na očuvanje životne sredine. Ovim konceptom obuhvaćeni su ne samo snabdevanje sirovinama i proizvodnja, već i potrošnja i odlaganje proizvoda nakon upotrebe. Zbog toga je, sa naglaskom na održivi razvoj, koncept prevencije zagađenja proširen na sve aktivnosti koje se dešavaju tokom kompletnog životnog veka proizvoda, kao i na sve aktivnosti čoveka koje utiču na privredu, životnu sredinu i društvo. Koncept održivog razvoja [2] sagledava i ukazuje na snažnu zavisnost ekonomije, društva i životne sredine koji predstavljaju tri osnovna stuba održivosti. U svemu ovom, ključnu ulogu ima čovek. Na njemu je odgovornost da nađe pravilan odnos svojih aktivnosti kojima ostvaruje ekonomsku dobit zarad društvenog boljitka, neugrožavajući pri tom životnu (i radnu) sredinu.

U takvom okruženju gde je za primarni cilj postavljen održivi razvoj kao odgovornost na potrebe budućih generacija, kreiran je osnovni pristup u održivom razvoju koji je zasnovan na industrijskoj ekologiji. Razvoj zelenih tehnologija doprineo je prevenciji zagađenja ali je i formirao još jednu metodologiju koja ima nekoliko sinonima poput zelenog dizajna, dizajna za okruženje ili ekodizajna. Ekodizajn pre svega predstavlja metodologiju nastalu

kao sveobuhvatan proces razmišljanja o životnom ciklusu proizvoda, sa krajnjim zadatkom da predvidi sve faze u životnom ciklusu proizvoda prateći pri tom pre svega tok materijala i njegovu transformaciju, utrošak energije i ostvarene emisije (u vodu, vazduh i zemlju) u svakoj od faza životnog ciklusa proizvoda [1].

Životni ciklus proizvoda [3] započinje iskopavanjem sirovina, njihovim transportom i obradom u materijal, da bi preko dizajna i proizvodnje, transporta i upotrebe proizvoda, došli do krajnjeg odlaganja proizvoda, tj. odluke šta uraditi na kraju životnog ciklusa određenog proizvoda (reparaciju, reciklažu ili deponovanje-odlaganje na deponiju). Primarni zadatak Ekodizajna [4] je da koncipira proizvod koji će u svim fazama životnog ciklusa proizvoda ostvariti minimalan negativni uticaj na životnu sredinu, tj. da se razvije tržišno orijentisan, ekološki prihvatljiv proizvod.

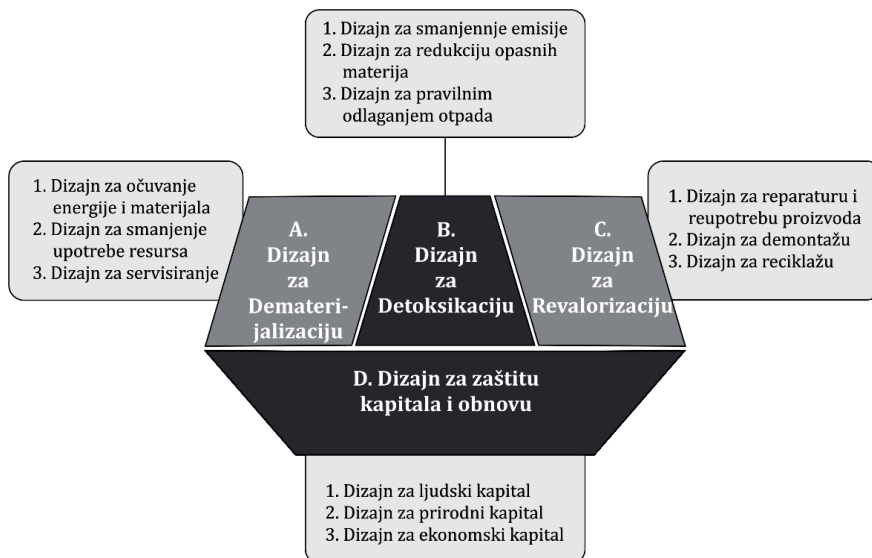
Ekološki aspekti razmatranja dizajna i proizvodnje određenog proizvoda u prvi plan ističu upotrebu energenata i emisije koje u tom procesu nastaju. Energija se prvenstveno sagledava u smislu količine upotrebene energije u određenim fazama, potrebne da bi se proizvod izradio, ali i u sagledavanju porekla energije (obnovljivi ili neobnovljivi resursi).

Konvencionalni (klasični) kamin [5] greje uglavnom direktnim zračenjem toplote iz vatre za šta nije potreban nikakav medijum. Različita vrsta energenata i konstrukcije čine da postoji veliki broj vrsta kamina. U ovom radu glavni aspekt biće na kaminu od opeke, gde se kao energent koristi drvo. Drvo u konvencionalnom kaminima, uz dovoljnu količinu vazduha, potpuno sagoreva pa je njegov produkt CO₂, koji okolno drveće, u tako malim količinama, fotosintezom lako razdvaja na vodu i ugljenik od koga se stvara nova drvena masa. Ceo proces odvija se u jednom zatvorenom krugu, bez štete po čovekovu okolinu. Iako su kamini u osnovi ekološki prihvatljivi proizvodi sa aspekta emisije CO₂, sagledavanjem životnog ciklusa proizvoda kao i njihovom energetske efikasnošću, primetan je znatno veći ekološki otisak ovog proizvoda [6, 7]. Zbog toga je u razvijenim zemljama gotovo standard da svi kotlovi sa otvorenim plamenom na čvrsto gorivo, pa tako i kamini, moraju da zadovolje potrebne propise u cilju energetske efikasnosti i ekološke prihvatljivosti.

2. METODOLOGIJA EKODIZAJNA U RAZVOJU EKOLOŠKI PRIHVATLJIVOG PROIZVODA

Ekološki prihvatljiv proizvod (eko proizvod) šteti životnoj sredini do zadovoljavajućeg (prihvatljivog) nivoa u svim fazama životnog ciklusa, a ne samo u fazi upotrebe proizvoda, kako se često podrazumeva. Savremeno odgovorno poslovanje naglašava pristup održivog razvoja kao jedan od prioriteta u projektovanju ne samo kvalitetnog i cenom prihvatljivog proizvoda, već i ekološki prihvatljivog.

Ekodizajn je pre svega metodologija u kojoj se ističu određeni strateški pravci. Te strategije nisu jedinstvene i ne mogu se univerzalno primenjivati, već se shodno specifičnim osobinama proizvoda drugačije primenjuju. Svaka od strategija nije nezavisna od drugih, već se prava mera pogodnog dizajna ostvaruje kombinovanjem ovih pristupa, kao što i prikazuje slika 2.



Slika 2. Četiri glavne strategije Ekodizajna [8, 9]

Preporuke Ekodizajna dobijene iz proizvodnih pogona, sa praktičnih projekata, u različitim industrijama su objedinjene u 4 glavne strategije [8]:

1. Dizajn za Dematerijalizaciju teži da smanji upotrebu resursa;
2. Dizajn za Detoksikaciju smanjuje ili eliminiše toksične, opasne ili štetne karakteristike proizvoda i njegovih procesa;
3. Dizajn za Revalorizaciju pokušava da obnovi, reciklira ili na neki drugi način ponovo upotrebi ostatak materijala i energije, eliminišući pri tom otpad i smanjujući upotrebu sirovina;
4. Dizajn za Zaštitu Kapitala i Obnovu obezbeđuje dostupnost, integritet, vitalnost, produktivnost i kontinuitet ljudskih, prirodnih i ekonomskih resursa.

3. KASETNI KAMIN – KD6

Firma DOO DLT INDUSTRIES [10] bavi se proizvodnjom kasetnih kamina poštovanjem standarda i zakonske regulative koji važe na teritoriji Nemačke. Na taj način kasetni kamin pod nazivom KD6 zadovoljava sve regulative ove države zbog čega mora da prođe sertifikaciju u pogledu ispunjavanja standarda za ekodizajn i ograničenja BImSchV 2 standarda kao i standarda ISO 9001, 14001 i DIN ISO 50001. Napredna rešenja osiguravaju uštedu energije i čine rad i čišćenje uređaja veoma jednostavnim.

Tehnička rešenja i primena novih materijala u projektovanju i izradi kamina daju sledeće prednosti u odnosu na klasični kamin [9]:

- Visoka iskorišćenost toplote - testirana efikasnost do 84.1%
- Snaga grejanja 5 - 12,5KV (zavisno o veličini i obliku)
- Mala potrošnja drva zahvaljujući podešavanju sagorevanja

- Automatska kontrola vazduha bez elektronike - jednostavan rad
- Nema opasnosti od požara - vatra iza stakla i samo zatvorenih vrata
- Ventilirani keramički disk - očuvana je atmosfera otvorene vatre
- Proizvodnja po meri - nije potrebno dugotrajno, skupo obnavljanje otvorenog kamina
- Energetska ušteda troškova



Slika 3. Kasetni kamin KD6 firme DOO DLT INDUSTRIES

Inovativna tehnička rešenja u projektovanju i izradi kasetnih kamina ogledaju se u:

- Primeni inovativnih rešenja
- Upotrebi novih materijala

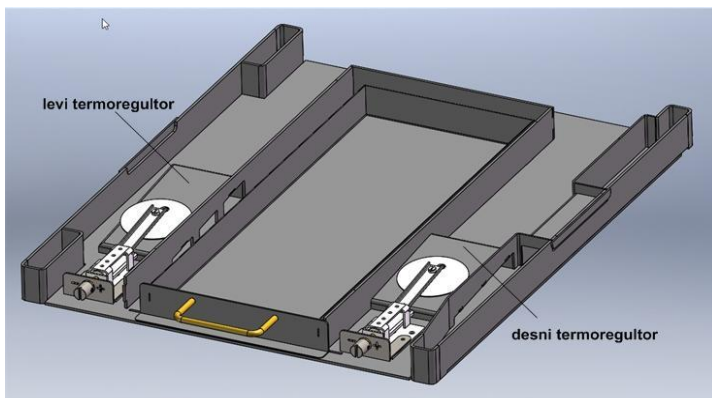
4. INOVATIVNA REŠENJA U PROJEKTOVANJU KASETNOG KAMINA

Inovativna rešenja koja su primenjena u izradi ovog kasetnog kamina su dovod sistemom primarnog i sekundarnog vazduha koji reguliše sagorevanje u ložištu kamina i primena sistema vazdušne zavese koja ima funkciju sprečavanja pojave čadji na staklu (prozoru) kamina. Primarni zadatak jeste poštovanje standarda [11] u projektovanju koji će ispuniti kriterijume potrebne za izradu kamina i otvorenih kamina na čvrsta goriva.

Pri izradi ovih kasetnih kamina iskorišćena su i neka nova tehnička rešenja kao što je ABC QUADRO i ABC ROLO [12]. To je tehničko rešenje kojim je sagorevanje potpomognuto regulisanjem primarnog i sekundarnog vazduha. Primarni vazduh je doveden u donju zonu peći ispod rešetke u ložištu i obezbeđuje brzo podizanje temperature peći tokom faze potpale. Sekundarni vazduh je doveden u gornju zonu peći i snabdeva ložište sa određenom količinom zagrejanog vazduha neophodnog za potpuno sagorevanje gasova koji se oslobađaju prilikom sagorevanja drveta.

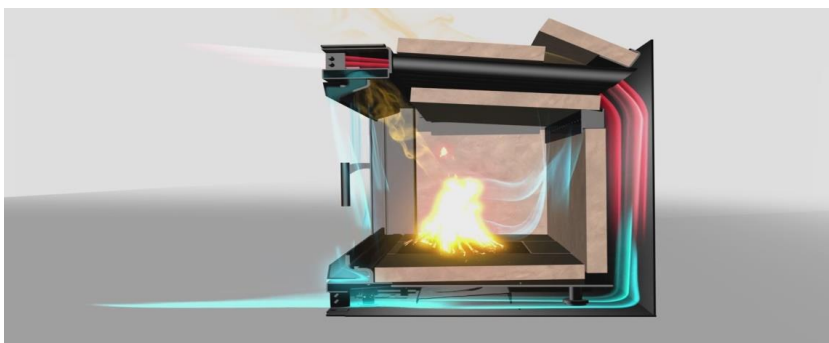
Sekundarni vazduh ima još jednu ulogu a to je da sprečava stvaranje naslaga čadji na staklu vrata ložišta. To znači da je u svakom momentu obezbeđeno potpuno sagorevanje (postoje dve poluge u donjem delu peći koje se koriste za pomenutu regulaciju).

Kod sagorevanja u ovim kaminima imamo dve različite faze. Njihova učinkovitost se postiže razvodom primarnog i sekundarnog vazduha koje je izvedeno tehničkim rešenjem kao na slici 4.



Slika 4. Presek razvodnika primarnog i sekundarnog vazduha [13]

Ovaj termoregulator protoka vazduha pruža automatsku kontrolu temperature i ekonomičnost u sagorevanju goriva. Regulator protoka vazduha je od robusne čelične konstrukcije sa bakarnim sensorima i kapilom. Ovaj uređaj kontroliše sagorevanje goriva tako što se kontroliše dotok primarnog i sekundarnog vazduha koji se prebacuje na vatru.



Slika 5. Protok primarnog i sekundarnog vazduha u gorioniku kamina [13]

Pored sistema primarnog i sekundarnog vazduha, ovaj kasetni kamin je opremljen sistemom vazdušne zavese, tako da se cirkulacija vazduha odvija direktno uz staklo kroz sistem kanala koji se nalaze na bočnim stranama kamina. Na ovaj način kiseonik se dovodi u gornji deo komore za sagorevanje, gde se dešava sekundarno sagorevanje gasova nastalih tokom sagorevanjem drveta. Istovremeno smanjuju se štetne emisije CO u atmosferu. Takav sistem vazduha omogućava vrlo precizan nadzor procesa gorenja.

Zbog dvostruke ventilacije kasetna i tercijarnog vazduha, koji dodatno dovodi vazduh u komoru za sagorevanje na zadnjoj strani, drvo i staklokeramička ploča uvek dobijaju optimalnu količinu svežeg vazduha. Način rada kasetnog kamina, sa njihovim dvostrukim kanalima, povećava performanse i sprečava prekomerno pojave čađi na oknu. Gasovi iz kasetnih kamina usporavaju se i sagorevaju znatno više zagađivača nego na otvorenim kaminima. Tehnologija sagorevanja je efikasna i funkcija je na taj način poboljšana [13].

Zagađivači se efikasno sagorevaju, a kasetni kamini ispunjavaju sve propise koji se tiču sitne prašine, pepela i emisija gasova.

5. PRIMENA SAVREMENIH MATERIJALA

U projektovanju i izradi kasetnih kamina upotrebljeni su novi materijali koji poboljšavaju sam kasetni kamin u pogledu inovacije a i u pogledu ekološki prihvatljivog proizvoda. Savremeni materijali koji su zamenili tradicionalne materijale i doprineli poboljšanju proizvoda su:

- VERMIKULIT za oblaganje ložišta kasetnog kamina
- Vatrostalno staklo ROBAX®

Vermikulit [14] je prirodni mineral, koji se ne širi sa povećanjem toplote, ne raspada se i ne razlaže, trajan je. Glavne karakteristike vermikulita jesu ta da je on pH neutralan, reaguje uglavnom alkalno, male je mase i sadrži mehure vazduha što utiče na njegove visoke izolatorske sposobnosti. Zbog povećane vatrootpornosti minimalne provodljivosti toplote, mogućnosti primene u temperaturnom opsegu od -260 °C do 1350 °C, kao i činjenica da je veoma jednostavan i praktičan za rad, ovaj materijal se, umesto šamota, koristi za oblaganje unutrašnjosti kamina.

Pored toga, materijali, uključujući ekspanziran vermikulit, brzo i bez smanjenja tehničkih karakteristika otporni su na klimatske promene, mehanički uticaj, te duže vreme zadržava svoj učinak u zaštiti od požara. Protiv požarna zaštita napravljena od njih zadržava svoje karakteristike na duži vremenski period. Primena vermikulit ploča kod kasetnih kamina prikazana je na slici 6.



Slika 6. Ložište kamina obloženo vermikulit pločama (levo) i dimni kanal obložen vermikulitom (desno)

Vatrostalno staklo ROBAX® je staklo keramičke strukture koje je otporno na ekstremne temperature, otvoreni plamen kao i temperaturne šokove (polivanje hladnom vodom po užarenom staklu) [15].

Vatrostalno staklo ROBAX ima veoma nizak stepen ekspanzije usled korišćenja pri velikim temperaturama. Pruža maksimalnu sigurnost koja ne utiče na providnost stakla kao ni na rok trajanja koji je procenjen da je doživotni uz adekvatno korišćenje propisano od strane proizvođača. Vatrostalno keramičko staklo ROBAX se proizvodi u Nemačkoj u firmi SCHOTT AG koja garantuje za kvalitet proizvoda sa visokim performansama i ispunjenost standarda ISO 9001, ISO 14001 i ISO 50001.

Vatrostalno staklo ROBAX postavlja se na prednjem delu kamina (prozor kamina) obično na vratima ložišta.

6. ZAKLJUČAK

Zahtevi održivog razvoja implementirani su metodologijom ekodizajna i to pre svega poštovanjem strategije dizajna sa aspekta smanjivanja upotrebe materijala. Takav pristup dao je primenu savremenih materijala upotrebljenih za izradu kamina vermikulita i vatrostalnog stakla.

Vermikulit je pokazao snažne termo izolacione sposobnosti, laku obradivost, malu masu. Ovaj materijal ističe se i činjenicom da je potpuno prirodan materijal. Vatrostalno keramičko staklo Robax pored činjanica da je otporno na ekstremne temperature, otvoreni plamen kao i temperaturne šokove, 95% je sačinjeno od prirodnih materijala.

Zbog dvostruke ventilacije kasete i tercijarnog vazduha, koji dodatno dovodi vazduh za sagorevanje u komoru za sagorevanje na zadnjoj strani, drvo i staklokeramička ploča uvek dobijaju optimalnu količinu svežeg vazduha.

Pored primene savremenih materijala, primarni aspekt ovog rada ogleda se u razvoju i primeni inovativnih tehničkih rešenja. Dvostrukom ventilacijom primarnog i sekundarnog vazduha dobiven je proizvod koji je povećao učinkovitost grejanja kamina sa 15% na oko 84% koliko pokazuje prikazani kamin KD6.

Pored toga, smanjene su emisije gasova i sagorevanje je potpunije sa znatno manje pepela i čađi, a iskorišćena je i toplota dimovodnih gasova za povećanje učinkovitosti.

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TECHNICAL SOLUTIONS IN FIREPLACE DESIGN AS AN INNOVATED ENVIRONMENTALLY ACCEPTABLE PRODUCT

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ABSTRACT:

Considering the mutual dependence of the economy, society and the environment, the main challenge in the development of contemporary products is not only the demands of the market, but also the impact of the product on the environment, which has grown from the concept of pollution prevention to the concept of sustainable development. This paper will briefly show the innovations and inventions that contributed to the development of the fireplace as an environmentally friendly product. Realized innovations contribute to reduced use of resources, that is, reduced use of energy sources. Also, the new materials used in the manufacture of this fireplace not only comply with energy efficiency regulations, but are also more environmentally friendly due to their structure.

Keywords: *Technical solutions, Fireplace, Product innovation, Eco-friendly product.*

***COMPUTER SCIENCE AND INFORMATION
TECHNOLOGY***

IMPLEMENTATION OF INFORMATION SYSTEM DEVELOPMENT AND PRODUCTION MONITORING IN THE MANUFACTURING COMPANY „JUGOPLAST“

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ABSTRACT:

In the chapters of this scientific research paper, there will be discussion about the application of information systems in a company, organization, the types of information systems represented in the company, the functional areas where these types of information systems are present, with a special focus on the CASE tool MS Access and its application in the manufacturing company Jugoplast. Additionally, there will be mention of an innovation that will significantly simplify the monitoring of the production process. Considering that serial (mass) production often faces the problem of recording the number of shipments (semi-finished or finished products resulting from the work of a machine), it is necessary to implement a system that will automatically record the number of pieces produced at the machine's output (horizontal and vertical presses for extraction, forming, cutting, etc.). The system would involve a sensor that electronically sends data to a PLC, from which the worker reads the result and records it in a form.

Keywords: *information system, application of information system, production, production volume, database.*

1. INTRODUCTION

The management information system - MIS is an information system that is used for decision-making and for coordination, control, analysis and visualization of information in the organization.

The goal of MIS is to be able to connect multiple data points to determine strategic ways to improve operations. For example, being able to compare this month's sales to a year ago, looking at staffing levels can indicate ways to increase revenue. Or, the ability to compare marketing costs by geographic location and relate them to sales can also improve decision-making. But the only way this level of analysis is possible is because of the data compiled through the MIS. Reports covering various data points is a key contribution of MIS. That feature, however, comes with a significant cost. Implementing an MIS is a costly investment that includes the purchase of hardware and software, as well as integration with existing systems and training of all employees.

A process (activity) that facilitates a work activity or a larger organizational setting by introducing a new socio-technical information system or by modifying or expanding an existing one. MIS includes the sub-activities of analysis, design, development,

implementation and evaluation. Depending on one's point of view, it can be seen as the software engineering process of software producers, the process of gathering applications by software users, or the process of developing works.

In the following chapters of this paper, there will be more words about the application of information systems in one company, organization, the types of information systems that are represented in the company, in which functional areas the types of information systems are represented, and a special emphasis will be on the CASE tool MS Access and its application in the company "Jugoplast".

2. Concept of information system

An information system is a set of people and equipment that collect, transfer, process, store and deliver data and information for use according to a certain organization and methods [1]. Information system means a set of different operations on information necessary for decision-making in an organizational system.

The information system must be an effective combination of people and devices, where machines are used to solve certain processes quickly and accurately, and people perform creative analysis in decision-making. Every information system has its three activities that are necessary for the IS user to make decisions [2]:

- To control information,
- Analyzes problems,
- Creates new products and provides services.

Information is a necessary resource for the purpose of quality management of any organization. According to its structure, information must have a source, duration and user. Also, the information must be accurate, precise, complete and, perhaps most importantly, it should be available at the right time, in order to make the right decision based on such information [3].

In MIS, information is recognized as a major resource like capital and time. If this resource should be well directed, it calls for management to plan and control, so that information becomes a vital resource of the system. The information management system should be well planned. This system should deal with management information, not just data processing. It should support management planning, decision-making and action. It should support the changing needs of business management.

The main challenges in the implementation of MIS are [4]:

- ✓ Amount, content and context of information - how much information and what exactly needs to be described,
- ✓ Nature of analysis and presentation - comprehensibility of information.
- ✓ Availability of information - frequency, contemporaneity, on demand or routine, occasional, one-time information or repetitive in nature and so on,
- ✓ Accuracy of information.
- ✓ Reliability of information.
- ✓ System security and authentication.

2.1. Information system life cycle

The development of information systems can be divided into several main areas or phases. These stages are born sequentially, within a linear life cycle, or are distributed among various iterations of an iterative (evolutionary) life cycle. Regardless of the linear or iterative, structural or object-oriented approach, the following four questions should be answered in the development of the information system [4]: What to do? In what domain? How? What skill? [5]

The life cycle of an information system includes several stages [6]:

1. System development planning,
2. Analysis and specification of requirements,
3. Projecting,
4. Implementation and
5. Maintenance.

System development planning includes: general architecture of the information system, defined subsystems, defined connections between subsystems, defined priorities, obtained consent for work - the BSP (Business System Planning) method.

Analysis and specification of requirements includes the following: specification of requirements (what the user wants), process model of the future state of the system, data structure, process logic - SSA (Structural System Analysis) method.

Program design includes: defined software modules (cohesion, connectivity) and defined data flows through the program - SP (Structural Projecting) methods.

Implementation - implies coding, testing. The result is software and a selected programming language (module implementation, introduction of new data types), program testing (Top-down, Bottom-up), test data.

Maintenance - maintenance means training of personnel (IS users), provision of resources for IS support, incorporation of new requirements, correction of errors.

Fig. 1 shows the life cycle of information systems development.



Fig. 1. Information system life cycle [7]

The methodology of the life cycle of information systems appears in the form of a classic, waterfall approach of application. The phases are implemented strictly sequentially, the next phase is not started until the previous phase is completed, the errors from the previous phases, which were discovered in the current phase, require that they be removed and documented by: returning to the previous phases and going through all the previous ones phases.

In the Fig. 2. is given a presentation of the IS waterfall model.

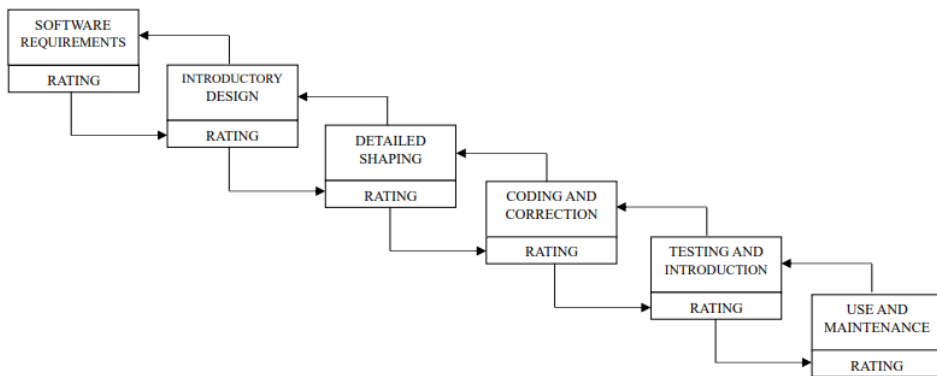


Fig. 2. Information system waterfall model [8]

2.2 The role of MS Access in creating an information system

MS Access stores data in its own format based on the Access Jet Database Engine. It can also import or directly link data stored in other applications and databases [9].

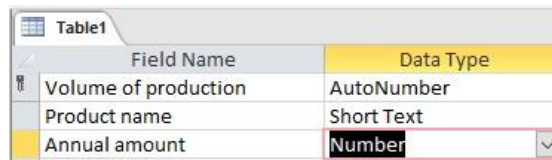
Its asset data is linked as it is entered, so it can be referenced, turning it into valuable information. A well-designed data model will enable you to collect and analyze information to better understand your customers, as well as predict future sales and market trends.

The software will be tailored exactly to the user's business requirements. It will be easy to use and will provide a full range of detailed charts and administrative reports.

MS Access is an excellent tool for creating custom systems with the database at its heart. It contains various wizards to speed up the process of creating a database application and a wide range of easily accessible functionalities. For an expert developer specializing in MS Access, we found that the development time was approximately half that required to create the same system using another platform. This is a huge advantage. This directly translates into cost savings, and that means turnaround time is usually a matter of weeks from start to delivery.

3. Development of the information system on the example of the production volume in the company "Jugoplast"

The production program of the company "Jugoplast" includes products such as moldings and profiles, pipes and hoses and electrodes. What will be presented first are the tables that form the beginning of creating an information system. In Fig. 3 will be presented a table - Volume of production.

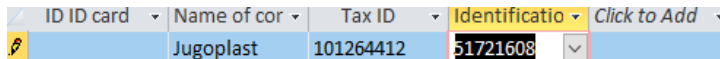


Field Name	Data Type
Volume of production	AutoNumber
Product name	Short Text
Annual amount	Number

Fig. 3. A Table Volume of production

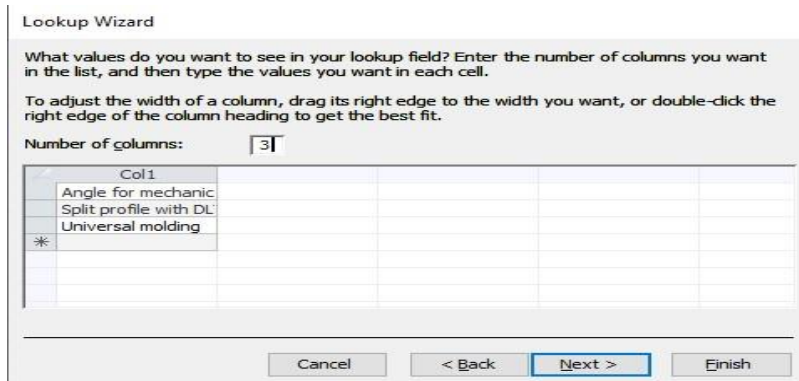
The table clearly shows its elements, as well as the method of selecting the data type. The AutoNumber data type always goes for the ID, the numeric data type for the numbers, such as the annual quantity in this case, and the text type for the product name. In Fig. 4, a Lookup Wizard was created for the product name, which can be seen in the following text.

The identity card of the company is shown in Fig. 4.



ID ID card	Name of cor	Tax ID	Identificatio	Click to Add
	Jugoplast	101264412	51721608	

Fig. 4. - Identity card of the company



Lookup Wizard

What values do you want to see in your lookup field? Enter the number of columns you want in the list, and then type the values you want in each cell.

To adjust the width of a column, drag its right edge to the width you want, or double-click the right edge of the column heading to get the best fit.

Number of columns:

Col 1			
Angle for mechanic			
Split profile with DL			
Universal molding			
*			

Cancel < Back Next > Finish

Fig. 5. Lookup Wizard

The final layout of the table can be seen in Fig. 6.

IDVolume of	Product name	Annual amo	Price per prc	Total annual
1	Angle for mech	397160	\$18,00	7109164
2	Spalette profil	42630	\$30,00	1292968
3	Universal mold	11652	\$132,00	1538064
(New)			\$0,00	

Fig. 6. Volume of production in the company "Jugoplast"

In the following text, a table with basic data about the company will be presented. Based on it, as well as the previous table, a query is created that sorts from the smallest to the largest annual quantity of products, which can be seen in the Fig. 7.

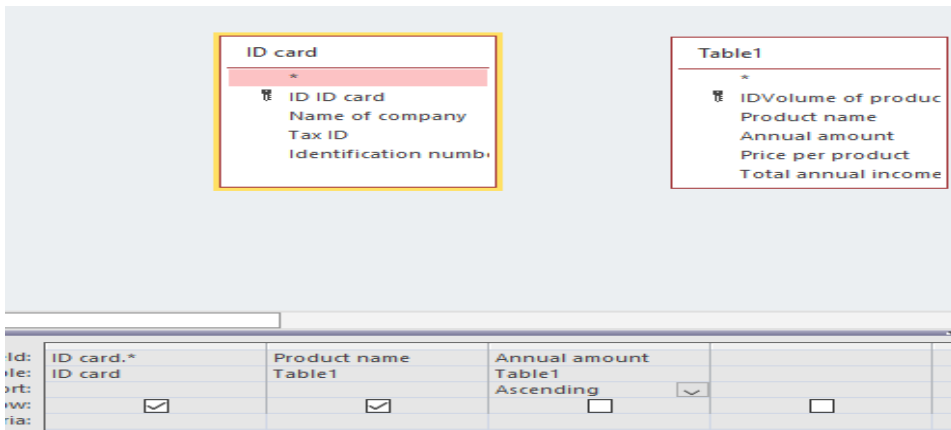


Fig. 7. Sorting of the annual amount of products

In the next step, we observe that the minimum annual quantity of production is the product Universal skirting, while the largest annual quantity is the angle for mechanical plastering.

The screenshot shows a database query result window with the following data:

IDVolume of	Product name	Annual amo
3	Universal mold	11652
2	Spalette profil	42630
1	Angle for mech	397160
(New)		

Fig. 8. Query result for annual product quantity

Sorting of price and total revenues is obtained in the same way, which can be seen in Fig. 9.

Product name	Price per prc	Total annual
Angle for m	\$18,00	7109164
Spalette profil	\$30,00	1292968
Universal mold	\$132,00	1538064
*	\$0,00	

Fig. 9. Sorting of price by product and total annual revenues

The form that will allow the selection option from the drop-down menu to select the data on the annual quantity of the product, by selecting the desired product for which we are interested in data from the drop-down menu, is shown in Fig. 10.

The image shows a software interface with a table and a form below it. The table has four columns: ID, Name of company, Product name, and Annual. Below the table is a 'Detail' section with four input fields corresponding to the columns in the table: ID, Name of company, Product name, and Annual.

Fig. 10. Selection of a filtered field

An integral part of every company is documentation, which facilitates the relationship between suppliers, sellers and buyers, the legal regulation of these relationships protects the mutual interests of all actors in the business chain.

4. Innovation in the production process monitoring system on the example of the production company "Jugoplast"

The information system for production planning is a subsystem of a wider information system for monitoring the entire process of making the final product [10].

When it comes to the very concept of production, and especially monitoring the production process of a certain product, its part (element, assembly, sub-assembly), considering that during my schooling and later I visited a large number of production facilities, one thing

remained striking to me. Namely, it is about mass productions, that is, productions that deal with the production of entire series of products.

I can present a concrete observation and explanation on the example of the press machine tool. Regardless of the type of press (extruding press, deep drawing, cutting, etc.), the number of manufactured pieces is generated on the PLC in such a way that each rotation of the camshaft (its 360° rotation) registers one manufactured piece.

It is systematically set up in such a way because one rotation of the shaft completes one cycle in the production process, which results in one manufactured piece (preparation, semi-finished product, finished product...). This way of recording manufactured pieces is a pretty good solution, but not 100% accurate and precise. In automatic machine operation mode, the result of counting the pieces made is accurate. The problem arises when a person (operator, regulator) replaces tools, adjusts and adjusts, and in the process manually turns the encoder (indirectly, the shaft is also turned, and thus the counter on the PLC increases). In that way, at the end of the working time (shift, day...) the counter on the PLC will show a higher number of pieces than actually produced.

A similar problem occurs in cases when the machine starts throwing out scrap pieces, which were also created in the process of the machine's operation and which entered the total collection of pieces detected by the system.

As one of the solutions, it could be the application of a sensor that would be positioned at the exit from the machine, i.e. at the place on the machine through which the pieces that are the final products for the aforementioned workplace pass. Production regulation includes production monitoring, control, study of causes of deviations and intervention measures.

Production must organize its resources in such a way that they must be available in a commercial capacity, in a certain time and to achieve a satisfactory level of quality. All production operations require planning and control, although the interrelationships and details of the production method itself may vary [11].

Namely, it is a motion and presence sensor, which detects pieces that physically "pass" past it, sends data to the control unit and thus prevents inaccurate information about the number of pieces produced. In this case, the counter does not depend on the physical movement of the shaft, but solely on the actual products that came out of the machine.

3. CONCLUSION

Information systems are a necessary need today, without which a company cannot operate. The speed of business depends on a well-chosen and implemented information system. Specifically, one database serves us so that a company has all its data in one place, where it is updated in a timely manner, as well as that the correlation between organizational units in the company runs smoothly, because the data that is contained in one database is supplied in a simple way, which it certainly makes the job easier for employees.

On the simple example of the company Jugoplast, we had the opportunity to see part of the data related to production that is supplied for business needs, in this case production. We received data on the annual volume of production of individual products, the price as

well as the total annual income, which are certainly relevant data for the head of production, who draws up the production plan.

What we can finally state is that by implementing an information system in a company, we not only speed up the work process, but also achieve a competitive advantage in the constant "market competition" with other companies. The production process must be supported by good practical as well as theoretical knowledge. Without practice, there is no quality product, which cannot exist as such without a theoretical foundation.

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[1%D0%A2%D0%95%D0%9C%D0%90&tbn=isch&source=lnms&sa=X&ved=2ahUKEwiX9u3mz6WEAxU-g_0HHdElCeYQ0pQJegQICBAB&biw=1366&bih=641&dpr=1#imgrc=Jtyz117qGCnSyM](https://www.researchgate.net/publication/380810710) accessed: 14. 02. 2024.

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FIXED POINT THEORY IN FUZZY METRIC SPACES WITH APPLICATION TO IMAGE PROCESSING

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ABSTRACT:

Fixed point theory in metric spaces as well as in spaces that represent the generalization of metric spaces is one of the most important areas of nonlinear analysis. There are numerous applications of this theory, such as: solving wide classes of differentials equation, optimization problems, theory of equilibrium, image processing and many other disciplines. In this paper we deal with fixed point theory in the frame of fuzzy metric spaces, where a new class of contractive mappings is introduced and the fixed point theorem for that class of mappings is proved. An example confirming the validity of the results is shown. Appropriate fuzzy metrics are applied to image processing.

Keywords: *fixed point, contractive mapping, Cauchy sequence, image processing.*

1. INTRODUCTION AND PRELIMINARIES

The history of fixed point theory can be traced back to the use of successive approximations, originally aimed at establishing the existence and uniqueness of solutions, especially in differential and integral equations. Its application spans a wide range of domains and includes image processing.

A most important milestone in fixed point theory is Banach's contraction principle. S. Banach [1] introduced the concept of contraction and then proved the famous theorem, laying the foundations for further progress in this field. Banach's contraction is a base of the new investigations of the theory of fixed points within metric spaces, directing attention not only to the generalization of the contractive condition but also to generalizations of the basic structure of metric spaces.

Theorem 1.1. ([1]) *Let (X,d) be a complete metric space and $f:X \rightarrow X$ q -contraction i.e. there exists $q \in (0,1)$ such that*

$$d(fx, fy) \leq qd(x, y) \tag{1.1}$$

for all $x, y \in X$. Then there exists a unique fixed point of the mapping f .

In 1965, Zadeh [13] pioneered the concept of fuzzy sets, which has since found extensive application. Fuzzy logic include a broad spectrum of applications spanning artificial intelligence, shape recognition, decision theory, image processing, and more.

The notion of fuzzy metric spaces was first introduced in 1975 by I. Kramosil and J. Mihalek [6]. Then, in 1997, A. George and P. Veeramani [2] redefined the concept of fuzzy metric spaces originally proposed by Kramosil and Mihalek [6] to establish the Hausdorff topology.

Below, we present the essential definitions and theorems necessary for the original contributions of this paper.

Definition 1.1. ([5]) *A mapping $T: [0, 1] \times [0, 1] \rightarrow [0, 1]$ is a continuous triangular norm if it satisfies the following conditions:*

- (t1) T is associative and commutative,
- (t2) T is continuous,
- (t3) $T(a, 1) = a$, for all $a \in [0, 1]$,
- (t4) $T(a, b) \geq T(c, d)$ whenever $a \geq c$ and $b \geq d$, for each $a, b, c, d \in [0, 1]$.

Example 1.1. *Basic examples of a continuous t -norm are*

$$T_M(p, q) = \min\{p, q\}, T_P = p \cdot q, T_L = \max\{p + q - 1, 0\}.$$

By

$$T_{i=1}^0 x_i = 1, T_{i=1}^n x_i = T(T_{i=1}^{n-1} x_i, x_n), x_1, x_2, \dots, x_n \in [0, 1]$$

t -norm T could be uniquely extended to an n -ary operation [4]. Extension of t -norm T to a countable infinite operation is done as follows

$$T_{i=1}^\infty x_i = \lim_{n \rightarrow \infty} T_{i=1}^n x_i, x_n \in [0, 1], n \in \mathbb{N}$$

where $T_{i=1}^\infty x_i$ exists since the sequence $(T_{i=1}^n x_i)_{n \in \mathbb{N}}$ is non-increasing and bounded from below.

$$\text{Let } \lim_{n \rightarrow \infty} x_n = 1 \text{ and } \lim_{n \rightarrow \infty} T_{i=n}^\infty x_i = \lim_{n \rightarrow \infty} T_{i=1}^\infty x_{n+i} = 1.$$

Then

$$\lim_{n \rightarrow \infty} T_{i=n}^{\infty} x_i = 1 \text{ if and only if } \sum_{i=1}^{\infty} (1 - x_i) < \infty$$

for $T = T_L$ and $T = T_p$, while

$$\lim_{n \rightarrow \infty} T_{i=n}^{\infty} x_i = 1 \text{ implies } \sum_{i=1}^{\infty} (1 - x_i) < \infty$$

for $T \geq T_L$ (see [4]).

Definition 1.2. ([2]) A 3-tuple (X, M, T) is called a fuzzy metric space if X is an arbitrary (non-empty) set, T is a continuous t -norm and M is a fuzzy set on $X^2 \times (0, +\infty)$, satisfying the following conditions for each $x, y, z \in X$ and $t, s > 0$

- (Fm-1) $M(x, y, t) > 0$,
- (Fm-2) $M(x, y, t) = 1$ if and only if $x = y$,
- (Fm-3) $M(x, y, t) = M(y, x, t)$,
- (Fm-4) $M(x, z, t+s) \geq T(M(x, y, t), M(y, z, s))$,
- (Fm-5) $M(x, y, \cdot): (0, +\infty) \rightarrow [0, 1]$ is continuous.

Definition 1.3. ([2]) The sequence $\{x_n\}$ in a fuzzy metric space (X, M, T) converges to $x \in X$ if $\lim_{n \rightarrow \infty} M(x_n, x, t) = 1$ for every $t > 0$.

Definition 1.4. ([2]) The sequence $\{x_n\}$ in a fuzzy metric space (X, M, T) is a Cauchy sequence if for all $\varepsilon \in (0, 1)$ and $t > 0$ there exists $n_0 = n_0(\varepsilon, t) \in \mathbb{N}$ such that $M(x_n, x_m, t) > 1 - \varepsilon$ for every $n, m \geq n_0$.

Lemma 1.1. ([3]) If for two points $x, y \in X$ and a positive number $k < 1$, it holds $M(x, y, kt) \geq M(x, y, t)$ then $x = y$.

The initial generalization of the Banach contraction principle within the context of fuzzy metric spaces was presented in the work by Sehgal and Bharucha-Reid [12].

Theorem 1.2. ([12]) Let (X, M, T_M) be a complete fuzzy metric space such that $\lim_{t \rightarrow +\infty} M(x, y, t) = 1$ for every $x, y \in X$ and $f: X \rightarrow X$. If there exists $q \in (0, 1)$ such that for all $x, y \in X$ and $t > 0$

$$M(fx, fy, t) \geq M(x, y, \frac{t}{q}). \tag{1.2}$$

Then there exists a unique fixed point of the mapping f .

2. FIXED POINT THEOREM

Lemma 2.1. ([8]) Let $\{x_n\}$ be a sequence in fuzzy metric space (X, M, T) , $\lim_{t \rightarrow \infty} M(x, y, t) = 1$. If there exists $k \in (0, 1)$ such that

$$M(x_n, x_{n+1}, t) \geq M\left(x_{n-1}, x_n, \frac{t}{k}\right), t > 0, n \in \mathbb{N} \quad (2.1)$$

and

$$\lim_{n \rightarrow \infty} T_{i=n}^{\infty} M\left(x_0, x_1, \frac{1}{\mu^i}\right) = 1, \mu \in (0, 1) \quad (2.2)$$

then $\{x_n\}$ is a Cauchy sequence.

Definition 2.1. Let (X, M, T) be a fuzzy metric space. Let \mathcal{F} be the class of mappings $F : (0, 1] \rightarrow [0, 1]$ such that

$$x < y \Rightarrow F(x) > F(y) \quad (2.3)$$

A mapping $f : X \rightarrow X$ is said to be fuzzy F -contractive mapping if

$$kF(M(x, y, t)) \geq F(M(fx, fy, kt)), x, y \in X, t > 0 \quad (2.4)$$

for some $k \in (0, 1)$ and $F \in \mathcal{F}$.

Theorem 2.1. Let (X, M, T) be a complete fuzzy metric space, $\lim_{t \rightarrow \infty} M(x, y, t) = 1$ and let $f : X \rightarrow X$ be fuzzy F -contractive mapping. Suppose that there exists $x_0 \in X$ such that

$$\lim_{n \rightarrow \infty} T_{i=n}^{\infty} M\left(x_0, fx_0, \frac{1}{\mu^i}\right) = 1, \mu \in (0, 1) \quad (2.5)$$

Then, f has unique fixed point.

Proof. Let $fx_n = x_{n+1}, n \in \mathbb{N}$. Using (2.4) we have that

$$F(M(x_{n-1}, x_n, t)) > kF(M(x_{n+1}, x_n, t)) \geq F(M(x_n, x_{n+1}, kt))$$

and since F is decreasing we conclude that

$$M(x_n, x_{n+1}, kt) > M(x_{n-1}, x_n, t) \text{ i.e. } M(x_n, x_{n+1}, t) > M\left(x_{n-1}, x_n, \frac{t}{k}\right)$$

and using Lemma 2.1. we have that a sequence $\{x_n\}$ is a Cauchy sequence. Since the space is complete there exists $x \in X$ such that

$$\lim_{n \rightarrow \infty} x_n = x$$

Let in (2.4) $x = x_n$ and $y = x$. Then

$$F(M(x_n, x, t)) > kF(M(x_n, x, t)) \geq F(M(x_{n+1}, fx, kt))$$

i.e.

$$M(x_n, x, t) < M(x_{n+1}, fx, kt)$$

Letting $n \rightarrow \infty$ we have that $1 \leq M(x, fx, kt)$ and so $x = fx$.

Suppose that there exist $x = fx, y = fy, x \neq y$. Then

$$F(M(x, y, t)) > kF(M(x, y, t)) \geq F(M(x, y, kt))$$

which implies that $M(x, y, t) < M(x, y, kt)$. This is contradiction. □

Example 2.1. Let $X = [0,1]$ and $T = T_p$.

a) Let $F(x) = -\ln x, fx = \frac{x}{2}$ and $M(x, y, t) = e^{\frac{-|x-y|}{t}}$. Then

$$kF(M(x, y, t)) = \frac{k|x-y|}{t} \geq \frac{|x-y|}{2kt} = F\left(M\left(fx, fy, \frac{t}{k}\right)\right)$$

whenever $1 > k \geq \sqrt{\frac{1}{2}}$. So all conditions of theorem are satisfied and $x = 0$ is a fixed point.

b) Let $fx = a, a < 1$ for all $x \in X$ and $F(x) = 1 - x$. Let $M(x, y, t) = \frac{x+y+2t}{2\max\{x,y\}+2t}$. Then all conditions of theorem are satisfied for every $k \in (0,1)$ and $x = \frac{1}{2}$ is a fixed point.

3. EXPERIMENTAL RESULTS

In order to improve the quality of the image, it is often necessary to remove perceived noise from it, i.e. filter it. In the corresponding algorithms, the most famous of which is the median filter, distance also plays a big role. In the article [9] by N. M. Ralević, D. Karaklić and N. Pištinjat, an algorithm for color image filtering, the so-called a fuzzy filter that uses a fuzzy metric instead of a classic metric.

Each pixel in an image (i, J_i) (representing "position" and "color") can be described by its spatial coordinates of pixel i_1, i_2 (points $i = (i_1, i_2) \in I \times I, I = \{0, 1, \dots, n - 1\}$ on the screen), and by vector $J_i = (J_i^1, J_i^2, J_i^3)$. The first component of the vector denotes the red color intensity, the second component denotes the green color intensity, and the third component denotes the blue color intensity, corresponding to the RGB color model.

When filtering an image, it is crucial to establish the criteria for replacing a noisy pixel with a noise-free one. This process involves substituting the central pixel in a window (a square-shaped section of the screen with an odd side length) with the pixel that is most similar in color and spatial distance to all other pixels in the window.

The fuzzy image filtering algorithm operates by selecting a replacement pixel for a suspected pixel in a defined window W . This selection depends on choosing a suitable fuzzy metric, denoted as c . Using the metric c will establish an ordering relation that is used to compare the pixels' ("position", "color") in the image and select the pixel that is least different from all other pixels in the window, i.e., the most similar to all other pixels in W in terms of color and distance. As a result, the central pixel within the window W is replaced with the selected pixel determined by the algorithm applied to each sliding window.

In a given window W , all pixels will be subject to an ordering relation induced by the metric c . This ordering relation serves to compare the pixels' ("position", "color") within the image and identify the pixel that exhibits the least deviation from all other pixels in the window, thereby being the most akin to the rest of the pixels in W in terms of color and distance. Consequently, the central pixel within window W is substituted with the pixel determined through the algorithm applied to each sliding window.

In the algorithm for filtering the image we use fuzzy metric $c : W \times W \rightarrow R$ defined with:

$$c\left((i, J_i), (j, J_j)\right) = M_1(J_i, J_j) \cdot M_2(i, j). \quad (3.1)$$

Fuzzy metric which is used in order to measure similarity in colors among pixels is marked with M_1 . It is defined in the following way:

$$M_1(J_i, J_j) = \frac{J_i^1 + J_j^1 + K}{\max\{J_i^1, J_j^1\} + K} \cdot \frac{J_i^2 + J_j^2 + K}{\max\{J_i^2, J_j^2\} + K} \cdot \frac{J_i^3 + J_j^3 + K}{\max\{J_i^3, J_j^3\} + K}. \quad (3.2)$$

Fuzzy metric that considers spatial distance between pixels is marked with M_2 . It is defined in the following way:

$$M_2(i, j) = e^{-\frac{|i_1 - j_1| + |i_2 - j_2|}{\tau}}. \quad (3.3)$$

In the following example, the picture grass.jpg is given in jpg format. To test the quality of that image, we will use the image quality index UIQI, defined in the paper of Z. Wang

and A.C. Bovik [14]. For measuring sharpness, we have used the image quality metrics introduced in the paper [7] of N.D. Narvekar and L.J. Karam.



Figure 1. Original image



Figure 2. Image with noise

As we can see, the filtered image given below is contaminated with $sp(\%)$ salt and pepper noise. The chosen size of window is 5. The metric c which is defined with (3.1), where M_1 and M_2 are defined by (3.2) and (3.3), respectively.

Let be $sp=10\%$.

The tested values of the parameters appearing in those metrics ranged from 125 to 2500 with a step of 125 for K , while t ranged from 1 to 101 with a step of 5.

The best values of the UIQI image quality metric (for each color) for the image filtered (using the method proposed in [9]) were obtained for $t=1$. And that is for $K=125$:

UIQI: [0.371363967, 0.431183083, 0.245116397], values increase to

UIQI: [0.479393541, 0.551562585, 0.344923049]

for $K=1125$, and then decrease to UIQI: [0.451652855, 0.512079213, 0.322199258] for $K=2500$.

The sharpness for image filtered by our metric is 0.9640.

The values of metric of image quality UIQI for each color for filtered image by median filter are equal to:

UIQI: [0.557198608, 0.662412133, 0.380876916].

The sharpness for image filtered by VMF is 0.5883.

Let be $sp=5\%$.

The tested values of the parameters appearing in those metrics ranged from 125 to 2500 with a step of 125 for K , while t ranged from 1 to 101 with a step of 5.

The best values of the UIQI image quality metric (for each color) are:
UIQI: [0.619678637, 0.682629745, 0.50167982].

The best result was obtained for $K=1500$ and $t=1$.

The sharpness for image filtered by our metric is 0.9342.

The values of metric of image quality UIQI for each color for filtered image by median filter are equal to:

UIQI: [0.557198608, 0.662412133, 0.380876916].

The sharpness for image filtered by VMF is 0.5820.

The tested values of the parameters appearing in those metrics ranged from 125 to 2500 with a step of 125 for K , while t ranged from 0.1 to 10 with a step of 0.1.

The best values of the UIQI image quality metric (for each color) are:
UIQI: [0.642312215, 0.709892784, 0.523081149].

The best result was obtained for $K=750$ and $t=0.4$.

The sharpness for image filtered by our metric is 0.9264.

4. CONCLUSION

In this paper, fuzzy metric spaces are discussed, in which a new class of contractive mappings is introduced and the fixed point theorem for that class of mappings is proved. Two representative fuzzy metrics are applied in image filtering.

The obtained results of simulations of image filtering contaminated with 10% salt and pepper noise indicate that the image filtered by our filter has lower values for the corresponding UIQI image quality index, but much higher sharpness. The best values were reached for the smallest of the considered values of the parameter t ($t=1$).

For images contaminated with 5% salt and pepper noise, they indicate that the image filtered by our filter has much higher values for the corresponding UIQI image quality index, especially for values of the parameter t from the range 0.1 to 10. In this case, the sharpness is much higher than with the median filter.

In other works where a filter based on **fuzzy** metrics was examined (such as [9], [10] and [11]), a higher sharpness of the considered images than for the VMF filter was also shown, while for the selected parameter values, the UIQI is also better.

All of these considerations will improve understanding of the intricate relationship between image quality and sharpness. This is very important in cases where the details of the image itself are important.

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DETERMINING THE OPTIMAL NUMBER OF CHARACTERISTIC VECTORS IN MEDICAL DIGITAL IMAGES

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ABSTRACT:

Determining sets of feature vectors is crucial in digital image processing. Feature vectors are essential characteristics or features extracted from the digital images. They serve as a concise and informative representation of the digital image content. Digital images often contain a very large number of pixels, and processing them directly can be computationally „expensive“ and inefficient. Feature vectors help in recognizing patterns and structures within the digital images. These patterns can be important for tasks such as object detection and their classifications and segmentation. The goal of this research is to use mathematical modelling to arrive at the set that would be the best for the problem of detecting changes in human liver.

Keywords: *copy/move forgery detection, digital image analysis, metaheuristic, clustering*

1. INTRODUCTION

In the realm of digital image processing, feature vectors play a pivotal role in representing and analyzing digital image data. A feature vector is essentially a compact representation of relevant information extracted from an digital image, typically in the form of numerical values. These values encapsulate various characteristics or features of the digital image, enabling machines to comprehend and make decisions based on the content of the digital image.

The significance of feature vectors in digital image processing cannot be overstated. They serve as the foundation for numerous applications, including object recognition, digital image classification, digital image retrieval, and more. By condensing complex visual data into manageable sets of features, feature vectors facilitate efficient computation and enable algorithms to effectively interpret and manipulate digital images.

Researchers in the field of digital image processing have extensively explored the effectiveness of different feature extraction techniques and their impact on various applications. Many studies emphasize the importance of selecting discriminative and robust features to ensure accurate and reliable digital image analysis. Additionally, advancements in machine learning and deep learning have led to the development of sophisticated feature extraction methods that can automatically learn relevant features directly from raw digital image data.

In this research, we delve into the significance of feature vectors in digital image processing and explore state-of-the-art techniques for feature extraction and representation.

The work is divided into several sections. In the following, Literature preview the importance of determining the feature vectors, as well as the vectors that we used in our research will be presented. The Results section will present the results obtained on the problem of copy/move forgery detection. Finally, in the Conclusion section we will give some of the further possibilities of research on this topic.

2. LITERATURE PREVIEW

Digital image segmentation is a fundamental task in computer vision and digital image processing, with applications spanning various domains such as object detection, semantic understanding, digital image compression, medical imaging, biometric identification, remote sensing, robotics, and more (Ibrišimović et al. 2023). It plays a critical role in enabling machines to understand and interpret visual information, leading to advancements in technology and enhancing our ability to analyze and interact with the visual world (Archana et. al, 2024).

Digital images often contain a large amount of data, with each pixel representing a feature. By extracting feature vectors from digital images, we can reduce the dimensionality of the data, making it more manageable for analysis. This reduction in dimensionality can lead to faster processing times and more efficient storage of digital image data (Gyamerah et al. 2023). Manakitsa et al. (2024) in our research represent why pattern recognition and analysis important. Feature vectors capture important patterns and structures within digital images, enabling tasks such as object detection and their classification and segmentation. By analyzing the extracted features, algorithms can identify meaningful patterns in the data, such as shapes, textures, and colors, and make decisions based on these patterns. Also, Humeau-Heurtier (2019) show the importance of texture as a key step in various digital image processing procedures, enabling tasks such as texture classification, segmentation, synthesis, pattern recognition, and digital image imaging by extracting significant texture features from raw digital images.

3. TECHNIQUES FOR DETERMINING CHARACTERISTIC VECTORS IN Fiji/Digital imageJ

Fiji, also known as Fiji/Digital imageJ, is an open-source digital image processing software package based on Digital imageJ, a popular and widely used digital image analysis program. It is designed for scientific and biomedical digital image analysis, providing a

comprehensive set of tools and functionalities for processing, analyzing, and visualizing digital images.

Fiji/Digital imageJ offers a userfriendly interface and a vast array of plugins, macros, and scripts, making it suitable for a wide range of digital image processing tasks. It supports various digital image file formats and offers features such as digital image enhancement, filtering, segmentation, quantification, and 3D visualization (Piccinini et al. 2024).

In Fiji/Digital imageJ, there are several techniques and methods for determining characteristic vectors (also known as feature vectors) from digital images. These techniques are used to extract relevant information from digital images for subsequent analysis, such as object detection, classification, segmentation, and more. Here are some common techniques for determining characteristic vectors in Fiji/Digital imageJ:

Manual Region of Interest (ROI) Selection: One of the simplest methods is manually selecting regions of interest (ROIs) within the digital image using Fiji/Digital imageJ's selection tools. Once an ROI is defined, various measurements and statistics can be obtained, such as intensity values, shape descriptors, and texture features.

Builtin Measurements: Fiji/Digital imageJ provides builtin measurement functions that can compute various characteristics of selected regions, including intensity statistics (mean, standard deviation, etc.), shape descriptors (area, perimeter, circularity, etc.), and texture features (e.g., entropy, moments, etc.).

Plugins: Fiji/Digital imageJ offers a wide range of plugins for feature extraction and analysis. These plugins extend the software's capabilities and provide additional tools for determining characteristic vectors. For example:

Texture Analysis plugins: Plugins such as GLCM Texture, Haralick Texture, and FracLac offer methods for computing texture features based on different texture analysis algorithms.

Shape Analysis plugins: Plugins like Shape Analysis and Shape Descriptors provide tools for quantifying shape characteristics of objects within digital images.

Intensity Measurement plugins: Plugins such as Digital image Calculator and Intensity Profiler offer functionalities for computing intensity-based features and profiles.

Segmentation Techniques: Segmentation methods can be used to partition digital images into meaningful regions, which can then be analyzed to determine characteristic vectors. Fiji/Digital imageJ offers various segmentation algorithms, including thresholding, region growing, edge detection, and watershed segmentation, which can be combined with feature extraction techniques to obtain characteristic vectors for different regions of interest.

Machine Learning and Deep Learning: Advanced techniques such as machine learning and deep learning can be applied to automatically extract characteristic vectors from digital images. While Fiji/Digital imageJ may not have builtin support for these methods, you can use external libraries or plugins that integrate with Fiji/Digital imageJ to perform machine learning-based feature extraction.

Custom Scripts and Macros: For more specialized or custom feature extraction tasks, users can develop custom scripts or macros using Fiji/Digital imageJ's scripting language. This allows users to implement specific algorithms or workflows tailored to their digital image analysis needs.

4. DATA AND RESULTS

In this research, we used our local digital image database to detect changes in human liver. We also used as an example of using feature vectors in digital image classification the (publicly available database copy move forgery detection (Table 1.)

<https://www.vcl.fer.hr/comofod/download.html>). In FijiDigital imageJ we used:

- **Intensity Features:** Mean intensity, Standard deviation of intensity, Median intensity and Min/Max intensity,
- **Statistical Features:** Skewness and Kurtosis.

Mean intensity:

Let $I(x, y)$ is the intensity value of the pixel at position (x, y) in the digital image.

The mean intensity (Mean) can be calculated as the sum of all pixel intensities divided by the total number of pixels in the digital image:

$$Mean = \frac{1}{N} \sum_{x=1}^W \sum_{y=1}^H I(x, y) \quad (1)$$

where W is the width of the digital image, H is the height of the digital image, and N is the total number of pixels.

Standard deviation of intensity:

The standard deviation (SD) measures the amount of variation or dispersion of the pixel intensities from the mean. It can be calculated using the formula:

$$SD = \sqrt{\frac{1}{N} \sum_{x=1}^W \sum_{y=1}^H (I(x, y) - Mean)^2} \quad (2)$$

The median intensity is the value that separates the higher half from the lower half of the intensity values. To calculate the median intensity, one first need to sort all pixel intensities and then find the middle value. If the number of pixels is even, take the average of the two middle values.

The minimum intensity (Min) is the smallest intensity value present in the digital image, while *the maximum intensity (Max)* is the largest intensity value present in the digital image. These can be found by iterating through all pixel intensities and keeping track of the smallest and largest values encountered.

Skewness (S) is calculated as the third standardized moment. For a sample of size n , with observations x_1, x_2, \dots, x_n , the skewness (S) can be computed using the formula:

$$S = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^3}{\left(\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2\right)^{\frac{3}{2}}} \quad (5)$$

Finally, *Kurtosis (K)* is calculated as the fourth standardized moment:

$$K = \frac{\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^4}{\left(\frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})^2\right)^2} \quad (4)$$

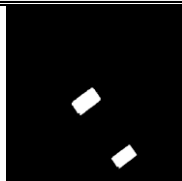



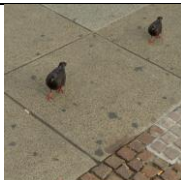







where \bar{x} is the sample mean, n is the number of observations (total number of pixels in the digital image) and x_i is the intensity of the i -th pixel.

We divided each of the pictures into blocks of dimensions 32x32, then 16x16 and finally 8x8 (see Equations 5). We calculated characteristic vectors (see Equations 1-4) in each step for each block. We then used the data thus obtained in the VNS algorithm for clustering into two clusters (Milosavljević et al. 2023). Our intention was to obtain groups of those parts of the digital image that were modified and those that were not. Our objective function was clustering success, which is the percentage of successfully classified blocks. For publicly available digital images, we got a high success rate of 95.32%.

Table 1. The digital images we used are from a publicly available database.

The first column represents the parts that were copied.

The second column is the modified digital image,
 and the third column is the original

Change	Modified digital image	The Original
		
		
		
		



Equations 5. These formulas give you the number of blocks n one can extract from the digital image in each dimension. If we have digital images dimension $H \times W$ (the digital image width is W and height is H)

$$\text{The number of horizontal blocks} = \frac{W}{n}, \text{The number of vertical blocks} = \frac{H}{n}. \quad (5)$$

We extended the research to medical digital images of changes in the human liver in order to examine how these feature vectors function in that case and we got a slightly higher success rate, over 98%. When we varied the number of characteristic vectors from 3 to 6, we noticed that the success rate remains the same for medical digital images, while it changes and varies on publicly available bases.

This was just a small example, certainly for a further more serious study it is necessary to introduce some other feature vectors as well as a larger data set.

5. CONCLUSION

The research we conducted indicates that the complexity of the problem of determining the characteristic vectors, as well as that the same model obtains different results for different problems.

Looking ahead, the future of feature vectors in digital image processing lies in the integration of advanced machine learning techniques and the development of more sophisticated feature representations. Research efforts will likely focus on enhancing the interpretability and generalization capabilities of feature vectors, as well as addressing challenges such as robustness to noise, scalability to large datasets, and adaptability to diverse imaging modalities. Additionally, the fusion of multimodal information and the incorporation of contextual knowledge are expected to further enrich feature representations, paving the way for more intelligent and contextaware digital image processing systems. Overall, the evolution of feature vectors will continue to drive innovation in digital image analysis and contribute to advancements in fields ranging from computer vision to medical imaging, and beyond.

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THE EVOLUTIONARY APPROACH FOR TUMOR DOSE WITH FOTELP-VOX TRANSPORT SIMULATIONS

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ABSTRACT:

This study introduces an evolutionary approach for minimizing risks to organs-at-risk during tumor therapy, utilizing the FOTELP-VOX program in voxel-based transport simulations (author R.Ilić). The use of voxels in the FOTELP program requires spatial constraints within a parallelepiped for targeted irradiation with a particle source. Particle interactions with the initial voxel are identified based on voxel density. The technique continues until the particle's fate is complete, verifying interactions on that path and modeling these processes. To simulate particle delivery, it uses Monte Carlo techniques. When particles are carried from an external source through the human body, the absorbed dose has a 3-D distribution. The CT data is used to characterize the anatomy of the patient.

The current methodology is based on a manual trial-and-error approach. In order to expedite the discovery of an optimized solution, we explored various optimization strategies, such as random search, Bayesian optimization (BO), and genetic algorithm (GA), within the framework of FOTELP-VOX. By evaluating these approaches, our research seeks to identify the most effective strategy for minimizing risks to organs-at-risk during radiation exposure. Two novel methodologies, namely FOTELP-VOX-BO and FOTELP-VOX-GA, are proposed.

The introduction of FOTELP-VOX-BO and FOTELP-VOX-GA methodologies further expands the research's potential applications and relevance within the domain of Monte Carlo transport simulations.

Keywords: Tumor therapy, Voxel-based simulations, evolutionary optimization, Monte Carlo techniques

1. INTRODUCTION

Artificial Intelligence (AI) is rapidly becoming a cornerstone in a multitude of sectors within modern society, revolutionizing the way we interact with technology and make

decisions [1]. Its integration ranges from enhancing user experience with personalized recommendations on social media platforms to driving the development of autonomous vehicles. Furthermore, AI plays a pivotal role in the analysis of large datasets in the business realm, providing invaluable insights that guide strategic planning and operational improvements [2]. Perhaps most critically, the application of AI in medical diagnostics and treatment has opened new frontiers in healthcare, offering the promise of more accurate diagnoses, personalized treatment plans, and improved patient outcomes. In the medical field, AI's impact is particularly profound in areas such as tumor therapy, where precision and accuracy are paramount [3]. The challenge of minimizing radiation exposure to healthy organs and tissues during treatment presents a significant obstacle, underscoring the need for innovative solutions that can enhance the safety and effectiveness of cancer therapies. This paper aims to explore the application of AI in addressing these challenges, specifically through the lens of a novel approach utilizing the FOTELP-VOX program for voxel-based particle transport simulations [4, 5]. By leveraging the capabilities of AI to optimize treatment parameters and reduce the risk of radiation damage, we can advance towards more targeted and less invasive cancer treatments.

The adoption of AI in medical treatment represents a critical step forward in our quest to mitigate the adverse effects of cancer therapies. Through a detailed examination of the FOTELP-VOX program and its application in minimizing radiation risk, we face the substantial challenge of accurately determining the FOTELP-VOX program's input parameters, which requires extensive manual effort and iterative processes to refine simulation accuracy and reduce errors. This challenge is classified as an optimization problem, which is being addressed through the application of Bayesian Optimization (BO) [6, 7], and Genetic Algorithms (GA) [8, 9], offering promising pathways to enhance the precision and efficacy of treatment planning. Leveraging real patient data from the Clinical Center in Kragujevac, the study contributes to the advancement of Monte Carlo transport simulations in medical physics, highlighting the potential for improved treatment planning and patient safety. Based on those findings, this paper proposes two novel methodologies: FOTELP-VOX-BO and FOTELP-VOX-GA, aimed at advancing the optimization process in radiation therapy planning.

2. MATERIALS AND METHODS

2.1 FOTELP-VOX Simulation framework

The FOTELP program (author R.Ilić) utilizes a sophisticated voxel-based simulation framework known as FOTELP-VOX for irradiating specific regions within a parallelepiped using particle sources [4]. In this framework, the use of voxels necessitates the definition of a limited portion of space to irradiate, including surrounding air if the particle source lies outside the irradiated region. Particle interactions with initial voxels are determined by voxel density, with each voxel assigned dimensions and six planes in the coordinate system. This process continues until the particle's fate is complete, with verification of interactions and modeling of these processes. By employing voxel addresses and temporary voxel placement coordinate levels, the framework optimizes memory usage, preventing the loading of fixed geometry planes from other programs. The GEMVOX function enables the temporary placement of the current voxel in the

coordinate system, further enhancing memory efficiency. Moreover, Monte Carlo techniques are utilized to simulate particle delivery, resulting in a three-dimensional absorbed dose distribution as particles traverse the human body from an external source. Before simulation, users can choose between photon or electron beams of any shape, with an energy threshold of 1 keV required for the computation of the three-dimensional distribution. CT data is leveraged to characterize patient anatomy, enabling accurate simulations tailored to individual patients.



Fig. 1. View of the dose planning interface in FOTELP-VOX

3. RESULTS

This study embarks on a comprehensive examination of the FOTELP-VOX program, a cutting-edge tool designed for voxel-based particle transport simulations, to enhance the precision and efficacy of tumor therapy through radiation. By incorporating real patient data from the Clinical Center in Kragujevac, including detailed Computed Tomography (CT) scans, the research adheres to the highest ethical standards, ensuring confidentiality and informed consent throughout the data acquisition process. Central to our methodology is the adaptation of the FOTELP-VOX program to facilitate compatibility with optimization algorithms, laying the groundwork for employing advanced optimization BO, and GA – aimed at optimizing radiation therapy by accurately determining input parameters and minimizing radiation exposure risk to non-targeted organs.

3.1 Defining the objective function

The objective function in radiation therapy optimization quantifies treatment efficacy by balancing tumor eradication against minimizing radiation exposure to organs-at-risk. We define the optimization search space X as comprising all possible scenarios for patient

treatment. A patient treatment $x \in X$ represents a combination of FOTELP-VOX input parameters, denoted as $x = (x_1, x_2 \dots x_n)$. Based on these findings, our goal is to minimize the objective function $f(x)$ as outlined below:

$$x_{opt} \in \underset{x \in X}{\operatorname{argmin}} f(x). \quad (1)$$

3.2. Optimization

In this chapter, we introduce two optimization techniques utilized in this research: the Tree-Structured Parzen Estimator (TPE), a Bayesian optimization method [6, 7], and the Genetic Algorithm.

Tree-Structured Parzen Estimator

TPE is a Bayesian optimization algorithm that efficiently explores and exploits the search space to find the optimal solution. At its core, TPE employs a probabilistic model to capture the relationship between the hyperparameters and the objective function. This model guides the search by iteratively updating its beliefs about the parameter space X , focusing on promising regions. Instead of using the Gaussian-process to model $p(y|x)$ directly, this strategy models $p(x|y)$ and $p(y)$. TPE divides the hyperparameters into two sets: "good" and "bad" and maintains separate probability density functions (PDFs) for each set. Let's denote the hyperparameters as $x \in X$, the objective function as $f(x)$, and the set of hyperparameters sampled so far as \mathcal{L} . TPE estimates two PDFs:

$$P(x|f(x), x \in \mathcal{L}, \text{good}), \quad (2)$$

$$P(x|f(x), x \in \mathcal{L}, \text{bad}). \quad (3)$$

TPE employs a non-parametric approach to model the PDFs using kernel density estimation. Specifically, it fits a kernel density estimator to the observed hyperparameters in each set. This allows TPE to flexibly capture the underlying distribution of hyperparameters that lead to desirable or undesirable outcomes. TPE uses the PDFs to guide the search for the next set of hyperparameters to evaluate. Instead of sampling hyperparameters uniformly or randomly, TPE samples from the "good" PDF more often than from the "bad" PDF. This adaptive sampling approach enhances efficiency by focusing computational resources on areas of high potential improvement. The strategy aims to balance exploration (sampling from areas with uncertainty) and exploitation (sampling from areas likely to yield better results). Specifically, TPE samples a set of hyperparameters $x \in X$ by maximizing the ratio:

$$\frac{P(x|f(x), x \in \mathcal{L}, \text{good})}{P(x|f(x), x \in \mathcal{L}, \text{bad})}. \quad (4)$$

This ratio indicates the likelihood that x belongs to the "good" set relative to the "bad" set, given the observed performance of x . After evaluating the chosen hyperparameters, TPE updates the sets of "good" and "bad" hyperparameters based on their performance. If the evaluated hyperparameters lead to a better outcome, they are added to the "good" set; otherwise, they are added to the "bad" set. This updating mechanism refines the PDFs over time, directing the search towards more promising regions of the hyperparameter space. By iteratively updating the probabilistic model and intelligently sampling from the PDFs, TPE efficiently explores the hyperparameter space X and converges to the optimal solution with fewer evaluations compared to traditional optimization methods.

Genetic Algorithm

GA is a widely recognized method in class of evolutionary optimization methods, inspired by the process of natural selection and genetics. The primary purpose of genetic algorithms is to efficiently search through large and complex solution spaces to find optimal or near-optimal solutions to optimization and search problems where traditional optimization techniques may struggle due to the complexity or non-linearity of the objective function. Rooted in the principles of natural selection, GAs emulate the process of evolution by favoring the survival and reproduction of the fittest individuals. The population in GA represents a collection of candidate solutions (individuals). Each individual in the population $x^\psi \in \omega \mid \omega \subseteq X$ is represented as a chromosome, often encoded as a string of binary digits, although other encoding schemes such as real-valued numbers or permutations can also be used depending on the problem domain. For this specific task, we propose integer encoding scheme where integer-based value gene x_i^ψ in chromosome x^ψ corresponds to FOTELP-VOX's input x_i .

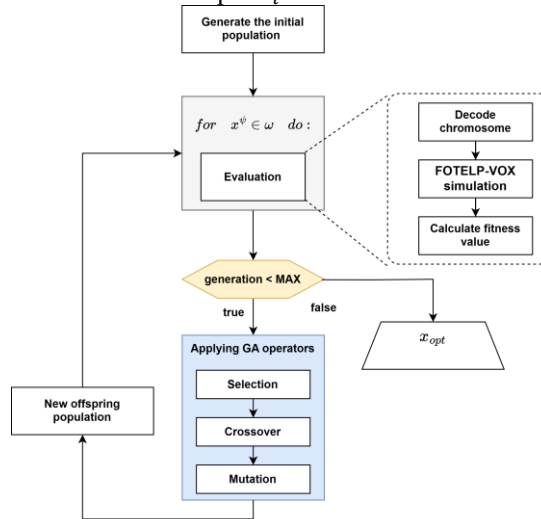


Fig. 2. FOTELP-VOX-GA algorithm

The GA operates through a series of iterative steps, known as generations or epochs. The process initiates with the creation of a randomly generated population. Each individual within this initial population is evaluated to assess their fitness. Subsequently, the population undergoes an iterative cycle comprising selection, crossover, mutation, and evaluation to produce the succeeding iteration (generation). Selection mechanisms determine which individuals are chosen to reproduce and contribute genetic material to the next generation based on their fitness values. Individuals with higher fitness values are more likely to be selected, following the principle of "survival of the fittest". We are using a selection method named binary tournament selection; two randomly selected individuals participate in the tournament and the winner is the individual with the higher fitness value. We apply crossover to selected individuals. Crossover is binary operator also known as recombination. It involves the recombination of genetic material from two parent individuals to produce offsprings with traits inherited from both parents. Combining good gene materials leads to exploration of the search space by combining promising solutions,

approaching the global optimum. In single-point crossover we randomly select the crossover point cp from the set $\{1 \dots n\}$ to split chromosome to head and tail. Suppose that two parents P_1 and P_2 are given as:

$$P_1 = (x_1^1, x_2^1, \dots, x_{cp-1}^1, x_{cp}^1, x_{cp+1}^1, \dots, x_n^1), \quad (5)$$

$$P_2 = (x_1^2, x_2^2, \dots, x_{cp-1}^2, x_{cp}^2, x_{cp+1}^2, \dots, x_n^2). \quad (6)$$

The crossover application over parents P_1 and P_2 produces offsprings O_1 and O_2 :

$$O_1 = (x_1^1, x_2^1, \dots, x_{cp-1}^1, x_{cp}^2, x_{cp+1}^2, \dots, x_n^2), \quad (7)$$

$$O_2 = (x_1^2, x_2^2, \dots, x_{cp-1}^2, x_{cp}^1, x_{cp+1}^1, \dots, x_n^1). \quad (8)$$

Mutation is the key part in searching for global optimum, it provides an escape mechanism from the local optimum. The mutation operator introduces random variations into the population by modifying a small proportion of individuals' chromosomes. This stochastic process helps maintain genetic diversity within the population, preventing premature convergence to suboptimal solutions. If a mutation discovers an individual with high fitness value, there is a high chance that this genetic material will be passed on to subsequent generations, directing the search into a new unexplored area of the search space. On the other hand, if the mutation has resulted in an individual with low fitness, due to the low probability of selecting that individual for crossover, the search will not be directed towards lower fitness solutions. The mutation operator is applied under a certain probability, we suggest a small mutation probability rate of 0.05.

4. CONCLUSION

This study demonstrates the significant potential of using artificial intelligence (AI) optimization strategies, particularly Bayesian Optimization (BO) and Genetic Algorithms (GA), to enhance radiation therapy planning. These methods effectively minimized radiation exposure to non-targeted organs while maintaining accurate tumor targeting. Bayesian Optimization showed a notable balance between precision and efficiency, whereas Genetic Algorithms excelled in quickly finding optimal solutions. This research underscores AI's role in improving medical treatment precision, offering a pathway to more personalized and effective radiation therapy approaches. The findings encourage further exploration of AI in healthcare, promising advancements in treatment planning and patient outcomes.

5. LITERATURE

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MODELING OF NATURAL HAZARDS INDICATORS IN THE R PROGRAMMING LANGUAGE

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ABSTRACT:

Modeling and simulation in the risk management of natural catastrophic events is, like the modeling of geographic processes, primarily a complex mathematical process based on a series of large amounts of data. The choice of locations for data collection, types of sensors, acquisition and validation of such series is a complex activity. However, the choice of an adequate mathematical model with the possibility of comparing results and executing several models represents a special challenge. One of the good ways is to execute the existing models contained in the R programming language library. The mentioned approach is implemented in the courses Modeling and simulation in risk management, Faculty of Technical Sciences and Fundamentals of modeling geographic processes, Faculty of Sciences in Novi Sad. By using SPEI and similar libraries containing the R programming language and data from eight experimental, climatological stations in the vicinity of Novi Sad, students and researchers are able to implement existing models, to perform their graphical representation and to predict possible trends in the future.

Key words: R, SPEI, modeling and simulation, risk management, hazard, risk, exposure, vulnerability.

1. INTRODUCTION

When discussing the modeling of natural hazard indicators, the subject predominantly relates to decision support information systems and to geographic information systems in general. These systems rely on modeling methods and computer simulations and essentially depend on the process of processing extensive series of multidimensional, spatial, and spatially based data. Due to the heterogeneity and often obsolescence of sources, data processing and interoperability become key aspects that require careful selection of programming language and processing methodology[1]. The R programming language is one of the logical choices, both in the preparation of raw data and in processing large series. A special quality of the R programming language and its accompanying libraries is the presence of a large number of already verified algorithmic solutions in various fields, both in the area of natural hazards and in the field of geographical processes in general. When this is combined with support from the online community, it is possible to speak of an ecosystem that combines mathematical, numerical, and statistical methods with methods of multidimensional analysis and visualization in a spatial context. In other words, modeling of natural hazard indicators in the R ecosystem can take place multi-

dimensionally and in multiple contexts. In other words, for modeling natural hazard indicators, it is necessary to clarify and organize mechanisms on how to import, prepare, manipulate, visualize, and model data using R[2].

Extreme meteorological phenomena, including heat and cold waves, droughts, and floods, are indicators of global changes in natural cycles. These changes, which are also a result of anthropogenic activities, lead to dramatic variations in climatic conditions. An increase in average temperatures leads to more frequent and intense extreme weather events, such as droughts which are becoming longer and harder to predict. These changes particularly threaten the agricultural sector, necessitating precise modeling and analysis of climate trends. In this paper, we will demonstrate the use of the R programming language with the SPEI library for analyzing and visualizing a large set of meteorological data, enabling the assessment of potential climate changes in the future[3].

Drought is characterized as a prolonged natural phenomenon caused by a precipitation deficit, affecting various regions of the world and causing significant economic and social consequences. This slow process is quantified by measuring the amount of precipitation and river flows that are below a certain optimal level. The intensity of drought is determined based on the degree of deviation from these standardized boundaries. In analyzing drought, we focus on spatial data, with predominant use of R for analyzing geospatial data, which is particularly useful in modeling natural disasters[4].

2. NATURAL HAZARDS AND GEOGRAPHICAL PROCESSES

Geographical processes encompass a variety of natural and anthropogenic activities that shape the Earth's surface and distribute life on the planet. Key examples include:

- Erosion is a natural process in which wind, water, ice, and gravity gradually remove soil, rocks, and sediments [5].
- Sedimentation is the process of accumulating solid materials such as sand and silt, which are transported by water, wind, or ice, and deposit in new locations [6].
- Tectonic shifts of the Earth's crust, caused by internal forces, create mountains, volcanoes, earthquakes, and form continental and oceanic ridges. Volcanism involves the expulsion of magma, ash, and gases from the Earth's interior to the surface, forming volcanoes [7].
- Glaciation is the process by which glaciers shape the land through erosion and deposition of materials as they move. Water cycle involves the movement of water through the atmosphere, the surface of the Earth, and the subsurface, including evaporation, condensation, precipitation, infiltration, and runoff [8].
- Urbanization is the process of expansion of urban areas, resulting in the transformation of natural habitats into urbanized surfaces [9].
- Deforestation is the process of removing forests, most often due to agriculture, urbanization, or timber exploitation [10].

- Climate change encompasses long-term variations in temperature, precipitation, winds, and other atmospheric parameters on Earth, caused by natural factors, anthropogenic emissions of greenhouse gases, and other human activities [11].

These processes play a crucial role in shaping the physical and biological landscape of the Earth, affecting living conditions and biodiversity.

3. DROUGHT AND MODELING DROUGHT INDICATORS

Drought is the result of a series of events at global and local levels, where several independent factors must coincide to result in a drought. Climate zones in mid-latitudes are characterized by high variability in conditions throughout the year, with pronounced seasonality. Summers are typically hot with high evapotranspiration, increasing the risk of drought. Air currents moving from north to south and vice versa, along with seasonal variations in solar radiation, greatly contribute to the possibility of drought. Annual changes affect atmospheric circulations, alternating dry and wet periods and shifting circulation centers.

The methodology represents a process that uses methods and techniques as tools for systematic theoretical analysis of applied methods to a specific problem. It includes ways of acquiring knowledge through paradigms, theoretical models, and technical phases, whether qualitative or quantitative. This methodology allows for the use of the same principles when evaluating or creating new climate drought indicators, with the goal of verifying their coherence, credibility, and usability in drought predictions. It defines methods, processes, and steps for standardized categorization and assessment of drought index capabilities.

The most commonly used drought indicators are:

Standardized Precipitation Index (SPI) - Measures precipitation amounts relative to historical data for a specific region and time period. It enables the identification of dry and wet periods.

Palmer Drought Severity Index (PDSI) - One of the oldest and most frequently used drought indicators, which considers not only precipitation but also temperatures and soil's water-holding capacity.

Standardized Precipitation Evapotranspiration Index (SPEI) - Takes into account both precipitation and potential evapotranspiration, providing a more detailed insight into the water balance.

Vegetation Health Index (VHI) - Uses temperature and vegetation data from satellites to assess plant health and potential stresses like drought.

Soil Moisture Index - Monitors soil moisture on the surface and is used to assess drought affecting agriculture.

Remote Sensing Drought Monitoring Indexes - Utilizes data obtained from remote sensors to monitor drought conditions, such as the Normalized Difference Vegetation Index (NDVI).

4. CALCULATING THE SPEI DROUGHT INDICATOR USING THE R PROGRAMMING LANGUAGE

The Standardized Precipitation Evapotranspiration Index (SPEI) is an adapted index that considers both precipitation and potential evapotranspiration for assessing drought. It was

developed by Vicente-Serrano, Beguería, and López-Moreno in 2010 to provide a better understanding of the impact of global warming on droughts, as SPEI also accounts for temperature changes affecting evapotranspiration.

To begin, it is necessary to enable the use of the SPEI package, which is specifically designed for this purpose. This package allows for easy calculation of SPEI based on monthly or daily precipitation and temperature data. Installing the SPEI package can be done directly from CRAN using the command:

```
install.packages("SPEI")  
library(SPEI)
```

Another method is from the RStudio environment, as shown in the image (Image 1).

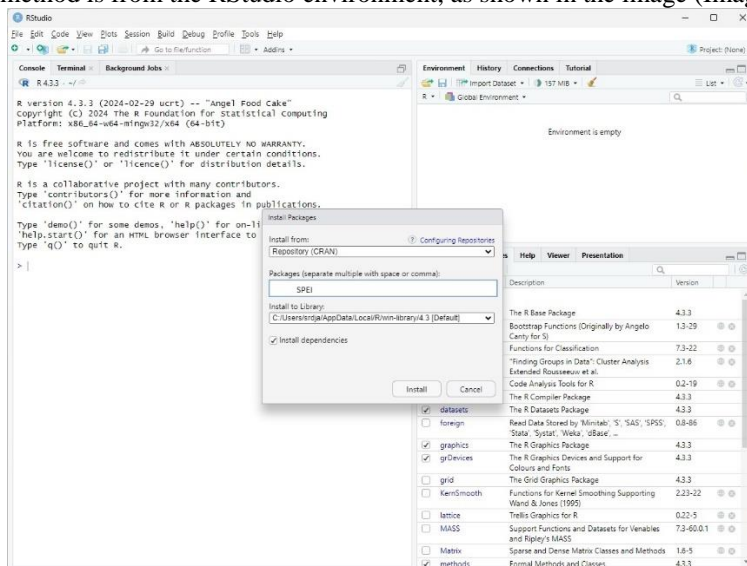


Image 1. Importing the SPEI Library in RStudio Environment

To calculate the Standardized Precipitation Evapotranspiration Index (SPEI), data on precipitation and temperature are required. The SPEI package uses these data to calculate potential evapotranspiration (PET) using the Thornthwaite method.

The data used are from the local climatological station WH5 "Titelski breg" in .csv format. The data must first be prepared, which can be done as follows:

```
data = read.csv("WH5_MeasurementExport.csv", sep =  
";", stringsAsFactors = FALSE)
```

Next, the total amount of precipitation in millimeters per month needs to be calculated:

```
precipitation2$Month = month(precipitation2$Day, label  
= TRUE)  
precipitation2$Year = format(precipitation2$Day,  
format = "%Y")  
precipitation3 = aggregate(Value ~ Month + Year,  
precipitation2, FUN = sum)
```

As well as the average temperature values per month in Celsius:

```

temperature2$Month = month(temperature2$Day, label =
TRUE)
temperature2$Year = format(temperature2$Day, format =
"%Y")
temperature3 = aggregate(Value ~ Month + Year,
temperature2, FUN = mean)
    
```

The prepared data are used to call the function:

```

spei(data, scale, kernel = list(type = 'rectangular',
shift = 0),
distribution = 'log-Logistic', fit = 'ub-pwm',
na.rm = FALSE,
ref.start=NULL, ref.end=NULL, x=FALSE,
params=NULL, ...)
    
```

Where the arguments of the `spei` function are as follows:

- **Data:** A vector, matrix, or data frame with time-specified values of the difference between precipitation and potential evapotranspiration, in this case, "TableSPEI".
- **Scale:** An integer representing the time scale over which the SPEI is to be calculated.
- **Distribution:** An optional query that allows the use of a desired regression model for calculating SPEI. The model used here is the logistic distribution.
- **Kernel:** An optional query that allows us to smooth the temporal variability of the data, meaning that by applying the kernel we create a core of rectangular, triangular, circular, or Gaussian shape. This query determines the rigidity or smoothness of the function.
- **Na.rm:** An optional logical query indicating whether to exclude NA values from the calculation.
- **Ref.start:** Indicates the starting point of the reference period used for calculating the index. The usual assigned value is NULL, which indicates that the first value in "data" will be used as the start.
- **Ref.end:** Indicates the ending point of the reference period used for calculating the index. The usual assigned value is NULL, which indicates that the last value in "data" will be used as the end.

The result of executing the previous function generates predictive data for drought analysis for the territory of central Bačka, in this case until the year 2030 (Image 2).

	Jan	Feb	Mar	Apr	May	Jun	Jul
2015		NA	NA	NA	NA	NA	NA
2016	NA	NA	NA	NA	NA	NA	NA
2017	NA	NA	NA	NA	NA	NA	NA
2018	-0.43205648	-0.84109153	-1.28875582	1.26408234	-0.24394723	1.16730283	1.32863476
2019	-1.28018859	-0.15922481	-0.02641530	1.77594214	1.77211566	1.01081967	0.98373347
2020	-0.27198563	0.60253581	1.78076530	0.64148761	0.67928312	1.59367075	1.25913982
2021	-0.70073844	-0.16876425	-0.98682099	-1.20212616	0.77422295	-0.84191741	0.31617215
2022	-0.22192060	-1.29399095	0.02436666	-0.22157388	1.28799414	0.97357666	0.11793372
2023	-0.21443490	0.08071024	1.12400193	0.68525235	0.16695245	-0.20442452	0.93239012
2024	-1.76050471	-0.56218577	0.01003243	-0.91078772	-1.51196317	-0.12290714	-1.37151883
2025	-0.06855174	0.16073187	-1.61356558	-0.19166274	-0.62848193	0.38651489	0.07301928
2026	0.72995687	0.17277056	0.38217142	0.38080172	0.20870895	-0.58795301	-0.98277115
2027	0.52245465	-1.79523355	-0.57977927	-0.20006012	-1.24628396	-1.45380646	-0.92684528
2028	0.69284690	0.41080624	0.49970913	-1.58020576	-0.60160020	-1.04968996	-0.52961771
2029	1.51753561	1.77857943	0.51729050	0.00793009	-0.07862701	-0.55980965	-1.22546820
2030	1.58664437	1.41573423					

Image 2. Predictive Data for Drought Analysis Up to the Year 2030

By interpreting the Standardized Precipitation Evapotranspiration Index (SPEI), we qualify drought conditions, calculated as the difference between precipitation and

potential evapotranspiration (the amount of water that would have evaporated and transpired under ideal conditions) over a certain period. SPEI can have positive and negative values, where negative values indicate droughts and positive values indicate periods above normal precipitation. Based on the following values, we can interpret the data:

SPEI > 0: Conditions are wetter than average; no signs of drought.

SPEI ~ 0: Conditions are around average; no signs of either drought or excessive moisture.

SPEI < 0: Conditions are drier than average; the lower the value, the more intense the drought.

Based on SPEI values, drought categories are classified as:

Mild Drought: SPEI between -0.99 to -1.5

Moderate Drought: SPEI between -1.5 to -2.0

Severe Drought: SPEI between -2.0 to -2.5

Extreme Drought: SPEI less than -2.5

SPEI results can be used for predicting droughts and managing water resources, agriculture, and ecosystem protection. It is also used for long-term planning to minimize the effects of droughts.

5. CONCLUSION

The R programming language stands out as a logical choice for processing and analyzing large data series, especially in the context of natural hazards. The presence of verified algorithmic solutions and community support make R ideal for multidimensional analyses that include mathematical, numerical, and statistical methods.

The SPEI library is efficient in modeling and analyzing climatic trends, which include droughts and extreme climatic conditions. The library allows for straightforward calculation of the Standardized Precipitation Evapotranspiration Index, using monthly or daily data.

Through the use of the SPEI index and other methods, it is possible to precisely quantify and predict droughts, which has a direct impact on agriculture and water resource management. This is particularly important in the context of global warming and climate changes that intensify the frequency and severity of drought periods.

The integration of Geographic Information Systems (GIS), modeling, and simulation in natural hazard research allows for a holistic approach to understanding and mitigating risks, underscoring the importance of data interoperability and methodological integration.

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MODELING MOBILITY PERFORMANCE WITHIN SMART CITY INFRASTRUCTURE USING URN DIAGRAMS

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ABSTRACT:

The implementation of "smart city" projects can undoubtedly benefit from a reliable information system to monitor autonomous electric car charging stations. Developing such a system is indeed a complex process that requires careful planning and consideration of various operating scenarios. It's crucial to ensure that all aspects of the system are well-designed and implemented to meet the needs of the users and the community. In this paper, one such scenario through the User Requirements Notation (URN) as a modeling language used to model and analyze requirements is developed. The centerpiece of this system is jUCM-Nav, an open modelling, analysis, and transformation tool for URN that operates on the Eclipse platform. Stored information on autonomous electric car charging stations includes the maximum energy capacity, current energy state, unit energy price, distribution cost, and identifier. The car database stores the owner's name and surname, the current energy state and capacity, and the account balance. The information system should simulate charging and record the receipts generated after charging.

Keywords: *User Requirements Notation (URN), Information System, charging stations, Eclipse platform*

1. INTRODUCTION

Smart mobility is an essential component of the city, emphasizing the need for urban transport systems to be more sustainable and efficient. Electric cars, autonomous cars, and intelligent transport systems are priority components to addressing "smart" urban mobility [1]. UBS Research Institute projects that by 2025, electric vehicles will make up 20% of global car sales. This report predicts that by 2030, 40% of cars sold will be electric, and by 2040, every new car sold will be electric [2]. According to recent research, battery technology advancements could offer a capacity of 32 to 62 terawatts by 2050 [3]. Electric car (EC) has the highest potential to enable the carbon neutrality of the transport sector, as long as "renewable" electricity is used to charge the battery, which is in line with current steps and guidelines for the electricity sector development.

Electric mobility is becoming a key trend in Serbia, aligned with global sustainability and emission reduction goals [4]. The country has made notable strides in electromobility through government incentives, private investment, and infrastructure development like more EV charging stations. Despite challenges like high costs and low consumer awareness, Serbia is enhancing its electromobility sector by supporting local production of electric vehicles and components [5]. As Serbia progresses towards sustainable transport, it focuses on expanding vehicle choices, improving infrastructure, and boosting public awareness to strengthen its electromobility landscape [6].

In the following section, we will introduce the fundamental concepts of GRL and UCM. Our approach involves utilizing GRL and UCM to model the requirements and system design incrementally. To demonstrate the proposed approach, we will use a case study in the autonomous EC charging stations in section 3. Related works will be discussed in the same section. Finally, we will conclude and discuss future work in section 4.

2. RESEARCH METHOD AND MODELS

The development of an information system is a complex process that requires careful planning and is divided into several stages. The first step in developing a new system is to identify what the new system needs to do. It is essential to find out what users require from the new system that the existing system cannot do. The research process (excavation, search, study, elicitation) of requirements represents one of the critical phases (as a sub-discipline) in requirements engineering [7].

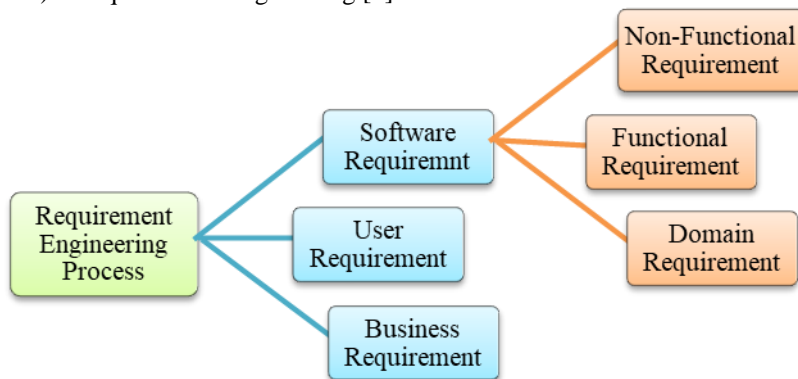


Fig. 1. Requirement Engineering Process

Due to the dynamics of the development of the environment, it is necessary to improve information systems within organizations. The collected information belongs to one of three categories:

- functional requirements,
- non-functional requirements,
- usage request.

Non-functional requirements should be addressed and studied from the earliest stages of IS development and monitored throughout the entire lifecycle. The research process (excavation, search, study, elicitation) of requirements represents one of the critical phases

(as a sub-discipline) in requirements engineering. Business process management through the User Requirements Notation (URN) as a modeling language used to model and analyze requirements can support various methods in the analysis, design, implementation, and evolution of information systems. URN is a tool that models and analyzes requirements as goals and scenarios before the design phase. It uses two notations: the Goal-oriented requirement language (GRL) for modeling goals and the Use Case Map (UCM) for modeling processes. URN offers a unique combination of goal and process views with traceability features, allowing alignment of business goals and processes through expert knowledge and experience [8].

2.1. GRL model

GRL supports an evaluation mechanism that lets users define sets of initial satisfaction values on chosen intentional elements in a GRL model called strategies. These values are propagated to other intentional elements in the model via their contribution, correlation, decomposition, and dependency links up to the highest-level goals. Contribution and correlation links can be positive or negative, with various weights, and this capability can be used for evaluating the effect of different tasks and processes on goal models, enabling global evaluations of alternatives and trade-off analysis. Using Goal-oriented Requirement Language (GRL) in modelling stakeholders' goals is a successful approach towards understanding stakeholder intentions and addressing pertinent issues. GRL can be utilized to model strategic goals and concerns using various intentional elements and relationships, including actors, goals, soft goals for qualities, and tasks for activities and alternative solutions.

GRL provides a comprehensive view of the business goals of multiple stakeholders, considering alternative solutions for a system, their impact on stakeholder goals made decisions, and rationales that helped make those decisions. Softgoals describe continuous goals with no clear-cut criteria or states that indicate full achievement. Figure 1 summarizes the notation elements used in GRL [9].

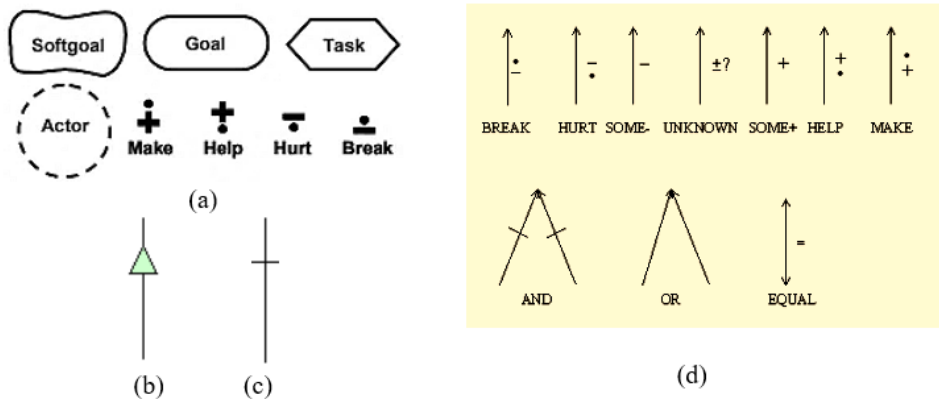


Fig. 1. (a) Subset of GRL notation; (b) Means-Ends; (c) Decomposition; (d) Contribution.

The objective of the GRL perspective is to offer a justification for the components of the business process, as well as a description of why particular solutions were selected or rejected.

2.2. UCM model

UCM model is a powerful tool that helps to define the who, when, and where of various responsibilities. With this model, you can easily keep track of all the tasks that need to be performed and ensure that everyone is on the same page. In UCMs, a scenario affects a partial depiction of system usage characterized by a set of partially ordered responsibilities (). These responsibilities represent the system's actions and operations, executed to transform inputs into outputs by the preconditions and postconditions specified. The activities involved in UCM scenarios, known as scenario activities, can be associated with or allocated to a component. In UCMs, a component is a generic and abstract entity representing software entities (processes, objects, servers, or databases) or non-software entities (such as actors or hardware).

The UCM notation serves as a visual language for process modelling used to describe causal scenarios and link activities to a framework of components and actors. UCMs depict processes and scenarios driven by causal links, mapping out sequenced responsibilities allocated to components. A UCM journey initiates at a start point (●) and concludes at an endpoint (◻). Within UCMs, stubs () represent placeholders for sub-maps, marking critical steps in the process such as conducting ethical, privacy, and technical reviews. Delving into a stub reveals a more detailed sub-map, or plug-in, for each step. The centrepiece of this framework is jUCM-Nav, an open modeling, analysis, and transformation tool for URN that operates on the Eclipse platform. Ensuring that processes conform to requirements, goals, and policies, the framework integrates goals/scenarios with a Requirement Management System, which serves as the foundation for validation and compliance verification.

The successful implementation of "smart city" projects requires a reliable information system to monitor autonomous EC car charging stations. The information system should simulate car battery charging and record the receipts generated after charging [10]. The equation by which it calculates the total price is:

$$\text{the total price} = (\text{the amount of energy}) * (\text{unit price}) + (\text{distribution price}).$$

3. RESULTS AND DISCUSSION

Stored information on autonomous electric car charging stations includes the maximum energy capacity, current energy state, unit energy price, distribution cost, and identifier. The car database stores the owner's name and surname, the current energy state and capacity, and the account balance [11]. This research will showcase URN diagrams in an information system for monitoring autonomous EC charging stations designed to promote electromobility in the Smart City Project [12]. The GRL model can facilitate a better understanding of stakeholder intentions and problem identifications that require resolution. Table 1 presents actors, goals, and soft goals, and Table 2 presents tasks.

Table 1. Three types of intentional elements: actors, goals and softgoals.

Actors	Goals	Soft goals
Car owner	/	Searching for EC charging stations
EC charging station	Charging the car battery	/
	Other services	
Website	Digital platform and application	Display of electric car charging stations
Advertisement	/	Advertising of EC charging stations
		The cost of advertising

The evaluation of the GRL diagram shows the impact of qualitative decisions on high-level, soft goals.

Table 2. Tasks model potential solutions for achieving higher-level goals.

Car owner	EC charging station	Website	Advertisement
Information about website	Information about the current amount of electricity	Display of available charging stations in the city	Acceptance of requests for advertising
Giving up searching	Knowledge of energy capacity	User authorization	Request processing
Going to the station	Information about the electricity price	User registration on the website	Information about station features
Knowledge of car features	Record of sold electricity/ car service	Download the app to find an electric car charging stations	Advertising by means of flyers or billboards
	Information about the cost of service		Media advertising

Each task associated with a goal through a means-ends link represents an alternate way of achieving the goal. In this research pairs of task-goal are: record of sold electricity-charging car battery; car service record-other services; information about website-display of electric car charging stations. Decompositions outline the necessary sub-elements required for performing a task. A decomposition "AND" links each soft goal and resource (centralized database) with its tasks, shown in each component in Figure 2. Because of the AND composition, the High Throughput soft goal needs to take into consideration both contributions Contribution links illustrate how soft goals, tasks, and links contribute to each other, displayed as an arrow with a quantitative (± 100) or qualitative value. A contribution is an effect that is the main priority during the modelling process [13]. Figure 2 displays a GRL model that uses intentional elements from previous tables.

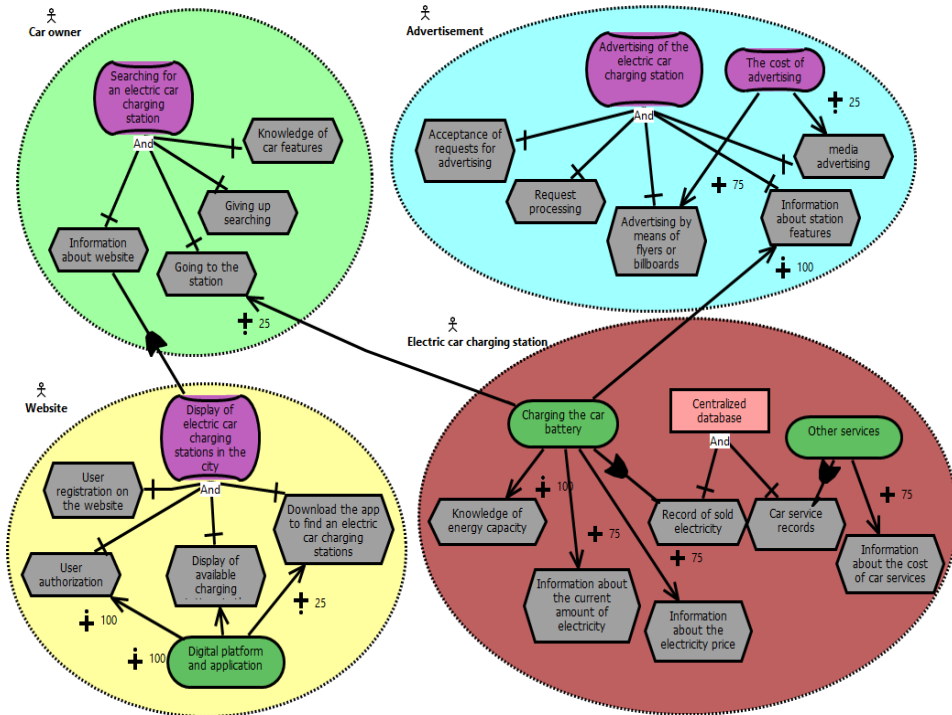


Fig. 2. Research model showing GRL diagram

The functional goal of the GRL model is realized through the UCM model, shown in Figure 3, where the wiggly line represents the scenario path and a causal sequence of responsibilities denoted by a cross. An OR-fork splits a path into two or more alternatives. In this EC charging stations system, after the responsibility of "Electricity demand", the "Charging needs" might be false or true. When it is true that the car owner is waiting for car data, the scenario may continue. Otherwise, the car owner will not have to purchase it. If the car data is ready, the scenario proceeds to the electricity purchase process, as presented in the stub. The stub includes a sub-map detailing several steps, each defined by responsibilities that denote either simple tasks or tasks that are not further detailed.

Also, a stub „Login to the website stub” in the „Website” component provides two exit paths, depending on whether an account access request is approved or rejected. Further, after the responsibility of „Searching” follows the responsibility of „Selected available electric charging stations” which might be false or true. When it is true that the selected station is displayed, the next is „Going to the station“. Otherwise, the car owner will not have to purchase it. An OR-join joins two paths: „Charging needs” and „Going to the station“, the scenario proceeds to the electricity purchase stub.

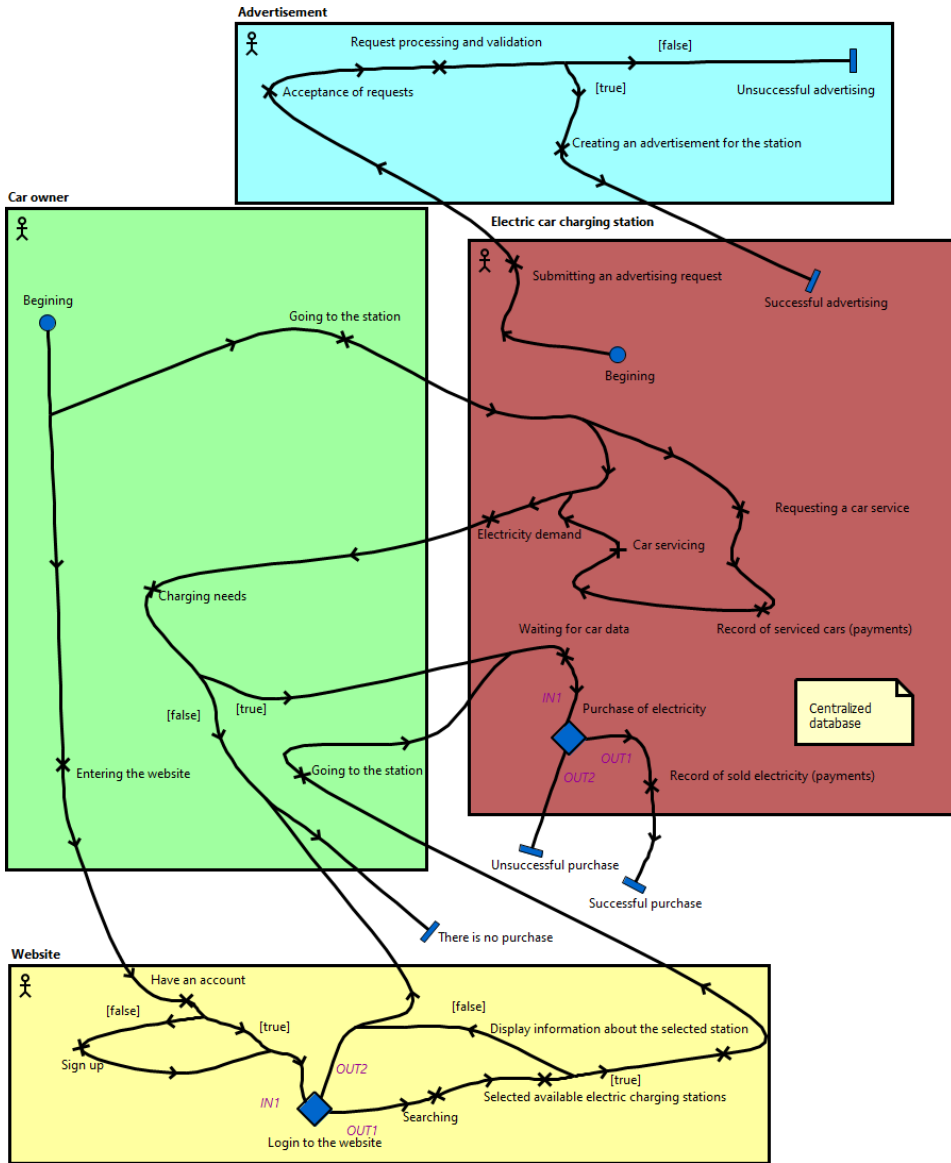


Fig. 3. Research model showing UCM diagram.

Stubs are used to hide details of certain sections of a scenario, e.g., the purchase of electricity stub and login to the website stub, as shown in Figure 4 and Figure 5, respectively. Although this UCM can be a standalone map, in our EC charging station system it is only a sub-map of a larger collection of scenarios, whose root UCM is shown in Figure 3.

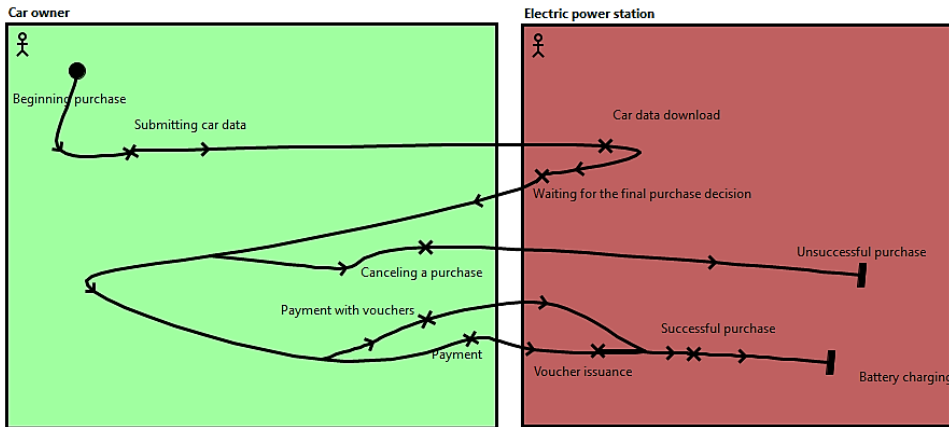


Fig. 4. Purchase of electricity

The Eclipse-based jUCM-Nav is an open tool for modelling, analyzing, and transforming URN, as shown in Fig. 5. In the same figure, the Car owner sub-map within the Website map contains the responsibilities of authentication and authorization.

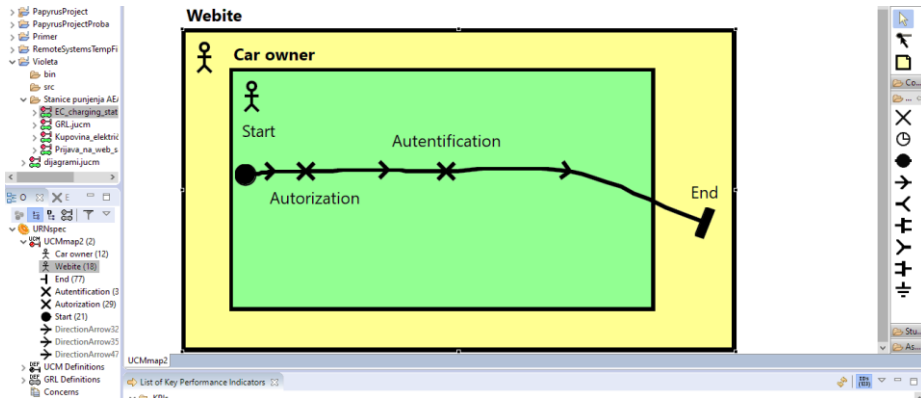


Fig. 5. Login to the website

4. CONCLUSION

By utilizing the GRL and UCM in conjunction with each other, it becomes feasible to describe both functional and non-functional requirements, abstract requirements, concrete information system models, intentional strategic design rationales, and non-intentional details of the concurrent, temporal aspects of the future system. The assessment implies the initial level of satisfaction with lower-level elements, the importance defined for lower-level elements, connections, and types of connections. It allows for a comprehensive evaluation of the strategy under consideration on a worldwide scale.

Future studies should focus on integrating new technologies to add and update features at charging stations. It's also essential to explore customization of the "smart" charging system to meet specific user and infrastructure needs, ensuring flexibility for changing demands.

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EVOLUTIONARY DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN EDUCATION: ANALYSIS OF RECENT TRENDS AND FUTURE DIRECTIONS

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ABSTRACT:

This review paper explores the dynamic development of Artificial Intelligence (AI) in education, along with analyzing recent trends and future directions in this field. We begin by examining various aspects of AI application in education, investigating how this technology is transforming the methods of learning and teaching. We focus on key research trends that encompass personalized learning, automated assessments, and advanced data analytics. We delve into the implications of these technological innovations for the future of education, exploring how AI will shape school systems and teaching strategies in the coming years. Through this paper, we investigate how the increasing influence of AI on education will alter the ways in which students acquire knowledge and how educators adapt their teaching methods.

Keywords: *artificial intelligence (ai), education, ethics, machine learning (ml)*

1. INTRODUCTION

Since its inception in the 1950s, the concept of artificial intelligence has garnered significant societal attention. Over time, it has evolved into a relatively mature technology with considerable prospects for future development [1].

It is the field of education is constantly expanding and deepening [2]. As a transformative force that has brought about significant changes in various sectors, AI has become pivotal in education. The integration of AI into educational environments has sparked considerable interest and discussions, as it promises to revolutionize traditional teaching and learning methods. This review aims to explore the evolutionary development of AI in education, analyzing recent trends and visionary directions in this rapidly growing field.

As we delve into the intricate interplay between AI and education, it becomes apparent that the application of AI technologies is reshaping the landscape of teaching and learning. From personalized learning experiences tailored to individual student needs to automated assessments that provide timely feedback, AI is ushering in a new era of educational innovation. The advent of advanced data analytics enables educators to gain deeper insights into student performance and learning patterns, facilitating more informed

decision-making processes. It is essential to critically examine the implications of AI in education, including ethical considerations and societal impacts. Looking ahead, the future of AI in education holds immense potential for transformative change.

2. THE APPLICATION OF AI IN EDUCATION

As AI technologies are increasingly utilized in education, there has been a rise in the number of published studies within this field [3]. AI is generating innovative teaching and learning solutions, which are currently undergoing testing across diverse contexts [4]. The utilization of AI introduces fresh opportunities, potentials, and challenges in educational settings. Through AI, computer systems can offer personalized guidance, support, or feedback to both students and educators during the learning process [5]. Teachers prepare lessons, arrange the classroom, and oversee students' comprehension [6].

2.1. Personalized learning

Learning is a tailored journey that enables individuals to broaden their knowledge, outlook, abilities, and comprehension. While personalized learning is not a novel strategy, its popularity in research and practice has surged since the beginning of the 21st century [7] [8]. Personalized learning frameworks can effectively address individual needs and objectives. Integrating technology can play a pivotal role in personalizing the learning experience [9].

Integrating AI algorithms, adaptive learning systems, and intelligent teaching systems, teachers can tailor instruction to meet the diverse needs and learning styles of individual students [10], thus improving learning outcomes and fostering success. However, ethical issues related to data privacy, algorithmic bias, and legal access to educational resources guided by AI must be carefully addressed to ensure responsible and effective use of AI in education. Personalized learning facilitated by AI technologies offers several advantages over traditional approaches to education. AI-guided adaptive learning systems can dynamically adjust the pace, content, and delivery of instruction based on each student's level of progress [11], abilities, and interests [12].

An individualized approach not only enhances student engagement but also promotes deeper conceptual understanding [13] and mastery of subjects, as well as providing real-time feedback. Traditional teaching approaches often cannot accommodate the wide range of diverse interests of students, instead catering to a one-size-fits-all approach [14]. AI-based educational platforms can leverage multimedia content, gamification elements, and interactive simulations to create a tailored learning experience [15].

2.2. Automated Assessments

Automated assessment technologies, which have been used in education for decades, are a key component of modern educational systems [16]. This technology enables quick and efficient evaluation of student progress and understanding, eliminating the need for manual grading. By utilizing various tools and platforms such as multiple-choice tests, problem-solving tasks, or even simulations, teachers can automatically analyze student responses and receive prompt feedback on their performance. This allows for a personalized approach to learning, tailored to the individual needs of each student, resulting in a more effective educational experience.

Automated assessments have evolved from traditional paper-based tests to e-systems powered by AI algorithms. These systems use machine learning algorithms to analyze students' responses, providing instant feedback and personalized learning [17]. Integrating AI into assessments is how teachers evaluate student performance, enabling scalability, efficiency, and adaptability to different learning needs [18]. One of the main advantages is their ability to provide instant feedback to students.

2.3. Advanced Data Analysis

By leveraging advanced data analysis techniques, AI algorithms can revolutionize the way we understand and utilize information in education. Through the use of machine learning algorithms and artificial intelligence, these technologies enable deeper insights into student performance, identification of patterns, and prediction of future trends. For instance, data analysis can uncover areas where students are struggling and offer personalized recommendations for support. Moreover, this technology can aid schools and educators in making informed decisions about adjusting curriculum and learning strategies to enhance student outcomes. By processing large amounts of data, AI algorithms can identify important findings, potentially saving researchers hours of manual data analysis [19].

By leveraging large datasets generated from various learning environments, AI algorithms can identify patterns, trends, and correlations that enhance decision-making in teaching and personalized learning [20]. One of the primary advantages of advanced data analytics in AI is its ability to facilitate adaptive learning systems. Adaptive learning platforms use sophisticated algorithms to dynamically adjust instructional content and delivery based on individual student's needs and preferences.

3. RESEARCH TRENDS IN EDUCATION

Research trends in education are continuously evolving, reflecting the dynamic nature of the field and the changing needs of learners. The field of education research has seen a shift towards more practical and action-oriented approaches, with a focus on the role of teacher research in professional development and school change [21]. This trend is supported by methodological guides that emphasize the importance of identifying and researching relevant topics, as well as the use of mixed-methods and action research [22]. However, there is a need for further exploration of innovative approaches in education research [23].

Additionally, other important factors influence research trends in education. For example, rapid technological advancement opens up new areas of research related to the use of digital tools and technologies in learning and teaching. Furthermore, demographic changes, social and economic dynamics in society, as well as changes in political and educational policies can affect research priorities in education.

Researchers and academic circles need to be aware of these broader contexts while shaping research programs and priorities in education. Collaboration among researchers, teachers, schools, and other stakeholders in education can provide valuable insights into the real needs and challenges faced by educational communities, and foster the development of relevant research approaches and solutions.

4. EVOLUTION OF AI IN EDUCATION

The evolution of artificial intelligence in education has significantly transformed the teaching-learning relationship [24]. This has been achieved through the development of knowledge-based systems that exhibit intelligent behavior [25].

In this chapter, we explore the evolution of the use of AI in education, which has resulted in significant changes in the way learning and teaching are conducted.

4.1. Transformation of Educational Processes

The digital transformation in education requires teachers to adapt and adopt digital technologies, methodologies, and mindsets.

The potential of AI to transform educational processes is a key focus in current research. Williamson et al. [26] emphasizes the need to re-examine the role of AI, automation, and datafication in education, while Hamal [27] proposes a multi-agent system based on AI techniques to optimize learning and teaching processes. Balta [28] discusses the transformative potential of AI in educational research, and Soelistiono [29] highlights the AI-integrated learning system design in AILS-based education, which uses machine learning to tailor approaches for each student and provide feedback.

Through the digitalization of learning experiences, both teachers and students can enhance their skills with a common goal: to create a more active and efficient educational process. The implementation of e-learning can significantly contribute to the enhancement of the quality of the educational process and its outcomes. It brings many advantages to the organization of the educational process, such as temporal and spatial flexibility in teaching and learning, access to up-to-date and interactive educational content, access to repositories of educational materials and digital libraries, archives, and museums, the possibility of adapting to individual learning styles, enabling collaborative learning, acquiring project and teamwork skills, as well as reaching a broader audience of students. Technology also enables teachers to utilize teaching and learning methods that are not possible in traditional classroom settings.

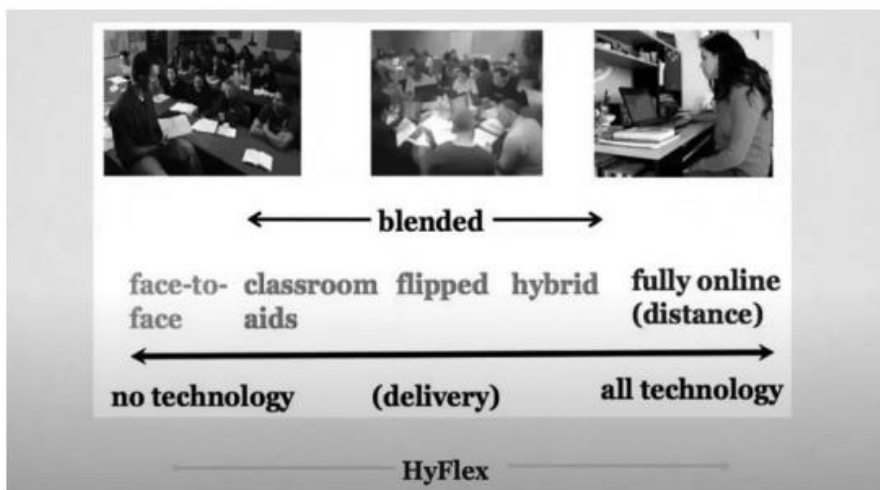


Fig. 1. Forms of Learning According to the Mode and Intensity of Information Technologies Usage [30]

4.2. Impact on School Systems

Digital transformation in education is significantly changing school systems worldwide, bringing with it a range of challenges and opportunities.

Digital transformation requires changes in the administrative processes of school systems, including tracking student progress, communicating with parents, and managing data. One of the key advantages of digital transformation in education is increased access to education. Online platforms enable students to access education from remote areas or in situations that prevent traditional schooling. However, with these changes come challenges. Existing infrastructure deficiencies, such as a lack of high-speed internet or a shortage of digital devices in schools, can limit the successful implementation of digital technologies.

In China, AI is used for tasks such as facial recognition, enrollment, and student attention monitoring [31]. However, the complex and controversial nature of AI's influence on teachers and students, including its potential to replace teachers, has also been highlighted [32]. On a more positive note, AI is being used to create a grading prediction system and digitalize student profiles, which can help identify at-risk students and provide them with appropriate support [33]. Despite these advancements, further research is needed to fully understand the implications of AI in education.

4.3 Ethics and Challenges

Although artificial intelligence brings numerous benefits to education, it also raises questions related to ethics and data privacy. As more data is collected about students and their learning, it is important to ensure that this data is used responsibly and transparently.

Teachers and educational institutions must be aware of potential risks and work to develop policies and procedures that will protect the privacy and integrity of students.

Rizvi [34] and Slimi [35] both highlight the need for careful consideration of ethical concerns, such as biased algorithms and displacement of human educators, and the importance of transparency and accountability in AI decision-making. Holmes [36] emphasizes the need for AIED systems to be designed with fairness and equity in mind, and suggests a shift towards a more collaborative model of AI design. Bu [37] further underscores the ethical risks of AI in education, including data security, role structure deconstruction, and alienation from educational goals, and proposes countermeasures such as redefining teachers' duties and promoting effective regulation. These studies collectively underscore the importance of addressing ethical concerns in the integration of AI in education.

Additionally, there is the issue of accessibility to technology, especially in cases where students come from rural or less developed areas. Ensuring equal opportunities for all students is crucial for a fair and inclusive educational system. Therefore, teachers and educational institutions should work to remove barriers that prevent access to technology and ensure that all students have equal chances for success.

5. CONCLUSION

In conclusion, artificial intelligence represents a significant potential for transforming education, offering new opportunities for personalized learning and improving teaching practices. However, to fully harness this potential, it is important to carefully consider the ethical and social implications of using artificial intelligence in education. It is also important to ensure the accessibility of technology and eliminate barriers that may prevent students from taking advantage of all the benefits of digital transformation. Through collaboration among teachers, researchers, and educational institutions, we can create an inclusive and equitable educational system that will prepare students for success in the 21st century.

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THE IMPACT OF INFORMATION SYSTEMS ON COMPANY DEVELOPMENT

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ABSTRACT:

This paper explores the impact of information systems on business development based on the author's experiences gained through the development of project and conceptual solutions in the field of enterprise development with the application of information systems. In today's era of globalization, information systems are an indispensable segment of every social activity. The analysis covers a wide range of topics, starting from introductory concepts to the integration of information systems into key business functions of the enterprise: management, marketing, production, logistics, as well as the cohesion of these functions with the purpose of enterprise development and improving market performance. Within the business functions, decision-making processes, management of business processes, analysis of the company's market position in line with product and service placement in the market are defined. Special attention is paid to financial analysis in order to maintain financial stability and profitability of the company. Through concluding considerations, the importance of efficient and effective enterprise development is emphasized both from the current position and in the context of strategy and goals. This paper provides a deeper insight into the complex interaction between information systems and enterprise development, and provides guidelines for further research and implementation in practice.

Keywords: *Information systems; Business development; Globalization; Decision-making processes; Financial analysis*

1. INTRODUCTION

Contemporary market, often referred to as the knowledge-based economy market, is characterized by the continuous impact of information and communication technologies and their segments, representing a new paradigm of business aimed at more efficient business execution on a global scale.

Globalization and the trend of dynamically observing all aspects of social action bring about a new era and commercialization of information systems. This paper focuses on a specific form of social action and organized grouping of people, known as a company. In addition to the proportionality between information systems and companies, we will analyze the specific impact of information systems on company development, considering that company development is the key goal of modern companies and their management.

In contemporary economic theories, it is often stated that the main cause of company failure is precisely a poorly coordinated information system in all company sectors, in as many as 92% of cases.

Considering the new market paradigms, companies must become more flexible to adapt to changes in the global environment and direct their strategies and goals towards effectively meeting the needs of both companies and consumers. In order for market paradigms to lead to quantum exponential growth in terms of company profitability, the informational foundation of every business and every type of company must be aligned with the principles of the modern market scene and the world order.

1.1. Related work

Citing Papic, M., Karic, K., Stojanovic, S.: Information Systems in Education: "Science, Teaching, Learning in a Changed Social Context" : *"Introducing information systems in various activities is of exceptional importance both in terms of time and efficiency, as well as in terms of keeping up with ubiquitous technologies"* [1].

At the 32nd National Quality Conference held in Kragujevac in 2005, the following hypothesis regarding the impact of Information Systems through the form of a company, which places its products on the market, was observed: *"The information system for new product development is built using the IDEF0 and IDEF1X standards implemented through the CASE tools BPwin and ERwin. The proposed working method using CASE tools involves future users who will use the appropriate application software and who will indicate deficiencies and their information needs while the system is being designed"* [2]. Virginia L. Lewis & Neil. C. Churchill state in their abstract on the topic *"The Five Stages of Small Business Growth"*: *"Knowledge of the developmental phase of a company starting from the end of the 20th century and in which the company finds itself will help directors, consultants, and investors make more informed decisions and prepare the company for later challenges"* [3].

Charles Davis and Elaine Sun from Toronto Metropolitan University, in 2006, note: *"Business development" is a corporate competence that has emerged in the information technology industry to support the practice of that industry in creating value in collaboration with customers and complements. As a set of practices linking the processes of creating enterprise value with its external environment, business development capabilities are a key factor in the success of small and medium-sized enterprises in information technology'* [4].

2. THE CONCEPT OF INFORMATION SYSTEMS

We live in a society where information represents an essential resource and where knowledge holds immense value. It's only in the last 30 to 40 years that people have truly realized that information and knowledge are elements every society should develop and effectively manage. This "discovery" marks the beginning of the "Information Age."

"Information systems can be seen as a complementary integration of hardware and software implemented and used within an organization. The goal of information systems is to collect, evaluate, analyze, create, and distribute data" [5].

In this way, employees in the organization can advance management, control, coordination, and optimization of business processes. This type of dissemination of collected data can greatly assist both employees at lower hierarchical levels and management in decision-making or general business process improvement. Information systems can be viewed from the perspective of their components (component aspect) and their roles (role aspect) in the organization [6].

Following modern trends, all companies, regardless of size, strive to implement information systems that will enhance their business operations. Technological advancement becomes the main weapon in the battle for market conquest. This process encompasses all companies aiming to globalize their operations, even those operating within national borders.

It is necessary to consider that information systems are a broad concept and, as such, require additional analysis to determine how to approach the implementation of solutions based on information systems.

2.1. Observation of Information Systems

Information systems can be viewed as systems based on the intensive application of knowledge and intellectual capital in business improvement. Such systems involve qualitative and quantitative data comparison, the use of digital tools, the internet, and social networks for business purposes, and general digitization of business processes [7].

2.2. Data as a Crucial Segment of Implementation

The functioning of a business system is described by data, which represent inputs and basic resources of the information system. Inputs relate to work and business processes, finances, goals, predictions, and similar. Inputs into the information system include products and the environment in which the real system exists [8]. The information system processes input data and produces information for managing segments of the business system. The main task of the business information system is to satisfy the information needs of the enterprise.

It enables [9]:

- Identification of the state of the business system,
- Measurement of parameters describing it (production status, cost and price levels, quality control, procurement and sales, income),
- Comparison of current with desired system states and control of deviations,
- Initiation of activities to ensure system control and functioning.

2.3. Components and Functions of Information Systems

Within the conceptual definition of information systems, it is crucial to specify the components and functions of the information system in the operations of every enterprise, regardless of the qualitative and quantitative criteria by which they differ.

The components of information systems represent the core structure of these systems and are integral parts that cannot be omitted. Five components of information systems are

hardware, software, data, human resources, or simply, people, and processes. Hardware, software, and data fall under technology. Additionally, alongside these five components, due to the expansion of ICT application, communication as a concept of exchange can also be considered a component of information systems [8].

3. APPLICATIONS OF INFORMATION SYSTEMS IN BUSINESS DEVELOPMENT AND MANAGEMENT

Information systems (Business Information Systems), as well as globalized systems, must have their beginning, flow, and end. The beginning, flow, and end are predetermined towards achieving objectives, while each objective has its place and distinctiveness from another objective within the same enterprise.

In Business Information Systems, this can be interpreted as follows [10]:

- Business development and management occur in every business function, sector, department;
- Each business function has its targeted value for which it was formed;
- Given the fact that the Information System circulates its so-called "molecules" circularly and circulates throughout the entire business system, it also has its significance and utility value in every business function.

Depending on the importance and role of the business function and its translation into the profitability of the company, the Information System (Business Information System) will have a more crucial or less crucial task.

Some of the business functions, which have their basis in every company and which are standardized generally for every company globally, are [11]:

- Business Function 1: Management;
- Business Function 2: Marketing;
- Business Function 3: Production; and
- Business Function 4: Logistic coverage and support.

Business Function 1: Management (equivalent to management; defined as for each business function, business processes, such as: Decision making and planning, Successful implementation and coordination of business activities according to the TQM methodology, Accounting and financial affairs, General and legal affairs, and HR service).
Business Function 2: Marketing (from the conceptual definition standpoint, according to F. Kotler: "Marketing is a human activity aimed at satisfying the desires and needs of consumers, in order to achieve profit and satisfy needs"; defined are business processes, similar to those in business function 1, such as: Research and development, Monitoring business partners, Procurement, sales, and distribution) [12].

Business Function 3: Production (from the standpoint of basic economic definitions: "Production is the organized action of people in the exploitation of natural resources, their processing, and the satisfaction of the needs of the entire society, and thus social welfare; business processes are also defined, such as: Analysis of requirements and production scheduling, Formation of production documentation, Monitoring production realization) [13].

Business Function 4: Logistic support and assistance (defined are business processes for managing and coordinating material and raw material stocks, Maintenance and Management of transportation).

Due to the consideration of the aforementioned issues related to Company Development, this paper must address Product Development itself, as it represents a precursor to Company Development and is closely related to it.

Product development entails the following business processes [11]:

- *Preparation of design documentation*: which is done based on the plan for the development of a new product, in line with the strategy for developing a new product that the company initiates before commencing the business venture process of product inception;
- *Preparation of technological documentation for product development*: which is done based on the projected plan for the development of a new product, as well as the Preparation of design documentation, but with a premiss of the prepared design documentation, which forms the backbone of the hierarchical modeling of business processes for product development, where each business process is mutually exclusive from the previous one;
- *Prototyping and implementation of the zero series*: if it is planned according to previously set goals, based on the development of a new product and based on the technical-technological documentation for the prototype and zero series; and
- *Implementation of changes*: also a mutually dependent and exclusive categorization performed on the technical-technological documentation.

Product development is carried out based on the *New Product Development Plan*, taking into account recommendations from production, information from supply, as well as licenses, standards, and internal regulations.

3.1. Development Component - Planning

The essence of planning lies in the selection and making of decisions based on which the company will be able to achieve optimal results. The result of the planning process is decisions about goals, plans, programs, and strategies.

Discussing the relationship between planning and decision-making, Mockler [14] says: *"Problem-solving - decision-making cannot be equated with planning. Two processes are different because decisions can be made all day without planning. But they are closely related. Planning requires a series of decisions. First, what are the important planning assumptions, then the best policy goals, etc. In other words, the planner goes through problem-solving - the decision-making process in each phase of the planning process. Planning therefore depends on good decision-making and is essentially a type of decision-making, namely predictable (anticipatory) decision-making."*

When we talk about a systemic approach to planning, it means that before making planning decisions, we must comprehensively consider the problems to be solved. This is precisely the difference between a systemic approach to planning and partial problem-solving that companies face in their business.

It is significant to emphasize that planning decisions are based on the current situation, while simultaneously considering the past and directing actions towards the future. This means that planning decisions always relate to measures of future events.

The goal of every planning decision should contribute to achieving the economic and social goals of the company.

Since the planning process ends with the making of a planning decision and the action processes begin, it is necessary to monitor what happens with the decision.

To prepare planning decisions, it is necessary to know the methodology of planning. One of the essential assumptions for making planning decisions is creativity, which must be in proportion to the intensity of considering the conditions and assumptions for making planning decisions. For a planning decision to meet the criteria of rationality, problems to be solved by planning decisions must be precisely defined.

There are two groups of planning decisions made in the company. One group of decisions relates to internal issues, and the other group relates to relationships with the environment. In terms of complexity, the latter are more complex. Certainly, in planning decisions, the probability of outcomes is significant, ranging from complete uncertainty to positive certainty [15].

3.2. Decision-Making Process and Its Composite Importance

During the decision-making process, company management has a so-called "permanent hunger" for new business and economic horizons. However, with a dose of risk and considering all relevant factors, often SLEPT environmental factors, the right decision can be made, which will be smart, useful, measurable, purposeful, and agile in meeting needs. Decision-making is the process of choosing among several alternative possibilities for changing the system's state to achieve a goal. Decision-making is present not only in planning but also in organizing, controlling with regulation, and a series of situations, but only as part of work content in which the manager is involved [16].

Decision-making is carried out in all phases of a company's operations. The result of decision-making is decisions that define the organization's goals, the necessary resources, personnel, and time to achieve the set goals, eliminate obstacles and dilemmas that arise. The decision-making process begins when the need for making a decision is identified. After making the decision, activities follow to implement the decision and control the achieved results in the implementation.

The decision-making process consists of the following activities [15]:

- *Setting goals to be achieved by the decision;*
- *Determining ways to achieve the goals;*
- *Identifying alternatives and selecting the most favorable one and*
- *Implementing and monitoring the chosen alternative.*

According to Adizes' opinion [17], for a decision to be implemented, there must be a convergence of interests among individuals who hold formal authority, power, and influence based on expertise:

- *Authority (A):* Individuals have the formal right or authorization to make a decision. For example, a sales manager has the right to grant a discount, and a production manager can relocate a worker.

- *Power (P)*: People in the organization possess the ability to cooperate, and their collaboration is necessary to implement decisions.
- *Influence (I)*: Based on expertise, individuals have the capacity to accomplish something without resorting to authority and power.

4.THE INFLUENCE OF EMPLOYEE EDUCATION AND TRAINING IN THE PROCESS OF BUSINESS INFORMATION SYSTEMS IMPLEMENTATION

Employees (human resources) represent the key and "foundation" of every business organization, i.e., company. Namely, in economic theories, based on empirical research, significant objectively verifiable indicators have been identified that support the fact that employees in a company, with their knowledge, abilities, habits, skills, and will, are referred to under the terminological designation "Human Capital". In order for every company to successfully align with market demands, as well as with the demands of its internal stakeholders, training, education, and professional development are essential starting points for their implementation.

As a result of detailed analysis and synthesis of the impact of employee education and training in the process of implementing information systems, according to some authors, the cruciality of the concept of "Employee Recruitment" is emphasized.

Recruitment is defined as the process of attracting and retaining sufficiently qualified and high-quality employees for job positions, who possess the aforementioned qualities (abilities, skills, and habits) for successfully performing tasks and achieving planned goals in that position [13].

Education and training of employees in the process of implementing business information systems represent the fifth business process within the business function of "Management".

Further elaboration of the mentioned processes follows [11]:

- Development of acts on organization and systematization, defining the Regulation on internal organization and systematization of job positions;
- Provision of necessary personnel (already elaborated in the section "Employee Recruitment"), which is defined by activities such as advertising and candidate selection, establishing employment relationship, ensuring employees based on the Contract for Work, etc.;
- Maintenance of employee records, defined by activities such as ensuring employee data security, monitoring personal data, employee work cycle.
- The implementation of the mentioned process activities follows the document "Procedure for the admission and allocation of employees."

Analyzing various research papers leads to the conclusion that education and training of employees are similar concepts but not identical. The following points are stated:

- Education of employees is a broader process: It involves the overall development of employees, including acquiring new knowledge, skills, and competencies that are not specific to business information systems.
- Education focuses on a broader understanding of information systems and their impact on the organization as a whole: It encompasses theoretical foundations,

conceptual understanding, and a high level of knowledge about information systems and their role in the organization [18].

On the other hand, the following qualitative values are cited for employee training:

- Employee training is a more specific process: It aims to provide employees with specific skills and knowledge necessary for the effective use of business information systems.
- Training focuses on the application of specific tools: The implementation of software and procedures that are part of the business information system forms the basic foundation of specific training tools.
- Training is narrowly specific and applicable to the current needs of the organization regarding information systems [18].

5. IMPACT OF INFORMATION TECHNOLOGIES ON ENTERPRISE COST PLANNING AND MANAGEMENT

Every enterprise, regardless of its categorization based on total revenue, annual turnover of goods/services, or number of employees in its regular business operations, incurs operating costs. Operating costs in general economic theory represent all investments and expenditures arising from regular business operations.

Namely, according to the generally accepted definition, costs represent the monetary value of expenses. All costs within an enterprise are divided, according to their comprehensiveness and scope, into:

- *Fixed costs*: These costs are not subject to adjustment due to changes in production volume, but they are subject to adjustment due to changes in the volume and structure per unit of product.
- *Variable costs*: These costs are subject to adjustment due to changes in production volume, but they are not subject to adjustment due to changes in the volume and structure per unit of product.

To understand and recognize the importance and relevance of costs in an enterprise, they must be effectively managed. In this regard, enterprise management faces a constant task with a significantly high risk of failure. If new costs are not timely addressed and successfully consolidated into regular expenses, the enterprise may face consequences and become illiquid.

For this purpose, various methods, procedures, and models have been developed, providing enterprise management with a critical mass of information necessary for the decision-making process aimed at cost optimization based on factual approach to decision making [19].

- *Traditional production cost management model;*
- *Cost management model of core processes;*
- *Cost management model of core activities;*
- *Target costing model;*
- *Activity-based budgeting;*
- *Balanced scorecard model;*
- *"Kaizen" costs and*
- *Value analysis and quality cost management model.*

5.1. Sublimation of Cost Management under the Patronage of Information Systems and Strategic Management

In section 5.1., we delve into the practical application of information systems within organizational strategy. This entails exploring how businesses strategically utilize information systems to streamline operations, enhance decision-making processes, and gain a competitive edge in the market. We examine case studies and real-world examples to illustrate the effective integration of information systems into strategic planning and execution. Additionally, we discuss the challenges and opportunities associated with aligning information systems with broader organizational goals, emphasizing the pivotal role of technology leadership and governance in driving strategic outcomes. *Equation related to Strategic Management of Information Systems:* In this equation, ROI (Return on Investment) is calculated by dividing the net profit (the profit after subtracting expenses) by the initial investment, and then expressing it as a percentage. This equation is often used in strategic management to evaluate the efficiency and profitability of investments in information systems [19].

$$ROI \left(\frac{\text{Net profit} - \text{Investment}}{\text{Investment}} \right)$$

6. CONCLUSION

Through this paper, the reader could familiarize themselves with comprehensive Information Systems used in the operations of each business system and their significance in today's era of globalization. Moreover, by examining specific segments interlinked with a critical perspective on individual thematic aspects of the thesis, the reader can retrospectively observe the topic beyond established theoretical norms.

In summary, the implementation of information systems significantly impacts the development of enterprises. Through efficient IS utilization, companies can achieve greater productivity, cost reduction, and better management of business processes. It is important to invest in employee education to ensure their adequate use of IS and maximize the benefits they offer.

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BUSINESS PROCESSES MODELLING FROM ASPECT OF PROJECTING FUTURE USER INTERFACE OF INFORMATION SYSTEM

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ABSTRACT:

In order to increase the comprehensibility of business processes and to ensure the projecting logic and potential changes of the information systems or to support the analysis of the modelling system it is very useful to introduce graphic visualisation of the aforementioned processes. Modelling processes enable the usage of the corresponding software tools in order to define business processes graphically. This paper presents the process of control and investigation by using Microsoft Viso and BPwin modelling tools. The aim of the paper is to show the flow chart of the control and investigation processes as well as their comparative analysis from the perspective of planning and projecting the future user interface of the information system.

Key words: *model processes, information systems*

1. INTRODUCTION

Business process modelling enables obtaining an organised structure with clearly defined rules according to which the processes occur. Graphical presentation of a particular process' stages is much clearer and more transparent for both the designer and the future user. MS Word symbols can be used for such layouts and special tools designed for that purpose. Appropriate CASE (Computer Aided Software Engineering) tools were developed for the modelling process. The standard for functional modelling IDEF0 (Integrated Computer Automated Manufacturing Definition), implemented through the BPwin CASE tool is used in the paper.

2. PROCESS DOCUMENTING

The quality management system should be regarded as a strategic problem that needs to be solved through concepts such as plans, goals, realisation of set goals, control, permanent education, traceability, and documentation. The documentation for the QMS must include the procedures required by the standard and documents which show that an organization effectively performs and manages its processes [1].

Procedures that describe processes contain a flow diagram for a graphic representation of the process in an organizational unit. The flow diagram enables the visualization of the range of activities and the responsibilities of the performers which are necessary for the

successful implementation of the process. Fig. 1 presents the flow diagram of reception control.

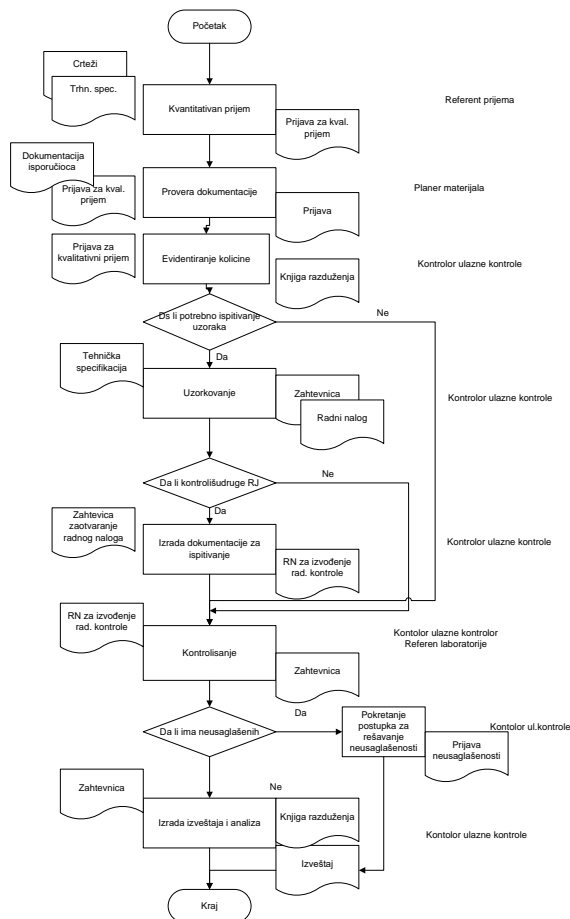


Fig. 1. Diagram of reception control flow

This diagram is a component of the procedure for reception control. The processing and final procedures also contain their flow charts which do not present graphical processes connecting [2].

3. FUNCTIONAL MODEL OF CONTROL AND TESTING PROCESS

The Process Approach is one of the eight principles of the ISO 9001 quality management system, which ensures that the desired result is achieved more efficiently when related resources and activities are controlled as a process [1].

This paper shows the modelling of the control and testing processes that were performed by using a process model, with the activities containing the information required for the

realization of the abovementioned processes, as well as the interconnections of functional relationships through the concrete process model.

Using IDEF0 methodology, ie. CASE tool BPwin, functional modelling was performed by defining the system limits and decomposition diagram.

3.1. Contextual Diagram

Defining the context diagram represents the limit of the model being studied, ie. the limits of the system are defined, the observation framework is established and the environment that affects the system is also defined. From the perspective of the Process Approach, the observed system at the highest level is viewed as a single process since it represents one whole. Inputs for the observed process necessary for its successful realization are defined in the form of outputs from the aspect of the end user [3].

Fig. 2 shows the context diagram of the control and testing processes, which includes receiving, process and final control.

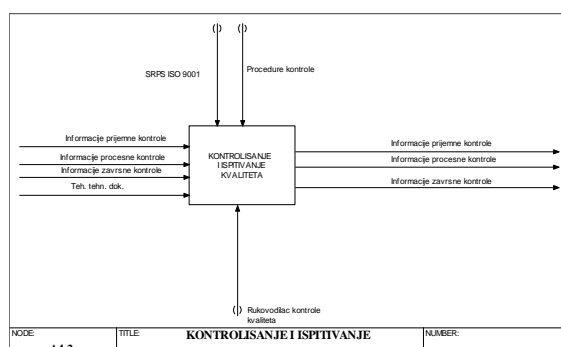


Fig. 2. Context diagram of control and testing

The diagram shows the arrows that transmit the information of reception control from the process entrance to the exit. They are placed within the documents of reception control as information transmitters, namely: Application for Qualitative Reception, Control Plan of Input Components, Contract, Technical Documentation, etc.

The process control information is placed within process control documents, such as control charts, first item verification protocol, quality monitoring recording, etc.

The final control documents contain final control information, such as Test reports, Test Protocol, Final Control Recording, etc.

Arrows pointing downwards signify rules governing the process, standards, policy, and procedures: Quality Policy, Procedure for Creating a Control Plan, Procedure for Qualitative and Quantitative Reception, Procedure for Managing Non-Conforming Products.

Arrows pointing upwards identify the meaning which supports a process of exerting responsibility.

3.2. Decomposition Diagram

Fig. 3 gives the overview of using the IDEF0 modelling technique, a horizontal decomposition diagram of the Control and Testing process. All types of control include the following processes: control plan design, quantitative control, qualitative control and analysis of obtained results.

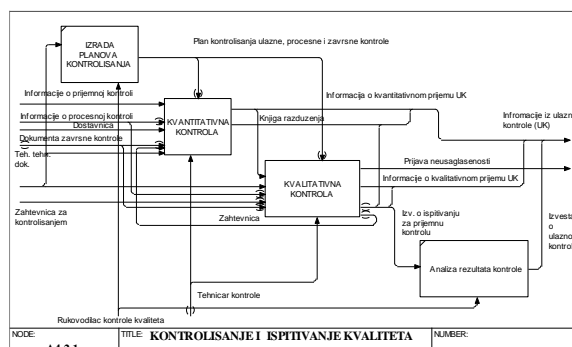


Fig. 3. Decomposition diagram of control and testing processes

3.2.1 Control Plan Design

Control plans for each type of control (input, final and process) are drawn to prescribe the characteristics to be controlled, measuring and control tools, methods or techniques for determining quality, method of quality monitoring and control intervals.

3.2.2 Quantitative Control

Quantitative control is performed by the reception clerk, the warehouse worker during material receipt, the process control inspector in the process, and the final inspection controller. For the received items, the quantity is determined and recorded through counting and measurement. In case of a discrepancy with the expected quantity, the discrepancy is noted in a report and returned to the supplier. Quantitative control includes Quantitative Acceptance, Documentation Verification, Input Recording, etc.

3.2.3. Quality Control

Quality control serves to determine the level of quality fulfilment established according to technical specifications. It contains sampling and test request design, as regulated by the control plans for input, processing and final control.

Quality control includes Sampling, Controlling, Reports and Reception of Control Items. If the results are not satisfying, the report of inconsistency is created and the procedure for inconsistency resolution is generated, only if it is possible to resolve the unsatisfactory quality by directing it towards fulfilling other purposes.

3.2.4. Results Analysis

This activity defines appropriate reports, graphs and statistical overviews as well as periodic reports that are subject to consideration by the appropriate professional services and quality committees. Appropriate corrective activities are undertaken based on these reports.

4. INFORMATION SYSTEM USER INTERFACE

Data modelling is our imaginative perspective of the state of the real system, i.e. defining the data structure. Information modelling is a simplified representation of a real system through a set of objects (entities), connections among objects and object features [4].

Further decomposition of quantitative and qualitative control results in processes that cannot be further decomposed. However, through information modelling by defining requirements from documents, a data model is designed for the database that represents the basis of the information system for the observed business segment.

Each process in the functional model represents an item in the menu of the future user interface for the information system. It is further necessary to create a data model that describes the data structure and business rules for the execution of that process. Each process that is shown at the lowest level of the decomposition diagram represents one form of the user interface for the implementation of the mentioned process.

5. CONCLUSION

Each process visualization represented by standardized graphic symbols is easier to understand than textual descriptions.

The paper presents two models of graphical representation of the same process. They both enable easier monitoring of the interactive processes, which helps the organization achieve more successful monitoring and higher-quality operations.

The results of the analysis show that the functional modelling excels in comparison to the other one. It clearly defines the affiliation of each process to its attributing unit of the functional organisation, defining the process owner since the processes define the function performed for a specific business reason. This enables the adjustment of functional and organisational units with the performing processes, which represents the solid ground for information system projecting and its user interface.

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DESIGN OF A HUNTING DOG STIMULATION SYSTEM

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ABSTRACT: *Electronic dog tracking systems are very useful during hunting. At any moment the hunter can see where the dog is and which way it is moving, allowing for a worry-free hunting experience. Some of the most popular manufacturers of dog tracking systems are Garmin, DogTrace, and Dogtra. The main disadvantage of these systems is their external antenna, which can disturb or even injure dog when moving through bushes and vegetation. A big competitor of the previously mentioned systems is the Canandi system, developed in Serbia. The Canandi system consists of 3 units, a dog collar, a hunter unit and a mobile application. The dog collar uses a GPS, in order to find the coordinates of the dog's location and then sends those coordinates via radio link to the hunter unit, which then forwards them to the hunter's mobile phone through Bluetooth. In this way, the hunter can track his dog's movements in real-time without the need for his phone to be within a range of a mobile network or connected to the Internet. With one hunter unit it is possible to track up to 20 dogs within a range of 20 km in line of sight. Compared to the competition, the Canandi system introduces several important innovations. In this paper, the Canandi dog collar system will be described. We will discuss the bark detection system, the system for detecting dog movement speed and we will also explore the system for sound and vibration stimulation.*

Keywords: *GPS, LoRa, bark detection, movement detection, stimulus*

1. INTRODUCTION

There are few innovations considering design of an electronic dog tracking system presented in this paper.

The first innovation that provides an advantage over the competition is the embedding of the antenna for communication with the hunter unit and the GPS antenna inside the collar housing. In this way, the free movement of the dog through vegetation and bushes is ensured without the possibility for the external antenna, which in some competing systems can be up to 50 cm in length, to get stuck or injure the dog.

The second innovation is anti-theft system. Each dog collar is equipped with a unique security code which is used when registering the collar in the mobile application and which enables its use. In this way, the collar can only be used by its owner who has the security code. The collar is turned on by pressing the button and it can only be turned off through mobile applications in which it is registered using previously mentioned security code. If

someone takes off the dog's collar, they will not be able to use it and connect to it because they don't have its security code. The stolen collar remains operational until the battery depletes, providing the hunter with enough time to locate it or the stolen dog.

The third innovative feature is smart hunting groups. Hunters are able to connect and share information with each other using their hunter units and mobile phones and thus communicate even in areas where there is no internet connection or mobile network. Each hunter in the group can designate points of interest such as check points, feeders, waterers, to mark the place where the wild animal track has been seen and also to mark the boundaries of the hunting ground.

The ability to stimulate the dog during the hunt is important for the hunter as it allows them to command to their dog even when the dog is not around. Stimulation can be done by vibration, sound or electricity [1], [2], [3]. The Canandi system [4] has been upgraded to include the option to stimulate the dog through vibration and sound. Given that the use of electricity to stimulate animals is prohibited in the EU, this type of stimulation will not be used. When the dog feels a vibration or hears a sound it will stop running or chasing prey.

In chapter 2, the Canandi dog collar system will be described. Following this, there will be a discussion about new parts of the system which are under development. Chapter 3 will cover the bark detection system. Chapter 4 will delve into the system for detecting dog movement speed and Chapter 5 will explore the system for sound and vibration stimulation. The conclusion of the paper will be presented in Chapter 6.

2. CANANDI DOG COLLAR

The central part of the Canandi dog collar system is the microcontroller that controls all the modules connected to it.

LoRa module (*Long Range Modulation*) is used for communication. With this module, the collar receives the data sent to it from the mobile phone via the hunter unit. LoRa is a radio communication technology developed to create low-power, wide-area networks required for IoT (*Internet Of Things*) applications. LoRa uses radio frequency bands that do not require a special license. In Europe, that frequency band is 863 - 870/873 MHz. The main characteristic of this radio technology is very low energy consumption and the range up to 20 km. Figure 1 shows a block-level schematic of the Canandi dog collar system.

The collar has a GPS module that determines the position of the dog. This module exchanges information with satellites via a radio link and, based on the received data, determines the dog's exact position (altitude, latitude and longitude). The network of GPS satellites covers the entire Earth, so the receiver GPS module on the collar will always be able to determine the position of the dog. Information about the position of the dog is constantly collected, processed in the microcontroller and sent. This information enables the hunter to track the dog's movements in real time.

Further improvements to the system are underway, including new modules that will be an upgrade to the existing system. The new modules are modules for vibration and sound stimulation, modules for detecting dog bark and acceleration, as well as an LED module. LED will be embedded in the collar housing and it will be turned on and off via a mobile application.

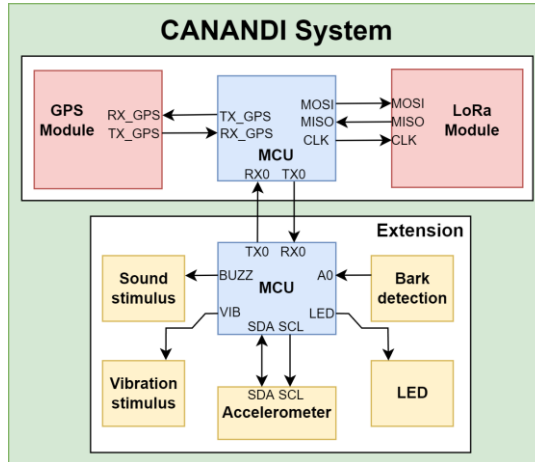


Fig.1. Block-level schematic of the Canandi dog collar system

3. BARK DETECTION SYSTEM

The bark detection system detects the sound emitted by the dog when it barks. Detection is performed using a microphone CMEJ-0415-42-LP [5] located on the printed circuit board inside the collar housing.

The microphone detects sound wave vibrations and generates a continuous signal at its output, which is further processed using the MAX9814 integrated circuit [6]. This integrated circuit is an amplifier with automatic gain control and low noise polarization. It consists of a low noise amplifier, a variable gain amplifier and a voltage generator for microphone polarization. The internal structure of the MAX9814 integrated circuit at the block level is shown in Figure 2.

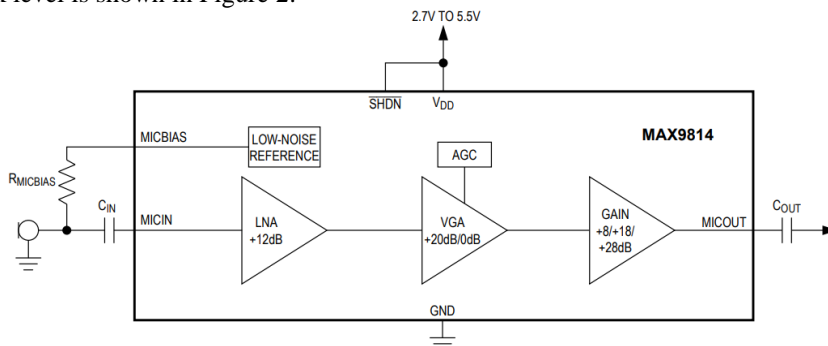


Fig.2. Block-level structure of the MAX9814 integrated circuit

The amplified continuous audio signal from the output of the integrated circuit MAX9814 is transferred to the analog input pin of the MCU. In the MCU, that continuous analog

signal is converted into a digital signal using an analog-to-digital converter. The digital value of the signal is then translated into decibels using (1):

$$Snd = 20 * \log_{10}(\sqrt{Snd_dig} / 512) \quad (1)$$

The variable *Snd* represents the sound value in dB, *Snd_dig* is the digital sound value in the range 0 to 511. A schematic of the sound detection system is presented in Figure 3.

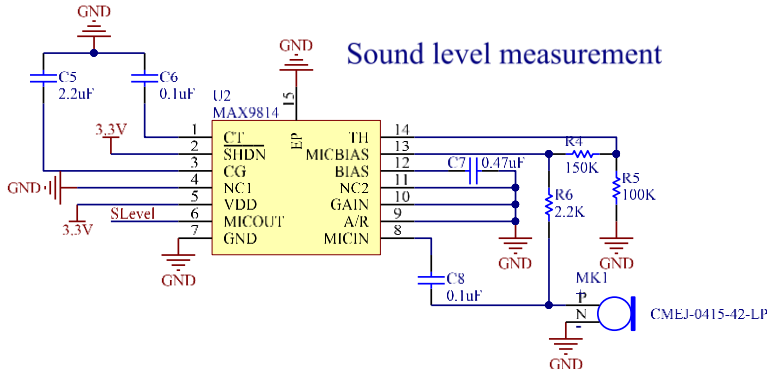


Fig.3. Schematic of the sound detection system

The MCU determines whether to discard or retain the sound value received from the microphone and MAX9814 circuit according to the barking detection algorithm. The MCU rejects sound values that are below a certain limit set by the hunter. In this way, it is ensured that only the barking of the dog is detected, and not the sounds and noise from the environment, which are much lower in intensity. Since the barking volume of different dogs varies, each hunter can use his mobile application to define the sound limit according to the volume of his dog's barking. Sound limit information is sent through Bluetooth to the hunter unit and then via radio link to the collar worn by the dog.

The detected sound value above the given limit is marked as barking, while the value below the given limit is rejected. Each time a bark occurs, the value of a bark counter in MCU is incremented. The value of the counter is periodically sent to the hunter unit and further to the mobile phone so that the hunter can have information about whether and how many times his dog barked.

4. MOTION SPEED DETECTION SYSTEM

The detection of the movement speed is performed using the integrated circuit ICM20602 [7], a sensor that detects the acceleration of the dog over time. The ICM20602 integrated circuit is a 6-axis motion tracker that combines a 3-axis gyroscope and a 3-axis accelerometer. It also contains a 16-bit analog-to-digital converter, programmable digital filters and a built-in temperature sensor.

Since the ICM20602 operates at 2.5V and the microcontroller at 3.3V, it is necessary to use a level shifter in order for the two chips to communicate. The level shifter is a circuit that allows lowering or raising the voltage level of a signal and consists of a transistor (BJT or MOSFET) and a pull-up resistor. The schematic of the ICM20602 integrated circuit is shown in Figure 4, while the level shifter schematics are shown in Figure 5.

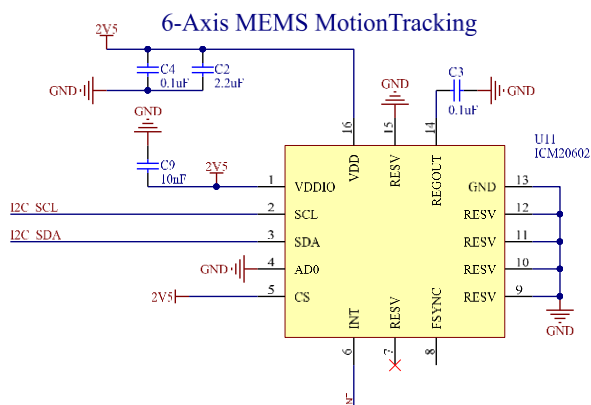


Fig.4. Schematic of the integrated circuit ICM20602

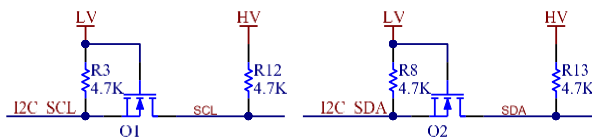


Fig.5. Level Shifter schematic

The dog, depending on its acceleration, can be in one of the following three conditions: standing, sneaking, running.

Since the acceleration information is a continuous value, the sensor chip itself has the analog-to-digital converter for converting the continuous information into the digital format suitable for processing in the MCU. Digital information about the acceleration is sent to the MCU via I2C communication lines, where it is further processed.

Based on the obtained processing results, the MCU determines in what condition the dog is. The obtained information about the condition of the dog is sent via radio link to the hunter unit, and then through Bluetooth to the mobile phone, so that the hunter can see the information about the condition of the dog in real time.

To determine the condition of the dog, there are two limit values of acceleration, lower and upper. Limit values can be defined by the hunter through the mobile application and sent to the collar, and their value is expressed in m/s^2 . Based on the received information about the current acceleration and the limit values set by the hunter, the MCU determines the state of the dog according to the algorithm shown in Figure 6. The labels *low_th* and *high_th* represent the values for the lower and upper bounds respectively.

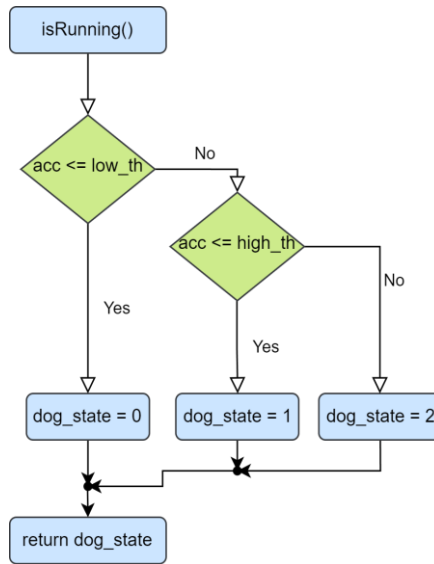


Fig.6. Algorithm for determining the state of the dog based on acceleration and limit values

If the acceleration obtained from the accelerometer is less than the lower limit value, it means that the dog is standing (first condition). When the acceleration value is in the range between the two limit values, then the dog is sneaking, moving slowly and silently approaching the prey (second condition), while if the acceleration value is higher than the upper limit value, it means that the dog is running (third condition). Figure 7 shows a graphic representation of the state of the dog, acceleration and limit values.

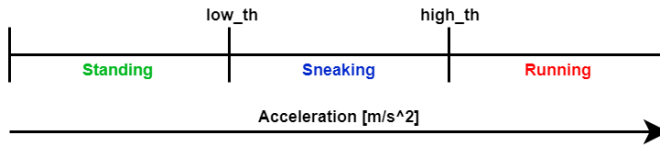


Fig.7. The condition of the dog depending on the acceleration and limit values

5. MOTION SPEED DETECTION SYSTEM

The ability to stimulate the dog is very important for hunting when it comes to chasing prey. When the dog is chasing prey, the moment the stimulation occurs, the dog will stop chasing.

The system is developed so that the hunter can give a stimulus command through the application on the mobile phone, which is sent through Bluetooth to the hunting unit and further via a radio link to the collar. In addition to choosing the type of stimulation, the hunter can also set the desired number of seconds of stimulation duration. Depending on the type of command received by the collar, sound or vibration stimulation is triggered. Sound stimulation is performed using the speaker CMT-0525-75-SMT-TR [8] located inside the collar housing. When the collar receives the sound stimulation command, the MCU activates the speaker by generating a *Buzz* signal for the time interval set by the hunter. The volume of the sound speaker emits is enough for the dog to recognize it and stop. The sound is not too loud because a loud sound can scare the prey. The scheme of the sound stimulation system is shown in Figure 8.

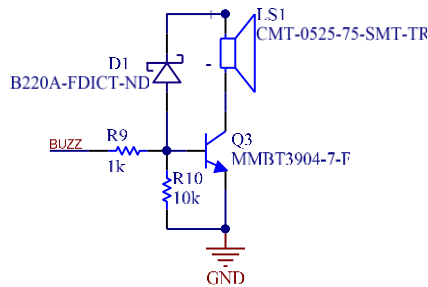


Fig.8. Schematic of the sound stimulation system

The vibration stimulation system works on a similar principle. For vibration stimulation, a VC1434B002U [9] vibration motor is used, which is located inside the collar housing. Figure 9 shows the used vibration motor.



Fig.9. Schematic of the sound stimulation system

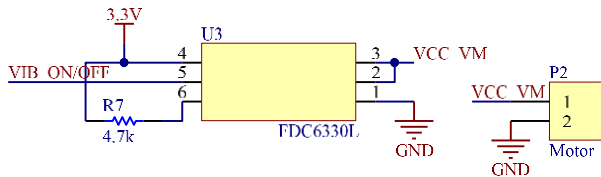


Fig.10. Schematic of the vibration stimulation system

When the collar receives the vibration stimulation command, the MCU generates a *VIB_ON/OFF* signal for the number of seconds specified by the hunter. Based on that signal the integrated circuit FDC6630L [10] activates the vibration using the *VCC_VM* signal. This circuit is an integrated load switch and is suitable for compact power management in portable electronic equipment where input voltages from 3 to 20V and

output currents up to 2.3A are required. The vibration is a signal to the dog to stop if it is chasing prey. Figure 10 shows the schematic of the vibration stimulation system. Figure 11 shows the layout of the stimulation system printed circuit board, while Figure 12 shows the assembled printed circuit board.

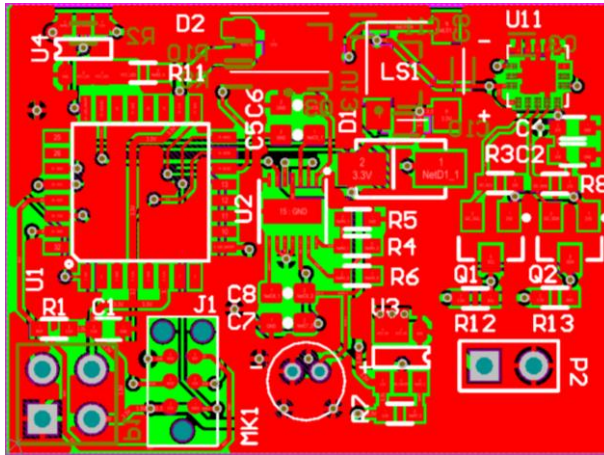


Fig.11. Layout of the stimulation system printed circuit board

The dog collar system with the stimulation board extension is shown in Figure 13.

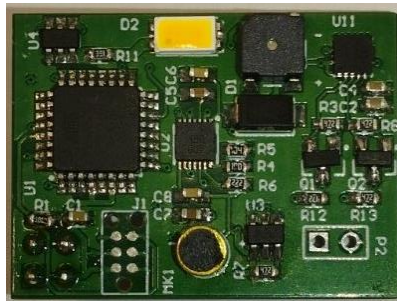


Fig.12. Assembled printed circuit board of the stimulation system

5. CONCLUSION

This paper describes the enhancement of the Canandi dog tracking system by adding the stimulation module, the bark detection module, and the dog speed tracking module. Stimulation modules are important for hunters because they allow them to send stimulating commands to their dog in situations when the dog is far from them, which is often the case during hunting.

Based on the speed of the dog's movement, the hunter can have an insight into whether his dog is standing, sneaking up on the prey or chasing it. This data, as well as the data on the frequency of barking, is of great importance for the further movement and reaction of the hunter.



Fig.13. Dog collar system with the stimulation board extension

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PROPOSING AN APPROACH FOR ADDRESSING CHALLENGES OF SMART EDUCATION IMPLEMENTATION: A SYSTEMATIC FRAMEWORK

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ABSTRACT:

All spheres of society are affected by digital transformation. One of the spheres is education. The application of information technologies in traditional education influenced the development of electronic education, and further integration and application influenced the emergence of smart education. Apart from the advantages of smart education, numerous challenges also arise during the implementation process. The primary aim of this scientific paper is to propose a comprehensive framework for effectively addressing the challenges of smart education implementation. The proposed framework includes various aspects of approaching the challenges. Following the outlined framework, future directions for the development of the framework are given.

Keywords: *smart education, smart technology, smart learning, education challenges, framework*

1. INTRODUCTION

With the increasing development of smart technology, its implementation has spread to different spheres of life, including the educational sphere. Smart education is a term that is being used more and more often. Although there is no universal definition, one of the definitions, according to [1], is that Smart education (SE) represents a collection of e-services that employ digital media and information and communication technologies (ICT) for supporting all educational processes. Numerous advantages of smart education contribute to improving the quality of elements of the educational process. With different learning styles, with the possibilities of providing infrastructure and technological training for educators, these advantages vary. One of the advantages is the possibility of more efficient management of education. It relates to various elements of the educational process and enables simpler monitoring of student performance by analyzing data with the help of smart technology. Smart technology can also be used in making decisions about the improvement of educational processes. This type of education encourages critical

thinking and creativity, and the application of information technologies encourages digital literacy. When it comes to smaller groups, simple personalization of the content and adaptation of the teaching process to each student is also possible. Figure 1, according to [2], shows the characteristics of smart education.

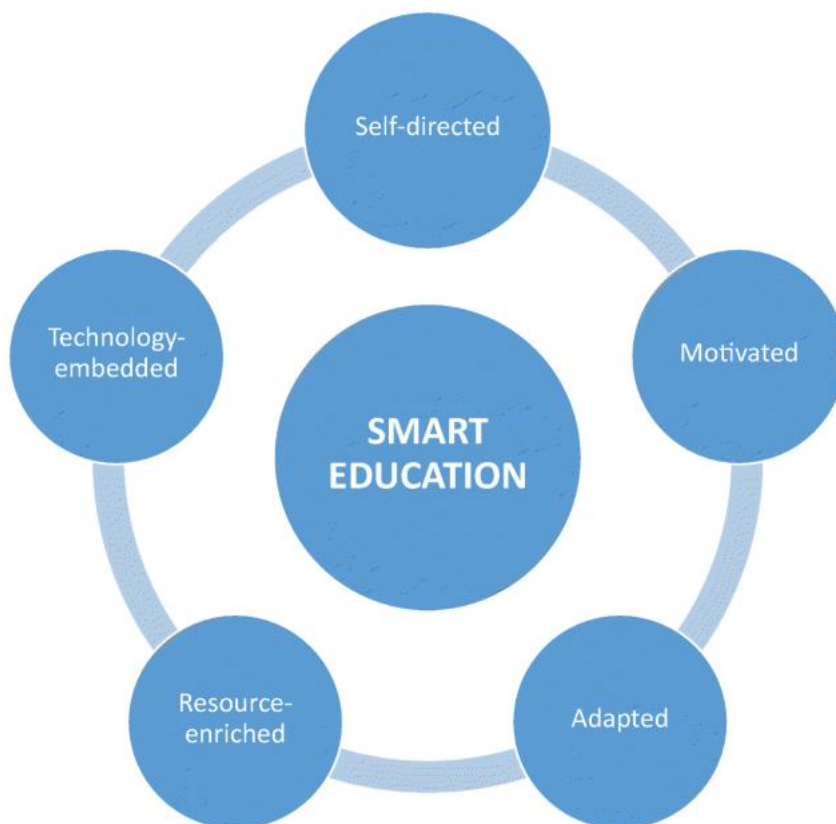


Fig.1. Smart education challenges [2]

In the next chapter, several challenges that arise during the implementation of smart education have been identified. The categorization has been tabulated, by the characteristics of the challenge. Chapter 3 offers a universal framework for dealing with challenges, emphasizing various categories. Directions for future development, as well as recommendations, are given, along with concluding remarks.

2. IDENTIFY CHALLENGES IN THE SMART EDUCATION IMPLEMENTATION

As already mentioned, apart from the advantages of smart education, there are also various challenges that arise during and after the implementation process. The number of challenges varies from several factors, some of which are geographical, demographic,

social, economic, and cultural. The prerequisite for facing the challenges is their recognition and identification. Recognizing and identifying challenges will enable a better understanding of the problems and the possibilities for solving them. Figure 2 shows a variety of challenges that arose in practice during the implementation of smart education. It is interesting to note that certain advantages of smart education are sometimes also its challenges.

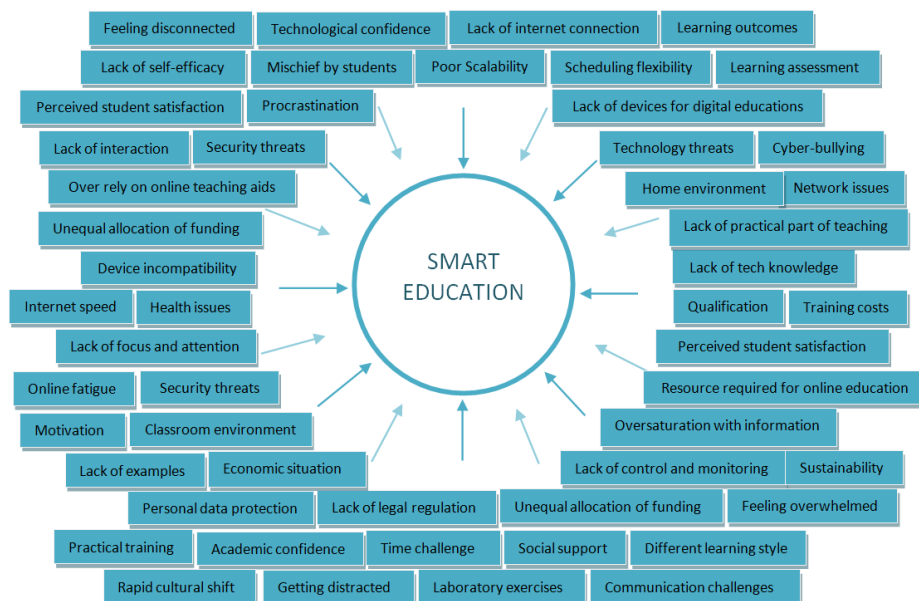


Fig.2. Smart education challenges

2.1. Categorization of the challenges

The challenges faced during the implementation of smart education change over time. These changes can be qualitative and quantitative. Qualitative changes refer to challenges that may become more or less complex with deeper implementation of smart education, while quantitative changes reflect the fact that the number varies because a certain number of challenges are overcome or arise with deeper implementation. Therefore, this paper presents a certain number of challenges that most often arise in smart education. Through a detailed analysis of the challenges, it was concluded that the challenges can be categorized according to their characteristics. Due to their complexity, some challenges cannot be categorized in such a way that they belong to one category, while some challenges can be classified exclusively in one category.

The categories in which the challenges are grouped are presented in tables (1-8).

Table 1. Challenges of smart education implementation – category Student

Category: Student	
Challenge	Ref
Lack of tech knowledge	[3], [4]
Lack of self-efficacy	[5]
Procrastination	[5]
Lack of control and monitoring	[5]
Perceived student satisfaction	
Personal data protection	
Cyber-bullying	[5]
Mischief by students	[5]
Resource required for online education	[4]
Economic situation	[5], [6]
Home environment	[5]
Training costs	
Scheduling flexibility	
Feeling disconnected	
Getting distracted	
Health issues	[5]
Lack of interaction	[5]
Feeling overwhelmed	
Academic confidence	[6]
Lack of focus and attention	[5]
Technological confidence	[4], [6]
Different learning style	
Social support	[6]
Rapid cultural shift	[7]
Motivation	[6]
Laboratory exercises	[7]
Practical training	[7]
Online fatigue	[7]
Communication challenges	
Time challenge	[6]

Table 2. Challenges of smart education implementation – category Competency

Category: Competency	
Challenge	Ref
Perceived student satisfaction	
Scheduling flexibility	
Feeling disconnected	
Health issues	[5]
Lack of interaction	[5]
Rapid cultural shift	[7]
Motivation	[6]

Laboratory exercises	[7]
Practical training	[7]
Online fatigue	[7]
Communication challenges	
Time challenge	[6]

Table 3. Challenges of smart education implementation – category Technical

Category: Technical	
Challenge	Ref
Lack of internet connection	
Internet speed	
Lack of devices for digital educations	[7], [1]
Device incompatibility	
Poor Scalability	
Network issues	[5]
Lack of tech knowledge	[3], [4]
Resource required for online education	[4]
Home environment	[5]
Classroom environment	[5]

Table 4. Challenges of smart education implementation – category Competency

Category: Competency	
Challenge	Ref
Perceived student satisfaction	
Lack of examples	
Learning assessment	
Learning outcomes	
Lack of practical part of teaching	
Classroom environment	[5]

Table 5. Challenges of smart education implementation – category Security

Category: Security	
Challenge	Ref
Security threats	
Technology threats	[5]
Personal data protection	
Cyber-bullying	[5]
Mischief by students	[5]
Lack of legal regulation	[6]

Table 6. Challenges of smart education implementation – category Content

Category: Content	
Challenge	Ref
Perceived student satisfaction	
Lack of examples	
Learning assessment	
Learning outcomes	
Lack of practical part of teaching	
Classroom environment	[5]

Table 7. Challenges of smart education implementation – category Finance

Category: Finance	
Challenge	Ref
Resource required for online education	[4]
Sustainability	
Economic situation	[5], [6]
Home environment	[5]
Classroom environment	[5]
Training costs	
Unequal allocation of funding	

Table 8. Challenges of smart education implementation – category Rules and regulations

Category: Rules and regulations	
Challenge	Ref
Lack of legal regulation	[6]
Unequal allocation of funding	

3. APPROACH FOR ADDRESSING CHALLENGES

After the most common challenges that arise during the implementation of smart education have been identified, it is necessary to approach their elimination. Since a detailed analysis was carried out and it is a question of a significant number of challenges, the categorization that was carried out is significant to approach the solution of the challenges in an appropriate way. As the number of challenges constantly varies, as some challenges are overcome while others arise, categorization provides the possibility of a systemic approach to dealing with challenges. Figure 3 shows a framework for coping with challenges, which includes 4 approaches for dealing with 8 categories of challenges. A certain number of categories were approached from one of the aspects, while the complexity of certain categories implies facing several different aspects.

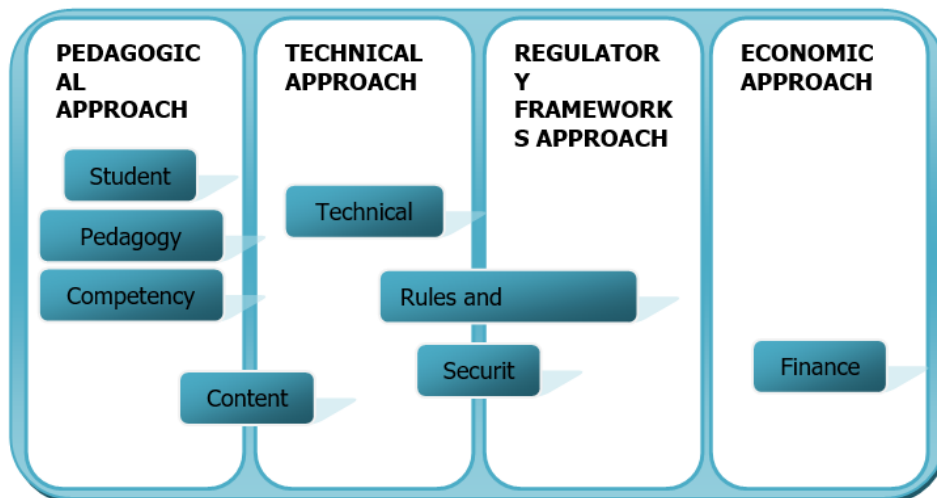


Fig.3. Framework for addressing challenges of smart education implementation

The pedagogical approach includes challenges that concern several categories, and refer to the student, the educator, competencies, and partly to the content. It includes different educational strategies for solving challenges, emphasizing teaching and learning methods, with specific approaches to different styles of learning, understanding material, and acquiring knowledge.

A technical approach implies facing challenges related to technological barriers, infrastructure limitations, security aspects, and data protection issues. It involves the development and application of problem-solving techniques and technologies in various domains.

The regulatory approach involves solving challenges through the application of legal and statutory regulations, and they relate to ensuring privacy, security, and data protection.

The economic approach involves facing challenges through economic principles, various market mechanisms, and incentives.

4. FUTURE DIRECTIONS AND RECOMMENDATIONS

The process of implementing smart education is complex and multidisciplinary. It implies a serious approach and extensive analysis. As already mentioned, a deeper application of smart education leads to the creation of new challenges, but also to the overcoming of old ones. This is the reason why great importance is attached to identifying challenges, but also to facing them. After presenting the framework for facing the challenges in smart education, the future direction of facing the challenges is the application of the aspects proposed by the framework. It should be borne in mind that the framework is general and globally applicable, but that, by the environment in which it is implemented, it is important to emphasize a certain approach, by the dominant categories. It is important to note that special attention should be paid to the proposed pedagogical aspect, which aims to deal

with the challenges faced by students, educators, and pedagogues because these are the most complex challenges, as they affect human well-being.

5. CONCLUSION

This paper presents the concept of smart education, as well as the challenges that arise during the implementation of smart education. Since there are a large number of challenges, according to their characteristics, they are grouped into categories. The complexity of the challenges resulted in certain challenges being grouped into two or more different categories. The grouping of challenges was done to create a framework for dealing with the challenges. The proposed framework consists of four aspects, and each aspect is proposed to approach one or more categories. Since the number of challenges in the implementation of smart education varies depending on the level of technology application, this framework provides the opportunity to access future challenges as well, and the prerequisite for this is their previous categorization.

6. ACKNOWLEDGEMENT

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OBLIK MAGNETNOG POLJA POD POLOM ASINHRONE MAŠINE SA KONVENCIONALNOM I SINUSOIDNOM KONFIGURACIJOM NAMOTAJA

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SAŽETAK:

Konvencionalno namotan stator mašine naizmenične struje generiše magnetno polje čija raspodela po unutrašnjem obodu statora nije čisto prostoperiodična. Usled uniformne raspodele namotaja javljaju se viši harmonici koji rezultuju trapezoidnim više nego sinusoidnim oblikom magnetnog polja pod polom mašine. Ipak, ukupno rezultujuće obrtno magnetno polje ima približno kružni karakter kao rezultat zbira sve tri faze mašine. Danas, u zavisnosti od namene i radnih režima, optimizovane mašine nauzmenične struje imaju različite konfiguracije pobudnih namotaja. U ovom radu prikazana je razlika između oblika magnetnih polja sa pod polom kod asinhrone mašine sa konvecionalnom (uniformnom) i sinusoidalnom raspodelom namotaja. Hall senzor je korišćen za snimanje oblika magnetnog polja unutar mašine a dobijeni rezultati su prikazani i diskutovani.

Ključne riječi: asinhrona mašina, konfiguracija namotaja, magnetno polje, Hall senzor

1. UVOD

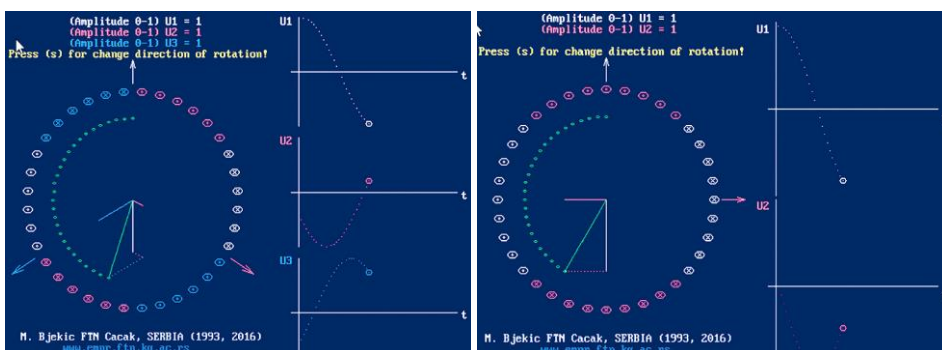
Višefazne električne mašine naizmenične struje stvaraju obrtno magnetno polje kao posledicu proticanja struje kroz statorske namotaje. Različiti faktori, kao što su ožlebljenost magnetnog kola mašine, različita raspodela namotaja duž oboda statora kao i uticaj rasipnog polja utiču na oblik magnetnog polja narušavajući njegov prosto-periodični karakter koji se očekuje kao posledica prosto-periodičnih pobudinih struja [1]. Ovakvo složeno periodično magnetno polje sastoji se od osnovnog harmonika i viših harmonijskih komponenti. Osnovni ili prvi harmonik zadužen je željene karakteristike i odgovoran za sam princip rada mašine dok su viši harmonici često nepoželjni jer imaju negativan efekat kao što su povećani gubici i degradacija mehaničkih karakteristika asinhrone mašine, izobličenje oblika indukovane elektromotorne sile u namotajima, kao i generisanje dodatne akustične buke i potencijalne rezonancije. Svaki prostorni harmonik obrtnog magnetnog polja u međugvožđu mašine stvara takođe odgovarajuće naponske više harmonijske komponente u statorskim i rotorskim namotajima rezultujući složeno periodičnim vremenskim oblikom indukovano napona [2].

U cilju smanjenja ili kompletnog eliminisanja određenih viših harmonijskih komponenti u obrtnom magnetnom polju i posledično dobijanje prostorne funkcije obrtnog magnetnog polja u međugvožđu mašine i vremenske funkcije napona indukovano u namotajima bez viših harmonijskih komponenti, primenjuje se nekoliko mera. Odgovarajuća raspodela

pobudnog (statorskog) namotaja duž žlebova mašine je obično najuticajniiji faktor i uz pažljivu modifikaciju konvencionalno uniformne raspodele može se doći do približno prosto-periodičnog oblika rezultujućeg magnetnog polja pod polom mašine.

2. MODIFIKACIJA RASPODELE NAMOTAJA STATORA

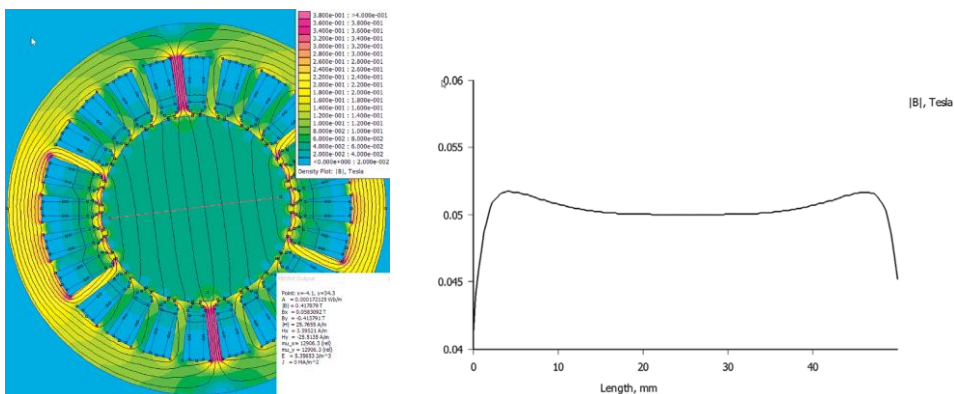
U cilju kvalitetnijeg i intuitivnijeg razumevanja principa formiranja obrtnog magnetnog polja, veliki napor uložen je u razvoj aplikacija i programa koje pomažu u vizualizaciji principa generisanja obrtnog magnetnog polja u mašinama naizmenične struje. Neke od aplikacija razvijene u ove svrhe analizirane su u [3] i [4]. Tako na primer slika 1 daje ekranski prikaz aplikacija koja prikazuje principe formiranja obrtnog magnetnog polja kod trofazne i dvofazne asinhronne mašine kao rezultat delovanja tri ili dve faze respektivno.



Slika 1. Obrtno magnetno polje kao posledica trofaznog (levo) i dvofaznog sistema (desno)

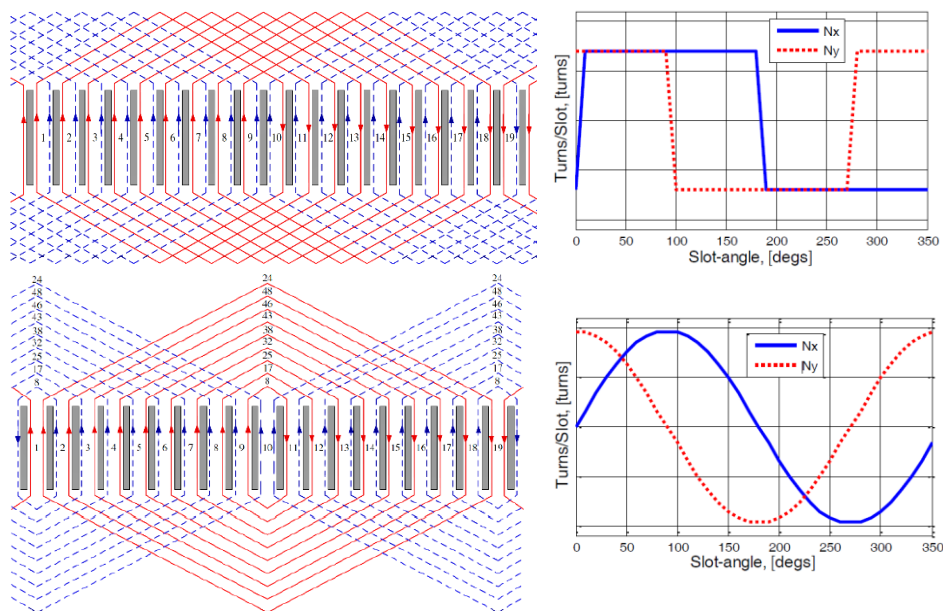
Softverski alati bazirani na analizi metodom konačnih elemenata (FEM) takođe su vrlo korisni u sagledavanju raspodele magnetnog polja u magnetnom kolu i duž međugvožđa mašine. Na slici 2 prikazana je raspodela magnetnog polja u poprečnom preseku mašine kao posledica konvencionalne (uniformne) raspodele statorskog namotaja u žlebovima. Rezultujuće magnetno polje odgovara približno trapezoidnom obliku duž poprečnog preseka mašine. Sličan trapezoidni oblik magnetnog polja može se izmeriti i duž samog unutrašnjeg oboda statora kao posledica uniformne raspodele namotaja u žlebovima statora.

U cilju dobijanja sinusoidalnog oblika magnetnog polja u vazдушnom zazoru mašine naizmenične struje potrebne su odgovarajuće promene u raspodeli odnosno broju navojaka u žlebovima statora. Kod konvencionalno namotane mašine raspodela navojaka je uniformna odnosno jednaka u svakom žlebu, kao što je to prikazano na slici 3 – gore. Kao posledica, rezultujuće magnetno polje pod polom mašine ima približno trapezoidni oblik, odnosno oblik koji odgovara zbiru osnovne komponente i odgovarajućeg trećeg harmonika. S druge strane, kod predložene sinusoidalne raspodele navojaka u žlebovima statora, gde je broj navojaka po žlebu statora prikazan na slici 3 – dole, može se očekivati da rezultujući oblik magnetnog polja pod polom ima željeni prosto periodični odnosno sinusoidalni oblik.



Slika 2. Intenzitet magnetnog polja duž poprečnog preseka statora asinhronne mašine

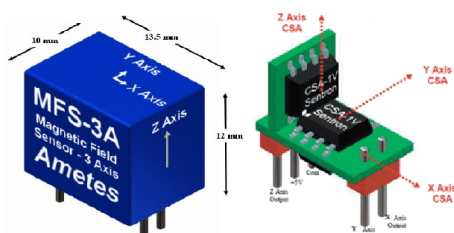
Predloženi dijagram raspodele namotaja sa slike 3 (dole) iskorišćen je za namotavanje statorskog kola dvofazne mašine čiji su namotaji prostorno pomereni za 90 stepeni. Ovakvo namotan stator mašine korišćen je za snimanje oblika magnetnog polja pod polom a čiji su rezultati prikazani u sledećem poglavlju i poređeni sa konvencionalno namotanom statorom.



Slika 3. Dijagram namotaja za konvencionalnu (gore) i sinusoidalnu (dole) raspodelu namotaja statora [5]

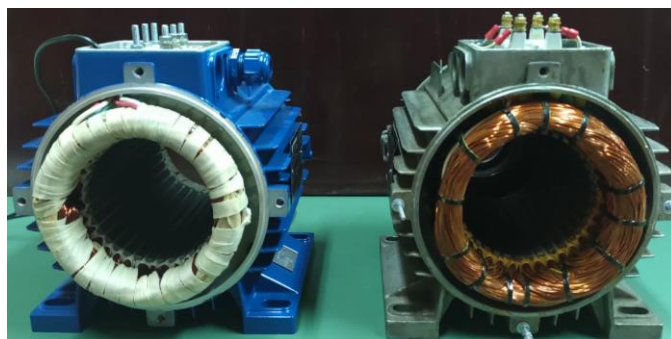
3. REZULTATI MERENJA MAGNETNOG POLJA

U cilju snimanja intenziteta magnetnog polja pod polom mašine korišćen je troosni Hall senzor. Senzor MFS-3A, sadrži tri ćelije CSA-1V i omogućava merenje magnetnog polja (magnetne indukcije) u x , y , i z osi kao što je prikazan na slici 4.



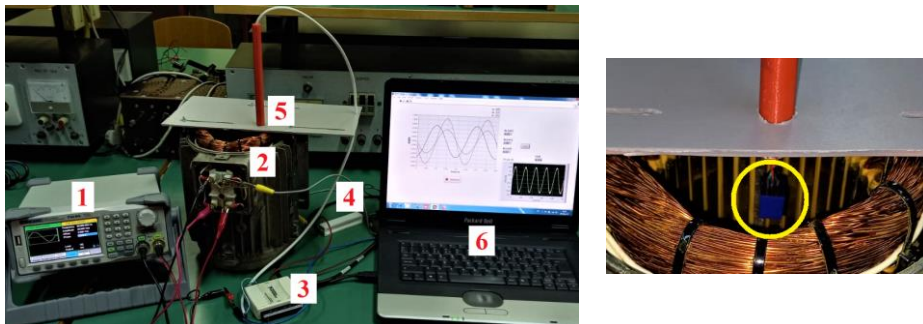
Slika 4. Spoljašnji i unutrašnji izgled troosnog Hall senzora MFS-3A

Za potrebe eksperimentalnih merenja analizirana su dva identična statorska kola mašine naizmenične struje sa uklonjenim rotorom kao što je prikazano na Slici 5. Merenje intenziteta magnetnog polja (odnosno magnetne indukcije) izvršena su pomeranjem senzora duž unutrašnjeg obima magnetnog kola statora. Identična procedura merenja magnetnog polja primenjena je i kod novonamotane mašine sa sinusoidalnom raspodelom.



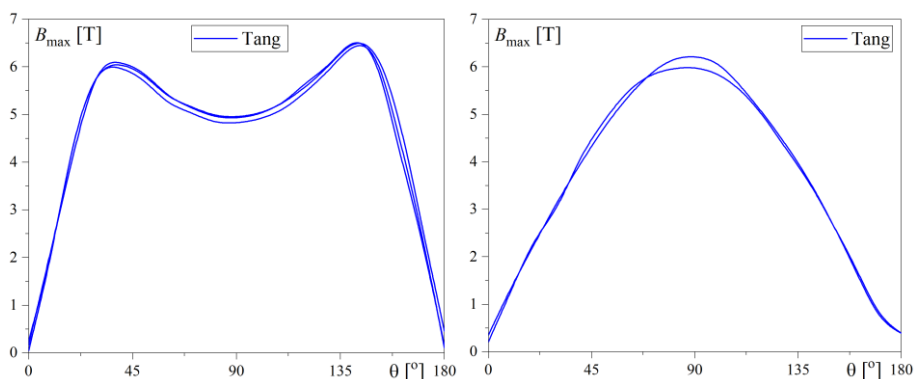
Slika 5. Statori mašina sa konvencionalnom (levo) i sinusoidalnom raspodelom namotaja (desno)

Statorski namotaji obe mašine napajani su preko autotransformatora uz redukovan napon kako usled uklonjenog rotora struje ne bi premašile nominalne vrednosti. Eksperimentalna postavka korišćena za dobijanje podataka jačine magnetnog polja prikazana je na Slici 6. Akvizicija podataka dobijenih od senzora MFS-3A realizovani su karticom NI6009 i aplikacijom razvijenom u LabView paketu. Dobijeni rezultati merenja magnetnog polja pod polom asinhronne mašine (180 električnih stepeni) za konvencionalno i sinusoidalnu raspodelu namotaja statora za svaku od faza mašine prikazane su na slici 7. Potrebno je naglasiti da je asinhronna mašina sa sinusoidalnom raspodelom namotaja realizovana za dve faze pod prostornim uglom od 90° .

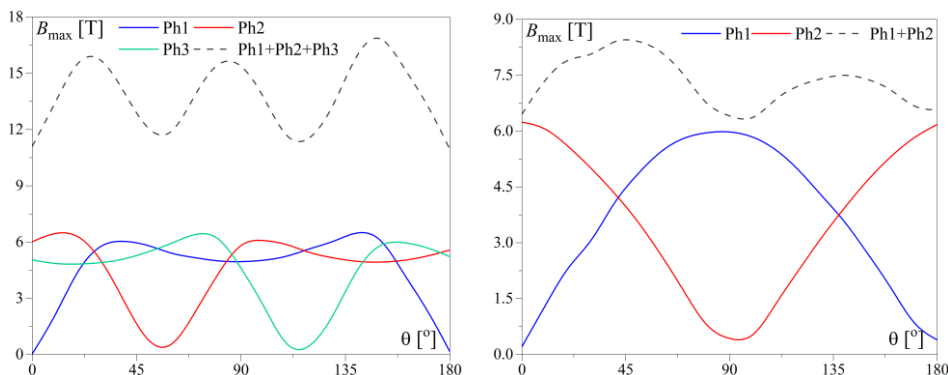


Slika 5. Eksperimentalna postavka za merenje magnetnog polja duž unutrašnjeg obima statora mašine asinhronne (levo) 1) signal generator, 2) asinhronna mašina, 3) akviziciona kartica NI 6009, 4) šant otpornik, 5) nemetalni nosač senzora, 6) PC sa LabVIEW softverom; (desno) pozicija senzora u unutrašnjosti mašine;

Dobijeni rezultati prikazani na slici 6 pokazuju da u slučaju konvencionalno namotane mašine oblik magnetnog polja pod polom ima približno trapezoidni karakter i odgovara prethodno prikazanom obliku dobijenim uz pomoć FEM softvera (prikazanog na slici 2). S druge strane merenja pokazuju da oblik polja kod magnetnog kola sa sinusoidalnom raspodelom navojaka u žlebovima statora rezultuju približno sinusnim oblikom pod polom za obe faze mašine kao što se može videti na slici 6 (desno). Iako kod konvencionalno namotane mašine prikazani oblik magnetnog polja jasno ukazuje na izraženo prisustvo trećeg harmonika u obliku magnetnog polja pod polom, rezultujuće magnetno polje koje potiče od zbira sve tri faze mašine prostorno pomerene za 120 stepeni imaće rezultujući kružni karakter sa manjim varijacijama u amplitudi duž oboda statora (rezultati prikazani na slici 7 - levo).



Slika 6. Rezultat magnetnog polja u sve tri faze kod konvencionalno (levo) i sinusoidalno (desno) namotane asinhronne mašine



Slika 7. Varijacije amplitude magnetnog polja pod polom kod konvencionalno trofazno namotane (levo) i sinusoidalno dvofazno namotane mašine

U slučaju mašine sa sinusoidalnom raspodelom namotaja oblik magnetnog polja je ima približno idealan prostoperiodični oblik. Na ovaj način obrtno magnetno polje ostvareno je sa dve faze pod uglom od 90 stepeni (sinusni i kosinusni oblik) kao što je prikazano na slici 6 (desno). U slučaju idealnog prostoperiodičnog oblika magnetnog oblika sa dve faze (sinusna i kosinusna funkcija) dobija se obrtno magnetno polje bez amplitudnih varijacija po obodu statora. U praktičnom primeru i dobijenim rezultatima sa slike 7 mogu se primetiti male varijacije u rezultujućoj amplitudi obrtnog magnetnog polja koje potiču od nedostataka u samoj proceduri merenja – nepreciznog ručnog pomeranja senzora, postojanja rasipnog magnetnog polja, uticaja bočnih veza, itd.

4. ZAKLJUČAK

Ovaj rad analizira oblik magnetnog polja pod polom asinhronne mašine sa konvencionalnom i sinusoidalnom raspodelom namotaja u žlebovima statora mašine. U radu su prikazani efekti uniformne raspodele namotaja u statorski žlebovima i odstupanje oblika magnetnog polja pod polom mašine od prosto periodičnog oblika kao i prisustvo viših harmonika. Sa druge strane, dat je prikaz modifikovane raspodele namotaja statora koji obezbeđuju približno prosto periodičan oblik magnetnog polja pod polom mašine bez značajnijeg uticaja trećeg ili viših harmonika. Na ovaj način rezultujući kružni oblik magnetnog polja u mašini ostvaren je sa samo dve namotane faze pod uglom od 90 stepeni. Prikazani eksperimentalni rezultati merenja intenziteta magnetnog polja pod polom mašine potvrđuju iznetu teorijsku pozadinu i očekivani oblik magnetnog polja u slučaju mašine sa konvencionalno i sinusoidalnom raspodelom namotaja statora.

5. ZAHVALNICA

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SHAPE OF THE MAGNETIC FIELD UNDER A POLE OF INDUCTION MACHINE WITH CONVENTIONAL AND SINUSOIDAL WINDING CONFIGURATION

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ABSTRACT:

A conventionally wound alternating current machine produces a magnetic field that is not simply periodic. Higher harmonics arise from the machine's uniformly distributed windings, which causes the resulting magnetomotive force to have a more trapezoidal like profile under the pole. However, the combination of the effects of all three phases results in a magnetomotive force that is roughly periodic and forms a circular rotating magnetic field. Nowadays, optimized machines have a variety of winding distributions, including sinusoidal, depending on the application and working regime. This study compares the distribution of magnetic fields under the stator pole of an alternating current machine with a conventional and sinusoidal winding distribution. A three-axis Hall sensor was used to measure the magnetic field, and the findings are presented and discussed.

Keywords: induction machine, winding configuration, magnetic field, Hall sensor

COMPARATIVE ANALYSIS OF THE RELATIONAL DATABASE MODEL WITH ITS EQUIVALENT GRAPH DATABASE MODEL

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ABSTRACT:

In today's digital age, databases are a key point of digital solutions, ranging from mobile applications to intricate business systems. Selecting an appropriate database model is paramount to facilitate efficient data management and enable swift, reliable analysis. The relational database model, characterized by its tabular structure and well-defined schemas, has long been the standard in the database realm. It offers effective data organization and furnishes robust data integrity and security management mechanisms. However, as applications evolve and become increasingly complex, a need arises for a more flexible approach to data modelling to capture the inherent relationships between entities better. In such cases, NoSQL databases may often be a superior solution for modern applications. This paper outlines the process of migrating a relational model to its corresponding graph database counterpart, specifically focusing on Neo4j, a leading graph database. It then presents a comparative analysis of the relational and graph database models, discussing the advantages and disadvantages of both approaches. A case study is also employed to illustrate scenarios where each approach is demonstrably better suited.

Keywords: relational model, NoSQL, graph databases, Neo4J, data migration

1. INTRODUCTION

Databases are data sets organized to enable the user to access the data quickly and then quickly search and manipulate the given data to obtain the desired data easily [1].

The development of computer systems also led to the development of the relational model of databases, the theory of which is presented in the paper [2]. The relational model is based on set theory and mathematical logic, organizing data into tables with defined rows and columns, and enables the establishment of links between entities through primary and secondary keys.

With the development of the Internet and the explosion of data, there has been a need for new database models that can effectively manage complex relationships among data. In this context, the database's graph model is becoming increasingly popular [3]. A graph

model represents data as nodes and connections between them, which enables efficient modeling of complex relationships and fast execution of queries that require depth and complexity.

In this paper, an example of the transition from a relational database to a graph database will be presented. The example presented in the paper is based on a real case, that is, on the case of a healthcare database. The clinic/hospital database is used daily.

2. RELATIONSHIP MODEL OF THE CLINIC DATABASE

In this part, the relational model of the clinic will be analyzed in detail, which is defined by entities such as:

- patients,
- doctors,
- medical records,
- types of reviews,
- department,
- hospital,
- sister,
- examinations,
- interconnections between entities.

This model aims to efficiently manage information about patients, medical examinations, and staff of a hospital or a given clinic.

Links between entities are a key part of the clinic's relational model, as they link information about patients, medical examinations, hospital staff, and other entities. The links between the entities are described below:

- Patient - Medical Record: Each patient can have one or more medical records.
- Patient - Examination: Each patient may undergo one or more medical examinations.
- Examination - Examination Type: Each medical examination is associated with a specific examination type.
- Examination - Department: Each medical examination is associated with a specific department in the hospital.
- Doctor - Examination: One doctor can perform one or more medical examinations.
- Nurse - Department: One nurse can be assigned to one or more departments in the hospital.
- Hospital - Department: A hospital can have one or more departments.

Figure 1 shows the relational model of the Clinic database.

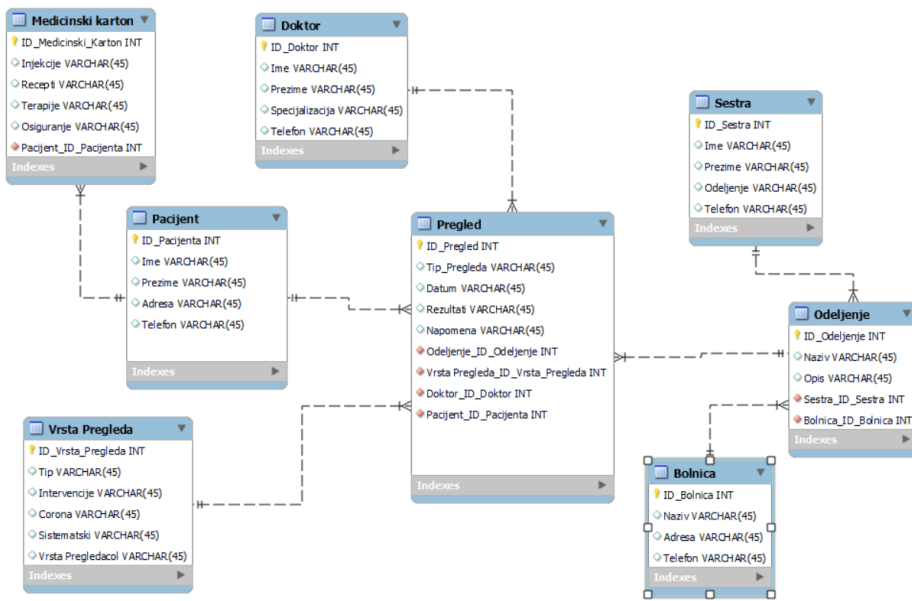


Fig. 1. Relational database model Clinic

3. GRAPH DATABASE

Figure 2 shows the growing trend of graph database popularity. The trend starting in January 2013 is shown, and the popularity of other databases and relational ones is clearly visible. The biggest growth trend is observed in Graph databases [4].

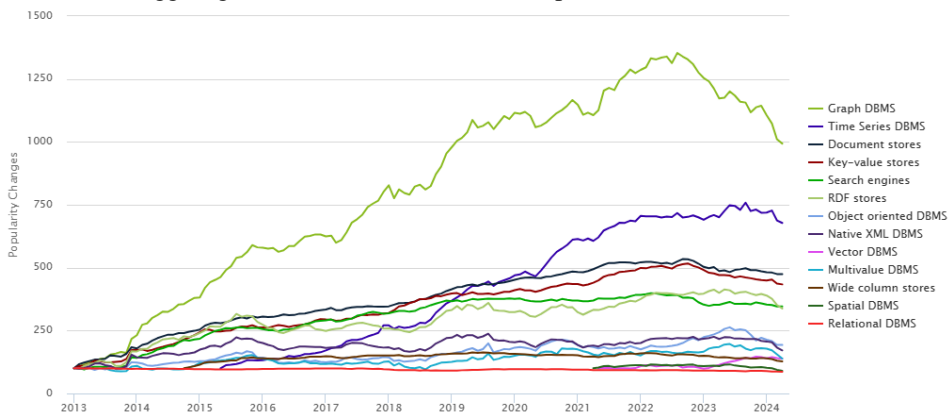


Fig. 2. Trend of growing popularity of graph databases [4]

3.1. Neo4J database

Neo4j represents a revolutionary innovation in the world of databases, setting new standards for how data can be organized, presented, and analyzed. Its origin dates back to 2000 when Johan Svensson started his work on the graph database concept. This initial work by Johan Svensson resulted in the development of Neo4j, officially launched in 2007 as the first publicly available and commercially supported graph database.

In the context of databases, Neo4j excels in organizing data into a graph structure consisting of nodes and branches. Nodes represent entities, while branches represent connections between these entities. This flexible structure allows Neo4j to accurately model and efficiently manage the interrelationships between entities, which is essential in many areas where data is complex and interconnected.

Neo4j's role in the database is crucial because it allows users to intuitively explore, analyze, and make informed decisions based on the connections between data. This is especially important in social networks, product recommendations, network analysis, geographic information systems, health information, and many others. Through its graph structure, Neo4j enables efficient modeling and analysis of complex interrelationships between entities, which makes this database an indispensable tool in modern data analysis and information systems.

Neo4J is currently the leading graph database, according to [5].

Many of the world's companies have improved their business with the help of the Neo4j graph base or improved their system between teams and parts of an entire system. NASA, eBay, and Walmart projects are the most popular and largest projects where Neo4j graph models are applied [6-8]. Ebay had an entire case study where they analyzed how graph bases work. All case studies and projects based on the Neo4j graph base further improved and strengthened Neo4j.

4. GRAPH DATABASE MODEL

The *cypher query language* [9] is used to create nodes and links in the Neo4J database. The appropriate code is used for each entity to create a node with all attributes, and the connections between them are defined using IDs as connection keys.

The following code is used to create the *Patient* node, i.e., creating a table from the relational model, which we will now present as a Neo4j graph. Based on this code, we create a *Patient* Node that has its ID 1 and the Name attribute that is Marko:

```
CREATE (p1:Pacijent {ID: 1, Ime: "Marko"})
```

In addition, it is necessary to add the following attributes to the node by entering a new attribute after ". For node *Patient*, there are other attributes that we will present with code from Figure 3.



Fig. 3. Creating the Patient node

The function `MATCH (N) RETURN N` displays a graph with code, with a node that we will later connect to the final graph of the Neo4j base. By clicking on the selected node, we are shown all the attributes connected to that node, as in Figure 4 for the *Pacijent* entity.

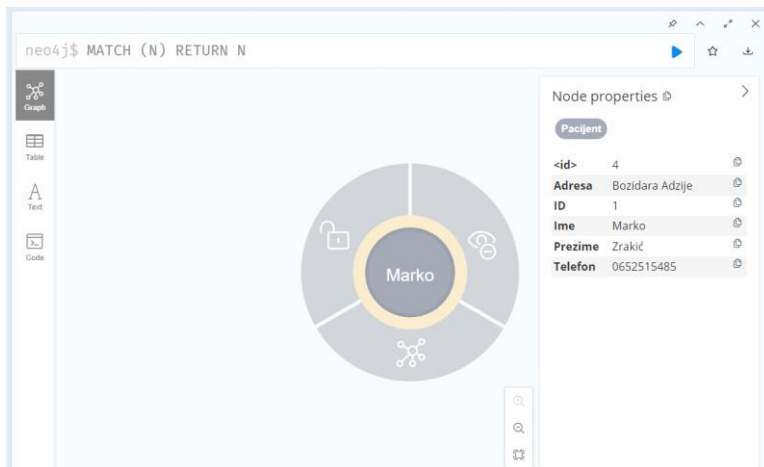


Fig. 4. Node with attributes

After the *Pacijent* node, the other nodes needed to create the graph were created, following the data and structure from the relational model. Figure 5 shows the process of creating the *Medical Record* node.

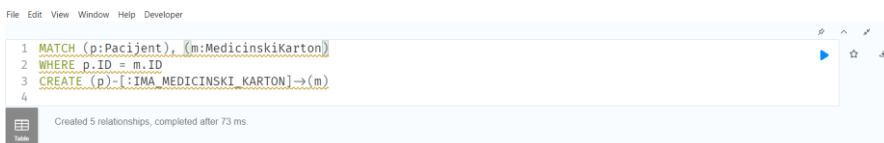


```
1 CREATE (m1:MedicinskiKarton {ID: 1, Description: "Medicinski karton za pacijenta Marka", Injekcije: "Bez
injekcija", Recepti: "Samo preko kartona", Osiguranje: "Zivotno DDOR", Terapije: "Invidicus" })
2 CREATE (m2:MedicinskiKarton {ID: 2, Description: "Medicinski karton za pacijenta Damjana", Injekcije:
"Bez injekcija", Recepti: "Samo preko kartona", Osiguranje: "Zivotno DELTA", Terapije: "Invidicus" })
3 CREATE (m3:MedicinskiKarton {ID: 3, Description: "Medicinski karton za pacijenta Peru", Injekcije: "Bez
injekcija", Recepti: "Samo preko kartona", Osiguranje: "Zivotno DUNAV", Terapije: "Invidicus" })
4 CREATE (m4:MedicinskiKarton {ID: 4, Description: "Medicinski karton za pacijenta Stefana", Injekcije:
"Bez injekcija", Recepti: "Samo preko kartona", Osiguranje: "Zivotno DDOR", Terapije: "Invidicus" })
5 CREATE (m5:MedicinskiKarton {ID: 5, Description: "Medicinski karton za pacijenta Slavka", Injekcije:
"Bez injekcija", Recepti: "Samo preko kartona", Osiguranje: "Zivotno DDOR", Terapije: "Invidicus" })
6
```

Added 5 labels, created 5 nodes, set 30 properties, completed after 43 ms.

Fig. 5. Creation of Medical Record node

After creating these two nodes, connecting the links between them is necessary. In the Neo4j model, links are called edges. ID from the MedicalRecord and the Patient ID will be used for connection. Connections between tables are obtained through the following query in Figure 6.



```
1 MATCH (p:Pacijent), (m:MedicinskiKarton)
2 WHERE p.ID = m.ID
3 CREATE (p)-[:IMA_MEDICINSKI_KARTON]->(m)
4
```

Created 5 relationships, completed after 73 ms.

Fig. 6. Connecting nodes

MATCH (p:Pacijent), (m:MedicinskiKarton): Starts with the MATCH clause, which finds nodes that meet certain conditions. In this case, all nodes labeled *Pacijent* and *MedicalRecord* are searched, and temporary labels p and m are assigned to be used later in the query.

WHERE p.ID = m.ID: The WHERE clause filters the results obtained from the MATCH part of the query. Here, it is checked whether the ID in the node *Pacijent* (p.ID) corresponds to the ID in the node *MedicalRecord* (m.ID). Those nodes will not be considered for linking if this does not match.

This part of the query creates a link between the *Pacijent* and *MedicalRecord* nodes. It uses the CREATE clause to create a new connection between the nodes. The connection is defined by (p)-[:IMA_MEDICINSKI_KARTON]->(m), which means that node p (patient) has a connection IMA_MEDICINSKI_KARTON with node m (medical record):

```
CREATE (p)-[:IMA_MEDICINSKI_KARTON]->(m)
```

The final appearance of the Neo4J database *Clinic* is shown in Figure 7. On the left side, you can see the data in the form of a graph; on the right side, you can see all the nodes and connections between them.

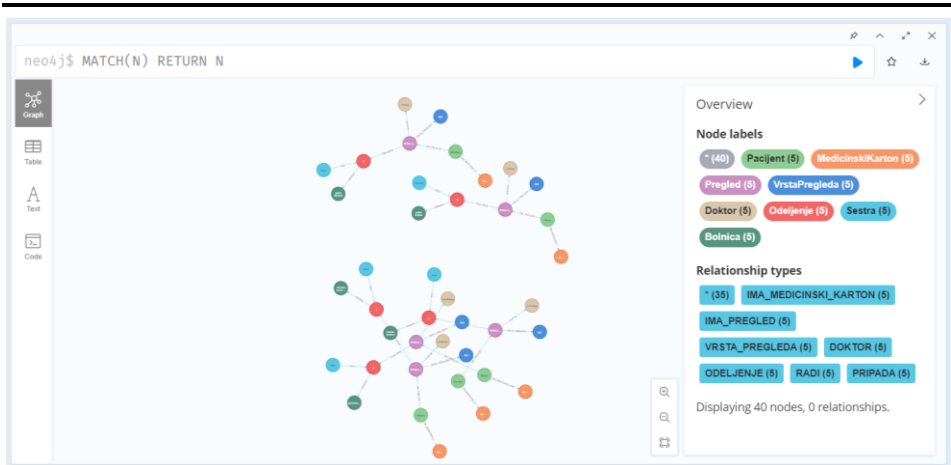


Fig. 7. Neo4J version of the *Clinic* database

5. CONCLUSION

With its tabular structure and clearly defined schemas, the relational model has long been the standard in the database world. It enables efficient data organization and provides reliable data integrity and security management mechanisms. However, as applications evolve and become more complex, there is a need for a more flexible approach to data modeling that can better reflect the actual relationships between entities.

Neo4j, the leading graph database, provides a newer and faster approach to data modeling. Graph structure allows the modeling of complex relationships between entities, which is particularly useful in social networks, content recommendation, and network analysis. Additionally, Neo4j offers efficient mechanisms for executing queries that seek information about relationships between entities, providing fast performance even for complex analyses.

Through the process of switching the relational model to Neo4j, there are various challenges, including planning the graph's structure, defining the relationships between entities, and ensuring data security. However, the advantages provided by Neo4j in terms of flexibility and performance make it an extremely attractive option for many applications.

It is concluded that switching to Neo4j can bring significant benefits in terms of efficient data modeling, fast analysis, and intuitive management of complex relationships between entities.

The relational model remains important for many applications, and Neo4j is a powerful tool for environments where the relationships between entities are critical to the application's success. In the future, further development of Neo4j and graph databases, in general, is expected, opening new possibilities for innovative applications and analyses.

Neo4j represents the future of data storage and entity relationship analysis. Its ability to model complex relationships between data enables the development of highly flexible and efficient applications. Compared to the traditional relational model, Neo4j excels in managing complex data relationships quickly and efficiently, making it an indispensable tool in the data era.

When we consider the queries that, in many ways, complicate and challenge the operation of the database, we can also touch on the fact that queries can be created in Neo4j that can be more complex and load less on the entire database. Query creation in Neo4j is powerful, allowing users to explore and analyze graphs of data easily. Unlike relational databases, where queries are often complex and require multiple steps to obtain the desired information, Neo4j allows direct graph management and simple query formation that explores complex relationships between entities.

Neo4j offers advanced security capabilities, including data encryption, authentication, and authorization. These security functionalities allow users to manage and protect their data confidently. In contrast, relational models also provide basic security mechanisms but may

be limited in handling complex data structures and require additional steps to implement security policies.

Whether it is a small application or a complex system solution, databases are the foundation of any application. They enable data storage, management, and analysis, enabling applications to provide users with valuable information and functionality. In this sense, choosing an appropriate database is a key step in developing any software project. Two key approaches in data storage are the relational model and Neo4j. The relational model has long been the standard in the database world, but the development of graph databases, such as Neo4j, shows that trends in data storage are changing.

In the end, each base display model can bring some progress in system problem solving, but the base as a base gives us the importance that it is the base of every possible application; the base is the solution to every application problem because it is the base of everything. Any further work and advancement of technology cannot be imagined without bases, as it could not be until now. Any progress of future software will follow the progress of the databases and how well the database can serve all the requests and connect all the application data.

6. LITERATURE

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APPLYING MLOPS IN SOFTWARE QUALITY ASSURANCE OF THE ANALYTICS APPLICATION MARKET

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ABSTRACT:

In this research, we explore the application of MLOps (Machine Learning Operations) as a strategy to optimize software quality assurance in the analytics application market. Using the MLOps approach, we integrate tools such as Databricks, Apache Zeppelin, KNIME and RapidMiner to automate the testing, analysis and optimization processes of software applications.

This case study illustrates specific examples of the application of MLOps in the context of analytics applications, but also provides a basis for understanding the broader range of opportunities that MLOps provides in improving software quality assurance in the marketplace. Through this integration of tools and practices, we explore how MLOps can be a key factor in achieving competitive advantage and long-term success in the analytics software market.

Keywords: ML model, MLOps, analytics application, software, quality assurance

1. INTRODUCTION

MLOps application context refers to the situations and circumstances in which MLOps, or machine learning operations management practices, are applied to ensure effective implementation, maintenance, and improvement of machine learning (ML) systems [1]. MLOps itself is not necessarily a web tool. MLOps is a repository of processes, practices, and tools used to manage the machine learning lifecycle. However, many MLOps platforms such as MLflow have web interfaces that allow viewing and managing ML models, experiments, and metrics via a web browser. MLOps is particularly important in environments where a diverse range of ML models are used. This context includes situations where image recognition, natural language processing or regression models are present, with the need to manage their diversity and complexity. In software development, MLOps is applied to integrate ML development with standard software processes. This includes version control, code management, testing and implementation. Situations where it is necessary to quickly adjust models or introduce new iterations require MLOps practices. This is especially useful in areas where data changes frequently or where it is necessary to respond quickly to new requirements. MLOps is crucial in sectors where high standards are set for data security and regulatory compliance [2]. Applications with high

data volume or variable requirements require an MLOps approach to ensure scalability and efficient resource management. In areas where data is dynamic and requires continuous model education, MLOps is critical to keeping models up-to-date and accurate. Introducing MLOps into these contexts allows organizations to effectively manage the complexity of ML systems, ensure high levels of performance, and adapt more quickly to changes in the environment.

2. MLOPS CYCLE

The MLOps cycle, or MLOps process, is a continuous sequence of activities implemented to develop, test, implement, and maintain ML models over time. Identification of the specific problem that the ML model could solve is presented on Figure 1. ML optimization phase involves cleaning, transforming and normalizing the data to make it suitable for creating and training a ML model using prepared data [3]. Here, different algorithms and parameters are experimented with in order to achieve the best possible accuracy. Evaluation of model performance on separate data sets that were not used during training includes parameter validation and testing to ensure the generalizability of the model. Integration of the model into the real environment are used to deploy the model into production, including automated processes for updating and rolling back old versions when needed. Setting up a real-time model performance monitoring system enables the identification of potential problems and performance degradation in anticipation of a negative impact on users [4]. Continuous optimization of the model is based on new data and experiences. Updating the model to maintain high accuracy and adequately respond to changes in the environment. The MLOps cycle is a dynamic process that implies continuous attention, adaptability and cooperation between different teams in order to achieve and maintain a high level of performance of ML models in production [5].

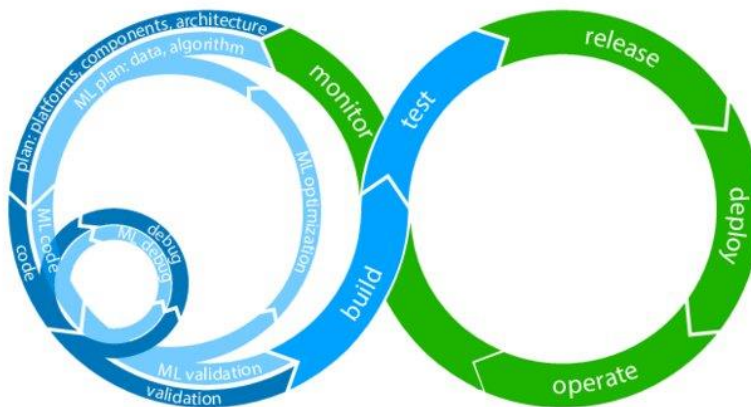


Fig. 1. MLOps cycle [6]

3. ELEMENTS OF MLOPS

Identification of key elements in MLOps, including automation and model performance monitoring, are implementing in all phase of software development life cycle (SDLC). Automation is a fundamental element of MLOps, and its goal is to reduce human intervention and accelerate all stages of development, [1] implementation and maintenance of ML models (Figure 2). There are new oportunities in automation:

1. **Continuous integration (CI):** Implementation of CI/CD (Continuous Integration/Continuous Deployment) practices enables automatic testing and integration of new code into a shared repository. This ensures a faster flow of the development cycle.
2. **Model training:** Creating processes that automatically train models when new data is delivered, while monitoring performance and adjusting models as needed.
3. **Deployment:** Automation of the process of deploying the model to the production environment, including dependency management, environment configuration and resource monitoring.
4. **Performance testing:** Regular automated testing of model performance to identify problems and ensure constant optimal functioning.

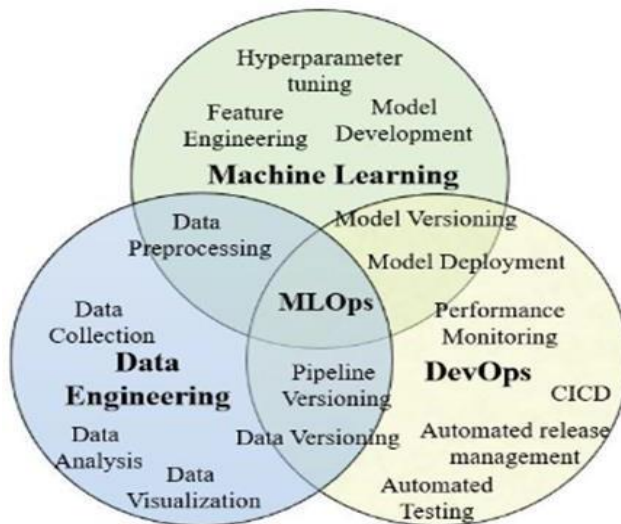


Fig. 2. MLOps combination [1]

4. INTEGRATING MLOPS IN SDLC

Software development faces a number of challenges, and the integration of MLOps provides the opportunity to solve some of the key problems in this area (Table 1). Integrating MLOps into existing software development processes requires a carefully planned implementation to ensure a smooth transition and realize the desired benefits. Detailed analysis of existing software development processes is to identify the correct

steps, resources and roles in the current environment. Identification of key stages in the SDLC where MLOps could bring added value, e.g. in training, testing, implementation and maintenance of the model. Conduct training for team members on MLOps concepts, tools to be used and changes to be introduced in the work process. Selecting appropriate tools and platforms to support MLOps, including tools for version control, automation, monitoring and resource management. Setting standards and guidelines for managing models, data, and code to ensure consistency and ease of maintenance. Implement continuous integration (CI) and continuous delivery (CD) into the model training process to ensure automatic model verification, testing, and deployment. Introducing a model performance monitoring system to automatically detect model degradation and respond to changes in a timely manner. Implementation of a configuration management system to enable efficient management of model settings and environment configuration. Conduct testing and validation on the integrated MLOps system to ensure functionality and quality. Defining the model maintenance process, including scheduled updates, tracking changes and responding to user needs. Introducing mechanisms for continuous improvement of the integrated MLOps system, taking into account feedback from the team and end users is presented as lifecycle pipeline for AI application (Figure 3). Monitoring the performance of the integrated MLOps system to assess effectiveness and take corrective action as needed.

Table 1. Contemporary challenges of software development with MLOps solution

	Challenge	MLOps solution
1. Complexity of development processes	Traditional development processes can be complex and inefficient, especially when it comes to implementing ML models.	MLOps enables the automation and standardization of the entire model life cycle, simplifying the processes from model training to its implementation.[7] [8]
2. Lack of coordination between development and operations teams	Lack of collaboration between development and operations teams can lead to problems in implementing	MLOps integration creates a bridge between development and operations teams, fostering collaboration through shared tools and processes. [9]
3. Lack of transparency in the life cycle of the ML model	Lack of clear visibility into the lifecycle of a model can lead to problems in monitoring performance	MLOps provides tools to track all stages of a model's life, from training to implementation, ensuring transparency and change tracking.[7] [8]
4. Difficulties in managing	Managing multiple versions of a model can be a challenge, especially	MLOps enables simple model versioning, supporting easy update, pull, and change

different versions of the ML model	when a large number of models need to be updated and maintained.	tracking.[8]
5. Lack of reproducibility in model training	Lack of reproducibility in the model training process can lead to problems in validation and retraining.	<p>MLOps provides an environment that enables accurate reproducible training of models, thus ensuring consistency and validity of results.</p> <p>accurate reproducible training of models, thus ensuring consistency and validity of results.</p>

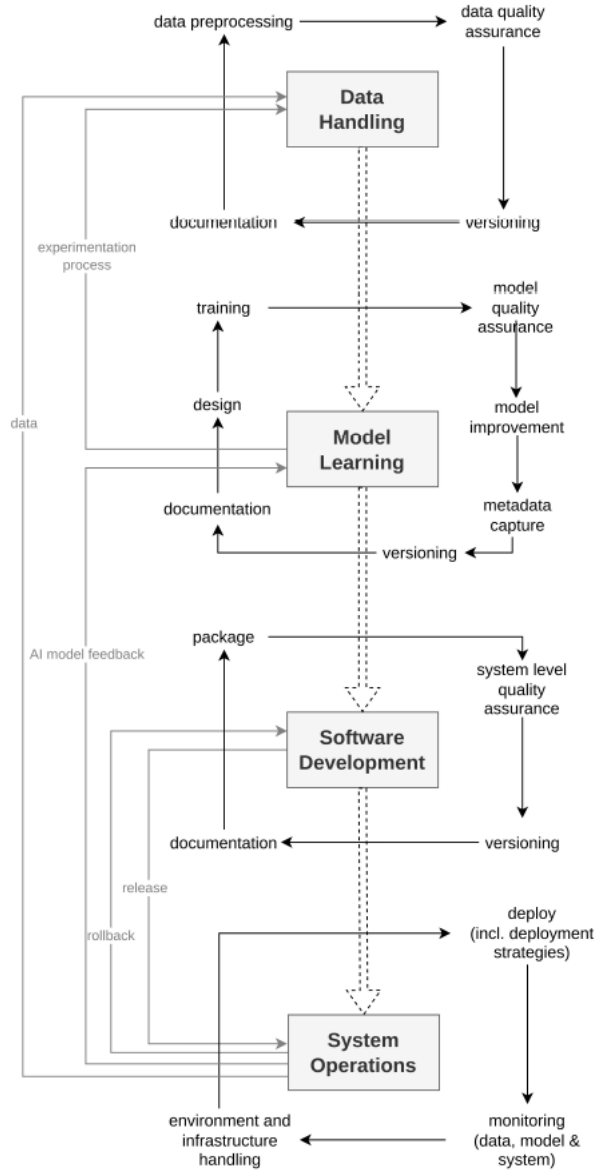


Fig. 3. Lifecycle pipeline for AI applications [9]

Integrating MLOps into existing software development processes requires a systematic and careful approach. These steps are the foundation for successful integration, ensuring consistency, transparency and efficiency in the management of ML models.

4. CASE STUDY: INTEGRATING MLOPS INTO ANALYTICS APPLICATION DEVELOPMENT

There are many software that we can use to integrate into MLOps to make faster SDLC. Here are presented Databricks, Apache Zeppelin, KNIME and RapidMiner as which are frequently used platforms. Potential integration through different plugins, different APIs or interfaces that enable communication from tools and MLOps.

Databricks provides a comprehensive ecosystem for data analytics and ML, offering tools for working with large data sets and support for integration with MLOps practices. As for Databricks, let it be the Databricks API because it can communicate with MLOps through the MLflow interface. It provides support for popular ML libraries like Apache Spark MLlib and Scikit-learn. Also, it enables easy training, evaluation and implementation of the model directly in the platform [9]. Databricks supports working with different data sources and formats, and also allows easy integration with various data warehouses, whether they are in the cloud or on-premises. Databricks platform is scalable and adaptable, which makes it suitable for working with large data sets and complex analyses. This scalability is essential for model management in a production environment. Model training process automation makes easy through the use of scripts and notebooks. This allows easy integration with CI/CD tools and setting up automatic training processes. Databricks can be easily integrated with MLOps tools like Apache Airflow, MLflow, Jenkins, or Azure DevOps, enabling automation, monitoring, and management throughout the model lifecycle. This allows the team to monitor metrics and identify the need to optimize the model.

Apache Zeppelin is another example of a data analytics application that can serve as a foundation for MLOps integration. Apache Zeppelin can also be integrated into MLOps via an API called the Zeppelin API. Zeppelin is an open-source project designed for interactive data analysis, visualization and ML execution [10]. It provides an interactive environment that supports multiple programming languages, including Scala, Python, R, and SQL. This enables analysts and data scientists to effectively explore and visualize data. Zeppelin has built-in ML libraries and tools, including support for Apache Spark, TensorFlow, and scikit-learn. This allows for easy training and testing of models directly within the Zeppelin environment [10]. Zeppelin can be integrated with popular MLOps platforms like MLflow, CI/CD tools like Jenkins, providing support for tracking metrics, managing experiments, implementing models evaluation and deployment processes. This platform allows easy sharing of analyzes and experiments, and also saves session state. This provides the ability to reproduce results and share analytical results within the team.

KNIME (Konstanz information miner) analytics platform is another powerful data analysis application that can be used as the basis for MLOps integration. KNIME - can be integrated into MLOps can be integrated with MLflow for tracking metrics experiment.

It is an open-source platform with an active community of users. This gives users the opportunity to customize and extend functionality according to specific needs. It provides

visual programming, allowing users to construct analytics workflows without having to write code [11]. KNIME enables users to create analytical workflows by connecting visual nodes, facilitating the construction of complex data analysis and ML models without the need for coding. This platform includes a rich library of nodes for data analysis, statistics, and ML. This provides flexibility in experimenting and applying different methods and techniques. Also, it supports integration with various data sources, including SQL databases, CSV files, Hadoop and others. This allows working with different types of data and sources of information. The automation of workflows is crucial for users to set scheduled tasks, optimize workflows and easily repeat analyses. KNIME is integrative and can be easily connected to MLOps platforms like MLflow, Kubeflow and others. This allows tracking experiments, managing models and applying MLOps principles within the KNIME environment.

RapidMiner is an advanced data analysis platform that allows users to easily build analytical models and perform complex data analysis [12]. It is also an active open-source project with a vibrant community of users. RapidMiner - can be integrated with MLOps can be integrated with MLflow. This integration enables experiment tracking, model management and metrics tracking via MLOps. This platform can serve as an excellent foundation for MLOps integration, providing support for automation, model performance monitoring, and team collaboration. RapidMiner uses visual programming that allows users to construct analytical models using a graphical interface without writing code. This simplifies the process of creating and understanding analytical workflows. RapidMiner provides an extensive library of tools and nodes for ML and data analysis. The platform enables users to automate analytical workflows, thereby reducing the need for manual interventions. Automation contributes to efficient model life cycle management. It can be integrated with various MLOps tools, including MLflow, Kubeflow and others. This integration enables model performance monitoring, experiment management and easier implementation of MLOps principles. RapidMiner is scalable and efficient in working with large data sets, thus providing the ability to manage models at different levels of complexity.

5. IMPLEMENTATION OF MLOPS IN APPLICATION DEVELOPMENT

Implementing MLOps in software development process involves a series of steps that include planning, modeling, testing, implementation, and maintenance. In tables 2, 3, 4 and 5 is a detailed breakdown of the steps involved in implementing MLOps for the example applications we've previously discussed: Databricks, Apache Zeppelin, KNIME Analytics Platform, and RapidMiner [10-13]. For each application, the tools and techniques that can be used are listed separately.

Table 2. Databricks platform

SDLC	Tools	Techniques
Defining MLOps objectives	<ul style="list-style-type: none"> • Databricks Workspace for defining goals and team communication. 	<ul style="list-style-type: none"> • Databricks notebooks for collaborative planning.
Model development	<ul style="list-style-type: none"> • Databricks notebooks, Apache Spark MLlib, MLflow for model experimentation, development and monitoring. 	<ul style="list-style-type: none"> • Databricks experimental libraries for model optimization and testing. • Apache Spark MLlib for ML. • MLflow to track experiments, manage models, and log metrics.
Testing	<ul style="list-style-type: none"> • MLflow for automatic tracking of test results and performance evaluation. 	<ul style="list-style-type: none"> • Integrating automated tests into the Databricks environment.) Monitoring of test results and evaluations.
Implementation	<ul style="list-style-type: none"> • Jenkins for deployment automation, Databricks API for integration with CI/CD tools 	<ul style="list-style-type: none"> • Setting planned tasks for regular model implementation.) Integration with CI/CD tools (eg Jenkins) for continuous delivery.
Maintenance	<ul style="list-style-type: none"> • MLflow for monitoring model 	<ul style="list-style-type: none"> • Automated model updating via MLflow tools.

	performance in production.	Automated model updating based on new data
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Table 3. Apache Zeppelin

SDLC	Tools	Techniques
Planning	Apache Zeppelin for setting goals and defining features for MLOps integration.	<ul style="list-style-type: none"> Zeppelin notebooks for collaborative team planning.
Model development	<ul style="list-style-type: none"> Apache Zeppelin notebooks, MLOps platforms like MLflow for tracking experiments. 	<ul style="list-style-type: none"> Zeppelin API to integrate with MLOps tools.
Testing	<ul style="list-style-type: none"> Zeppelin notebooks for implementing automated tests. 	<ul style="list-style-type: none"> Track test results directly in the Zeppelin environment.
Implementation	<ul style="list-style-type: none"> Jenkins for deployment automation, Zeppelin API for integration with CI/CD tools. 	<ul style="list-style-type: none"> Setting planned tasks for regular implementation of the model.
Maintenance	<ul style="list-style-type: none"> MLflow for monitoring model performance. 	<ul style="list-style-type: none"> Periodic model updating and optimization through the Zeppelin environment.

Table 4. KNIME Analytics Platform

SDLC	Tools	Techniques
Planning	<ul style="list-style-type: none"> Defining MLOps objectives in the KNIME environment. 	<ul style="list-style-type: none"> Identification of key functionalities for monitoring and managing models.
Model development	<ul style="list-style-type: none"> Creating analytical workflows for 	<ul style="list-style-type: none"> Integration with MLOps tools like MLflow to track metrics and experiments.

	development and experimentation.	
Testing	<ul style="list-style-type: none"> Defining model performance tests within KNIME workflows. 	<ul style="list-style-type: none"> Automated testing using KNIME analytics nodes.
Implementation	<ul style="list-style-type: none"> Automation of the implementation process through integration with CI/CD tools. 	<ul style="list-style-type: none"> Using KNIME Server to manage models in production.
Maintenance	<ul style="list-style-type: none"> Model performance monitoring through KNIME Server and MLOps platforms. 	<ul style="list-style-type: none"> Periodic model updating and optimization.

Table 5. RapidMiner Platform

SDLC	Tools	Techniques
Planning	<ul style="list-style-type: none"> Setting goals for integrating MLOps into RapidMiner. 	<ul style="list-style-type: none"> Identification of key functionalities for model lifecycle management.
Model development	<ul style="list-style-type: none"> Using visual programming in RapidMiner Studio to build models. 	<ul style="list-style-type: none"> Integration with MLOps platforms like MLflow for tracking experiments and models.
Testing	<ul style="list-style-type: none"> Creation and implementation of model performance tests within RapidMiner Studio. 	<ul style="list-style-type: none"> Test automation using RapidMiner Server.
Implementation	<ul style="list-style-type: none"> Automation of the implementation process through integration with CI/CD tools. 	<ul style="list-style-type: none"> Using RapidMiner Server to manage models in production.
Maintenance	<ul style="list-style-type: none"> Model performance monitoring through 	<ul style="list-style-type: none"> Periodic model updating and optimization.

	RapidMiner Server and MLOps platforms.	
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6. CONCLUSION

Results of this research confirm that the application of MLOps is of critical importance for the optimization of software quality assurance in the analysis application market. We hope that this case study will serve as a basis for further research and application of MLOps in various industrial contexts, thus contributing to the innovation and advancement of software development worldwide. This case study highlights the key benefits of implementing MLOps, including faster iterations, real-time error detection, and continuous software optimization. Through this integration of tools and practices, we emphasize the importance of continuous evolution and adaptation in order to achieve a competitive advantage in the analytics applications market as Microsoft Azure, Google Cloud and Amazon Web Services.

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ANDROID APPLICATION FOR MOTION SICKNESS PARAMETERS MONITORING

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ABSTRACT:

In this paper motion sickness as a specific problem is analyzed. It is a common condition characterized by nausea, vomiting, dizziness, and discomfort that some people experience when they are in motion. It can occur while traveling by car, boat, plane, or other forms of transportation. In order to monitor and analyze parameters that lead to motion sickness Android application is developed to collect accelerometer data. Collected data are processed with low pass filter in real time so low frequencies are only present in final signal because they are main cause of motion sickness. Application usage with signals are presented with ideas for future work.

Keywords: *Android, accelerometer, low pass filter, motion sickness*

1. INTRODUCTION

Motion sickness, also known as kinetosis, is a common condition characterized by nausea, vomiting, dizziness, and discomfort that some people experience when they are in motion. It can occur while traveling by car, boat, plane, or other forms of transportation. Motion sickness happens when there is a conflict between what eyes see and inner ear senses about movement. For example, while reading a book in a car, eyes may be focused on a stationary object, but inner ear senses the motion of the car. This sensory mismatch can lead to symptoms like nausea, vomiting, sweating, and dizziness. Motion sickness can vary in severity from person to person and can be managed with various strategies like medication, focusing on the horizon, and avoiding certain activities that trigger symptoms. Motion sickness on boats, often referred to as seasickness, is a common form of motion sickness due to the unique motion patterns of watercraft. When on a boat, the constant rocking, swaying, and pitching can disrupt the body's sense of balance, leading to symptoms of motion sickness.

Similar to other forms of motion sickness, seasickness arises from a sensory conflict between what the eyes perceive and what the inner ear detects. For example, when on a boat, eyes may see the stationary interior of the cabin or the horizon, but inner ear senses the continuous movement of the vessel. Seasickness can affect individuals differently, with some people experiencing mild discomfort while others may suffer from severe

symptoms that interfere with their ability to enjoy the journey. Factors such as the size and stability of the boat, the weather conditions, and individual susceptibility can influence the severity of seasickness. Managing seasickness often involves a combination of preventive measures and treatments.

2. RELATED WORK

Motion sickness is interesting topic in science community. In medicine society it is interesting to explain, prevent and cure this kind of problems. In technical society it interesting to detect, monitor and predict this conditions on various ways and situations. This review article [1] delves into the physiological and psychological mechanisms underlying motion sickness, providing insights into its causes and potential treatment strategies. Study [2] explores the impact of motion sickness on passenger comfort and well-being during various modes of transportation such as cars, planes, ships, and trains. The paper [3] discusses the emergence of motion sickness as a significant issue in autonomous vehicles and proposes potential solutions such as adaptive control algorithms and interior design modifications. There are various therapy treatments for motion sickness. The review paper [4] examines the efficacy and safety of various pharmacological interventions for motion sickness, including antihistamines, anticholinergics, and antiemetics. On the other hand, the review paper [5] evaluates the effectiveness of virtual reality therapy as a treatment for motion sickness, summarizing existing literature and providing recommendations for future research.

Motion sickness detection approaches cover several fields including sensors or variable devices, machine learning algorithms, and even virtual reality. Review article [6] provides an overview of wearable sensor technologies used for motion sickness detection, discussing their accuracy, usability, and potential applications. The study [7] investigates the feasibility of using smartphone sensors for real-time detection of motion sickness symptoms, such as nausea and dizziness, during various activities. Common sensors found in smartphones that can be leveraged include accelerometer, gyroscope, magnetometer, barometer. Paper [8] proposes a deep learning-based approach to detect motion sickness using data collected from wearable sensors, achieving high accuracy in identifying motion sickness symptoms. Besides already mentioned sensors it uses hart rat, skin conductance and temperature sensors. A machine learning-based approach to detect motion sickness in users experiencing virtual reality environments, using physiological signals and behavioral data is presented in paper [9]. The paper [10] shows usage of cameras and environmental sensors in autonomous vehicle for motion sickness detection.

Motion sickness on boats - seasickness is especially interesting since constant instability of a boat. Article [11] provides an overview of motion sickness specifically in the context of boating, discussing its causes, symptoms, and various preventive measures such as medication, dietary considerations, and behavioral strategies. Paper [12] explains risk factors for seasickness for recreational boaters while [13] examines the impact of seasickness on crew performance and safety in maritime operations, highlighting the potential consequences of impaired cognitive and physical abilities due to motion sickness. On the other hand, paper [14] discusses design considerations for minimizing

motion sickness in boat interiors, including layout, furniture arrangement, lighting, and ventilation, to enhance passenger comfort and reduce the risk of seasickness.

According to international standards, ride comfort is explained in the ISO 2631 "Evaluation of human exposure to whole-body vibration", where part 3 to ISO 2631/3 [15] is focused on seasickness: "Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0.1 to 0.63 Hz" The seasickness criterion according to gives limits for RMS values of the accelerations as a function of frequency. The variables related to motion sickness include, without limitations, the axis of vibration, frequency of vibration, amplitude, and duration of exposure. Low frequencies in the range of 0.1 to 0.63 Hz cause seasickness, especially around 0.2 Hz.

In ISO 2631/3 [15], the guidance on human exposure to whole-body vibration is divided into different zones based on the frequency-weighted root mean square (RMS) acceleration values. These zones provide criteria for assessing the severity of vibration exposure and its potential effects on human health and comfort. Here are the typical values for each zone:

- **Zone A:** This zone represents low vibration exposure levels where there is minimal risk of adverse health effects. The frequency-weighted RMS acceleration for Zone A typically ranges from 0.5 m/s² to 0.8 m/s².

- **Zone B:** Zone B represents moderate vibration exposure levels. Exposure within this zone may cause discomfort and **fatigue**, particularly during prolonged exposure. The frequency-weighted RMS acceleration for Zone B typically ranges from 0.8 m/s² to 1.4 m/s².

- **Zone C:** Zone C represents high vibration exposure levels where there is an increased risk of adverse health effects, including discomfort, **motion sickness**, and potential injury. The frequency-weighted RMS acceleration for Zone C typically ranges from 1.4 m/s² to 2.5 m/s².

- **Zone D:** This zone represents very high vibration exposure levels where there is a significant risk of adverse health effects and potential injury. Exposure within this zone can lead to severe discomfort, increased risk of motion sickness, and other health issues. The frequency-weighted RMS acceleration for Zone D typically exceeds 2.5 m/s².

According to these, the values of arms in Zone B and Zone C could produce fatigue and motion sickness in passengers. Ranges of aRMS from 0.5 m/s² up to 1.4 m/s² are of interest to this study.

3. ANDROID APPLICATION FOR MOTION SICKNESS PARAMETERS MONITORING

Developed Android application functionalities are based on 3 axes accelerometer signals. For seasickness vertical Z axis is most important but, in this paper, all 3 axes are monitored. In order to collect parameters suitable for comfort analysis, several parallel tasks need to be performed. Most important are: accelerometer calculations, GPS monitoring, data saving to files, UI thread that plot live accelerometer signals and main application threads. This is achieved using RxJava. RxJava is a popular Java library (<https://github.com/ReactiveX/RxJava>) for composing asynchronous and

event-based programs. At its core, it introduces the concept of observables, which represent a sequence of data or events that can be observed over time. Developers can subscribe to observables and react to the emitted data or events using a variety of operators provided by RxJava. It is widely used in modern Java development, especially in applications where concurrency, reactive programming, or handling asynchronous events is essential.

The Android application is mainly developed for gathering signals in real usage for further analysis. On the first screen shown in Fig 1 user can set up name of the measurement, decision time interval, and file formats that the data will be saved in.

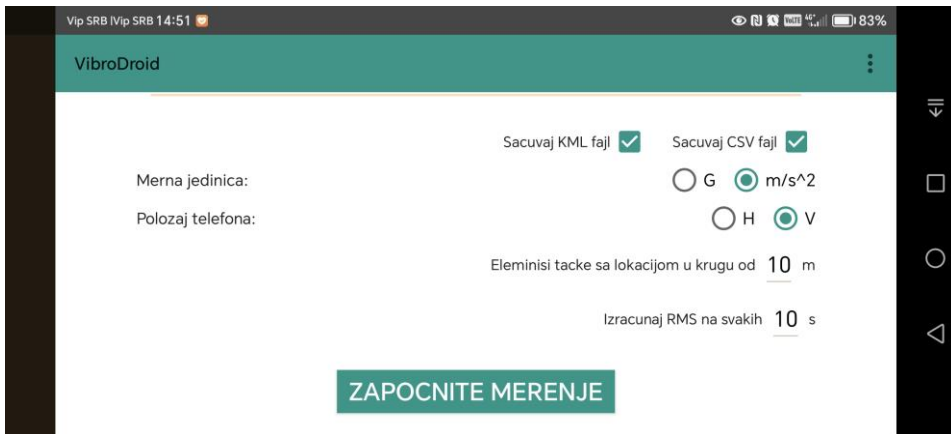


Fig. 1. Android application setup screen

The Android application is designed to calculate parameters in standard time intervals. Since low frequencies are interested in motion sickness 50ms time interval is set. It provides 20 samples per second for every axis which is more than enough for signal processing. Accumulated vibrations are detected with 3 axis accelerometers.

Raw collected signals are filtered with low pass filter. The equation for a first-order low-pass filter, commonly used for filtering signals from accelerometers, can be represented as (1):

$$y[n]=(1-\alpha)\cdot y[n-1]+\alpha\cdot x[n] \quad (1)$$

Where:

- $y[n]$ is the filtered output at time n .
- $x[n]$ is the input signal at time n .
- α is the filter coefficient, often referred to as the smoothing factor or time constant. It determines the amount of smoothing applied to the input signal.

The value of α is calculated based on the cutoff frequency (f_c) and the sampling frequency (f_s) using the equation (2):

$$\alpha = \frac{2\pi \cdot f_c}{2\pi \cdot f_c + f_s} \quad (2)$$

Where:

- f_c (1Hz) is the cutoff frequency (the frequency below which the signal is attenuated).
- f_s (20Hz) is the sampling frequency (the rate at which the signal is sampled).

This equation describes a recursive filter where the current output ($y[n]$) is a function of the previous output ($y[n-1]$) and the current input ($x[n]$). This type of filter is commonly used to remove high-frequency noise from signals obtained from accelerometers while preserving the lower frequency components related to the actual motion or vibration being measured. If the cutoff frequency (f_c) is set to 1 Hz and the sampling frequency (f_s) is 20 Hz than $\alpha \approx 0.0909$.

For every filtered acceleration sample, the application calculates the magnitude of all three-axis accelerations (3).

$$a_{iRMS} = \sqrt{a_{xi}^2 + a_{yi}^2 + a_{zi}^2} \quad (3)$$

where a_{xi} , a_{yi} , a_{zi} are X-, Y-, and Z-axis acceleration in the i -th sample, and a_{iRMS} is the magnitude of all three-axis accelerations.

For the motion sickness passenger need to be affected by low frequencies oscillations for some time. For this purpose, 10 second time interval is set for decision time interval. In that interval accumulated vibration-oscillations (a_{RMS}) can be measured. According to these, a_{RMS} for the decision time interval is calculated according to equation (4).

$$a_{RMS} = \sqrt{\frac{1}{n} * (a_{1RMS}^2 + a_{2RMS}^2 + \dots + a_{nRMS}^2)} \quad (4)$$

where a_{iRMS} is the i^{th} magnitude of all three-axis accelerations, and n is the number of samples. This value and all live signals from the accelerometer are plotted in real-time on a developed android application presented in Fig 2.

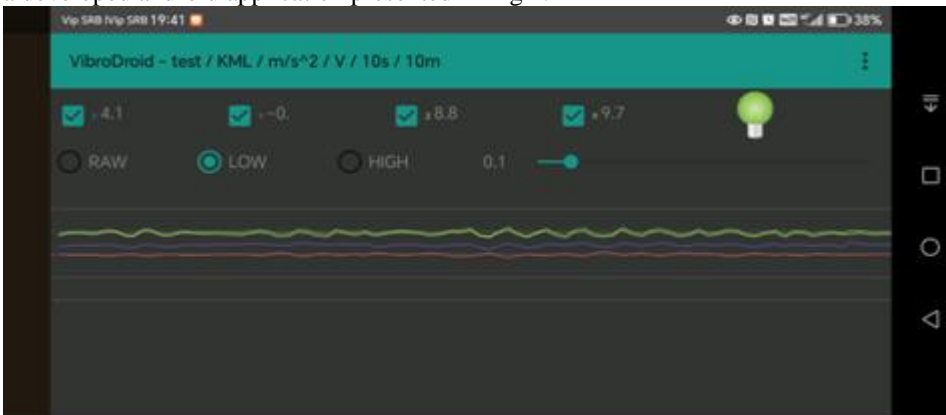


Fig. 2. Android application main screen with steady oscillations

X, Y, and Z axis signals and a_{RMS} calculated values are plotted to screen. The application enables signal filtration in order to eliminate unwanted signals. It can be set to show and

calculate raw signal, low pass filtered signal, and high pass filtered signal. Since for motion sickness, low frequencies are the main cause of discomfort low pass filter is applied. With slider setup 0.1 shown in Fig 2, it passes 1Hz of low frequencies while the other frequencies are cut off. Fig 1 presents signals on a steady water with little oscillations and a green bulb at the top right corner. This means that there should be no seasickness with passengers.

Fig. 3 presents signals with higher oscillation amplitudes. This kind of signal can produce seasickness. Higher calculated aRMS values are indicated with orange bulb at the top right corner of the screen.

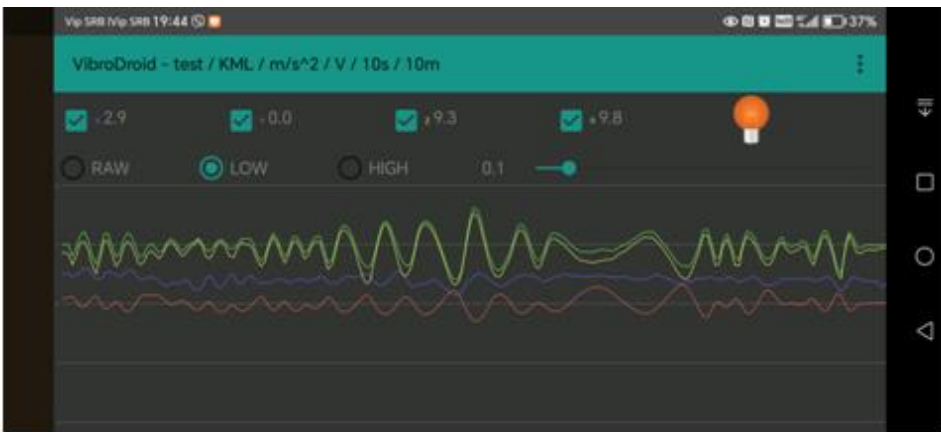


Fig. 2. Android application main screen with larger oscillations

Based on the initial setup at the end of the measurement, application save the collected data in files for further analysis.

3. CONCLUSION

This paper presented developed Android application suitable for motion sickness parameter monitoring. For this final decision about seasickness detection condition, main goal is to calculate arms threshold values. In practical terms, thresholds for motion sickness can vary widely among individuals and depend on factors beyond just the vibration level, including motion characteristics, environmental conditions, and individual differences in physiology and tolerance. Therefore, it's essential to consider a range of factors when evaluating the risk of motion sickness in maritime environments rather than relying solely on a single threshold value for arms acceleration.

For further analysis large amount of data will be collected and a machine-learning approach will be implemented to help in motion sickness detection.

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BIOLOGY, PHYSICS, CHEMISTRY, MATEMATICS

O ZBIRLJIVOSTI U \mathbf{R}^2

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SAŽETAK: U ovom radu, mi eksplicitno dokazujemo da neophodan i dovoljan uslov, da bi funkcija ostatka $\mathfrak{R}_{(L-F)}$, gde L je naboj nad $\mathbf{P}(I)$, takav da mu je granična vrednost dL totalni diferencijal na kompaktnom intervalu I u \mathbf{R}^2 , $F = \langle f, \mu \rangle$, f je punktualna funkcija nad I i μ je Lebeg-ova mera, bila u osnovi zbirljiva na intervalu I , je da postoji naboj K nad $\mathbf{P}(I)$, takav da njegova diferencijalna forma dK je totalni diferencijal na I i naboj $\langle L - K \rangle$ je (BS) antiderivativ na I funkcije f .

Ključne riječi: funkcija ostatka, zbirljivost

1. UVOD

U prezentovanom radu, definiše se funkcija ostatka \mathfrak{R} , kao sinonim za diferencijalnu formu intervalno-punktualne funkcije u \mathbf{R}^2 . Zatim se dokazuju potrebni i dovoljni uslovi da funkcija ostatka \mathfrak{R} bude u osnovi zbirljiva na kompaktnom intervalu I u \mathbf{R}^2 .

2. PRELIMINARNI POJMOVI

Ako skup svih realnih brojeva označimo sa \mathbf{R} , tada $\mathbf{R}_+ = [0, +\infty)$. Uz to, $\mathbf{N} = \{1, 2, 3, 4, 5, \dots\}$. Sa \mathbf{R}^2 označimo Dekart-ov proizvod $\mathbf{R} \times \mathbf{R}$. Za kompaktne intervale i_x i i_y u \mathbf{R} , Dekart-ov proizvod $i_x \times i_y$ je kompaktni interval I u \mathbf{R}^2 . Uređeni par (x, y) elemenata $x \in i_x$ i $y \in i_y$ je uređeni par koordinata proizvoljne tačke z u \mathbf{R}^2 , čija norma $\|z\|$ je rastojanje ρ tačke z od koordinatnog početka $o = (0, 0)$ u \mathbf{R}^2 . U simbolima, $\|z\| = \rho(z, o) = |(x^2 + y^2)^{1/2}|$. U prostoru \mathbf{R}^2 koristimo isključivo metriku indukovanu normom $\|z\|$. Rastojnje neke tačke $z \in \mathbf{R}^2$ od proizvoljnog skupa E u \mathbf{R}^2 je $\rho(z, E) = \inf\{\rho(z, w) | w \in E\}$. Sa $\text{int}.E$, $\text{cl}.E$ i ∂E označavamo unutrašnjost, zatvaranje i granicu skupa E , respektivno. Dijametar skupa E u \mathbf{R}^2 , označen sa dE , definiše se tako da $dE = \sup\{\rho(z, w) | z \in \text{int}.E \text{ i } w \in \partial \text{cl}.E\}$. Funkcija $\chi_E: \mathbf{R}^2 \rightarrow \mathbf{R}$ je karakteristična funkcija (indikator) skupa E , jednaka 1 , ako je tačka z u skupu E i jednaka 0 , ako tačka z nije u skupu E .

Kompaktni intervali u \mathbf{R}^2 se ne preklapaju, ako su im unutrašnjosti disjunktni skupovi. Neka $\mathbf{P}(I)$ je partitvni skup intervala I i neka $\mathbf{I}(I)$ je familija svih kompaktnih intervala J , takvih da $J \subseteq I$. Tada, neka skupovna funkcija $L: \mathbf{P}(I) \rightarrow \mathbf{R}$ je prebrojivo aditivna, ako za svaku, najviše prebrojivu familiju $\{E_n\}_{1 \leq n}$, po parovima disjunktnih skupova E_n , takvih da $\bigcup_{1 \leq n} E_n \in \mathbf{P}(I)$, zadovoljava uslov $L(\bigcup_{1 \leq n} E_n) = \sum_{1 \leq n} L(E_n)$. Svaka prebrojivo aditivna funkcija L je spoljna mera. U teoriji mera, naziv za spoljnu meru je naboj. Stoga, kada

kažemo naboj nad $\mathbf{P}(I)$, mi zapravo mislimo na prebrojivo aditivnu skupovnu funkciju, definisanu na skupu $\mathbf{P}(I)$. Pozitivna mera se može smatrati preciznim pojmom "veliĉine" skupa. *Lebeg*-ovu meru u \mathbf{R}^2 oznaĉavamo sa μ , meĊutim, za $I \in \mathbf{R}^2$, ponekad pišemo ili $\Delta x \Delta y$ ili $|I|$, umesto $\mu_I = \mu_{I_x} \mu_{I_y}$. Nulti skup je skup *Lebeg*-ove mere nula. Za funkciju f nad I se kaŹe da je nulta funkcija na intervalu I , ako je skup $\{z \in I \mid f(z) \neq 0\}$ nulti skup, vidi **2.4 Definiciju** u [1]. Ako je, uz to, skup $\{z \in I \mid f(z) \neq 0\}$ prazan skup, onda funkcija f je nula funkcija na I . Funkcija, koja je ili kompozicija više punktualnih i skupovnih funkcija, ili je kombinacija punktualnih i skupovnih funkcija, povezanih elementarnim algebarskim operacijama, je punktualno-skupovna funkcija. Sa $\langle f|I \rangle$ oznaĉavamo proizvod punktualne funkcije f i skupovne funkcije I , primera radi.

Za punktualnu funkciju $\delta: i_y \rightarrow (0, +\infty)$, nazvanu meraĉ, intervalno-punktualni par (i_y, y_j) , gde i_y je kompaktni podinterval intervala i_y i $y_j \in i_y$, je δ -fina intervalno-punktualni par, ako $i_y \subset (y_j - \delta(y_j), y_j + \delta(y_j))$. Skup (familija) intervalno-punktualnih parova (i_y, y_j) , takvih da se podintervali i_y ne preklapaju i da $\bigcup_{j=1}^m i_y = i_y$, je particija (podela) P_{i_y} intervala i_y . Taĉke $y_j \in i_y$ su tagovi particije P_{i_y} .

Za kompaktne intervale i_x i i_y realne prave \mathbf{R} i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka interval i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial} i_y = v(\hat{\partial} i_x) = v(\hat{\partial} i_x)$, gde $\hat{\partial}$ i ∂ oznaĉavaju donju i gornju granicu intervala i_x i intervala i_y , respektivno. Za zadati meraĉ $\delta: i_y \rightarrow (0, +\infty)$, svaka δ -fina particija P_{i_y} intervala i_y indukuje δ -finu particiju P_{i_x} intervala i_x , takvu da $P_{i_x} = \bigcup_{i=1}^n (i_x, x_i)$, a granice $\hat{\partial} i_{x_i}$ i ∂i_{x_i} podintervala i_{x_i} i tagovi x_i su u skupu taĉaka intervala i_x , koje se funkcijom v preslikavaju u granice $\hat{\partial} i_{y_j}$ i ∂i_{y_j} podintervala i_{y_j} i tagove y_j . Shodno tome, indukovana particija (podela) P_I intervala $I = i_x \times i_y$ u \mathbf{R}^2 , je skup (familija) intervalno-punktualnih parova $(I_{i,j}, z_{i,j})$, takvih da $I_{i,j} = i_x \times i_{y_j}$ i $z_{i,j} = (x_i, y_j)$, za svako $i = 1, 2, \dots, n$ i $j = 1, 2, \dots, m$. Oĉigledno $z_{i,j} \in I_{i,j}$ i $\bigcup_{i,j=1}^m I_{i,j} = I$. Taĉke $z_{i,j}$ su tagovi particije P_I intervala I . Razliĉiti izbori tagova $z_{i,j}$, u odnosu na odgovarajuće podintervale $I_{i,j}$, indukovane particije P_I intervala I , vode nas ka razliĉitim definicijama generalisanog *Riman*-ovog integrala u \mathbf{R}^2 , [1]. Za skup $E \in \mathbf{P}(I)$, restrikcija indukovane particije P_I na skupu E je skup intervalno-punktualnih parova $(I_{i,j}, z_{i,j})$, takvih da $z_{i,j} \in E$. U simbolima, $P_I|_E = \{(I_{i,j}, z_{i,j}) \in P_I \mid z_{i,j} \in E\}$. Neka h je punktualno-intervalna funkcija nad $I \times I(I)$ i neka $E \in \mathbf{P}(I)$. U onome što sledi, skup i sumu vrednosti h na $P_I|_E \subset P_I$, oznaĉavamo sa $h(P_I|_E)$ i $s(h, P_I|_E)$, tako da $h(P_I|_E) = \{h((I_{i,j}, z_{i,j})) \mid (I_{i,j}, z_{i,j}) \in P_I|_E\}$ i $s(h, P_I|_E) = \sum_{(I_{i,j}, z_{i,j}) \in P_I|_E} h((I_{i,j}, z_{i,j}))$. Sa $|h|(P_I|_E) < \varepsilon \zeta(P_I|_E)$, oznaĉavamo skup relacija $\{|h((I_{i,j}, z_{i,j}))| < \varepsilon \zeta((I_{i,j}, z_{i,j})) \mid (I_{i,j}, z_{i,j}) \in P_I|_E\}$. Za punktualnu funkciju f i intervalnu funkciju *Lebeg*-ove mere μ u \mathbf{R}^2 , F je oznaka za punktualno-intervalnu funkciju $\langle f\mu \rangle$.

Definicija 1. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial} i_y = v(\hat{\partial} i_x) = v(\hat{\partial} i_x)$ i neka $E \in \mathbf{P}(I)$. Tada, δ -fina indukovana particija P_I intervala I je potpuno tagovana u skupu E , ako i samo ako $z_{i,j} \in E$, kadgod $E \cap I_{i,j} \neq \emptyset$ i $(I_{i,j}, z_{i,j}) \in P_I$.

3. KONCEPT OSNOVNE ZBIRLJIVOSTI U \mathbf{R}^2

Neka h i k su dve punktualno-intervalne funkcije nad $I \times I(I)$. Startovaćemo sa definicijom diferencijalne forme $d\langle h - k \rangle$ nad skupom $E \in \mathbf{P}(I)$ funkcije $\langle h - k \rangle$.

Definicija 2. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial}i_y = v(\hat{\partial}i_x) = v(\hat{\Theta}i_x)$, neka $E \in \mathbf{P}(I)$ i neka h i k su dve punktualno-intervalne funkcije nad $I \times I(I)$. Tada, punktualna funkcija $d\langle h - k \rangle$ nad intervalom I , je diferencijalna forma nad skupom E , funkcije $\langle h - k \rangle$, ako i samo ako za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad i_y , takav da

$$\left| \langle \langle h - k \rangle - d\langle h - k \rangle \rangle (P_I|_E) \right| < \varepsilon, \quad (1)$$

kadgod $P_I|_E \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , koja je potpuno tagovana u skupu E . Ovdje, $d\langle h - k \rangle(E) = \lim_{P_I|_E \rightarrow E} \langle h - k \rangle(P_I|_E) = \lim_{\delta_\varepsilon \rightarrow 0^+} \langle h - k \rangle(P_I|_E)$.

Jasno, iz diferencijabilnosti funkcije $v: i_x \rightarrow \mathbf{R}$, sledi da za bilo koju δ_ε -finu indukovanu podelu P_I intervala I , kada $\delta_\varepsilon \rightarrow 0^+$, to znači da $\mu_{h,v} \rightarrow 0^+$ i da $P_I \rightarrow I$.

U slučaju da je na skupu $E \in \mathbf{P}(I)$ zadovoljen uslov $|d\langle h - k \rangle| < +\infty$, tada za h i k kaže se da su diferencijalno uporedivi na skupu E . Ako, uz sve to, diferencijalna forma $d\langle h - k \rangle$ je nula funkcija na E , tada za h i k kaže se da su diferencijalni ekvivalenti na skupu E . Ako ζ je strogo pozitivan naboj nad $I(I)$, čija diferencijalna forma je nula funkcija na intervalu I , a granična vrednost $\lim_{P_I|_E \rightarrow E} \langle \langle h - k \rangle / \zeta \rangle (P_I|_E)$, kao skup vrednosti punktualne funkcije $d_\zeta \langle h - k \rangle$ na skupu E , je definisana na skupu E , što znači da $|d_\zeta \langle h - k \rangle| < +\infty$, na skupu E , tada h i k su derivativno uporedivi na skupu E u odnosu na naboj ζ .

Definicija 3. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial}i_y = v(\hat{\partial}i_x) = v(\hat{\Theta}i_x)$, neka $E \in \mathbf{P}(I)$, neka h i k su dve punktualno-intervalne funkcije nad $I \times I(I)$ i neka ζ je strogo pozitivan naboj nad $I(I)$, čija diferencijalna forma je nula funkcija na I . Funkcije h i k su derivativni ekvivalenti na skupu $I|_E$, u odnosu na naboj ζ , ako i samo ako za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad i_y , takav da

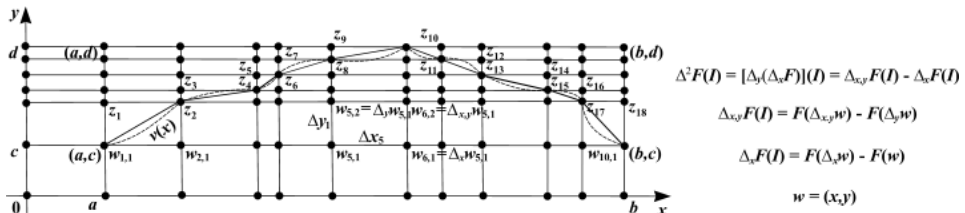
$$\left| \langle h - k \rangle \right| (P_I|_{I|_E}) < \varepsilon \zeta (P_I|_{I|_E}), \quad (2)$$

kadgod $P_I|_{I|_E} \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , koja je potpuno tagovana u skupu E .

Ako je na skupu $E \in \mathbf{P}(I)$ definisana granična vrednost $\lim_{P_I|_E \rightarrow E} \langle h / \Delta x \Delta y \rangle (P_I|_E)$, kao skup vrednosti punktualne funkcije $d^2_{xy} h$ na skupu E , tada za punktualnu funkciju $d^2_{xy} h$ kaže se da je prostorna derivacija funkcije h na skupu E . Diferencijalna forma $d^2 h$ funkcije h je nula funkcija na skupu E . Ako, uz to, za $z \in I$, skup $\{z\}$ je skup E , tada $d^2_{xy} h$ je prostorna derivacija funkcije h u tački z . Punktualna funkcija f je prostorna derivacija na intervalu I u \mathbf{R}^2 funkcije h , ako f je prostorna derivacija funkcije h u svakoj tački z intervala I . Za

punktualno-intervalnu funkciju h kaže se da je prostorno diferencijabilna na intervalu I u \mathbf{R}^2 , do punktualne funkcije f , ako f je prostorna derivacija funkcije h na intervalu I . Za zadatu punktualnu funkciju $F: I \rightarrow \mathbf{R}$ i podinterval $I_{i,j} = \mathbf{i}_{xi} \times \mathbf{i}_{yj}$ indukovane particije P_I intervala I u \mathbf{R}^2 , *Lebeg*-ove mere $\mu_{I_{i,j}} = \mu_{ix} \mu_{iy} = \Delta x_i \Delta y_j$, gde Δx_i i Δy_j su *Lebeg*-ove mere μ_{ix} i μ_{iy} podintervala i_{xi} i i_{yj} , respektivno, sa svoje četiri temene tačke: $w_{i,j} = (x_i, y_j)$, $\Delta_x w_{i,j} = (x_i + \Delta x_i, y_j)$, $\Delta_y w_{i,j} = (x_i, y_j + \Delta y_j)$ i $\Delta_{x,y} w_{i,j} = (x_i + \Delta x_i, y_j + \Delta y_j)$, neka primera radi, $\Delta^2 F$ je intervalna funkcija, pridružena datoj funkciji F , na taj način da $\Delta^2 F(I_{i,j}) = \Delta_y(\Delta_x F) = \Delta_x(\Delta_y F)$, gde $\Delta_y(\Delta_x F) = \Delta_{x,y} F - \Delta_x F = F(\Delta_{x,y} w_{i,j}) - F(\Delta_y w_{i,j}) - [F(\Delta_x w_{i,j}) - F(w_{i,j})]$ i $\Delta_x(\Delta_y F) = \Delta_{y,x} F - \Delta_y F = F(\Delta_{y,x} w_{i,j}) - F(\Delta_x w_{i,j}) - [F(\Delta_y w_{i,j}) - F(w_{i,j})]$, slika 1. U tom slučaju, budući da $\Delta_{x,y} F = F(x_i + \Delta x_i, y_j + \Delta y_j) - F(x_i, y_j + \Delta y_j) = \int_{\Delta x_i} d_x F(x, y_j + \Delta y_j) dx$ i da $\Delta_x F = F(x_i + \Delta x_i, y_j) - F(x_i, y_j) = \int_{\Delta y_j} d_y F(x_i, y) dy$, sledi da je $\Delta^2 F(I_{i,j}) = \int_{\Delta y_j} \int_{\Delta x_i} d_x d_y F(x, y) dx dy$, odnosno

$$d_{xy}^2 F(z) = \frac{d^2 F}{dxdy}(z) = \lim_{\mu_{i,j} \rightarrow 0^+} \frac{\Delta^2 F(I_{i,j})}{\Delta x_i \Delta y_j} = - \lim_{\mu_{i,j} \rightarrow 0^+} \frac{1}{\Delta x_i \Delta y_j} \iint_{\partial I_{i,j}} d_y F(x, y) dy = \lim_{\mu_{i,j} \rightarrow 0^+} \frac{\Delta x_i \Delta y_j}{\Delta x_i \Delta y_j} \iint_{\partial I_{i,j}} d_x F(x, y) dx. \quad (3)$$



$$\begin{aligned} & \sum_{j=2}^5 -2\Delta^2 F(I_{1,j}) + \sum_{j=3}^5 -2\Delta^2 F(I_{2,j}) + \sum_{j=4}^5 -4\Delta^2 F(I_{3,j}) + \Delta^2 F(I_{4,3}) + \Delta^2 F(I_{7,6}) + \\ & + \sum_{j=4}^5 -4\Delta^2 F(I_{8,j}) + \sum_{j=3}^5 -2\Delta^2 F(I_{9,j}) + \sum_{j=2}^5 -2\Delta^2 F(I_{10,j}) = F(b,d) - F(a,d) - \sum_{j=1}^9 [F(z_{2j}) - F(z_{2j-1})] \\ & \Delta^2 F(I_{2,2}) + \sum_{j=1}^2 -\Delta^2 F(I_{3,j}) + \sum_{j=1}^3 -1\Delta^2 F(I_{4,j}) + \sum_{j=1}^4 -1\Delta^2 F(I_{5,j}) + \\ & + \sum_{j=1}^5 -1\Delta^2 F(I_{6,j}) + \sum_{j=1}^2 -\Delta^2 F(I_{8,j}) + \Delta^2 F(I_{9,2}) = F(a,c) - F(b,c) + \sum_{j=1}^5 [F(w_{6+j,1}) - F(w_{5+j,1})] + [F(w_{6+1,6}) - F(w_{5+1,6})] \end{aligned}$$

sl.1

Ako četiri temene tačke $w_{i,j}$, $\Delta_x w_{i,j}$, $\Delta_{x,y} w_{i,j}$ i $\Delta_y w_{i,j}$ podintervala $I_{i,j}$, indeksiramo redom sa $0, 1, 2$ i 3 ($w^k_{i,j}$, $k = 0, 1, 2, 3$), tada je $\Delta^2 F(I_{i,j}) = \sum_{k=0}^3 (-1)^k F(w^k_{i,j})$. Shodno tome, priraštaj $\Delta^2 F$ je ciklični (mešoviti) priraštaj punktualne funkcije F , a prostorna derivacija $d^2_{xy} F$ je ciklična (mešovita) derivacija punktualne funkcije F .

Ovo je bio primer za 2-dimenzionalnu diferencijalnu formu. Granična vrednost intervalne funkcije ΔF , pridružene funkciji F , na taj način da $\Delta F(I_{i,j}) = F(\Delta_{x,y} w_{i,j}) - F(w_{i,j})$, u slučaju kada temene tačke $\Delta_{x,y} w_{i,j}$ i $w_{i,j}$ intervala $I_{i,j}$ su na krivoj v i $\Delta F(I_{i,j}) = F(\Delta_x w_{i,j}) - F(\Delta_y w_{i,j})$, kada temene tačke $\Delta_x w_{i,j}$ i $\Delta_y w_{i,j}$ su na krivoj v , je primer 1-dimenzionalne diferencijalne forme. Stoga, u tačkama z krive v , derivacija funkcije F , duž krive v , ima vrednosti

$$d_s F(z) = \frac{dF(z)}{ds} = \frac{d_x F(z) + d_y F(z) \operatorname{tg} \varphi(z)}{\left[\lim_{\mu_{i,j} \rightarrow 0^+} \frac{v \int_{\Delta x_i} \sqrt{F(x, \operatorname{tg}^2 \varphi(x)) dx} + v \int_{\Delta y_j} d_y F(x_i, y) \sqrt{(\Delta x_i, y)} dy (\Delta y_j)^2}{\Delta s_{i,j}} \right]} = \lim_{\mu_{i,j} \rightarrow 0^+} \frac{v \int_{\Delta x_i} d_x F(x, y) dx - v \int_{\Delta y_j} d_y F(x_i, y) dy}{\Delta s_{i,j}}, \quad 376$$

(4)

gde φ je ugao, koji grade tangenta, u tački z krive v i pozitivni deo apscisne ose (ose x).

Budući da je $\rho(\Delta_{x,y}w_{i,j}, w_{i,j}) = \rho(\Delta_x w_{i,j}, \Delta_y w_{i,j}) = |[(\Delta x_i)^2 + (\Delta y_j)^2]^{1/2}| = \Delta s_{i,j}$, linijski elemenat $\Delta s_{i,j}$ je *Lebeg*-ova linijska mera podintervala $I_{i,j}$, a za razliku od $\Delta x_i \Delta y_j$, koja je *Lebeg*-ova površinska mera podintervala $I_{i,j}$.

Očigledno je moguće da na nekom skupu tačaka $E \in \mathbf{P}(I)$, na kome funkcije h i k ili jesu ili nisu, to je irelevantno, diferencijalni ekvivalenti, ali nisu i derivativni ekvivalenti, oni budu diferencijalno uporedivi, a što znači da granična vrednost $\lim_{P_k \rightarrow E} \langle h - k \rangle (P_{I|E})$, kao skup vrednosti punktualne funkcije $d\langle h - k \rangle(z)$ na skupu E , je skup definisanih vrednosti. Shodno tome, sledi definicija skupa singularnih tačaka.

Definicija 4. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial} i_y = v(\hat{\partial} i_x) = v(\hat{\partial} i_x)$, neka $E \in \mathbf{P}(I)$, neka h i k su dve punktualno-intervalne funkcije nad $I \times I(I)$ i neka ζ je strogo pozitivan naboj nad $I(I)$, čija diferencijalna forma je nula funkcija na I . Skup E je skup singularnih tačaka (singulariteta) funkcije $\langle h - k \rangle$ u odnosu na naboj ζ , ako i samo ako za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad i_y , takav da

$$\varepsilon \zeta(P_{I|E}) \leq \left| \langle h - k \rangle (P_{I|E}) \right|, \quad (5)$$

kadgod $P_{I|E} \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , koja je potpuno tagovana u skupu E .

Kao što je prethodno rečeno, ako punktualna funkcija $d\langle h - k \rangle$ je nula funkcija na skupu E , tada punktualno-intervalne funkcije h i k su diferencijalni ekvivalenti na skupu E . Ako h i k nisu i derivativni ekvivalenti na skupu E , prethodna nejednakost postaje dvostruka nejednakost

$$\varepsilon \zeta(P_{I|E}) \leq \left| \langle h - k \rangle (P_{I|E}) \right| < \varepsilon. \quad (6)$$

Ako punktualna funkcija $d\langle h - k \rangle$ nije nula funkcija na skupu E , a h i k su diferencijalno uporedivi na skupu E , tada je zadovoljena sledeća dvostruka nejednakost

$$\varepsilon \zeta(P_{I|E}) \leq \left| \left\langle \langle h - k \rangle - d\langle h - k \rangle \right\rangle (P_{I|E}) \right| < \varepsilon, \quad (7)$$

a skup singulariteta E je skup otklonjivih singulariteta funkcije $\langle h - k \rangle$, u odnosu na naboj ζ .

Pod uslovom da se prethodno, diferencijalna forma dh punktualno-intervalne funkcije h , preimenuje u funkciju ostataka \mathfrak{R}_h funkcije h , u poziciji smo da definišemo osnovnu sumu funkcije ostataka \mathfrak{R}_h funkcije h , kao što sledi. Shodno tome, u nastavku rada, korićićemo, potpuno ravnopravno, dh i \mathfrak{R}_h , kao sinonime.

Definicija 5. Za kompaktni interval $I = i_x \times i_y$ u \mathbb{R}^2 i funkciju $v: i_x \rightarrow \mathbb{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial}i_y = v(\hat{\partial}i_x) = v(\hat{\partial}i_x)$, neka $E \in \mathbf{P}(I)$ i neka h je punktualno-intervalna funkcija nad $I \times I(I)$. Tada, realni broj $\sigma_{\mathfrak{R}_h}(E)$ je osnovna suma nad skupom E , funkcije ostataka \mathfrak{R}_h funkcije h , ako i samo ako za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad i_y , takav da

$$|s(h, P_I|_E) - \sigma_{\mathfrak{R}_h}(E)| < \varepsilon, \quad (8)$$

kadgod $P_I|_E \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , koja je potpuno tagovana u skupu E . Ovde, $(B)\Sigma_{z \in I}(\mathfrak{R}_h \chi_E)(z) = \sigma_{\mathfrak{R}_h}(E) = \lim_{P_I|_E \rightarrow E} s(h, P_I|_E) = \lim_{\delta_\varepsilon \rightarrow 0} s(h, P_I|_E)$.

Ako sumu $s(h, P_I|_E)$, u relaciji (8), zamenimo sumom $s(|h|, P_I|_E)$, tada **Definicija 5.** definiše pojam apsolutne sume $\sigma_{d|h|}(E)$. U slučaju da je suma $\sigma_{\mathfrak{R}_h}(E)$ konačna, drugim rečima da je $|\sigma_{\mathfrak{R}_h}(E)| < +\infty$, za funkciju ostataka \mathfrak{R}_h kaže se da je u osnovi zbirljiva nad skupom E .

Definišimo $\|\mathfrak{R}_h\|_{BS} = |\mathfrak{R}_h| + \sup\{|\sigma_{\mathfrak{R}_h}(E)| \mid E \in \mathbf{P}(I)\}$. Prostor $(BS(I), +, \cdot)$, koji je prostor u osnovi zbirljivih funkcija, je vektorski prostor i $\|\cdot\|_{BS}$ je norma tog prostora, dok prostor $(BS(I), +, \cdot, \|\cdot\|_{BS})$ je normirani vektorski prostor. Ako $|\sigma_{\mathfrak{R}_h}(E)| \leq +\infty$, tada funkcija \mathfrak{R}_h je u osnovi prošireno zbirljiva nad skupom E . Uz to, ako je $\sigma_{\mathfrak{R}_h}(E) = 0$, funkcija ostatka \mathfrak{R}_h je zanemarljivo u osnovi zbirljiva nad skupom E . Za funkciju \mathfrak{R}_h kaže se da je zanemarljivo u osnovi zbirljiva na intervalu I , ako i samo ako $\sigma_{\mathfrak{R}_h}(J) = 0$, kadgod $J \in I(I)$. Jasno, u tom slučaju je $\sigma_{\mathfrak{R}_h}(E) = 0$ i za svako $E \in \mathbf{P}(I)$.

Punktualna funkcija \mathfrak{R}_h može biti zanemarljivo u osnovi zbirljiva, ali ne i zanemarljivo apsolutno zbirljiva, na skupu. Funkcija \mathfrak{R}_h , koja je zanemarljivo apsolutno zbirljiva nad skupom E , je zanemarljivo apsolutno zbirljiva i nad svim podskupovima skupa E . Jasno, ovo ne važi za funkciju, koja je zanemarljivo u osnovi zbirljiva nad intervalom I , ali ne i na intervalu I .

Neka $E \in \mathbf{P}(I)$. Za dve diferencijalne forme dh i dk kaže se da su apsolutni (u osnovi) zbirljivi ekvivalenti nad E , ako diferencijalna forma $d(h - k)$ je zanemarljivo apsolutno (u osnovi) zbirljiva nad E . Ako dh i dk su apsolutno zbirljivi ekvivalenti nad intervalom I , tada funkcija ostatka $\mathfrak{R}_{(h-k)}$ je nula funkcija na intervalu I , što znači da diferencijalne forme dh i dk su diferencijalni ekvivalenti na I . Obrnuto ne važi, u opštem slučaju. Neka tvrđenja su apsolutno (u osnovi) istinita \mathfrak{R}_h -skoro svuda, ako su ona istinita svuda, osim na skupu E , takvom da je $\sigma_{\mathfrak{R}_h}(E) = 0$ ($\sigma_{\mathfrak{R}_h}(E) = 0$). Za skup E se u tom slučaju kaže da je apsolutno (u osnovi) \mathfrak{R}_h -zanemarljiv skup. Ako h zamenimo **Lebeg**-ovom merom μ , tada se za skup E kaže da je zanemarljiv skup. Jasno, svaki zanemarljiv skup je ujedno i nulti skup.

Prethodno definisani pojam osnovne sume $\sigma_{\mathfrak{R}_h}$ funkcije ostatka \mathfrak{R}_h funkcije h , preciznije jednakost $\lim_{\delta \rightarrow 0^+} s(h, P_I|_E) = \lim_{P_I|_E \rightarrow E} s(h, P_I|_E) = \sigma_{\mathfrak{R}_h}(E) = (B) \sum_{z \in I} \langle \mathfrak{R}_h, \chi_E \rangle(z)$ **Definicije 5.**, eksplicitno ukazuje na krucijalno važnu činjenicu da je granična vrednost sume vrednosti funkcije h jednaka sumi njenih graničnih vrednosti \mathfrak{R}_h . Ako funkcija ostatka \mathfrak{R}_h funkcije h je u osnovi zbirljiva na kompaktnom intervalu I u \mathbf{R}^2 , mi onda intuitivno pretpostavljamo da je ona u osnovi zbirljiva i na bilo kome podskupu E intervala I . To je lako dokazivo. Za ono što sledi, neophodno je definisati pojam totalnog diferencijala naboja L na intervalu I .

Definicija 6. Za kompaktni interval I u \mathbf{R}^2 , neka L je naboj nad $P(I)$. Tada, diferencijalna forma dL naboja L je totalni diferencijal na I , ako i samo ako je u osnovi zbirljiva na I i $\sigma_{\mathfrak{R}_L}(E) = L(E)$, za svako $E \in I(I)$.

Naredna lema ukazuje nam na činjenicu da su zbirljivost i derivacija, uopšteno govoreći, dve inverzne operacije, iz razloga što su diferencijalne forme $d\sigma_{\mathfrak{R}_h}$ i dh u osnovi zbirljivi ekvivalenti na intervalu I .

Lema 1. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{v}i_y = v(\hat{v}i_x) = v(\hat{v}i_x)$ i neka h je punktualno-intervalna funkcija nad $I \times I(I)$. Tada, ako diferencijalna forma dh je u osnovi zbirljiva na I , diferencijalne forme dh i $d\sigma_{\mathfrak{R}_h}$ su u osnovi zbirljivi ekvivalenti na I .

Dokaz: Za funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{v}i_y = v(\hat{v}i_x) = v(\hat{v}i_x)$, neka h je punktualno-intervalna funkcija nad $I \times I(I)$, takva da dh je u osnovi zbirljiva na intervalu I . Budući da je $\lim_{P_I|_J \rightarrow J} s(\sigma_{\mathfrak{R}_h}, P_I|_J) = \sigma_{\mathfrak{R}_h}(J)$, kadgod $P_I|_J \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , potpuno tagovana u nekom intervalu $J \in I(I)$, sledi da za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad i_y , takav da

$$\begin{aligned} \left| s(\langle h - \sigma_{\mathfrak{R}_h} \rangle, P_I|_J) \right| &= \left| s(h, P_I|_J) - \sigma_{\mathfrak{R}_h}(J) - [s(\sigma_{\mathfrak{R}_h}, P_I|_J) - \sigma_{\mathfrak{R}_h}(J)] \right| \leq \\ &\leq \left| s(h, P_I|_J) - \sigma_{\mathfrak{R}_h}(J) \right| + \left| s(\sigma_{\mathfrak{R}_h}, P_I|_J) - \sigma_{\mathfrak{R}_h}(J) \right| < 2\varepsilon, \end{aligned}$$

kadgod $P_I|_J \subset P_I$ i P_I je δ_ε -fina indukovana podela intervala I , koja je potpuno tagovana u intervalu $J \in I(I)$. Shodno tome, $\lim_{P_I|_J \rightarrow J} s(\langle h - \sigma_{\mathfrak{R}_h} \rangle, P_I|_J) = \lim_{\delta \rightarrow 0^+} s(\langle h - \sigma_{\mathfrak{R}_h} \rangle, P_I|_J) = 0$, odnosno $\sigma_{d(h - \sigma_{\mathfrak{R}_h})}(J) = 0$, za svako $J \in I(I)$, što znači da su diferencijalne forme dh i $d\sigma_{\mathfrak{R}_h}$ u osnovi zbirljivi ekvivalenti na I .

Sa jedne strane, granična vrednost dh neke punktualno-intervalne funkcije h je punktualna funkcija, a sa druge strane, granična vrednost dL konvergentne intervalne funkcije L je funkcija **Bera** klase jedan [3]. Ako ciklični (mešoviti) priraštaj $\Delta^2 F$ funkcije F je funkcija ograničene varijacije na intervalu I , tada suma $\sigma_{\mathfrak{R}_{\Delta^2 F}}$ je prostorna funkcionalna varijaciona mera intervala I , indukovana sa $\Delta^2 F$, preciznije **Lebeg-Stiltjes**-ova mera [7]. Shodno tome, možemo uzeti apsolutnu vrednost osnovne sume $|\sigma_{\mathfrak{R}_h}|$, kao i apsolutnu sumu $\sigma_{|\mathfrak{R}_h|}$, da budu

osnovna funkcionalna mera indukovana sa \mathbf{h} i apsolutna funkcionalna mera indukovana sa \mathbf{h} , respektivno.

Podsetimo se, pod nabojem nad $\mathbf{P}(\mathbf{I})$, mi podrazumevamo prebrojivo aditivnu skupovnu funkciju nad $\mathbf{P}(\mathbf{I})$. Stoga, za mere $|\sigma_{\mathfrak{R}_h}|$ i $\sigma_{\mathfrak{R}_h}$, može se reći da su naboji nad $\mathbf{P}(\mathbf{I})$. Zbirna mera $\sigma_{\mathfrak{R}_h}$ indukovana sa \mathbf{h} , takođe je naboj nad $\mathbf{P}(\mathbf{I})$. Neka $\mathbf{E} \in \mathbf{P}(\mathbf{I})$. Ako naboj $\Delta^2\mathbf{F}$ nad $\mathbf{I}(\mathbf{I})$ poseduje svojstvo: Svaki zanemarljiv podskup skupa \mathbf{E} je apsolutno $d^2\mathbf{F}$ -zanemarljiv skup, tada diferencijalna forma $d^2\mathbf{F}$, naboja $\Delta^2\mathbf{F}$, je nula funkcija na skupu \mathbf{E} , a sam naboj $\Delta^2\mathbf{F}$ je apsolutno kontinualna (AC_δ) funkcija na skupu \mathbf{E} . Ako, uz to, skup \mathbf{E} je prebrojiva unija skupova, na svakom od kojih naboj $\Delta^2\mathbf{F}$ je AC_δ funkcija, tada $\Delta^2\mathbf{F}$ je generalisana apsolutno kontinualna (ACG_δ) funkcija na \mathbf{E} [1]. Na osnovu **Leme 1.**, ako diferencijalna forma $d^2\mathbf{F}$ je u osnovi zbirljiva na intervalu \mathbf{I} , tada diferencijalna forma $d(\mathbf{F} - \sigma_{\mathfrak{R}_{d^2\mathbf{F}}})$ je nula funkcija na \mathbf{I} .

Lema, koja sledi, je blago modifikovana **Saks-Henstok**-ova lema, dobro poznata u teoriji generalisanih **Riman**-ovih integrala [3].

Lema 2. Za kompaktni interval $\mathbf{I} = \mathbf{i}_x \times \mathbf{i}_y$ u \mathbf{R}^2 i funkciju $\mathbf{v}: \mathbf{i}_x \rightarrow \mathbf{R}$, diferencijabilnu na \mathbf{i}_x , neka \mathbf{i}_y je skup vrednosti funkcije \mathbf{v} na intervalu \mathbf{i}_x , takav da $\underline{\partial}\mathbf{i}_y = \mathbf{v}(\underline{\partial}\mathbf{i}_x) = \mathbf{v}(\hat{\mathbf{e}}\mathbf{i}_x)$ i $\mathbf{E} \in \mathbf{P}(\mathbf{I})$. Ako obe diferencijalne forme $d\mathbf{h}$ i $d\mathbf{k}$, punktualno-intervalnih funkcija \mathbf{h} i \mathbf{k} nad $\mathbf{I} \times \mathbf{I}(\mathbf{I})$, su u osnovi zbirljivi ekvivalentni na intervalu \mathbf{I} , tada skup \mathbf{E} je i u osnovi i apsolutno $d(\mathbf{h} - \mathbf{k})$ -zanemarljiv skup.

Dokaz: Neka $d\mathbf{h}$ i $d\mathbf{k}$ su u osnovi zbirljivi ekvivalentni na intervalu \mathbf{I} i neka $\mathbf{E} \in \mathbf{P}(\mathbf{I})$. Prema **Definiciji 5.**, za svako $\varepsilon > 0$ postoji merač $\delta_\varepsilon > 0$ nad \mathbf{i}_y , takav da $s(\langle \mathbf{h} - \mathbf{k}, P_I \rangle) < \varepsilon$, kadgod P_I je δ_ε -fina indukovana podela intervala \mathbf{I} , koja je potpuno tagovana u skupu \mathbf{E} . Označimo sa \mathbf{P}_0 skup $P_I|_{\mathbf{E}} = \{(I_{i,j}, z_{i,j}) \in P_I \mid z_{i,j} \in \mathbf{E}\}$. Kako je $\mathbf{P}_0 \subseteq P_I$, to je $s(\langle \mathbf{h} - \mathbf{k}, \mathbf{P}_0 \rangle) < \varepsilon$. Prema **Definiciji 5.** je $\sigma_{\mathfrak{R}_{(\mathbf{h}-\mathbf{k})}}(\mathbf{E}) = \mathbf{0}$, odnosno skup \mathbf{E} je u osnovi $\mathfrak{R}_{(\mathbf{h}-\mathbf{k})}$ -zanemarljiv skup. Da bi se dokazao drugi deo leme, označimo sa \mathbf{P}_0^+ podskup svih elemenata skupa \mathbf{P}_0 , koji zadovoljavaju uslov $\langle \mathbf{h} - \mathbf{k} \rangle(I_{i,j}, z_{i,j}) \geq \mathbf{0}$ (\mathbf{P}_0^- za relaciju $\leq \mathbf{0}$). Tada,

$$0 \leq s(\langle \mathbf{h} - \mathbf{k} \rangle, \mathbf{P}_0^+) = \sum_{(I_{i,j}, z_{i,j}) \in \mathbf{P}_0^+} \langle \mathbf{h} - \mathbf{k} \rangle(I_{i,j}, z_{i,j}) < \varepsilon,$$

odnosno

$$-s(\langle \mathbf{h} - \mathbf{k} \rangle, \mathbf{P}_0^-) = \sum_{(I_{i,j}, z_{i,j}) \in \mathbf{P}_0^-} \langle \mathbf{h} - \mathbf{k} \rangle(I_{i,j}, z_{i,j}) < \varepsilon.$$

Stoga, $s(\langle \mathbf{h} - \mathbf{k} \rangle, \mathbf{P}_0) < 2\varepsilon$. Shodno tome je $\sigma_{\mathfrak{R}_{(\mathbf{h}-\mathbf{k})}}(\mathbf{E}) = \mathbf{0}$, što znači da skup \mathbf{E} je apsolutno $\mathfrak{R}_{(\mathbf{h}-\mathbf{k})}$ -zanemarljiv skup. λ

Kao posledicu **Saks-Henstok**-ove leme, odnosno **Leme 2.**, moguće je formulisati sledeći stav: *Diferencijalne forme $d\mathbf{h}$ i $d\mathbf{k}$ su u osnovi zbirljivi ekvivalentni na \mathbf{I} , ako i samo ako su apsolutno zbirljivi ekvivalentni nad \mathbf{I} . Uz sve to, prema **Lemi 1.**, ako funkcija ostatka \mathfrak{R}_h je u osnovi zbirljiva na \mathbf{I} , tada funkcija ostatka $\mathfrak{R}_{(\mathbf{h}-\sigma_{\mathfrak{R}_h})}$ je nula funkcija na intervalu \mathbf{I} , $\sigma_{\mathfrak{R}_h}$ i \mathbf{h} su diferencijalni ekvivalentni na \mathbf{I} , odnosno $d\sigma_{\mathfrak{R}_h}$ je totalni diferencijal na \mathbf{I} .*

Sada smo u mogućnosti da redefinišemo već definisani pojam osnovne zbirljivosti, preko pojma u osnovi zbirljivog (BS) antiderivativa.

Definicija 7. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial}i_y = v(\hat{\partial}i_x) = v(\hat{\Theta}i_x)$, neka f je punktualna funkcija nad I i neka ζ je strogo pozitivan naboj nad $I(I)$, takav da mu je diferencijalna forma nula funkcija na I . Naboj L nad $P(I)$, čija granična vrednost dL je totalni diferencijal na I , je (BS) antiderivativ na I funkcije f , u odnosu na naboj ζ , ako i samo ako su naboj L i punktualno-intervalna finkcija $\langle f \zeta \rangle$ u osnovi zbirljivi ekvivalenti na intervalu I . Ovde, $L(E) = (B) \sum_{z \in I} \langle \mathfrak{R}_{f \zeta} \chi_E \rangle(z)$, za svako $E \in P(I)$.

Teorema, koja sledi, uprkos činjenici da je njen rezultat trivijalan, kao što se može videti iz dokaza teoreme, krucijalna je, jer nam nudi mogućnost za analizu posebnih slučajeva, vezanih za teoriju generalisanih Riman-ovih integral.

Teorema 1. Za kompaktni interval $I = i_x \times i_y$ u \mathbf{R}^2 i funkciju $v: i_x \rightarrow \mathbf{R}$, diferencijabilnu na i_x , neka i_y je skup vrednosti funkcije v na intervalu i_x , takav da $\hat{\partial}i_y = v(\hat{\partial}i_x) = v(\hat{\Theta}i_x)$, neka f je punktualna funkcija nad I i neka L je naboj nad $P(I)$, takav da mu je granična vrednost dL totalni diferencijal na I . Funkcija ostatka \mathfrak{R}_{L-f} je u osnovi zbirljiva na intervalu I , ako i samo ako postoji naboj K nad $P(I)$, takav da njegova diferencijalna forma dK je totalni diferencijal na I i $\langle L - K \rangle$ je (BS) antiderivativ na I funkcije f , što znači da

$$(B) \sum_{z \in I} \langle \mathfrak{R}_f \chi_E \rangle(z) = \langle L - K \rangle(E), \quad (9)$$

kadgod $E \in P(I)$.

Dokaz: Neka f je punktualna funkcija nad I u \mathbf{R}^2 i L je naboj nad $P(I)$, čija diferencijalna forma dL je totalni diferencijal na I . Ako funkcija ostatka \mathfrak{R}_{L-f} je u osnovi zbirljiva na I , tada, na osnovu Leme 1., sledi da $\sigma_{\mathfrak{R}_{L-f}} = \sigma_{\mathfrak{R}_{L-f}}$ na I . Dakle, naboj $\sigma_{\mathfrak{R}_{L-f}}$ je naboj K nad $P(I)$ i $\langle L - K \rangle$ je (BS) antiderivativ na I funkcije f . Kontra, ako K je naboj nad $P(I)$, čija granična vrednost dK je totalni diferencijal na intervalu I , a uz to i naboj $\langle L - K \rangle$ je (BS) antiderivativ na I funkcije f , tada $\sigma_{\mathfrak{R}_{L-f}}(E) = K(E) = \sigma_{\mathfrak{R}_L}(E)$, za svako $E \in P(I)$. λ

Dakle, moguće je, da u tački intervala I , u kojoj derivativna $d_\mu h$ funkcija h nije definisana, funkcija ostatka \mathfrak{R}_h funkcije h bude definisana. Stoga, ako je skup $E \in P(I)$, skup tačaka u kojima nije diferencijabilna funkcija h , moguće je domen derivativne funkcije $f_{ex} = d_\mu h$ proširiti sa skupa $I \setminus E$ na skup I . Tada, pod uslovom da diferencijalne forme dh i dF_{ex} su u osnovi zbirljive nad intervalom I , funkcija ostatka $\mathfrak{R}_{(h-F_{ex})}$ je nulta funkcija, ali nije i nula funkcija, na intervalu I , na kome diferencijalne forme dh i dF_{ex} nisu ni u osnovi zbirljivi ekvivalenti. Shodno tome, ako naboj L nad $P(I)$, čija diferencijalna forma dL je totalni diferencijal na I , je takav da L i F_{ex} nisu diferencijalni ekvivalenti na intervalu I , ali su derivativni ekvivalenti na skupu $I \setminus E$ u odnosu na μ , tada $d_\mu L = d_\mu F_{ex}$ na skupu $I \setminus E$, sa jedne strane, a sa druge, funkcija ostatka $\mathfrak{R}_{(L-F_{ex})}$ nije nula funkcija na intervalu I , što znači da dL i dF_{ex} nisu zbirljivi ekvivalenti na intervalu I .

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ON SUMMABILITY IN \mathbb{R}^2

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ABSTRACT: *In this paper, we explicitly prove that a necessary and sufficient condition for the residue function $\mathfrak{R}_{\langle L-F \rangle}$, where L is the charge over $\mathbf{P}(I)$, such that its limit value dL is the total differential on the compact interval I in \mathbb{R}^2 , $F = \langle f\mu \rangle$, f is a point function on I and μ is a Lebesgue measure, would be basically summable on the interval I , is that there is a charge K over $\mathbf{P}(I)$, such that its differential form dK is the total differential on I and the charge $\langle L-K \rangle$ is the (BS) antiderivative on I of the function f .*

Keywords: *residue function, summability*

SYNTHESIS, CHARACTERIZATION AND HSA INTERACTIONS OF NEW [PdL₂Cl₂] COMPLEX

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ABSTRACT:

In this report, we have synthesized a new palladium(II) complex, [PdL₂Cl₂], where L = 5-(methylamino)-3-morpholine-4-ylisothiazole-4-carbonitrile. To an aqueous solution (15 mL) of K₂[PdCl₄] (0.1632 g, 0.50 mmol) was added 15 mL of a methanolic ligand solution (0.2243 g, 1 mmol). The resulting mixture was stirred for 1 hour at room temperature until the reagents had completely dissolved. The solution was then filtered off under vacuum and washed with diethyl ether, yielding an orange powdery residue. The characterization of the synthesized complex [PdL₂Cl₂] was carried out by elemental microanalysis, IR spectroscopy and determination of the melting point. The interaction of the new complex with human serum albumin (HSA) was investigated by fluorescence spectroscopy. The high value of the binding constant, K_b, and the Stern-Volmer quenching constant, K_{SV}, are the result of good binding of the complex to HSA.

Keywords: palladium(II), metal complex, isothiazole ligand, HSA interaction

1. INTRODUCTION

As the leading cause of death, cancer is a global health problem that caused almost 10 million deaths in 2020 [1]. The era of antitumor drugs began with the discovery of cisplatin and its use in medicine [2]. Given the numerous side effects of cisplatin and the emergence of resistance, scientists around the world are working to synthesize new complexes that could be more selective and thus have the greater antitumor potency and fewer side effects [3,4]. An ideal anticancer drug must be able to destroy tumor cells while leaving the adjacent healthy tissue unharmed. Great attention is being paid to platinum group metals, i.e. their complexes, including palladium complexes. Compounds of Pd(II) ions have shown antifungal, antituberculous and antimicrobial effects [5,6]. Due to the presence of sulfur and nitrogen atoms in the structure, thiazole derivatives are good candidates for complexation with Pd(II) ions as soft Lewis acids. In this work, we have described the synthesis and characterization of a new palladium(II) complex, [PdL₂Cl₂], where L = 5-(methylamino)-3-morpholine-4-ylisothiazole-4-carbonitrile. The characterization of the synthesized complex was carried out by elemental microanalysis, IR spectroscopy and

determination of the melting point. Fluorescence spectroscopy was used to investigate the structural changes in the HSA molecule caused by the addition of the complex and simultaneously to determine the binding constant and the number of binding sites.

2. EXPERIMENTAL

2.1. Materials and physical measurements

K₂[PdCl₄], CH₃OH, human serum albumin (HSA) and phosphate buffered saline (PBS) were purchased from Sigma-Aldrich and used as received. Elemental microanalyses for C, H, N were performed at the Department of Science, Institute for Information Technologies, University of Kragujevac, Serbia. IR spectra in the range 400-4000 cm⁻¹ were recorded on a Perkin Elmer FT-IR spectrophotometer Spectrum Two using the KBr pellet technique. Fluorescence spectra were performed using an RF-1501 PC spectrofluorometer (Shimadzu, Japan). The melting point was measured on the Stuart melter with an accuracy of ±1 °C.

2.2. Synthesis of the complex

The [PdL₂Cl₂] was synthesized following by the method described elsewhere [7]. To an aqueous solution (15 mL) of K₂[PdCl₄] (0.1632 g, 0.50 mmol) was added 15 mL of a methanolic ligand solution (0.2243 g, 1 mmol). The resulting mixture was stirred for 1 hour at room temperature until the reagents had completely dissolved. The solution was then filtered off under vacuum and washed with diethyl ether, yielding an orange powdery residue. (196 mg, 62.6%). Anal. Calcd. for (C₁₈H₂₄Cl₂N₈O₂PdS₂) C: 34.54; H: 3.86; N: 17.90. Found: C: 34.67; H: 3.98; N: 17.68. IR (KBr, ν_{max}/cm^{-1}) 3468.08 ($\nu_{\text{-CH}}$), 2964.73, 2918.34, 2860.62 (ν_{CH}), 2210.29 ($\nu_{\text{C=N}}$), 1579.86 ($\nu_{\text{C=C}}$). Melting point: 229 °C.

2.3. Interactions of the complex with HSA fluorescence spectroscopy

Double distilled water was used to prepare all solutions. The solutions of HSA and complex were prepared by dissolving in a phosphate buffer (PBS, 5×10⁻² mol dm⁻³, pH 7.4) at room temperature. Fluorescence spectra were measured to investigate the structural changes in HSA caused by the addition of the complex and to determine the binding constant (K_b) and the number of binding sites (n) for the compound formed between the complex and HSA. The HSA concentration was fixed at 2.0 μM and the concentration of the compound was varied from 0 to 20.0 μM. Fluorescence quenching spectra were measured at an excitation wavelength of 295 nm between 310 and 460 nm. The fluorescence quenching is described by the Stern-Volmer equation [8]:

$$\frac{F_0}{F} = 1 + K_{sv}\tau_0[\text{complex}] = 1 + K_{sv}[\text{complex}] \quad (1)$$

where F_0 is the emission intensity in the absence of the compound, F is the emission intensity in the presence of the compound, K_{sv} is the Stern-Volmer quenching constant, k_q is the bimolecular quenching constant, τ_0 (10⁻⁸ s) is the lifetime of the fluorophore in the absence of the quencher, and [complex] is the concentration of the compound. The K_{sv}

value is determined as the slope from the plot of F_0/F versus [complex]. The binding constant (K) and binding stoichiometry (n) of the HSA compound system can be estimated from the following equation (2) [8] using the fluorescence intensity data:

$$\log \frac{F_0 - F}{F} = \log K + n \log [Q] \quad (2)$$

The values of K_b and n were obtained from the intercept and slope of the plots of $\log (F_0 - F)/F$ versus $\log [Q]$.

3. RESULTS AND DISCUSSION

In this work, we have synthesised a new palladium(II) complex with the formula $[\text{Pd}(5\text{-MA-3-MorphCN-ITZ})_2\text{Cl}_2]$ (Fig. 1). The complex was obtained in good yield as an orange-coloured powder, soluble in DMSO and DMF and is stable both in the solid state and in solution in air. The IR spectrum is consistent with the complex structure.

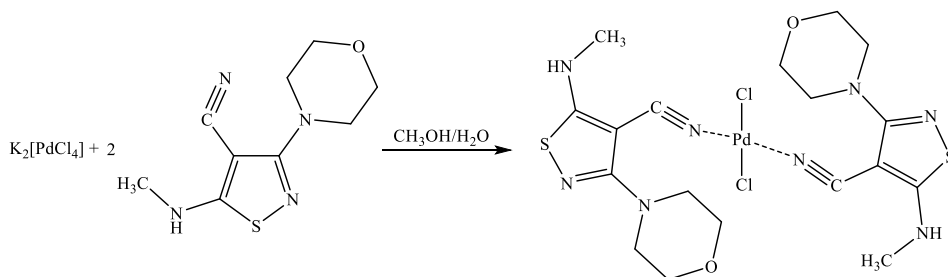


Fig.1. Pathway for the synthesis of $[\text{Pd}(5\text{-MA-3-MorphCN-ITZ})_2\text{Cl}_2]$

3.1. Interaction of the complex with HSA

It is known that the most important task of serum albumin is the transport of metal ions and metal complexes and other biologically active compounds in the blood. To study the structural changes in HSA caused by the addition of complex and to determine the quenching constants (k_q), binding constant (K_b), and number of binding sites (n) for the complex formed between the palladium(II) complex and HSA, fluorescence spectra were measured. HSA solutions exhibit strong fluorescence emission with a peak at about 350 nm, which is due to the tryptophan residues when excited at 295 nm [9]. The fluorescence spectra of HSA with different concentrations of the new palladium(II) complex were recorded and are shown in Fig. 2.

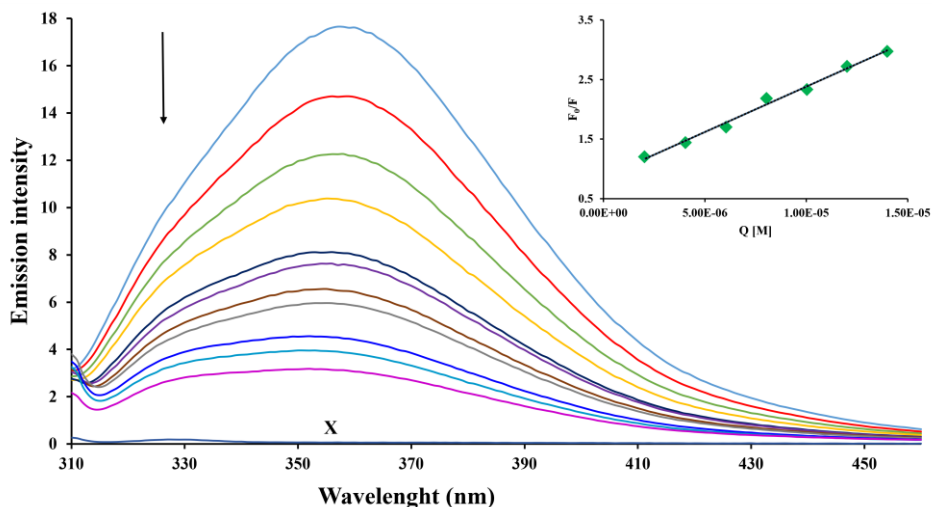


Fig. 2. Fluorescence emission spectra of HSA in the presence of different concentrations of the complex ($T = 298 \text{ K}$, $\text{pH} = 7.4$). $[\text{HSA}] = 2.0 \mu\text{M}$. $[\text{Complex}] = 0\text{-}20 \mu\text{M}$. Curve x shows the emission spectrum of the complex only. The arrow shows the change in intensity as the complex concentration is increased. Inset: plot of F_0/F versus $[\text{complex}]$.

The K_{SV} and quenching constants (k_q) of the interactions of the complex with albumin were calculated using the Stern-Volmer quenching equation (Eq. (1)) (Table 1), where the fluorescence lifetime of tryptophan in HSA was assumed to be $\tau_0 = 10^{-8} \text{ s}$. As can be seen from Table 1, the quenching constants ($>10^{12} \text{ M}^{-1} \text{ s}^{-1}$) are higher than the different quenching types for biopolymer fluorescence ($10^{10} \text{ M}^{-1} \text{ s}^{-1}$), indicating that a new conjugate was formed between the complex and HSA and that the interaction of the complex with albumins occurs by a static quenching mechanism. Using the equation (Eq. (1)), the values of K_b (association binding constant) and n (number of binding sites per albumin) for the complex were determined from the intercept and slope of the plots of $\log(F_0 - F)/F$ versus $\log [Q]$. The values for the binding constant K_b and for n are given in Table 1. The calculated value for n is one, indicating the presence of only one binding site in HSA.

Table 1. The binding constants and parameters (K_{sv} , k_q , K_b , n) derived for complex

	$K_{sv} (\text{M}^{-1})$	$k_q (\text{M}^{-1} \text{ s}^{-1})$	R^{2a}	$K_b (\text{M}^{-1})$	n	R^{2a}
Pd-HSA	1.53×10^5	1.53×10^{13}	0.9915	3.78×10^6	1.28	0.9890
^a R is the correlation coefficient						

3. CONCLUSION

In this work, we have described the synthesis and characterization of a new palladium(II) complex, [Pd(5-MA-3-MorphCN-ITZ)₂Cl₂]. The results of elemental microanalysis, melting point, as well as IR spectrum, are in agreement with the proposed structure of the complex. The results of the complex-HSA interaction study showed good binding of the complex to protein, which means that this complex could be transported by the bloodstream via protein to the target cells.

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UTILIZATION OF IMMOBILIZED HORSERADISH PEROXIDASE AS BIO-CATALYST FOR PESTICIDES REMOVAL FROM WATER

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ABSTRACT:

Anthropogenic activities and industrial production lead to increased levels of organic pollutants in various environmental resources. Consequently, pesticides present in water resources pose a significant risk to health and the environment due to their potential or known adverse effects on human and ecosystem. Processes that have attracted considerable attention in removing pesticides from water are enzyme-catalysed transformation reactions, as a potential alternative to classical chemical methods. In this work, the potential application of immobilized peroxidase on a magnetite-biochar solid support as a biocatalyst for the removal of pesticides from water was investigated. To examine the effect of removal, the mixture of eight pesticides with initial concentration of 10 µg/L (for each of them) was prepared in deionized water. The utilization of immobilized peroxidase in the concentration of 0.5 U/mL in the presence of hydrogen peroxide achieves high pesticide removal efficiency (43-100%). A removal efficiency above 80% compared to the initial concentration after one hour of reaction was recorded at acetamiprid, malathion, and propiconazole.

***Keywords:** pesticides, bio-catalyst, peroxidase, water treatment*

1. INTRODUCTION

Organic pollutants present in wastewaters, such as pesticides, pharmaceutical active compounds, personal care products, etc., mainly are characterized as compounds with high persistence in nature, as well as high toxicity. Most of those compounds are synthetic organic pollutants that enter watercourses and the environment through the release of insufficiently treated wastewater, which are closely related to the rapid development of industry and agriculture in the 20th century [1].

Pesticides, as synthetic organic compounds, have a significant application for controlling problems caused by harmful insects, weeds, and microorganisms in agriculture. However, the presence of pesticides in natural watercourses and drinking water resources causes concern and risk to human health and the environment. The main pesticide types are organophosphate, carbamates, organochlorine insecticides, pyrethroids, triazoles, amides

and neonicotinoids; and some of the representatives of these groups are shown in Figure 1.

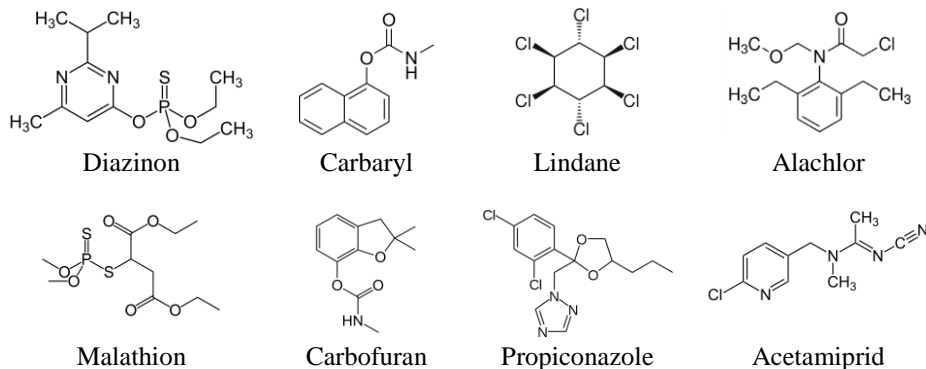


Figure 1. The representatives of the main groups of pesticides

For now, numerous physical, chemical, and biological techniques have been developed to remove pesticides from water, such as adsorption, advanced oxidation, biodegradation, photocatalytic degradation, etc. Enzyme-catalysed degradation has recently attracted much attention due to its broad selectivity, high efficiency and environmental protection. Horseradish peroxidase (HRP) is an enzyme that is most often obtained from horseradish root and is widely used in laboratory research due to its specific activity, stability, low molecular weight, and ease of purification. HRP shows high efficiency in the degradation of phenolic compounds and has a wide application in the degradation of organic pollutants [2-4]. The binding of enzymes onto suitable solid supports, such as biochars, geomaterials, metal oxides, polymers, etc., the enzyme properties like stability and resistance could be significantly improved. This enables easy control and multiple reuses enzyme. Enzyme immobilization helps to increase enzyme activity and lower production costs.

Enzyme immobilization on carbon material supports, such as biochar, has a dual role. In addition to increasing the enzyme stability and enabling their reusability, biochars contribute to the process of removing organic pollutants from water. Biochars are known to have a high adsorption capacity for polar/non-polar organic pollutants [2,4]. However, the separation of used biochar from water after treatment is very difficult and this problem can be overcome by modifying biochar with various iron oxides. By impregnating biochar with magnetic particles, a magnetite-biochar composite was obtained, which enables easy separation from the mixture under the action of an external magnetic field [5].

The aim of this work was to investigate the application of HRP immobilized on magnetic-biochar composite as solid support in order to remove the selected pesticide from contaminated aqueous solution. In order to comparison, the adsorption affinity of the magnetic support towards the removal of pesticides was examined as well.

2. MATERIALS AND METHODS

Preparation of magnetite-biochar solid support. Biochar was produced in company Basna doo, Čačak, Serbia, from waste wood biomass (beech and oak mixture) by pyrolysis at 700°C. Obtained biochar was functionalized by the concentrated nitric acid. The magnetite-biochar composite (MBC) was synthesized by co-precipitation method in basic conditions at 80°C. Synthesized magnetite-biochar composite was treated by 5% glutaraldehyde and prepared for covalent enzyme immobilization [6].

Preparation of biocatalyst. Commercial Horseradish peroxidase (HRP EC: 1.11.1.7) were purchased from Sigma Aldrich and used for investigation. HRP was covalently bonded onto prepared magnetite-biochar support via glutaraldehyde (MBC-HRP). The activity of immobilized HRP (Units per gram of a solid support, U/g) were measured spectrophotometrically according to Worthington method [7].

Characterisation of MBC and MBC-HRP. The surface morphology characteristics of MBC and immobilized HRP onto MBC were investigated by using scanning electron microscopy (SEM) JEOL JSM-6460LV on 25 kV. The method of microanalysis using X-ray energy dispersion (EDS) is performed in combination with the SEM method and provides insight into the elementary composition of the sample.

Water treatment procedure. The impact of MBC-HRP on pesticides removal from water was investigated according to the procedure given in Petronijević et al [3]. A mixture of eight pesticides with an initial concentration of 10 µg/L (for each of them) in deionized water was used for investigation. The batch reactions were set up with pesticides and immobilised enzyme (0.5 U/g) in 50 mM phosphate buffer pH = 7.0 (at 25 °C) during 1 h, and the reaction continued with addition of H₂O₂. The treatment was performed with an equivalent amount of MBC alone.

Analysis of the selected pesticides. The content of the following pesticides was analyzed: carbaryl, linuron, diazinon, tebuconazole, propiconazole, acetamiprid, carbofuran and malathion. In tested water samples, the concentration of the analyzed pesticides was quantified using ultra-high performance liquid chromatography coupled with triple quadrupole mass spectrometry (UHPLC-MS/MS) before and after the applied treatment processes.

3. RESULTS AND DISCUSSION

Enzyme immobilization by covalent bonding provides a permanent bond between the enzyme and the solid support. The covalent immobilization of HRP onto MBC takes place in two steps. The first part of the process is synthesis of MBC and its chemical modification using nitric acid, which results in the functionalization of MBC surface. The second part of the process involves the immobilization of the enzyme onto MBC via glutaraldehyde as cross-linker.

3.1. Morphological characteristics of MBC and MBC-HRP

The surface morphology of the MBC and MBC-HRP are shown in Figure 1, respectively. Both samples are characterized by heterogeneous surface and developed porous structure. Samples contain particles of different sizes, mostly macroporous honeycomb structures, on which magnetite particles can be observed. However, no clear and visible change in the surface texture of MBC was observed after enzyme immobilization.

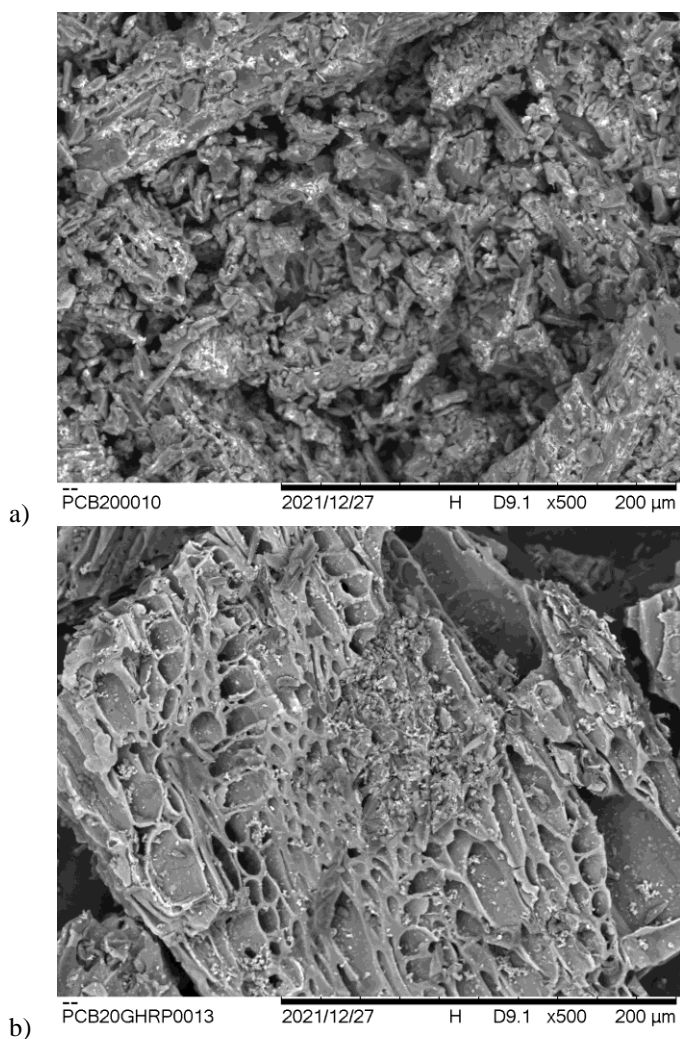


Figure 2. SEM images of a) magnetite-biochar composite (MBC) and b) immobilized HRP onto magnetite-biochar composite (MBC-HRP).

Based on the EDS results, tested MBC samples mainly consist of carbon, oxygen and iron (Table 1). In MBC the content of carbon was 62-64%, content of oxygen 17-22%, and iron 9-19%, while Na and Al were detected in traces. The elemental composition of MBC-HRP include 43-45% of carbon, around 36% of oxygen, 12% of iron, as well as nitrogen (4%), phosphor (1%), and other elements in traces (Na, Al, Ca, K). The free HRP is rich in both non-metallic elements (nitrogen and phosphorous), as well as metallic elements, which was found in MBC-HRP [6]. The presence of nitrogen in the MNP-HRP sample originates from the $-NH_2$ group of the peroxidase, which indicates that enzyme binding has occurred on the support surface.

Table 1. Elemental composition of MBC samples

Elements	Content (wt.%)			
	MBC (position 1)	MBC (position 2)	MBC-HRP (position 1)	MBC-HRP (position 2)
C	63.66	61.93	45	43.1
O	22.58	17.5	36.7	35.95
Fe	9.28	19.16	12.18	11.38
Na	4.48	/	2.21	2.18
Al	/	0.23	/	0.11
Ca	/	/	0.57	/
P	/	/	1.43	1.17
Ca	/	/	0.57	/
N	/	/	/	4.39
K	/	/	/	1.73

3.2. Pesticides removal from water

The efficiency of biocatalytic removal of pesticides from water using MNP-HRP was investigated. The catalytic reaction was performed using enzyme content of 0.5 U/ml during the reaction time of 1 h. To determine the MBC ability to adsorb pesticides, the appropriate amount of MBC was used. The results of pesticides content in water samples before and after water treatments were present in Figure 3.

The total amount of pesticides in reaction mixture was 80 $\mu\text{g/L}$. During water treatment with MBC as adsorbent, the content of total pesticides decreased for 27% compared to the content in untreated water. The highest removal (around 50%) was obtained for carbaryl, linuron, diazinon and tebuconazole. Other authors showed similar results that magnetite-biochar composites were efficient adsorbents for pesticides removal from water [5].

The utilization of peroxidase-based biocatalytic process in the presence of hydrogen peroxide the 77% of total pesticides was achieved. In the case of individual pesticides, a removal efficiency above 80% compared to the initial concentration after one hour of reaction was recorded at acetamiprid, malathion, and propiconazole.

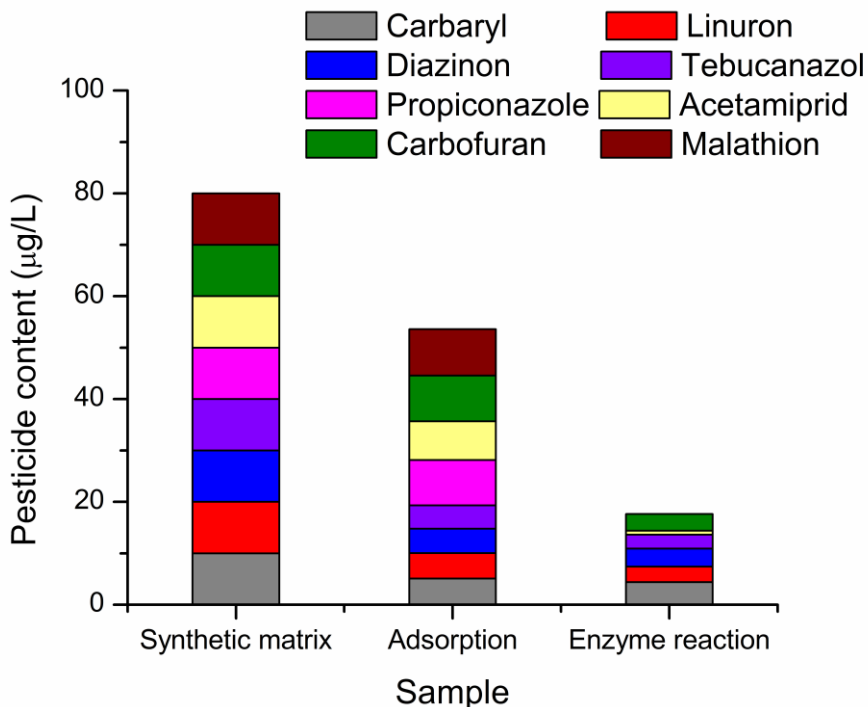


Figure 3. Pesticides removal during investigated water treatment processes.

4. CONCLUSION

This study discusses biocatalysis based on immobilized HRP onto magnetite-biochar composite as a promising and sustainable method towards the removal of pesticides from water. Using MBC-HRP biocatalyst the total amount of pesticides in reaction mixture was decreased for 77% after 1 h, while applying the adsorption process with MBC removes only 27% of total pollutants. The investigated pesticides from reaction mixture were removed in range 43-100%, and the highest efficiency was observed for acetamiprid, malathion, and propiconazole.

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DIVERSITY OF PHOTOTROPHIC MICROBIAL ORGANISMS IN GORNJA TREPČA SPA, SERBIA

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ABSTRACT:

The main objective of this research is to document the floristic characteristics of cyanobacteria and algae in Gornja Trepča Spa, Serbia. Gornja Trepča Spa is located in the central part of Serbia, surrounded by the Vujan and Bukovik mountains, at an altitude of 460 m.a.s.l. The water is characterized by low mineralization, with a temperature ranging around 29°C, and a pH of 7.4, signifying neutral to slightly alkaline conditions. It is characteristic for the complete absence of iron and hydrogen sulfide. Literature sources indicate that the water has low radioactivity, with an emission of 29.6 Bq/L. Algological samples were collected in May and July 2023. Phytobenthos samples were collected by brushing stones and using a pipette from the surface of the bottom deposits. All collected samples were promptly fixed with formaldehyde to a final concentration of approximately 4%. All non-diatom algae were examined by preparing temporary slides, while permanent slides were made for diatoms. Light microscope observations and micrographs were conducted using a Zeiss AxioImagerM.1 microscope equipped with DIC optics and AxioVision 4.9 software. On the basis of relevant literature 72 taxa from 4 phyla (Cyanobacteria, Chlorophyta, Charophyta, and Heterokontophyta) were identified. Cyanobacteria and diatom taxa were the most diverse.

Keywords: *algae, cyanobacteria, Gornja Trepča, Serbia*

1. INTRODUCTION

The history of thermal water research in Serbia dates back to 1903 [1], and research has continued to the present day [2, 3, 4, 5, 6, 7]. Microorganisms adapted to specific environmental conditions inhabit such habitats. The diversity of algae in these habitats is significant, although not sufficiently explored. The primary aim of this study was to assess the diversity of algal flora in the Gornja Trepča Spa. According to the available data, this is the first algological study at this particular site.

1.2. Study area

The Gornja Trepča Spa is located in southwestern Serbia, in the valley of the Banjska stream, at the foothills of the Bukovik and Vujan mountains, at an altitude of 460 m.a.s.l. Georeference: 43°57'07"N, 20°29'04"E. (Figure 1).



Fig. 1. Sampling site in the Gornja Trepča Spa (Photo: Sanja Šovran)

2. MATERIAL AND METHODS

The algae samples were collected in May and July 2023. Epilithic samples of algae were collected by scraping stones (diameter > 5 cm) using a toothbrush. Macroalgae were collected using tweezers. Temperature and pH were measured at the sampling site. All algal samples were fixed with formaldehyde to a final concentration of 4%. For diatoms (Heterokontophyta, Bacillariophyceae) analysis, the method with KMnO_4 and HCl was used in order to remove the organic content from the cells [8]. After this laboratory treatment, diatom permanent slides were made using Naphrax[®] mounting medium. Temporary and permanent algal slides were microscopied using a Zeiss AxioImagerM.1 microscope with AxioVision 4.9.1 software. The material is deposited in the wet collection of the Department of Algology and Mycology, Faculty of Biology, University of Belgrade. Algae were identified on the basis of standard literature [9, 10, 11, 12, 13, 14].

3. RESULTS AND DISCUSSION

The water is characterized by low mineralization, with a temperature ranging around 29°C, and a pH of 7.4, signifying neutral to slightly alkaline conditions. It is characteristic for the complete absence of iron and hydrogen sulfide. Literature sources indicate that the water has low radioactivity, with an emission of 29.6 Bq/L. A total of 72 taxa from 4 algal divisions were determined: Cyanobacteria (22), Chlorophyta (1), Charophyta (3) and Heterokontophyta (46) (Table 1). The largest number of detected taxa belongs to the group of diatoms and cyanobacteria, which are very characteristic for this habitat type [15, 16].

Table 1. List of algae in thermal water at Gornja Trepča Spa

Cyanobacteria
<i>Anathece minutissima</i> (West) Komárek, Kaštovský & Jezberová
<i>Aphanothece</i> sp. Nägeli
<i>Chroococcus minutus</i> (Kützing) Nägeli
<i>Chroococcus membraninus</i> (Meneghini) Nägeli
<i>Jaaginema angustissimum</i> (West & G.S.West) Anagnostidis & Komárek
<i>Jaaginema geminatum</i> (Schwabe ex Gomont) Anagnostidis & Komárek
<i>Kamptonema animale</i> (Gomont) Strunecký, Komárek & J.Smarda
<i>Leptolyngbya angustissima</i> (West & G.S.West) Anagnostidis & Komárek
<i>Leptopyngbya</i> sp. Anagnostidis & Komárek
<i>Leptolyngbya tenuis</i> (Gomont) Anagnostidis & Komárek
<i>Nostoc pruniforme</i> C.Agardh ex Bornet & Flahault [Fig 2.a]
<i>Nodularia</i> cf. <i>spumigena</i> Mertens ex Bornet & Flahault [Fig 2.b]
<i>Oscillatoria subbrevis</i> Schmidle
<i>Oscillatoria tenuis</i> C.Agardh ex Gomont
<i>Phormidium chalybeum</i> (Mertens ex Gomont) Anagnostidis & Komárek
<i>Phormidium</i> sp. Kützing ex Gomont
<i>Pseudanabaena thermalis</i> Anagnostidis [Fig 2.e]
<i>Spirulina major</i> Kützing ex Gomont [Fig 2.f]
<i>Spirulina robusta</i> H.Welsh
<i>Symploca</i> sp. Kützing ex Gomont

<i>Synechocystis aquatilis</i> Sauvageau
<i>Synechocystis minima</i> Woronichin
Chlorophyta
<i>Cladophora glomerata</i> (Linnaeus) Kützing
Charophyta
<i>Closterium aciculare</i> T. West
<i>Closterium cornu</i> Ehrenberg ex Ralfs
<i>Spirogyra</i> sp. Link
Heterokontophyta
Bacillariophyceae
<i>Achnantheidium microcephalum</i> Kützing
<i>Achnantheidium affine</i> (Grunow) Czarnecki
<i>Amphora pediculus</i> (Kützing) Grunow
<i>Caloneis lancettula</i> (P. Schulz) Lange-Bertalot & Witkowski
<i>Caloneis</i> sp. 1 Cleve
<i>Cocconeis euglypta</i> Ehrenberg
<i>Surirella librile</i> (Ehrenberg) Ehrenberg
<i>Encyonema silesiacum</i> (Bleisch) D.G. Mann
<i>Epithemia adnata</i> (Kützing) Brébisson [Fig 2.g]
<i>Epithemia sorex</i> Kützing
<i>Eunotia</i> sp. 1 Ehrenberg
<i>Eunotia</i> sp. 2 Ehrenberg
<i>Fragilaria deformis</i> (W. Smith) Van de Vijver & Ector
<i>Frustulia vulgaris</i> (Thwaites) De Toni [Fig 2.c]
<i>Gomphonella olivacea</i> (Hornemann) Rabenhorst
<i>Gomphonema micropus</i> Kützing
<i>Gomphonema subclavatum</i> (Grunow) Grunow

<i>Gomphonema zellense</i> E.Reichardt
<i>Grunowia solgensis</i> (A.Cleve) Aboal
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst
<i>Halamphora veneta</i> (Kützing) Levkov
<i>Humidophila contenta</i> (Grunow) Lowe, Kociolek, Johansen, Van de Vijver, Lange-Bertalot & Kopalová
<i>Humidophila perpusilla</i> (Grunow) R.L.Lowe, Kociolek, J.R.Johansen, Van de Vijver, Lange-Bertalot & Kopalová
<i>Luticola mutica</i> (Kützing) D.G.Mann
<i>Melosira varians</i> C.Agardh
<i>Meridion circulare</i> (Greville) C.Agardh
<i>Navicula caterva</i> Hohn & Hellerman
<i>Navicula cryptocephala</i> Kützing
<i>Navicula cryptotenella</i> Lange-Bertalot
<i>Navicula tripunctata</i> (O.F.Müller) Bory
<i>Navicula trivialis</i> Lange-Bertalot [Fig 2.d]
<i>Nitzschia amphibia</i> Grunow
<i>Nitzschia clausii</i> Hantzsch
<i>Nitzschia dissipata</i> (Kützing) Rabenhorst
<i>Nitzschia fonticola</i> (Grunow) Grunow
<i>Nitzschia linearis</i> W.Smith
<i>Pinnularia subrupestris</i> Krammer
<i>Planothidium frequentissimum</i> (Lange-Bertalot) Lange-Bertalot
<i>Planothidium lanceolatum</i> (Brébisson ex Kützing) Lange-Bertalot
<i>Sellaphora saugerresii</i> (Desmazières) C.E.Wetzel & D.G.Mann
<i>Stauroneis</i> sp. 1 Ehrenberg
<i>Surirella angusta</i> Kützing
<i>Surirella lacrimula</i> Kützing [Fig 2.h]

<i>Tryblionella apiculata</i> W.Gregory
<i>Ulnaria ulna</i> (Nitzsch) Compère
Xanthophyceae
<i>Tribonema viride</i> Pascher

A total of 22 cyanobacteria species were identified in the thermal waters of Gornja Trepča Spa. Some of the identified species are specific to thermal waters and were also found in other thermal spas in Serbia. The species *Jaaginema geminatum* has been previously found in Jošanička, Radaljska, and Vranjska Banja [5, 6], while the species *Pseudanabaena thermalis* was found in Bogatić, Radaljska Banja, Lukovska Banja and Vranjska Banja [6]. It is interesting to note the species of the genus *Nodularia*, which morphologically corresponds to the species *N. spumigena*. Considering that this toxic species inhabits marine and brackish waters, further research is necessary to obtain genetic confirmation of the species. Our results shows a high diatom diversity compared to thermal springs in Europe [16, 17]. Diatom community diversity and species richness decrease at water temperatures above 25°C [17]. The most species-rich genera were *Nitzschia* and *Navicula*. *Nitzschia* was also the most frequent genus in various springs in Europe [16, 18]. The common species in both cold and thermal springs is *N. amphibia*, which is also recorded in the Gornja Trepča Spa. *Gomphonema* species are widely distributed in freshwater diatom communities, especially in rivers and lakes, but are not abundant in springs [16]. Our study revealed three taxa with low abundance. Gathering knowledge about diatoms inhabiting thermal springs helps to improve data on the temperature preferences of some diatom taxa and the effects of this parameter on diatom diversity. This knowledge can lead to a prediction of diatom diversity with an increase in global water temperature [17]. The micrographs of some identified taxa are shown in Figure 2.

4. CONCLUSION

This is the first algological survey of the thermal water in the Gornja Trepča Spa. A total of 72 algal taxa have been identified. The most diverse groups were diatoms and cyanobacteria. Thermal habitats are unique environments hosting specific communities of microorganisms. There are numerous factors endangering such habitats and the algae inhabiting them. Threatening factors include tourism (construction and expansion of spa facilities) and recreational activities near or at the thermal water springs, wastewater from urban areas, households, agricultural and forestry estates, climate change - especially drought, as well as habitat alterations over time. It is essential to provide additional protection for these habitats and the organisms living in them.

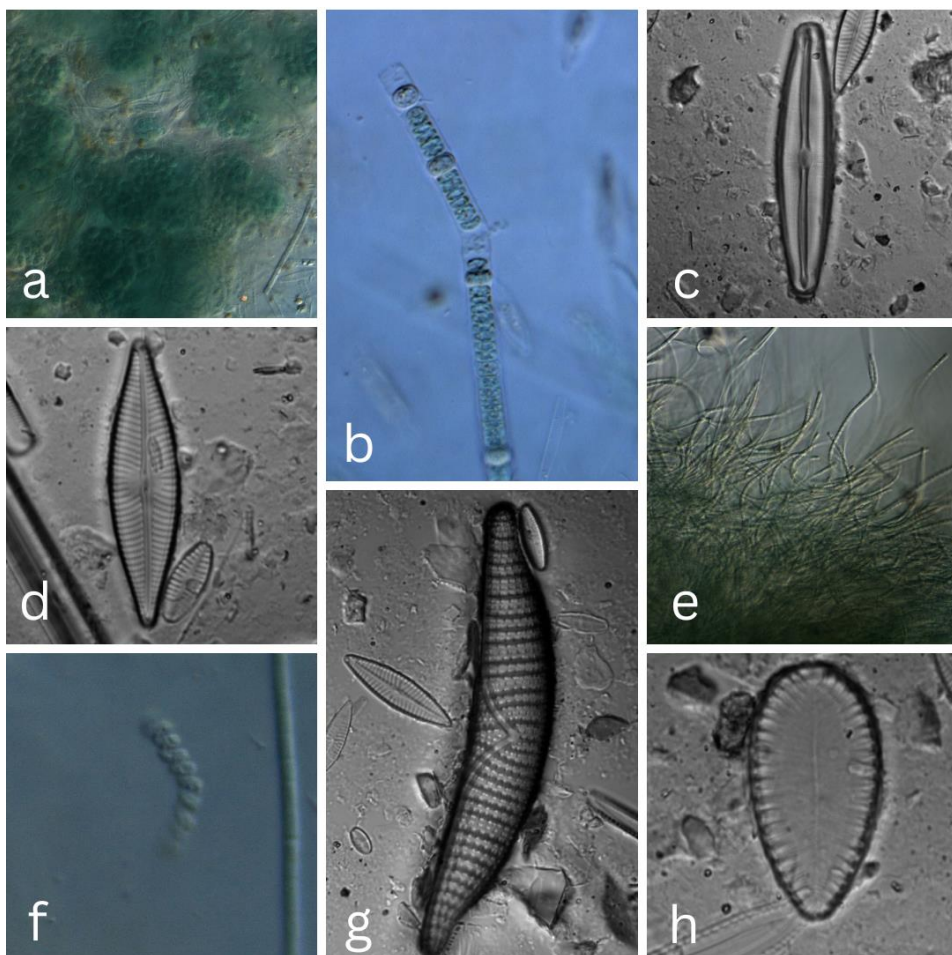


Fig 2. a) *Nostoc pruniforme* b) *Nodularia cf. spumigena* c) *Frustulia vulgaris* d) *Navicula trivialis* e) *Pseudanabaena thermalis* f) *Spirulina major* g) *Epithemia adnata* h) *Surirella lacrimula*

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DIVERSITY OF FOULING ORGANISMS ON A CARGO SHIP SAILING THE SAVA RIVER, SERBIA

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ABSTRACT:

*The study investigates the constituents of biofilm formed on a hull of a cargo ship in the Sava River, Serbia. Thickness of biofilm plays a major role in energy efficiency of ship during exploitation. A biofilm sample was collected from the ship's surface on March 2023 from the site of the "Vahali" Shipyard in Mačvanska Mitrovica using a brushing method. For microbiological analysis a 100 µL aliquot made from the biofilm sample was inoculated onto a PDA medium under aseptic conditions. The average bacterial count in the sample was 315.33 CFU per Petri dish, while the average fungal count was 11 CFU per Petri dish. Based on colony characteristics and microscopic features of reproductive structures, filamentous fungi *Cladosporium cladosporioides*, *Mucor megalocarpus*, and *Penicillium* spp. were identified. Additionally, yeast *Candida* sp. was observed alongside filamentous fungi. Microscopic analysis of the ship's biofilm revealed densely interwoven, branched hyphae predominantly enveloping threads of green algae from the *Cladophora* genus. Besides mycelia, the presence of micro- and macroconidia, as well as chlamydo-spores of *Fusarium* species, was noted in the biofilm. . Seven algal species from four divisions were identified through microscopic analysis: *Aphanothece* sp., *Audouinella chalybea*, *Cladophora glomerata*, *Cocconeis pediculus*, *Gomphonema parvulum*, *Navicula* sp., and *Rhoicosphaenia abbreviata*. Quantitatively, the most dominant biofilm species was *Cladophora glometara*, completely covered with diatoms *Cocconeis pediculus* and *Rhoicosphaenia abbreviata*.*

Keywords: *biofilm, ship, energy efficiency, microalgae, microfungi*

1. INTRODUCTION

Submerged parts of floating objects are typically exposed to colonization by photoautotrophic and heterotrophic microorganisms from water. These microorganisms (algae, cyanobacteria, and fungi) form biofilms that often cover large surfaces of floating objects constructed from various materials (wood, plastic materials, paints, etc.). All these materials are biodegradable and subject to biodeterioration by all biofilm constituents. Biofouling research, up to date, is predominantly focused on marine ecosystems, so there is no available data for vessels used in inland waters. This study represents an initial step

towards further research on biofouling in inland waters, aiming to improve energy efficiency in the transportation of goods and people by vessels in inland waters.

2. MATERIAL AND METHODS

2.1 The biofilm sampling

The biofilm sample from the cargo ship was taken on March 21, 2023, at the Vahali Shipyard site, Mačvanska Mitrovica, using the brushing method. It is important to note that the ship was thoroughly cleaned two months before sampling.

2.2 Microscopic analysis of photoautotrophic constituents of the biofilm

The photoautotrophic constituents of the collected biofilm were analyzed by preparing temporary slides. For diatoms (Heterokontophyta, Bacillariophyceae) analysis, the method with KMnO_4 and HCl was used in order to remove the organic content from the cells [1]. After this laboratory treatment, diatom permanent slides were made using Naphrax[®] mounting medium. Temporary and permanent algal slides were microscopied using a Zeiss AxioImagerM.1 microscope with AxioVision 4.9.1 software. The material is deposited in the wet collection of the Department of Algology and Mycology, Faculty of Biology, University of Belgrade. Algae were identified on the basis of standard literature [2, 3, 4, 5].

2.3 Microscopic analysis of fungal constituents of the biofilm

For the analysis of fungal biofilm constituents, microscopic slides of the native sample were prepared using glycerol and the mycological stain Lactophenol Cotton Blue. The slides were examined under an optical microscope Zeiss Axio Imager M.1 with AxioVision Release 4.9.1 software.

2.4 Microbiota - Isolation of bacteria and fungi

From the biofilm sample, a 100 μL aliquot was inoculated onto standard mycological medium PDA under aseptic conditions. Inoculation was performed in triplicate, after which Petri dishes were placed in an incubator (7 days; $25 \pm 2^\circ\text{C}$). During the incubation period, the development of filamentous fungi, yeasts, and bacteria was successively monitored. After 7 days of incubation, colonies of filamentous fungi, yeasts, and bacteria were counted, and the results were expressed as CFU per Petri dish, or in 100 μL of the sample (Colony Forming Units - number of colonies per Petri dish/100 μL of the sample). Isolated fungi were identified on the basis of microscopic characteristics of reproductive structures and colony morphology using identification key by Samson et al. [6].

3. RESULTS AND DISCUSSION

3.1 Qualitative Algological Analysis

Microscopic analysis revealed the presence of 7 algal taxa: *Aphanothece* sp., *Audouinella chalybea*, *Cladophora glomerata*, *Cocconeis pediculus*, *Gomphonema parvulum*, *Navicula* sp., *Rhoicosphaenia abbreviata*. The quantitatively most dominant species of the biofilm was *Cladophora glomerata*. It was entirely covered with diatoms *Cocconeis pediculus* and *Rhoicosphaenia abbreviata* (Figure 1a) An interesting finding is the freshwater red alga *Audouinella chalybea* (Figure 1b). All previous findings of this alga are associated with fast, well-aerated waters. There is only one record from the Danube River [7].

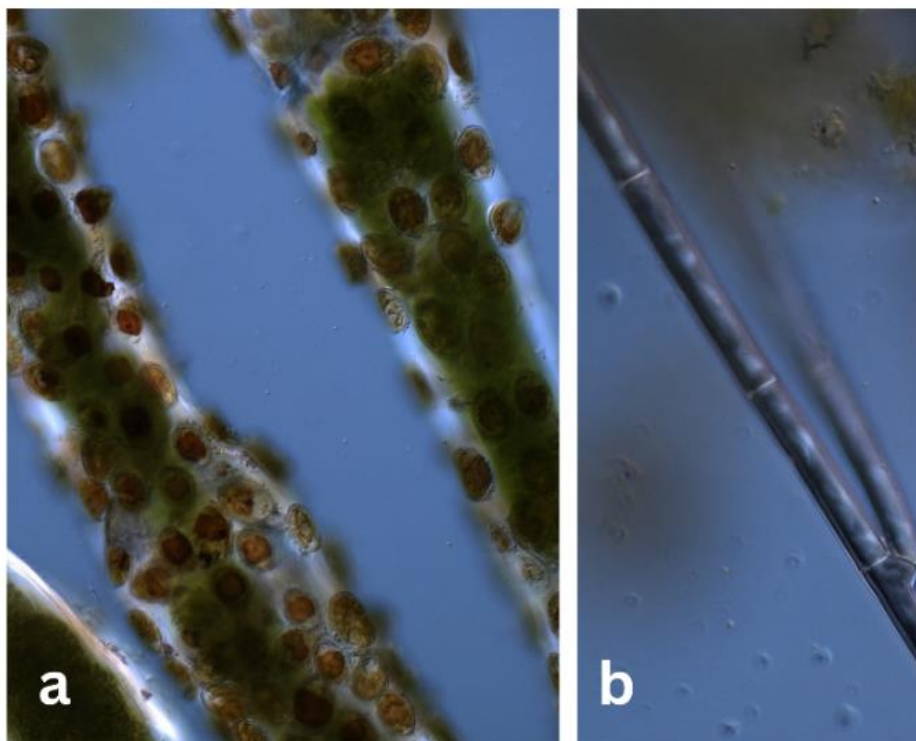


Fig 1. a) *Cladophora glomerata* covered with epiphytic diatom b) *Audouinella chalybea*

3.2 Quantitative analysis of the cultivable microbiota

The average bacterial count in the biofilm sample was 315.33 CFU per Petri dish, while the average fungal count was 11 CFU per Petri dish.

3.3 Qualitative analysis of culturable microbiota

After the incubation period, mixed cultures of filamentous fungi, yeasts, and bacteria were observed. Based on colony characteristics and microscopic features of reproductive structures, filamentous fungi *Cladosporium cladosporioides*, *Mucor megalocarpus*, and *Penicillium* spp. were identified. Besides filamentous fungi, the presence of yeast *Candida* sp. was also noted. Analysis of the culturable microbiota from the biofilm sample revealed the presence of the rare filamentous fungus *Mucor megalocarpus* (Figure 2e).

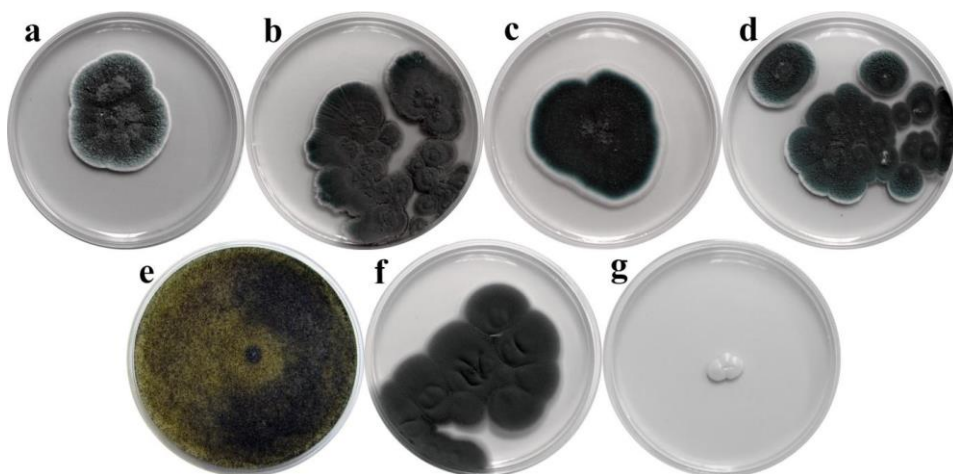


Fig. 2. a-d) *Penicillium* spp., e) *Mucor megalocarpus*, f) *Cladosporium cladosporioides*, g) *Candida* sp.

3.4 Composition of the fungal constituents of the biofilm

Microscopic analysis of the biofilm from the ship revealed the presence of densely intertwined hyphae often enveloping the filaments of green algae of the genus *Cladophora*. In addition to the mycelium, the presence of micro- and macroconidia and chlamydoconidia of *Fusarium* species was observed in abundance (Figure 3).

4. CONCLUSION

This is a pioneering study on the constituents of biofilms on vessels in inland waters. The quantitative microbiological analysis of the biofilm sample revealed the presence of a large number of viable bacterial propagules and a significantly smaller number of propagules of filamentous fungi and yeasts per μL of sample. The cultivable microbiota consisted of species from the genera *Candida*, *Cladosporium*, *Mucor*, and *Penicillium*. It is known that saprophytic species from the genera *Cladosporium*, *Penicillium*, and *Mucor* are common colonizers and metal deteriorators, with various mechanisms that cause

damage to metal surfaces, especially in aquatic environments. The presence of potentially pathogenic species known as the causative agents of candidiasis (*Candida* sp.) was observed. Microscopic analysis revealed a biofilm composed of densely interwoven, granular hyphae and propagules of *Fusarium* species in abundance. Species of this genus are known to be among the most frequently isolated fungi from metal surfaces and to produce carboxylic acid that corrodes iron. Microscopic analysis also confirmed the presence of 7 taxa of cyanobacteria and algae from 4 divisions, with *Cladophora glomerata* being quantitatively dominant.

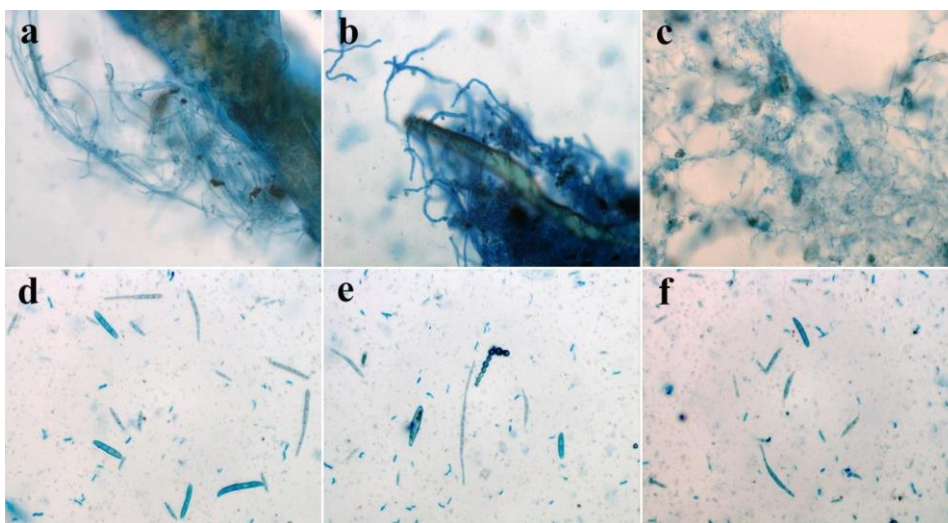


Fig. 3. a-c) dense network of mycelium, d-f) micro- and macroconidia and chlamydospores of *Fusarium* species.

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POTENTIAL ANTI-INFLAMMATORY EFFECT OF NEWLY SYNTHESIZED 3-(1-((4-HYDROXY BUTYLAMINO)ETHYLIDENE)CHROMAN-2,4-DIONE

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ABSTRACT:

In this work, we have reported synthesis of new coumarin derivative, 3-(1-((4-hydroxy butylamino)ethylidene)cromane-2,4-dione. A mixture of 3-acetyl 4-hydroxy coumarine (0.500 g, 0.002 mol) and 4-aminobutanol (0.183 g, 0.002 mol) in methanol (50 ml) was refluxed for 2 h. The progress of the reaction was monitored by TLC (toluene:acetone = 8:2). After the completion of the reaction the solvent was evaporated to half of its volume. Upon the addition of 5 ml of water, the obtained white precipitate was filtered, dried, and washed from 96% ethanol. The characterization of the synthesized coumarin derivative was carried out by elemental microanalysis, IR and NMR spectroscopy. The molecular docking study was used to investigate the potential anti-inflammatory effect of newly synthesized compound on the enzyme lipoxygenases.

Keywords: coumarin derivative, characterization, molecular docking

1. INTRODUCTION

The coumarin nucleus, bicyclic heterocycle, combines γ -pyrone and benzene rings with a carbonyl group situated at position 2 of the pyrone ring. These compounds belong to a class of natural substances present in essential oils like lavender and cassia leaf oil, as well as specific types of cinnamon [1]. The first documented isolation of coumarin from tonka beans, sourced from Dipteris odorata plants, dates back to 1980 when Vogel conducted the research [2]. Subsequent studies have delved into coumarin isolation from diverse plant sources and its synthesis, alongside analogs. It's estimated that up to 1300 distinct coumarins emerge as byproducts of plant, fungi, and bacterial secondary metabolism [3]. Coumarin derivatives exhibit a wide range of pharmacological activities including anti-inflammatory, antimicrobial, antifungal, anticoagulant, anticancer [4-8]. Some coumarin derivatives, such as warfarin and acenocoumarol, are widely used as anticoagulants in the prevention and treatment of thromboembolic disorders [9,10].

Coumarin derivatives have been extensively studied for their anti-inflammatory activities, which are attributed to their ability to modulate various inflammatory pathways and mediators. Many coumarin derivatives exhibit antioxidant properties, which contribute to their anti-inflammatory effects. By scavenging reactive oxygen species (ROS) and reducing oxidative stress, these compounds help alleviate inflammation and prevent tissue damage [11,12].

Lipoxygenases (LOXs) are a family of non-heme iron-containing enzymes that catalyze the oxygenation of polyunsaturated fatty acids (PUFAs), particularly arachidonic acid and linoleic acid, to form bioactive lipid mediators known as leukotrienes and hydroxyeicosatetraenoic acids (HETEs). These lipid mediators play crucial roles in inflammation, immune responses, and various physiological processes.

Several naturally occurring coumarins are known as inhibitors of pro-inflammatory liposynthesis, such as esculetin, fraxetin, and daphnetin [13].

Bearing in mind everything previously mentioned the aim of this paper is to show investigation of potential inhibitory activity of novel synthesised coumarine derivative, 3-(1-((4-hydroxy butylamino)ethylidene)cromane-2,4-dione (**L**).

2. MATERIALS AND METHODS

2.1. Substances

4-aminobutanol, methanol, toluene, acetone and 96% ethanol were purchased from Sigma-Aldrich. The starting compound, 3-acetyl 4-hydroxy coumarine, was obtained as explained earlier [14].

2.2. Spectral Analysis

Elemental microanalyses for C, H and N were done by standard methods at the Institute for Information Technologies, University of Kragujevac, Republic of Serbia.

Infrared spectra were recorded by Perkin-Elmer Spectrum One FT-IR spectrometer using the KBr pellet technique (4000-400 cm^{-1}).

^1H and ^{13}C NMR spectra were recorded by Varian Gemini-2000 (200 MHz) spectrometer in CDCl_3 .

2.3. Molecular docking

Molecular docking simulations were used to examine the inhibitor efficiency of **L** against Lipoxygenase receptor. To examine the binding affinity of the investigated compounds, the AutoDock 4.2 software [15] was utilized. The AMDock programme [16] was employed to determine the receptor's pockets and binding sites. The crystal structures of the investigated receptors (PDB IDs: 4NRE [17]) were extracted in PDB format from the RCSB Protein Data Bank. The target receptor was prepared for docking by removing the co-crystallized ligand, water molecules, and cofactors. For this purpose, the AMDock program was employed. The AutoDockTools (ADT) [15] graphical user interface was used to calculate the Kollman partial charges and to adding polar hydrogen. The protein-ligand flexible docking was done using the Lamarckian Genetic Algorithm (LGA) method

[18]. The grid centers with dimensions 13.1655×-2.881×28.964 Å³ in -x, -y, and -z directions of the Lipoxygenase receptor were used to cover the protein binding sites and accommodate ligands to move freely. The binding affinity of title molecules was investigated and discussed. The free energy of binding values is calculated according to paper Khorshidi et al., 2023 [19].

2.4. Synthesis and characterization of the compound

A reaction mixture of 0.500 g (0.002 mol) of 3-acetyl 4-hydroxy coumarin and 0.183 g (0.002 mol) of 4-aminobutanol in 50 mL of methanol was refluxed for 2 hours (**Fig.1**). The reaction progress was observed using TLC (with a toluene to acetone ratio of 8:2). After the reaction was complete, the solvent volume was reduced by half through evaporation. Upon addition of 5 mL of water, a white precipitate was filtered, dried, and washed with 96% ethanol.

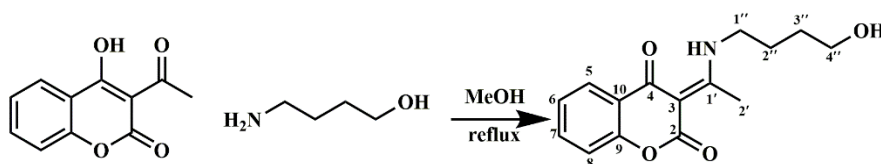


Fig. 1. Schema of synthesis 3-(1-((4-hydroxy butylamino)ethylidene)cromane-2,4-dione (**L**) with numbering used for NMR data analysis

Yield: 65.5%.

$M(C_{15}H_{17}NO_4) = 275.30$ g/mol

Table 1. Results of elemental microanalysis

	C(%)	N(%)	H(%)
Calculated:	65.44	5.09	6.22
Found:	65.35	5.05	6.28

¹HNMR (200 MHz, CDCl₃-d₆): 1.8 (m, 4H, C2''-H, C3''-H), 2.74 (s, 3H, CH₃), 3.49 (t, 2H, C''-H), 3.60 (t, 2H, C4''-H), 4.69 (s, 1H, -OH), 7.18 (m, 1H, C6-H), 7.50 (m, 2H, C7-H, C8-H), 8.00 (dd, H, C5-H), 14.17 (s, 1H, NH). ¹³C NMR (50 MHz, CDCl₃-d₆): 18.59 (C2'), 25.69 (C3''), 29.60 (C2''), 44.19 (C1''), 61.96 (C4''), 97.04 (C3), 123.51 (C5,C8), 125.7 (C10), 125.89 (C6), 133.17 (C7), 153.58 (C9), 162.4 (C2), 173.9 (C1'), 176.40 (C4).

IR (KBr, cm⁻¹): 3486 (NH and OH), 2937, 2884 (CH), 1680 (C=O), 1607, 1575, 1486, (C=C), 1068 (C-O).

3. RESULTS AND DISCUSSION

3.1. Chemistry

The Schema of synthesis of new coumarine derivative **L** is presented in [Fig. 1](#). Compound is good soluble in chloroform. The structure of synthesized compound was predicted based on result of elemental microanalyses and their IR and NMR (¹H and ¹³C) spectra. The results of microanalysis is in good agreement with calculated values for C, N and H. The formation of 3-(1-((4-hydroxy butylamino)ethylidene)cromane-2,4-dione was confirmed by IR spectra. Presence of bands positioned at 3486 cm⁻¹ was assigned to NH and OH group vibrations, while stretching vibrations corresponding to the C=O and C–O groups were found at 1680 and 1068 cm⁻¹, respectively.

In ¹H NMR spectrum, the singlet observed at 2.74 ppm was assigned to protons on CH₃ group. Aromatic protons of the phenyl group of coumarine part were detected in the range from 7.18 to 8.00 ppm. The protons of the aliphatic chain were identified as multiplet at 1.8 and triplets at 3.49 and 3.60 ppm. The singlet proton originating from the amino NH group was detected at 14.17 ppm, while the signal of the hydroxyl group was at 4.69 ppm. In ¹³C NMR spectra of coumarine part carbon atoms was observed in the range from 97.04 to 176.4 ppm. The signals of sp³ carbon atoms of the substituent in position 3 are at significantly lower chemical shifts.

3.2 Molecular docking studies

The most stable docking conformation of the investigated compound is presented in [Fig. 2](#). The predicted free energy of binding ($\Delta G_{\text{bind}} = -30.2 \text{ kJ mol}^{-1}$) suggests strong affinity the investigated compound to the Lipoxigenase receptor.

The docking analyses revealed several non-covalent interactions between the **L** and the Lipoxigenase receptor. The hydrogen bonds, carbon-hydrogen bonds, alkyl- π , π - π , and alkyl-alkyl interactions are the most important interactions ([Fig. 2](#)). The amino acids that form strong hydrogen bonds in the primary structure of the chain of the Lipoxigenase receptor have a predominant role as the active site of this receptor regarding the investigated ligand. The other amino acids form weak carbon-hydrogen bonds, alkyl- π interactions and π - π with the coumarin moiety of investigated ligand, as well as alkyl- π , and alkyl-alkyl interactions with alkyl moiety ([Fig. 2](#)).

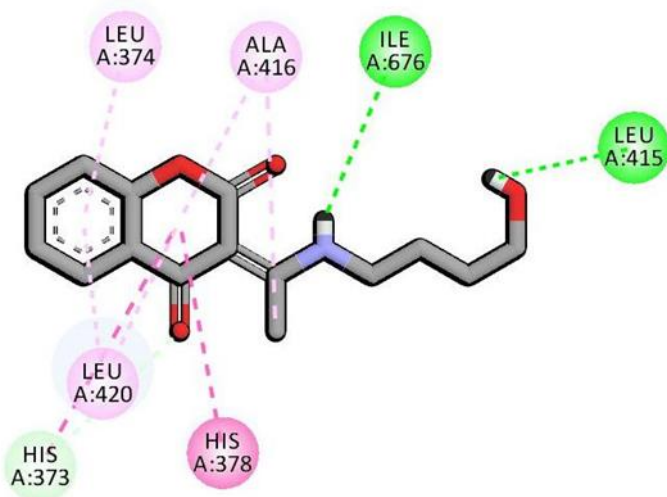


Fig. 2. The hydrogen bond (green dotted lines) and hydrophobic (rose pink dotted lines) docking interactions of the most stable conformations of L with Lipoxigenase receptor

4. CONCLUSION

The new compound 3-(1-((4-hydroxy butylamino)ethylidene)cromane-2,4-dione (**L**) was synthesised and characterized by microanalysis, NMR and IR spectroscopy. All observed results of elemental microanalysis and spectroscopic data were in alignment with proposed structure of novel compound.

To evaluate the inhibitory nature of compound towards Lipoxigenase receptor, the molecular docking study was performed. According to the results of the molecular docking study, the investigated ligand forms a stable complex with Lipoxigenase receptor as evident from the binding energy (ΔG_{bind}).

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ANTIMICROBIAL AND ANTIOXIDANT ACTIVITY OF THE LICHENS *CLADONIA RANGIFERINA* AND *LOBARIA PULMONARIA*

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ABSTRACT:

The aim of this study is to investigate the in vitro antimicrobial and antioxidant activity of the methanol extracts of lichens Cladonia rangiferina and Lobaria pulmonaria. The antimicrobial activity was assessed by determining the minimum inhibitory concentration (MIC) using the microdilution method against four species of bacteria and four species of fungi. The tested extracts exhibited relatively strong antimicrobial activity. The obtained MIC values ranged from 0.39 to 50 mg/mL. The lowest measured MIC value (0.39 mg/mL) was observed with the species Cladonia rangiferina against Staphylococcus aureus. As for the antioxidant activity, the effect of the extracts on the inhibition of DPPH radicals was examined. The tested extracts showed weak antioxidant activity, with the lichen Lobaria pulmonaria exhibiting slightly stronger antioxidant effects compared to the species Cladonia rangiferina. The obtained results suggest that the tested lichens represent potential antimicrobial agents that could be used for pharmaceutical purposes in treating various diseases.

Keywords: antimicrobial activity, antioxidant activity, lichen extracts

1. INTRODUCTION

In developed countries, scientists are showing increasing interest in researching biologically active natural agents, so phytochemistry plays a significant role in contemporary scientific research. Interestingly, the search for new sources of bioactive substances has so far been focused on studying various biological activities of plants, with only a small number of researchers engaged in studying the biological activity of lichens. The scarcity of information on the biological activity of lichens has motivated us to intensify research in this area.

Lichens are symbiotic organisms composed of a fungus and a photosynthetic partner, which can be either algae or cyanobacterium [1]. More than 20,000 known species of lichens have been identified and inhabit diverse ecosystems ranging from arctic tundra to

desert climates [2]. For many years, numerous species of lichens have been utilized in traditional medicine for treating various infectious diseases. For example, the species *Lobaria pulmonaria* has been used as a cure for pulmonary diseases, *Parmelia sulcata* for headaches, *Xanthoria parietina* as a treatment for hepatitis, and *Peltigera canina* has long been used against rabies [1, 3].

Lichens, as symbiotic organisms, produce characteristic secondary metabolites called lichen acids, which are unique to them and not produced separately by algae and fungi. These secondary metabolites precisely determine their wide range of biological activities. Various biological properties of lichens are known, such as antimicrobial, antitumor, antioxidant, antipyretic, and antiinflammatory effects [4].

Therefore, the aim of this study is to evaluate the antimicrobial activity of methanol extracts of *Lobaria pulmonaria* and *Cladonia rangiferina* lichens against eight test microorganisms, including food spoilage agents and pathogens of humans, animals, and plants. In addition to the antimicrobial effect, we also tested the antioxidant potential of selected lichen species for antioxidant protection. Finding significant antimicrobial and antioxidant activities of the tested lichens could lead to their utilization in various industries (pharmaceutical, food, cosmetic, etc.), particularly contributing to more effective control and suppression of various human, animal, and plant diseases.

2. MATERIALS AND METHODS

2.1. Lichen samples and preparation of the lichen extracts

Lichen samples of *Lobaria pulmonaria* (L.) Hoffm., and *Cladonia rangiferina* (L.) Weber (Fig. 1), were collected from Kopaonik, Serbia, in summer of 2021. The voucher specimen of the lichens was deposited at the Department of Biology and Ecology, Faculty of Science, University of Kragujevac, Serbia. The determination of the investigated lichens was accomplished using standard keys [5, 6].



Fig. 1. (a) *Lobaria pulmonaria*; (b) *Cladonia rangiferina*.

Finely pulverized thalli of the investigated lichens (50 g) were extracted using methanol in a Soxhlet extractor. The extracts were filtered and then concentrated under reduced

pressure in a rotary evaporator. The dry extracts were stored at -20°C until they were used in the tests. The extracts were dissolved in 5% dimethyl sulfoxide (DMSO).

2.2. Antimicrobial activity

The following bacteria were used as test organisms in this study: *Bacillus subtilis* (ATCC 6633), *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922), and *Proteus mirabilis* (ATCC 12453). The fungi used as test organisms were: *Aspergillus niger* (ATCC 16888), *Penicillium italicum* (ATCC 10454), *Trichophyton mentagrophytes* (ATCC 9533), and *Cladosporium cladosporioides* (ATCC 11680). Bacterial cultures were maintained on Müller-Hinton agar substrates (Torlak, Belgrade). Fungal cultures were maintained on potato dextrose agar and Sabourad dextrose agar (Torlak, Belgrade). All cultures were stored at 4°C and subcultured every 15 days. The sensitivity of microorganisms to tested samples was tested by determining the minimal inhibitory concentration (MIC).

Bacterial inoculi were obtained from bacterial cultures incubated for 24 h at 37°C on Müller-Hinton agar substrate and brought up by dilution according to the 0.5 McFarland standard to approximately 10⁸ CFU/mL. Suspensions of fungal spores were prepared from fresh mature (3- to 7-day-old) cultures that grew at 30°C on a potato dextrose agar substrate. Spores were rinsed with sterile distilled water, and used to determine turbidity spectrophotometrically at 530 nm, then further diluted to approximately 10⁶ CFU/mL according to the procedure recommended by NCCLS [7].

The minimal inhibitory concentration (MIC) was determined by the broth microdilution method using 96-well microtiter plates [8]. A series of dilutions with concentrations ranging from 50 to 0.02 mg/mL for extracts was used in the experiment against every microorganism tested. Two-fold dilutions of test samples were prepared in Müller-Hinton broth for bacterial cultures and Sabourad dextrose broth for fungal cultures. The minimal inhibitory concentration was determined with resazurin. Resazurin is an oxidation-reduction indicator used for the evaluation of microbial growth. The boundary dilution without any changing color of resazurin was defined as MIC. As a positive control of growth inhibition, streptomycin was used in the case of bacteria, and ketoconazole in the case of fungi. A DMSO solution was used as a negative control for the influence of the solvents.

2.3. Antioxidant activity

The antioxidant activity of *Lobaria pulmonaria* and *Cladonia rangiferina* extracts was evaluated using free radical scavenging assay. The free radical scavenging activity was measured by the 1,1-diphenyl-2-picryl-hydrazil (DPPH) method, according to Kosanić *et al.* [9]. Two milliliters of a methanol solution containing DPPH radical at a concentration of 0.05 mg/mL were mixed with 1 mL of test samples (1000, 500, and 250 µg/mL) in cuvettes. The mixture was shaken vigorously and allowed to standard room temperature for 30 min. Then, the absorbance was measured at 517 nm using a spectrophotometer (“Jenway” UK). Ascorbic acid was used as a positive control. The DPPH radical concentration was calculated using the following equation (1):

$$\text{DPPH scavenging effect (\%)} = [(A_0 - A_1) / A_0] \times 100 \quad (1)$$

where A₀ is the absorbance of the negative control and A₁ is the absorbance of reaction mixture or standard.

3. RESULTS AND DISCUSSION

In our experiments, it was recorded relatively strong antimicrobial activity of tested lichen extracts (Table 1). Both extracts inhibited the growth of all tested bacteria and fungi. The MIC values varied from 0.39 to 50 mg/mL for bacteria, and from 6.25 to 50 mg/mL for fungi. The lowest measured MIC value (0.39 mg/mL) was observed for *C. rangiferina* against *S. aureus*. Additionally, *L. pulmonaria* exhibited strong antibacterial activity against *E. coli*. The most sensitive among the fungi was *T. mentagrophytes*. The antimicrobial activity of the lichens was compared to standard antibiotics, streptomycin (for bacteria) and ketoconazole (for fungi). The results showed that standard antibiotics were more active than the lichen extracts. DMSO, the negative control, had no effect on the growth of microorganisms.

Table 1. Minimum inhibitory concentration (MIC) of methanol extracts of *Lobaria pulmonaria* and *Cladonia rangiferina* for the test organisms

Test organism	<i>L. pulmonaria</i>	<i>C. rangiferina</i>	Streptomycin	Ketoconazole
MIC (mg/mL)				
<i>B. subtilis</i>	3.12	3.12	0.016	-
<i>P. mirabilis</i>	3.12	50	0.062	-
<i>E. coli</i>	1.56	25	0.062	-
<i>S. aureus</i>	6.25	0.39	0.031	-
<i>A. niger</i>	50	25	-	0.078
<i>P. italicum</i>	25	12.5	-	0.156
<i>C. cladosporioides</i>	50	12.5	-	0.039
<i>T. mentagrophytes</i>	25	6.25	-	0.078

In the present research, the results indicate that the studied extracts induced relatively strong antimicrobial activity. The intensity of the antimicrobial effect depended on the species of organism tested. The extracts used in this study had stronger antibacterial than antifungal activity. Among the tested lichens, *L. pulmonaria* showed stronger antibacterial activity, while *C. rangiferina* showed more powerful antifungal activity. Fungi were assumed to be more resistant to the tested extract than bacteria due to more complex structure of the cell wall. This observation is in accordance with many other studies focused on antimicrobial activity [10, 11], which have demonstrated that the structure and the permeability of the cell wall are main reasons for different sensitivities in bacteria and fungi.

Previous researches showed significant bioactive characteristics of similar lichens. Kello *et al.* [12] found out that the methanol extract of the lichen *L. pulmonaria* had a strong antimicrobial influence. Similar results were reported by Kosanić *et al.* [11] for different solvent used for extraction from the lichen *C. rangiferina*.

Antioxidant activity of tested extracts has shown in Table 2. The results of this assay present that tested lichens showed weak DPPH radical scavenging activity. The results indicate that the extract derived from *L. pulmonaria* exhibited higher antioxidant activity than *C. rangiferina*. The antioxidant activity of the tested samples was also compared to ascorbic acid, which demonstrated stronger activity as a standard antioxidant.

Table 2. DPPH radical scavenging (%) activity of methanol extracts of *Lobaria pulmonaria* and *Cladonia rangiferina*

Lichen species	1000 µg/mL	500 µg/mL	250 µg/mL
% DPPH radical scavenging			
<i>L. pulmonaria</i>	12.41	4.63	4.55
<i>C. rangiferina</i>	3.42	3.33	2.40
Ascorbic acid	99.87	98.74	97.01

In the literature, there are several data for the antioxidant activity of tested lichen species. For instance, Odabasoglu *et al.* [13] tested methanol and water extracts of several lichen species, including *L. pulmonaria*, for which they found relatively strong antioxidant activity. Similar results were obtained by other researchers [14, 15].

Moderate antioxidant activity has also been recorded for *C. rangiferina* by other researchers [16]. The reasons for differences in the results of antioxidant activity between our and other studies may be different environmental conditions of the tested lichens, the method used for testing, extract dosage, solvent used for extraction, etc.

4. CONCLUSION

Based on the obtained results, it can be concluded that the tested lichens exhibited significant antimicrobial activity against the tested bacteria and fungi. This suggests that lichens can be a good source of natural antibiotics, potentially replacing synthetic products that may have additional negative impacts alongside their positive effects. Further research will require fractionation to identify the compounds responsible for the found antimicrobial effect, as well as determine the mechanisms of their antimicrobial action. Discovering new bioactive metabolites from lichens and conducting more detailed investigations will enable the discovery of new biologically active agents in controlling various diseases, which is of great interest to the human population.

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COMPARATIVE ANALYSIS OF TURBULENCE INTENSITY AND NUSSELT NUMBER PREDICTION IN INTERNAL FLOWS: EVALUATING ALGEBARIC MODEL AGAINST COMMERCIAL CFD SIMULATIONS

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ABSTRACT:

This research delves into the determination of turbulence intensity and Nusselt number within internal flows using Prandtl's mixing-length model. The study employs heat transfer and pressure drop analogies to predict these parameters, with a particular emphasis on comparing the obtained results with those from commercial Computational Fluid Dynamics (CFD) software for water and air flows. The accuracy of turbulence predictions is pivotal in various engineering applications, motivating the examination of Prandtl's model and its comparison with advanced CFD simulations. The investigation aims to validate the empirical findings against established CFD results, providing insights into the model's applicability and accuracy for internal flow analyses.

Keywords: CFD, flow, model, turbulence

1. INTRODUCTION

Turbulence modeling is an indispensable aspect of fluid dynamics, particularly in understanding complex flows such as those occurring in pipe systems [1,2]. Within this domain, the Prandtl Length Model stands as a significant framework, offering valuable insights into the turbulent behavior of fluid flow. Developed on the foundation laid by Ludwig Prandtl, whose pioneering work revolutionized fluid mechanics in the early 20th century, the Prandtl Length Model provides a structured approach to comprehend the intricacies of turbulence within pipe flows [3,4,5].

Prandtl's contributions to fluid mechanics, including boundary layer theory and his insights into turbulence, remain foundational in contemporary research. His work laid the groundwork for understanding the dynamic interactions between fluid layers and the effects of viscosity, pivotal in turbulence modeling.

In the context of pipe flow, turbulence poses numerous challenges, ranging from increased energy losses to heightened material wear within pipelines. Effective turbulence modeling not only enhances our understanding of these phenomena but also facilitates the design of

more efficient and robust piping systems across various industries, including energy, transportation, and manufacturing.

The Prandtl Length Model offers a distinctive perspective by introducing the concept of an integral length scale, denoted as the Prandtl length, which characterizes the extent of turbulent fluctuations within the flow. This model has found widespread application in computational fluid dynamics (CFD) simulations, where it provides a framework for predicting turbulent behavior and estimating relevant flow parameters.

Moreover, advancements in computational capabilities have enabled researchers to delve deeper into the intricacies of turbulence modeling, refining simulations and validating theoretical models against experimental data. Such endeavors contribute to the continual improvement of turbulence models, including those based on the Prandtl Length Model, fostering innovation and enhancing the accuracy of predictions in practical engineering scenarios.

In this paper, we explore the application of the Prandtl Length Model in turbulence modeling for pipe flow, examining its theoretical underpinnings, computational implementations, and practical implications. Through a comprehensive review of relevant literature and numerical simulations, we aim to elucidate the role of this model in enhancing our understanding of turbulent flows within pipe systems and its significance in engineering applications.

2. MATHEMATICAL MODEL

The Navier-Stokes equations are nonlinear partial differential equations of the second order. In some simple cases, such as, for example, Stokes flow, the equations can be simplified to the level of linear equations. However, in all real situations, it is difficult or impossible to solve the equations, so simplification or modeling is often used. Based on the required level of detail, computational time, ease of application, applicability, and accuracy, these equations can be solved by direct numerical simulation (DNS), which is the most detailed but also requires the most resources and time (far beyond the capabilities of today's computers). Another possibility is the simulation of large eddies (LES), which directly solves equations up to a certain scale, while the rest of the spectrum is modeled, sometimes also treated with additional stress terms. The model provides a lot of detail, can show current flow values, but still requires significant resources. It has great potential for further research, with expected improvements in computer characteristics. In this work, the RANS approach was used, which solves averaged Reynolds equations, is numerically less demanding, but provides averaged flow characteristics and cannot show details of current turbulent structures, providing results in an averaged form. This results in an equation of the form:

$$\frac{\partial \bar{W}_i}{\partial t} + \bar{W}_j \frac{\partial \bar{W}_i}{\partial x_j} = -\frac{1}{\rho} \frac{\partial \bar{p}}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\nu \frac{\partial \bar{W}_i}{\partial x_j} - \rho \overline{W_i' W_j'} \right). \quad (1)$$

On the right side, new quantities called Reynolds turbulent stresses $-\overline{W'_i W'_j}$ appear. Written in matrix form, they are as follows:

$$\tau_t \equiv -\rho \begin{bmatrix} \overline{W_x'^2} & \overline{W_x' W_y'} & \overline{W_x' W_z'} \\ \overline{W_y' W_x'} & \overline{W_y'^2} & \overline{W_y' W_z'} \\ \overline{W_z' W_x'} & \overline{W_z' W_y'} & \overline{W_z'^2} \end{bmatrix}. \quad (2)$$

When we talk about Reynolds turbulent stresses, they emerge in the context of turbulent fluid flows and represent additional stress components that arise from velocity fluctuations of the fluid. These components are crucial for understanding and modeling turbulent flows as they contribute to the total momentum transfer within the fluid. Mathematically, Reynolds stresses are expressed as averages of the products of velocity fluctuations in different directions.

The symbol $\overline{(\quad)}$ denotes the operation of taking the average of these products. It's important to note that these stresses result from the non-homogeneity and anisotropy of turbulent flow, and therefore cannot be directly calculated without empirical models or detailed flow simulations, such as Direct Numerical Simulation (DNS) or Large Eddy Simulations (LES).

For the energy equation, we obtain:

$$\rho c_p \left[\frac{\partial \overline{T}}{\partial t} + \frac{\partial (\overline{T W_i})}{\partial x_i} \right] = \lambda \frac{\partial^2 \overline{T}}{\partial x_i \partial x_i} - \rho c_p \frac{\partial (\overline{W_i' T'})}{\partial x_i}. \quad (3)$$

Analogously to the Newtonian relation, the turbulent stress is expressed through the local gradient of the corresponding component of the mean velocity as follows:

$$\tau_{txy} = -\rho (\overline{W_x' \cdot W_y'}) = -\rho \cdot \varepsilon_v \frac{\partial W_x}{\partial y}. \quad (4)$$

Where ε_v is the turbulent kinematic viscosity. The turbulent heat flux is expressed through the local gradient of the mean temperature:

$$q_{ty} = -\rho \cdot c_p (\overline{W_y' \cdot T'}) = -\rho \cdot c_p \cdot \varepsilon_q \frac{\partial T}{\partial y}. \quad (5)$$

Where ε_q is the turbulent kinematic thermal diffusivity. A model based on the so-called "mixing length" concept is still very popular today and was developed by Prandtl. In his model, viscosity is variable and equal to:

$$\varepsilon_v = l^2 \left| \frac{\partial W_x}{\partial y} \right|. \quad (6)$$

To express the fluctuating velocity component W'_x as a function of dW_x/dy using the previously shown relation:

$$W'_x = l \cdot \frac{dW_x}{dy}. \quad (7)$$

Fluctuating velocity component W'_y is of the same order of magnitude as W'_x :

$$W'_y \sim l \frac{dW_x}{dy}. \quad (8)$$

Based on this consideration, the mean value of the product of fluctuating velocity components is:

$$\overline{W'_x W'_y} = -l^2 \left| \frac{dW_x}{dy} \right| \frac{dW_x}{dy}, \quad (9)$$

and it follows that the turbulent kinematic viscosity is:

$$\varepsilon_v = l^2 \left| \frac{dW_x}{dy} \right|. \quad (10)$$

When analyzing the velocity distribution in turbulent flow near a wall, Prandtl introduced the assumption of the constancy of the total tangential stress τ_z :

$$\frac{\tau_z}{\rho} = \mu \frac{dW_x}{dy} - \rho \overline{W'_x W'_y} \quad (12)$$

For the turbulent core, the molecular (laminar) tangential stress is neglected compared to the turbulent tangential stress $\tau_t \gg \tau_l$:

$$\frac{\tau_z}{\rho} = -\overline{W'_x W'_y} \quad (13)$$

2.1. Heat transfer modeling

Based on the definition, turbulence intensity I is equal to the ratio of the magnitude of the fluctuating component to the mean velocity [5]:

$$I = \frac{W'_x}{W_x}. \quad (14)$$

Considering that fluctuating velocity component W'_y is of the same order of magnitude as W'_x It can be written that:

$$\left| \frac{\tau_z}{\rho} \right| = I^2 W_x^2. \quad (15)$$

For fully developed duct flow the turbulence intensity at the core can be estimated as [5,6]:

$$I = 0.16 \cdot Re^{-1/8}. \quad (16)$$

According to eq.

$$\frac{\xi}{8} W_{av}^2 = I^2 W_{av}^2, \quad (17)$$

and according to Reynolds analogy [3]:

$$\frac{\xi}{8} = \frac{Nu}{RePr} = I^2, \quad (18)$$

and by substituting into the expression, we can write that:

$$Nu = 0.0256 \cdot Re^{0.8} \cdot Pr. \quad (19)$$

In general, the Reynolds analogy is applicable to ideal gases where $Pr \sim 1$, so typically the following correction can be applied:

$$Nu = 0.0256 \cdot Re^{0.8} \cdot Pr^{1/3}. \quad (20)$$

The expression given by the equation is quite close to the expression by Ditus-Boelter [7]:

$$Nu = 0.023 \cdot Re^{0.8} \cdot Pr^n, \quad (21)$$

where $n=0.4$ for heating of fluid, and 0.3 for fluid cooling, or Sieder and Tate:

$$Nu = 0.027 \cdot Re^{0.8} \cdot Pr^{1/3} \left(\frac{\mu}{\mu_w} \right). \quad (22)$$

2.2. Turbulent viscosity modeling

For the turbulent core, the logarithmic law of velocity distribution could be written as [3,5]:

$$W_x = \frac{1}{k} \sqrt{\frac{\tau_z}{\rho}} \ln y + C', \quad (23)$$

and

$$\frac{dW_x}{dy} = \frac{1}{k} \sqrt{\frac{\tau_z}{\rho}} \frac{1}{y}. \quad (24)$$

So the turbulent kinematic viscosity could be written as:

$$\frac{\tau_z}{\rho} = \varepsilon_v \left(\frac{1}{k} \sqrt{\frac{\tau_z}{\rho}} \frac{1}{y} \right) = I^2 W_x^2, \quad (25)$$

thus after rearranging,

$$\varepsilon_v = \frac{k \cdot y \cdot I^2 \cdot W_x^2}{\sqrt{\frac{\tau_z}{\rho}}}, \quad (26)$$

where for turbulent flow in smooth pipes is the friction factor [4]:

$$\xi = \frac{0.316}{Re^{1/4}}, \quad (27)$$

or

$$\xi = (1.82 \log(Re) - 1.64)^{-2}. \quad (28)$$

3. RESULTS AND DISCUSSION

For comparing the results, both the logarithmic law of velocity distribution and Computational Fluid Dynamics (CFD) simulations were utilized. The simulation focused on analyzing turbulent flow through a pipe with a diameter of 32 mm and a length of 1 m to capture developed flow conditions.

The settings for the model were as follows: k-ε turbulence model, second-order discretization scheme, and a simplified flow algorithm, while standard wall functions were employed.

For the presented model, the following algorithm was used: for the distance y^+ up to 30, the logarithmic velocity distribution was employed as the wall function for the near-wall layer [3,5]:

$$W_x^+ = 5,0 \ln y^+ - 3,05 \quad \text{za} \quad 5 \leq y^+ \leq 30. \quad (29)$$

The turbulent kinematic viscosity was calculated in the first iteration based on the mean flow velocity as follows:

$$\varepsilon_{av}^{(1)} = \frac{k \cdot y \cdot I^2 \cdot W_{av}^2}{\sqrt{\frac{\tau_z}{\rho}}}, \quad (30)$$

and the velocity distribution starting from the layer $y^+=30$:

$$W_x^{(1)}(y + dy) = W_x^{(1)}(y) + \frac{\tau_z \cdot dy}{\varepsilon_{av}^{(1)}}, \quad (31)$$

while each subsequent iteration is performed according to:

The turbulent kinematic viscosity was calculated in the first iteration based on the mean flow velocity as follows:

$$\varepsilon_{av}^{(k+1)} = \frac{k \cdot y \cdot I^2 \cdot W_x^{(k)2}}{\sqrt{\frac{\tau_z}{\rho}}}, \quad (32)$$

and the velocity distribution starting from the layer $y^+=30$:

$$W_x^{(k+1)}(y + dy) = W_x^{(k)}(y) + \frac{\tau_z \cdot dy}{\varepsilon_{av}^{(k+1)}}. \quad (33)$$

3. RESULTS AND DISCUSSION

As can be observed, the velocity field and the value of turbulent viscosity converge very fast in a few iterations, while the velocity field shows a good agreement with the logarithmic law of velocity distribution. Figure 1 represent air flow at 18000 Reynolds, and water flow at 35000 Reynolds.

Figure 2 represent turbulent kinetic viscosity for air and water flow.

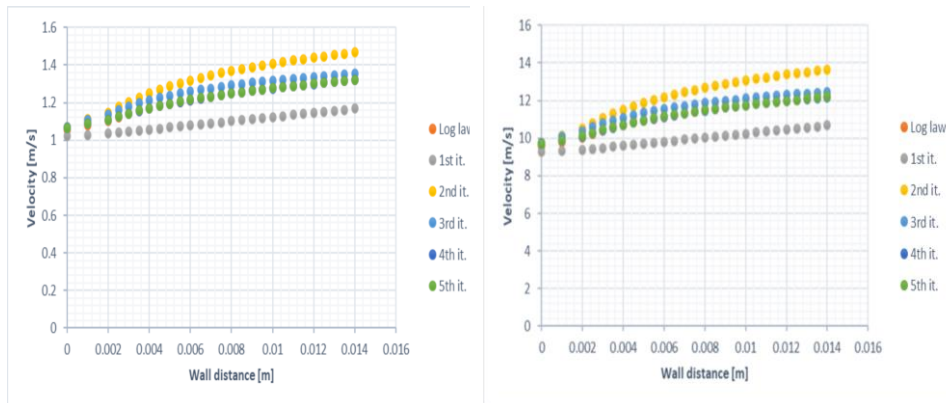


Figure 1. Velocity distribution for air flow and water flow

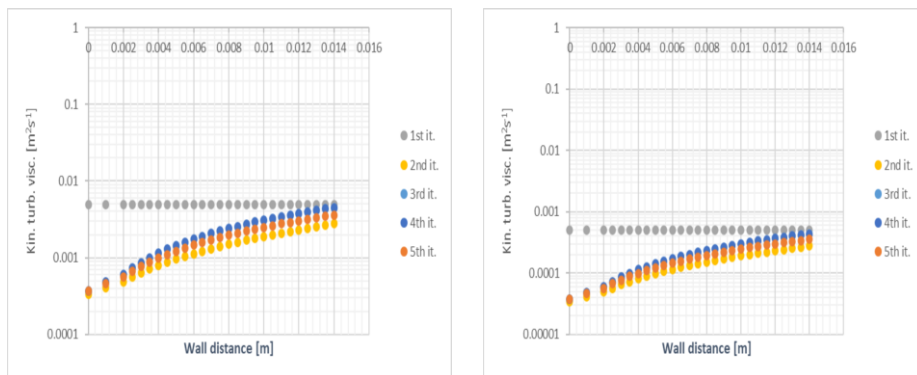


Figure 2. Turbulent kinematic viscosity for air flow and water flow

Similar observations can be noticed in the comparison with CFD results. The Fig. 3 represent the velocity distribution for air and water flow.

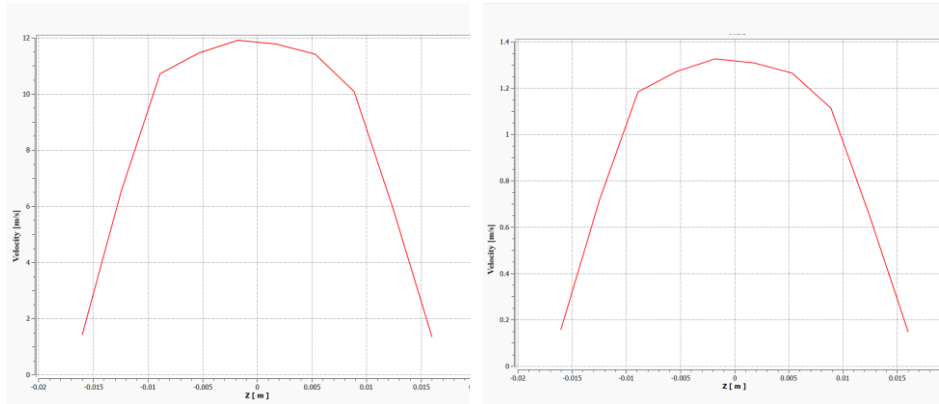


Figure 3. CFD result for air flow and water flow velocity field

4. CONCLUSIONS

In conclusion, this research successfully extends the theoretical and computational framework of fluid dynamics through a focused examination of turbulence intensity and Nusselt number in internal flows, employing Prandtl's mixing-length model. Through rigorous analysis and comparison with CFD simulations, the study has not only validated the empirical findings against sophisticated CFD results but also underscored the efficacy and relevance of Prandtl's model in contemporary engineering applications.

Significantly, the research findings highlight the Prandtl mixing-length model's capacity to approximate turbulence characteristics within internal and developed flows with commendable accuracy. By comparing these results with those obtained from commercial CFD software for both water and air flows, this study reaffirms the model's robustness and its potential as a viable computational tool in predicting fluid dynamics phenomena.

Moreover, the iterative approach to determining velocity fields and the analysis of turbulent viscosity within the context of this model have shown a rapid convergence to the established logarithmic law of velocity distribution. This not only attests to the model's computational efficiency but also its practical applicability in engineering scenarios where precise flow characteristics are paramount.

The implications of this research are manifold, providing a solid foundation for future studies aimed at refining turbulence models and enhancing the accuracy of fluid flow predictions in various engineering domains. Additionally, by bridging the gap between traditional theoretical models and modern CFD simulations, this study paves the way for more integrated and comprehensive approaches to solving complex fluid dynamics problems.

In essence, this work not only pays homage to Ludwig Prandtl's seminal contributions to fluid mechanics but also dynamically propels his legacy into the future, demonstrating the enduring relevance and adaptability of his theories in addressing the challenges of modern engineering and computational fluid dynamics.

5. LITERATURE

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TANACETUM BALSAMITA ESSENTIAL OIL FROM FLOWER EXERTS ANTITUMOR EFFECTS BY DOWNREGULATING NRF2 AND MMP-9 EXPRESSION IN HUMAN BREAST CANCER CELLS

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ABSTRACT:

One of the most common women's malignancies worldwide is the breast cancer. Nrf-2 is one of the main regulators of redox homeostasis and its up-regulation is indicated in the growth and progression of breast cancer cells, and represents one of the major novel therapeutic targets in cancer treatments. MMP-9 is an important protease associated with cancer progression, including invasion and metastasis. The aim of this study was to investigate an antitumor capacity of flower Tanacetum balsamita essential oil (FEO) by measuring apoptosis rate, MMP-9 concentration and Nrf-2 expression level in human breast cancer cell lines MDA-MB-231 and MDA-MB-468. The cells were treated with two different concentrations of FEO (1 µg/mL and 10 µg/mL) during 24 h and 72 h. The tested essential oil expressed proapoptotic effects. The investigated oil significantly inhibited the MMP-9 concentration and downregulated the expression level of Nrf-2. The obtained data suggest that the tested FEO exert considerable antitumor activity, decreasing oxidative resistance, elevating apoptosis level and inhibiting the migration capacity of tested breast cancer cell lines. The reduced levels of Nrf-2 expression suggest decreased defense potential for oxidative disturbances, which could be the major antitumor mechanism detected in the study. Targeting apoptotic pathways is an efficient strategy for identifying candidates from natural products to improve chemotherapeutic treatment of breast cancer. The obtained results suggest that the investigated essential oil poses the capacity to be potentially promising novel chemotherapeutic agent against breast cancer progression and metastasis.

Keywords: *Tanacetum balsamita* essential oil of flower, breast cancer cells, Nrf-2, MMP-9, apoptosis ratio

1. INTRODUCTION

Tanacetum balsamita L., also known as costmary, has recently attracted the interest of scientists once more due to its wide range of biological activity. Despite having numerous recognized scientific names, *Tanacetum balsamita*, a member of the *Tanacetum* genus and Asteraceae family, is most commonly referred to as costmary. Approximately 200 species of this genus are found in North America, Europe, Asia, and Africa. *T. balsamita* was first mentioned in early modern times, in the 18th century, and was described as an astringent and laxative that was beneficial for stomach aches as well as conditions involving melancholy and hysteria. Previous investigations have demonstrated the anti-inflammatory, analgesic, immune-modulatory, and antioxidant properties of *T. balsamita* (Asl-Gavvani et al., 2022).

One of the most common diseases with a high global death rate is cancer. The advent of chemoresistant cancer morphologies has diminished the efficacy of existing chemotherapies, highlighting the need for innovative treatment combinations with greater cytotoxicity against malignant cells and less adverse effects on healthy tissues. More than 500,000 women die from breast cancer every year, making it the second most common cause of cancer-related death in women. The balance between cell proliferation and apoptosis regulates normal breast development, and there is compelling evidence that tumor growth is caused by both diminished apoptosis and unchecked proliferation. The overall development or regression of the tumor in response to chemotherapy, radiation, and, more recently, hormonal treatments depends critically on the balance between proliferation and apoptosis. Thus, by analyzing apoptosis and its control and regulation, it is possible to distinguish the biology of specific tumors at the molecular and biochemical level and to take advantage of these for therapeutic benefit (Parton et al., 2001).

Nrf-2 (Nuclear factor erythroid 2-related factor 2) is considered the key regulator of the oxidative cellular state through the interaction of the proteins, expressed everywhere and regulates the expression of genes that contain the cis-acting antioxidant response element. Chemopreventive drugs activate Nrf-2 and pharmacological activation of Nrf-2 has been extensively supported as novel method for cancer prevention. According to recent study, Nrf-2 activity is frequently elevated in cancer cells, and its cytoprotective action may promote cancer cell survival and proliferation, implying that inhibition of Nrf-2 during cancer treatment may be crucial for beneficial outcome. Nrf-2 can exert chemopreventive properties in normal cells through ROS-dependent activation process, but aberrant expression in breast cancer imparts cytoprotective effects to cancerous cells by suppressing ROS-dependent DNA damage, promoting cancer cell survival and carcinogenicity. Nrf-2 could be one of the major hallmarks in the development and regulation of breast cancer. It was also suggested that Nrf-2 is highly expressed in ER-negative breast cancer. Due to the dual role of Nrf-2 as pro-oncogenic and anti-oncogenic in breast cancer cells and healthy cells, also other factors, such as metabolic genes, proliferative genes, and angiogenesis genes, should also be considered for inhibiting Nrf-2 through Nrf-2 inhibitors. Because of its cytoprotective function, Nrf-2 has been identified as a tumor suppressor (Kumar et al., 2022).

Matrix metalloproteinases (MMPs) are a family of proteases that have multiple biological functions in cancer development and progression and are abundantly upregulated in breast cancer. MMP-9 plays an important role in extracellular matrix (ECM) remodelling, protein cleavage, and is associated with tumour invasion, metastasis and modulation of tumour microenvironment. MMP-9 has the capability to degrade collagens, which plays a

role in basement membrane degradation promoting migration, invasion and metastasis (Joseph et al., 2020).

The aim of this study was to investigate antitumor capacity of flower *Tanacetum balsamita* essential oils by measuring apoptosis rate, Nrf2 expression level and MMP-9 concentration in human MDAMB231 and MDAMB468 cell line.

2. MATERIALS AND METHODS

2.1. Cell culture and treatment

Essential oil of *Tanacetum balsamita* from flower (FEO) was used in experiments. The stock solution was prepared in the concentration of 10 mg/mL, while during the experiment were used the concentrations of 1 µg/mL and 10 µg/mL for all the measurements. The human breast cancer cell line MDA-MB-231 and MDA-MB-468 were obtained from American Tissue Culture Collection. The cells were grown according to the procedure described in detail in the paper Obradovic et al., 2020.

2.2. Determination of the concentrations of Human NFE2L2 (Nuclear Factor, Erythroid Derived 2, Like 2)

This test uses a quantitative sandwich enzyme immunoassay technique. Samples and reagents from NFE2L2 (Elabscience, ELISA) must first be prepared as described in the provided instructions. Untreated cells and cells with FEO treatment at 2 different concentrations (1 µg/mL and 10 µg/mL), after both exposure times (24h (short-term) and 72h (long-term), were trypsinized and then centrifuged and washed three times in PBS. After that cells were sonificated and the supernatant was used further in the protocol. A monoclonal antibody specific for total NFE2L2 was placed in a 96-well microtiter plate. The supernatant in a volume of 100 µL is added to the microtiter plate in which the present NFE2L2 binds to the immobilized antibody. This is followed by incubation for 90 minutes at room temperature. The liquid from each well was decanted, and, without wash, 100 µL of Biotinylated Detection Ab working solution was immediately added to each well. This was followed by 60 minutes incubation at 37°C. After washing (Wash Buffer) of unbound substances, 100 µL of HRP Conjugate working solution was added to each well. Incubation for 30 min at 37°C was next. This was followed by rinsing and aspiration again and then adding a substrate solution (Substrate Solution) in a volume of 90 µL to each well followed by incubation for 15 minutes at room temperature in the dark. After the third incubation, Stop Solution was added to each well in a volume of 50 µL.

Absorbance was measured by using ELISA reader at 450 nm. The absorbance is proportional to the concentration of Human NFE2L2. The concentration of Human NFE2L2 in the samples is calculated by comparing the absorbance of the samples to the standard curve.

2.3. Determination of invasive potential of MMP-9 concentration

Matrix metalloproteinases are endopeptidases that play a key role in cell invasion by degrading matrix components. Quantitative determination of the concentration of total MMP-9 and analysis of the invasive potential of cells from cell lysates was performed with the help of a kit for MMP-9. This test uses a quantitative sandwich enzyme immunoassay technique. Samples and reagents from MMP-9 (Elabscience, ELISA) must first be prepared as described in the provided instructions. Untreated cells and cells with FEO at 2 different concentrations (1 µg/mL and 10 µg/mL), after short-term (24h) and long-term treatment (72 h), were trypsinized, centrifuged, and washed three times in PBS. After that cells were sonicated and the supernatant was used further in the protocol. A monoclonal antibody specific for total MMP-9 was placed in a 96-well microtiter plate. The supernatant in a volume of 100 µL was added to the microtiter plate in which the present MMP-9 binds to the immobilized antibody. This was followed by incubation for 90 minutes at room temperature. The liquid from each well was decanted, and, without wash, 100 µL of Biotinylated Detection Ab working solution was immediately added to each well. This was followed by 60 minutes incubation at 37°C. After washing (Wash Buffer) of unbound substances, 100 µL of HRP Conjugate working solution was added to each well. Incubation for 30 min at 37°C was next. This was followed by rinsing and aspiration again and then adding a substrate solution (Substrate Solution) in a volume of 90 µL to each well followed by incubation for 15 minutes at room temperature in the dark. After the third incubation, Stop Solution was added to each well in a volume of 50 µL. The color changes from blue to yellow.

Absorbance was measured by using ELISA reader at 450 nm. The absorbance is proportional to the concentration of Human MMP-9. The concentration of Human MMP-9 in the samples is calculated by comparing the absorbance of the samples to the standard curve.

2.4. Determination of type of cell death

Apoptotic cells were detected using the Annexin V-FITC/7-AAD Kit (Apoptosis Detection Kit, Beckman Coulter, USA). Staining was performed according to the manufacturer's instructions and Shounan protocol (Shounan et al., 1998). After treatments with FEO at a concentration of 1 µg/mL and 10 µg/mL in durations of 24 h and 72 h, the cells were collected, washed in PBS and resuspended in ice-cold binding buffer. Ten thousand events were analyzed on Flow cytometer Cytomics FC500 (Beckman Coulter, USA). Apoptosis and necrosis were analyzed by double staining with annexin V-FITC and 7-AAD. Annexin V binds to the cells with exposed phosphatidylserine, whereas 7-AAD labels the cells with membrane damage. The percent of viable (Annexin V-7-AAD-) cells, early apoptotic (Anexin V⁺7-AAD⁺) cells, late apoptotic (Annexin V⁺7-AAD⁺) cells, and necrotic cells (Anexin V-7-AAD⁺) cells were evaluated by Flowing Software (<http://www.flowingsoftware.com/>).

2.5. Statistical analyses

All experiments were performed in triplicate for all the used methods. All data were evaluated using IBM-SPSS 23 software for Windows (SPSS Inc., Chicago, IL, USA). The

data were presented as a mean \pm standard error (S.E.M). The statistical significance was determined using Paired-Samples – T test. The level of statistical significance was set at $p < 0.05$.

3. RESULTS AND DISCUSSION

Cancer cells are characterized by abnormal metabolism and signalling, allowing them to survive and divide uncontrollably. Numerous chemicals, elements, and circumstances have been identified as fundamental contributors to the onset and development of the illness. A successful treatment for this one of the most serious clinical disorders appears to be elusive, despite the abundance of literature on the subject. Research has been focused on studying herbal medications, which are used in traditional medicine, as a potential source of new chemical entities for the treatment of cancer due to the high cost of drugs, growing resistance, and adverse effects of current therapeutic approaches (Upadhyay, 2020).

Lower Nrf-2 expression in healthy cells helps to sustain physiologically optimal free radical production on the other hand, overexpressed Nrf-2 in malignant cells is linked to a number of phenomena, including metastasis, angiogenesis, drug resistance, and the generation of cancer stem cells. Elevated Nrf-2 expression contributes to the survival of cancer cells, also reducing the toxicity and effectiveness of therapeutic anticancer medications (Kumar et al., 2022).

Normal cell cytoprotection is mostly carried out by Nrf-2 through detoxification processes involving oxidation, electrophilic stress, or xenobiotic activities. In patients with breast cancer, higher expression of Nrf-2 led to decreased survival and increased proliferation and tumor progression (Kumar et al., 2022).

A number of genes involved in glutathione production and chemoresistance are activated by Nrf-2, which regulates antioxidant and cytoprotective qualities. Redox mechanism-based therapy is known to play a significant part in cancer treatment. According to Kumar et al. (2022), suppressing Nrf-2 during cancer treatment may be crucial, and targeting the progression of the disease with Nrf-2 can open up new avenues for therapeutic development.

The results of our study show that FEO exerted a statistically significant decrease in the expression of Nrf-2 after both treatments compared to the control group of cells as presented in **Fig. 1**. The strongest effect was shown by FEO at a concentration of 10 $\mu\text{g/mL}$ on the MDA-MB-468 cells line after long-term treatment (72 h).

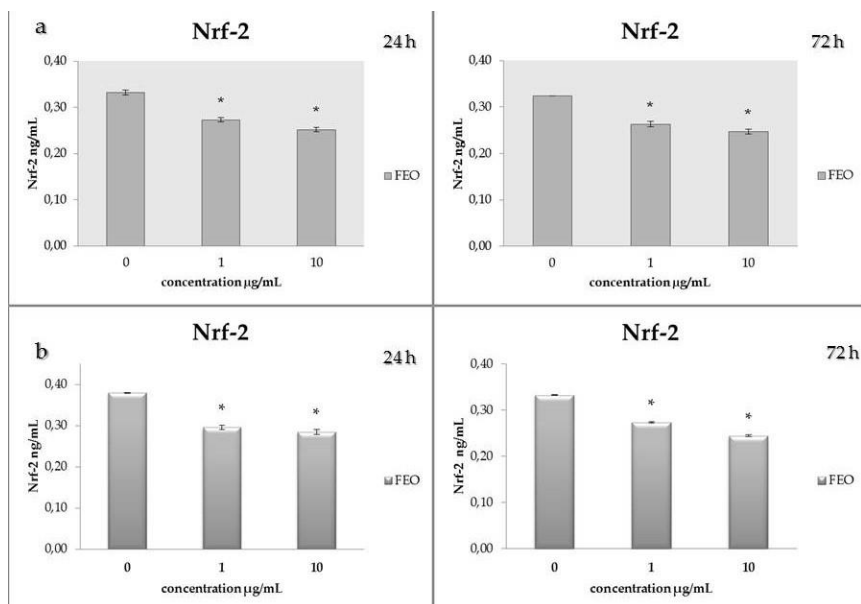


Fig. 1. The effects of two concentrations of FEO on concentration of Nrf-2 in a) MDA-MB-231 cells and b) MDA-MB-468 cells after 24 h and 72 h of treatment. Results are presented as the mean of three independent experiments \pm standard error; * $p < 0.05$ relative to control.

In addition to the examination of the migration potential of the cells, in our previous study (Vukic et al., 2022), an analysis of the parameters of the invasion abilities of these cells was carried out. The group of matrix metalloproteinases to which MMP-9 belongs is considered particularly important for the invasiveness of cancer cells during metastasis. The total concentration of MMP-9 is detected by an enzymatic, ELISA reagent kits method. The results of our study show that FEO exerted a statistically significant decrease in the concentration of MMP-9 after long-term treatment compared to the control group of cells as presented in **Fig. 2**. The most significant effect of FEO is in the prolonged treatment at concentration 10 $\mu\text{g/mL}$, in the MDA-MB-231 cell line.

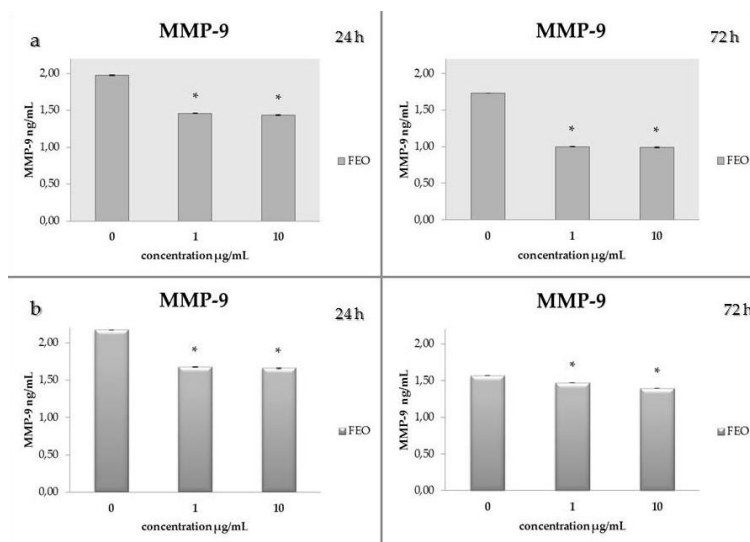


Fig. 2. The effects of two concentrations of FEO on concentration of MMP-9 in a) MDA-MB-231 cells and b) MDA-MB-468 cells after 24 h and 72 h of treatment. Results are presented as the mean of three independent experiments \pm standard error; * $p < 0.05$ relative to control.

Cancer biomarkers can play an essential role in fields such as cancer diagnosis and prognosis, monitoring disease progression, monitoring, and predicting treatment efficacy, and cancer screening. MMP-9 is involved as essential molecules in multiple and diverse physiological processes, such as reproduction and regulation of inflammatory process, but also help cancer cells to evade primary tumor tissue. MMP-9 plays an important role in cancer cell invasion, and it has been found to be a potential biomarker for several cancers (Huang, 2018).

Apoptosis is highly regulated process of cell death and is crucial in maintaining tissue homeostasis, regulating cell division ratio and preventing carcinogenesis. The components of essential oil from various plants have been indicated to induce apoptosis in numerous cancer cell types. Since our results suggest decreased viability of the tested essential oil, we have measured apoptotic potential as one of the mechanisms of recorded antitumor activity in this study. Apoptosis-inducing agents are expected to be successful antitumor drugs since apoptosis is a protective mechanism against cancer development that acts to remove genetically damaged cells from the tissue before they undergo clonal expansion (Goldar et al., 2015).

The type of cell death was determined by flow cytometric analysis of the treated cells stained with Annexin V FITC and 7-AAD. Both cell lines (MDA-MB-231 and MDA-MB-468) were treated for 24 h and 72 h, with concentrations of 1 $\mu\text{g/mL}$ and 10 $\mu\text{g/mL}$. These two concentrations were chosen as representative for applied in the majority of the studies. The effects of FEO showed statistically significant time- and dose-dependent proapoptotic effects in MDA-MB-231 and MDA-MB-468 cells, as shown in **Fig. 3**. The strongest

apoptosis level compared to non-treated cells was recorded for FEO essential oil in a concentration of 10 µg/mL in MDA-MB-231 cell line, after 72 h.

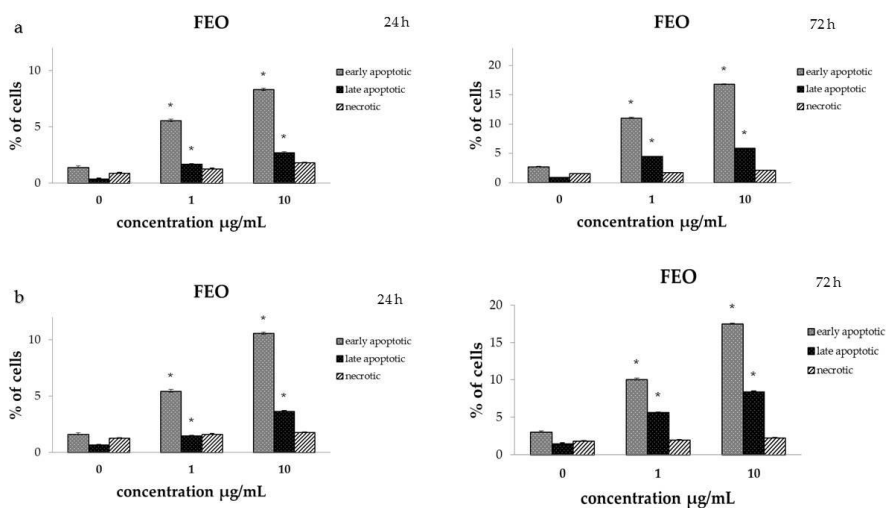


Fig. 3. Flow cytometric analysis of Annexin V-FITC/7-AAD stained a) MDA-MB-231 cells and b) MDA-MB-468 cells for 24 h and 72 h with FEO. The percentages of early apoptotic (Annexin V+7-AAD-, lower right quadrant), late apoptotic (Annexin V+7-AAD+, upper right quadrant) and necrotic cells (Annexin V-7-AAD+, upper left quadrant) in non-treated and treated cells are indicated on dot plots). Results are presented as the mean of three independent experiments ± standard error; * p < 0.05 relative to control

3. CONCLUSION

The obtained data suggest that the tested oil exerts considerable proapoptotic and antimigratory potential, while intensifying the sensitivity of breast cancer cells to reactive oxygen species and oxidative disturbances, by reducing the levels of Nrf2, which could be the major antitumor mechanism detected in this study.

4. LITERATURE

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BIODIVERZITET U URBANOM KONTEKSTU: PRELIMINARNA STUDIJA EKOSISTEMA I STANIŠTA SPOMEN-PARKA „Kragujevački oktobar“

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SAŽETAK:

Cilj rada je istraživanje ekosistemskog diverziteta, prisustva invazivnih biljnih vrsta, kao i popis gljiva na teritoriji Spomen-parka „Kragujevački oktobar“, zaštićenog kulturnog dobra koje obeležava stradanje nekoliko hiljada nedužnih civila u II svetskom ratu. Ovo područje, pored velikog istorijskog, nacionalnog i kulturnog značaja poseduje i izuzetne prirodne vrednosti. Terenska istraživanja izvedena su u vegetacionom periodu 2016 – 2023. godine. Analizirana je prisutnost faktora kao što su antropogeni uticaj i invazivne vrste, procenjujući njihov potencijalno štetan uticaj na biodiverzitet ovog područja. Detaljna analiza zemljišnog pokrivača, dobijena iz „CORINE Land Cover“ baze, otkrila je prisustvo sedam kategorija zemljišnog pokrivača, uključujući urbana zelena područja, livade, poljoprivredna područja sa značajnim udelom prirodne vegetacije, kao i listopadne šume i vodene površine. Analizom gustine drvenaste vegetacije, koristeći podatke na pan-evropskom nivou (The High Resolution Tree Cover Density), mereno na skali od 0 do 100%, identifikovani su različiti nivoi gustine i uočena je značajna površina parka sa gustom drvenaste vegetacije preko 30%, što ukazuje na relativno dobro očuvane šumske ekosisteme. Takođe, utvrđeno je prisustvo 9 jako invazivnih biljnih vrsta sa razvijenim populacijama koje predstavljaju opasnost po autohtoni biodiverzitet, funkcionisanje prirodnih ekosistema, ekonomiju i ljudsko zdravlje. Identifikovano je 125 vrsta gljiva, od kojih jedna pripada strogo zaštićenim, dok tri pripadaju zaštićenim vrstama. Ovi nalazi doprinose dubljem razumevanju strukture ekosistema i staništa unutar Spomen-parka „Kragujevački oktobar“ i naglašavaju potrebu za njegovim očuvanjem. Dobijeni podaci mogu poslužiti kao polazna tačka za očuvanje biodiverziteta i održivo upravljanje ovim jedinstvenim područjem.

Ključne riječi: ekosistemi, gljive, staništa, invazivne vrste, zaštita prirode.

1. UVOD

Urbane zelene površine, kao što su parkovi i memorijalni kompleksi, služe kao ključni refugijumi biodiverziteta, obezbeđujući staništa za različite vrste, nudeći ekološke, estetske i kulturne koristi stanovništvu [1]. Spomen-park „Kragujevački oktobar“ predstavlja područje od izuzetnog prirodnog, istorijskog, nacionalnog i kulturnog značaja za Srbiju. Prostire se na teritoriji grada Kragujevca i obuhvata površinu od 352 hektara. Spomen-park je osnovan 1953. godine, na mestu gde je u oktobru 1941. godine streljano više hiljada građana Kragujevca – Srba, Jevreja, Roma, muslimana, Makedonaca, Slovenaca i pripadnika drugih nacionalnosti.

Usled zabrane izgradnje stambenih i drugih objekata i samim tim manjeg antropogenog uticaja u odnosu na urbanu sredinu ili seoska domaćinstva, prirodna staništa i ekosistemi na ovom području su relativno dobro očuvani. Međutim, proces urbanizacije oko Spomen-parka često dovodi do značajnih promena u biodiverzitetu i strukturi ekosistema. Uočeni problem na ovom prostoru je i povremena nelegalna seča šuma, koja može da dovede do gubitka raznovrsnosti živog sveta, ali i do pojave erozije zemljišta i širenja invazivnih i korovskih vrsta.

Na području memorijalnog kompleksa do sada nije bilo prisutno sistematsko istraživanje ekosistema i staništa biljaka, gljiva i životinja, a svi pokušaji bili su rađeni sporadično. Ova studija pruža preliminarni prikaz urbanog biodiverziteta Spomen-parka „Kragujevački oktobar“ fokusirajući se na raznovrsnost ekosistema i staništa, invazivne biljne vrste i gljive unutar ovog kompleksa.

2. MATERIJAL I METODE

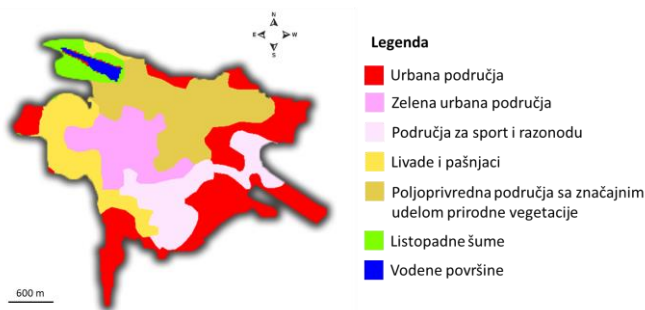
Terenska istraživanja izvedena su u vegetacionom periodu 2016 – 2023 godine na više različitih lokaliteta u okviru Spomen-parka „Kragujevački oktobar“. Istraživana je raznovrsnost zemljišnog pokrivača, staništa, biljaka (sa akcentom na invazivne vrste) i gljiva. Analiziran je i antropogeni faktor i procenjen njegov potencijalni štetni uticaj na biodiverzitet ovog područja. Baza podataka CORINE Land Cover je korišćena za klasifikaciju tipova zemljišnog pokrivača unutar spomen-parka, dopunjena satelitskim snimcima i verifikacijom na terenu. Pored pomenutog, korišćeni su podaci o tipovima šuma (High Resolution Layer Forest Type) i gustini drvenaste vegetacije (The High Resolution Tree Cover Density), takođe dobijeni iz Copernicus programa. Analiza zemljišnog pokrivača izvršena je korišćenjem programa QGIS Desktop 3.22.4 u koji su importovane rasterske slike zemljišnog pokrivača.

Svaka zabeležena biljna vrsta i gljiva adekvatno je identifikovana, primenom odgovarajućih ključeva za determinaciju, georeferencirana i dokumentovana odgovarajućom fotografijom, a pojedine vrste biljaka i gljiva sačuvane su u vidu herbara i eksikata na Institutu za biologiju i ekologiju, Prirodno-matematičkog fakulteta u Kragujevcu. Za identifikaciju gljiva korišćena je standardna literatura [2].

3. REZULTATI I DISKUSIJA

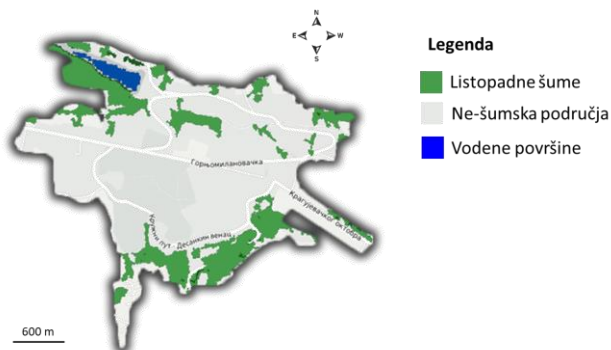
Rezultati ove studije obuhvataju identifikovane, popisane i georeferencirane ekosisteme, staništa, kao i različite vrste biljaka i gljiva, sa posebnim naglaskom na invazivne biljne vrste i zaštićene i strogo zaštićene vrste gljiva. Utvrđena je prisutnost faktora kao što su antropogeni uticaj i invazivne vrste i procenjen njihov potencijalno štetan uticaj na biodiverzitet u Spomen-parku "Kragujevački oktobar".

Prema podacima o zemljišnom pokrivaču, dobijenim iz baze CORINE Land Cover, na teritoriji Spomen-parka „Kragujevački oktobar“ uočeno je prisustvo sedam kategorija zemljišnog pokrivača: (1) urbana područja, (2) zelena urbana područja, (3) područja za sport i razonodu, (4) livade i pašnjaci, (5) poljoprivredna područja sa značajnim udelom prirodne vegetacije, (6) listopadne šume i (7) vodene površine. Uočljivo je da je Spomen-park smešten u urbanoj zoni, sa svih strana okružen područjima sa izraženom urbanizacijom. Centralni deo Spomen-parka čine zelena urbana područja, livade i poljoprivredna područja sa značajnim udelom prirodne vegetacije. Uz vodene površine (jezero) prisutne su prirodne listopadne šume (Slika 1).



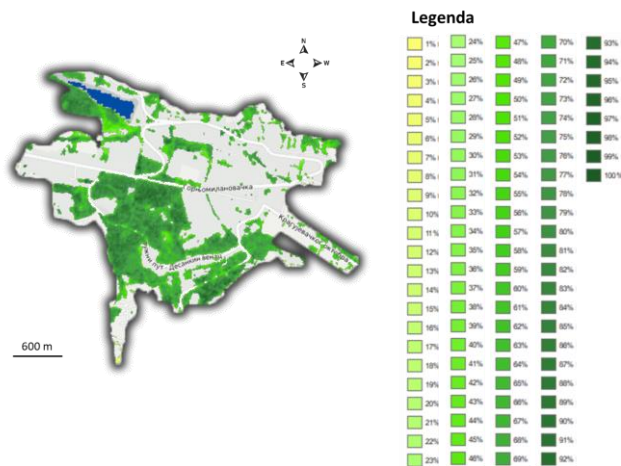
Slika 1. Mapa Spomen-parka „Kragujevački oktobar“ sa prikazom glavnih tipova zemljišnog pokrivača prema bazi CORINE Land Cover

Na osnovu podataka o tipu vegetacije na pan-evropskom nivou (The High Resolution Forest Tree Type), uočljivo je da su na teritoriji Spomen-parka „Kragujevački oktobar“ prirodno prisutne isključivo listopadne šume, što je u skladu sa nadmorskom visinom, geografskom širinom i dužinom na kojoj se Spomen-park nalazi (Slika 2).



Slika 2. Mapa Spomen-parka „Kragujevački oktobar“ sa prikazom tipova šuma

Na osnovu podataka o gustini drvenaste vegetacije na pan-evropskom nivou (The High Resolution Tree Cover Density), na skali od 0 do 100%, uočljivi su različiti nivoi gustine. Značajna površina nalazi se pod gustinom drvenaste vegetacije iznad 30% (Slika 3).



Slika 3. Mapa Spomen-parka „Kragujevački oktobar“ sa prikazom gustine drvenaste vegetacije (%)

Terenskim istraživanjima utvrđeno je prisustvo 9 jako invazivnih biljnih vrsta na istraživanom području (Tabela 1). Udeo familija ukazuje da su Asteraceae i Fabaceae najzastupljenije. Većina navedenih vrsta potiče iz Severne Amerike, što ukazuje na značajan uticaj transkontinentalnog prenosa vrsta na lokalnu floru. Ove vrste su se pokazale kao invazivne u novim sredinama zbog svoje sposobnosti da se brzo šire i prilagođavaju različitim ekosistemskim uslovima, često na štetu lokalnih vrsta i ekosistema [3]. Prisutnost jako invazivnih vrsta, poput *Ailanthus altissima* i *Ambrosia artemisifolia* ukazuje na potencijalno štetne uticaje koje invazivne vrste mogu imati na lokalnu floru, faunu i zdravlje ljudi, što zahteva dalje analize i mere kontrole i eradikacije kako bi se očuvala prirodna vrednost i istorijski značaj ovog područja [4].

Tabela 1. Spisak invazivnih vrsta biljaka na teritoriji Spomen-parka „Kragujevački oktobar“

Vrsta	Familija
<i>Acer negundo</i> L.	Aceraceae
<i>Ailanthus altissima</i> (Mill.) Swingle	Simaroubaceae
<i>Ambrosia artemisifolia</i> L.	Asteraceae
<i>Amorpha fruticosa</i> L.	Fabaceae

<i>Bidens frondosa</i> L.	Asteraceae
<i>Erigeron annuus</i> (L.) Pers.	Asteraceae
<i>Helianthus tuberosus</i> L.	Asteraceae
<i>Robinia pseudoacacia</i> L.	Fabaceae
<i>Xanthium orientale</i> L.	Asteraceae

Tabela 2 predstavlja detaljan spisak gljiva identifikovanih tokom terenskih istraživanja na teritoriji Spomen-parka „Kragujevački oktobar“. Ukupno je utvrđeno 125 vrsta gljiva, koje pripadaju različitim familijama, čime se potvrđuje bogatstvo mikrobiote ovog područja. Značajna je zastupljenost familija kao što su Agaricaceae, Polyporaceae i Tricholomataceae, koje su poznate po svojoj ekološkoj važnosti u šumskim ekosistemima. Zabeležene su i neke zaštićene vrste, poput *Cantharellus cibarius* i *Marasmius oreades*, kao i strogo zaštićena vrsta *Amanita vittadinii*, što ukazuje na prisustvo biološki značajnih i potencijalno ugroženih vrsta u ovom području.

Tabela 2. Spisak identifikovanih vrsta gljiva na teritoriji Spomen-parka „Kragujevački oktobar“

Vrsta	Familija
1. <i>Agaricus urinasces</i> (Jul. Schäff. & F.H. Møller)	Agaricaceae
2. <i>Agaricus xanthodermus</i> Genev.	Agaricaceae
3. <i>Agrocybe molesta</i> (Lash) Singer	Strophariaceae
4. <i>Agrocybe praecox</i> (Pers.) Fayod	Strophariaceae
5. <i>Amanita pantherina</i> (DC.) Krombh.	Amanitaceae
6. <i>Amanita rubescens</i> Pers.	Amanitaceae
7. <i>Amanita vaginata</i> (Bull.) Lam.	Amanitaceae
8. <i>Amanita vittadinii</i> (Moretti) Vitad.**	Amanitaceae
9. <i>Armillaria mellea</i> (Vahl) P. Kumm.	Physalacriaceae
10. <i>Artomyces pyxidatus</i> (Pers.) Jülich	Auriscalpiaceae
11. <i>Astraeus hygrometricus</i> (Pers.) Morgan	Diplocystidaceae
12. <i>Auricularia auricula-judae</i> (Bull.) Quél.	Auriculariaceae
13. <i>Auricularia mesenterica</i> (Dicks.) Pers.	Auriculariaceae
14. <i>Calocybe gambosa</i> (Fr.) Singer	Lyophyllaceae
15. <i>Candolleomyces candolleanus</i> (Fr.) D. Wächt. & A. Melzer	Psathyrellaceae
16. <i>Cantharellus cibarius</i> Fr. *	Hydnaceae
17. <i>Cerioporus squamosus</i> (Huds.) Quél.	Polyporaceae
18. <i>Cerrena unicolor</i> (Bull.) Murrill	Cerrenaceae
19. <i>Chondrostereum purpureum</i> (Pers.) Pouzar	Cyphellaceae
20. <i>Clitocybe nebularis</i> (Batsch) P. Kumm.	Tricholomataceae

21. <i>Clitocybe odora</i> (Bull.) P. Kumm	Tricholomataceae
22. <i>Clitocybe rivulosa</i> (Pers.) P. Kumm.	Tricholomataceae
23. <i>Collybiopsis confluens</i> (Pers.) R.H. Petersen	Omphalotaceae
24. <i>Collybiopsis peronata</i> (Bolton) R.H. Petersen	Omphalotaceae
25. <i>Coprinellus disseminatus</i> (Pers.) J.E. Lange	Psathyrellaceae
26. <i>Coprinus comatus</i> (O.F. Müll.) Pers.	Agaricaceae
27. <i>Coprinus domesticus</i> (Bolton) Gray	Psathyrellaceae
28. <i>Coprinus micaceus</i> (Bull.) Fr.	Psathyrellaceae
29. <i>Coprinus picaceus</i> (Bull.) Fr.	Psathyrellaceae
30. <i>Crepidotus variabilis</i> (Pers.) P. Kumm.	Crepidotaceae
31. <i>Cyathus striatus</i> Willd.	Nidulariaceae
32. <i>Daedalea quercina</i> (L.) Pers.	Fomitopsidaceae
33. <i>Daedaleopsis tricolor</i> (Bull.) Bondartsev & Singer	Polyporaceae
34. <i>Desarmillaria tabescens</i> (Scop.) R.A. Koch & Aime	Physalacriaceae
35. <i>Entoloma clypeatum</i> (L.) P. Kumm.	Entolomataceae
36. <i>Entoloma sepium</i> (Noulet & Dass.) Richon & Roze	Entolomataceae
37. <i>Entoloma sinuatum</i> (Bull.) P. Kumm.	Entolomataceae
38. <i>Exidia glandulosa</i> (Bull.) Fr.	Auriculariaceae
39. <i>Fistulina hepatica</i> (Schaeff.) With.	Fistulinaceae
40. <i>Flammulina velutipes</i> (Curtis) Singer	Physalacriaceae
41. <i>Fomes fomentarius</i> (L.) Fr.	Polyporaceae
42. <i>Fomitopsis pinicola</i> (L.) Fr.	Polyporaceae
43. <i>Fuscoporia torulosa</i> (Pers.) T. Wagner & M. Fisch.	Hymenochaetaceae
44. <i>Ganoderma applanatum</i> (Pers.) Pat.	Polyporaceae
45. <i>Ganoderma lucidum</i> (Curtis) P. Karst.	Polyporaceae
46. <i>Ganoderma resinaceum</i> Boud.	Polyporaceae
47. <i>Gymnopus dryophilus</i> (Bull.) Murrill	Omphalotaceae
48. <i>Gymnopus foetidus</i> (Sowerby) P.M. Kirk	Omphalotaceae
49. <i>Gymnopus fusipes</i> (Bull.) Gray	Omphalotaceae
50. <i>Hapalopilus rutilans</i> (Pers.) Murrill	Phanerochaetaceae
51. <i>Hebeloma sinapizans</i> (Paulet) Gillet	Hymenogastraceae
52. <i>Hydnoporia tabacina</i> (Sowerby) Spirin, Miettinen & K.H. Larss.	Hymenochaetaceae

53. <i>Hygrocybe conica</i> (Schaeff.) P. Kumm.	Hygrophoraceae
54. <i>Hygrophorus eburneus</i> (Bull.) Fr.	Hygrophoraceae
55. <i>Hymenochaete rubiginosa</i> (Dicks.) Lév.	Hymenochaetaceae
56. <i>Hymenopellis radicata</i> (Relhan) R.H. Petersen	Physalacriaceae
57. <i>Hypholoma fasciculare</i> (Huds.) P. Kumm.	Strophariaceae
58. <i>Infundibulicybe geotropa</i> (Bull.) Harmaja	Tricholomataceae
59. <i>Infundibulicybe gibba</i> (Pers.) Hamaja	Tricholomataceae
60. <i>Inonotus hispidus</i> (Bull.) P. Karst.	Hymenochaetaceae
61. <i>Laccaria amethystina</i> Cooke	Hydnangiaceae
62. <i>Laccaria laccata</i> (Scop.) Cooke	Hydnangiaceae
63. <i>Lactarius torminosus</i> (Schaeff.) Pers.	Russulaceae
64. <i>Lactarius zonarius</i> (Bull.) Fr.	Russulaceae
65. <i>Laetiporus sulphureus</i> (Bull.) Murril	Laetiporaceae
66. <i>Lentinus arcularius</i> (Batsch) Zmitr.	Polyporaceae
67. <i>Lenzites betulinus</i> (L.) Fr.	Polyporaceae
68. <i>Lepiota clypeolaria</i> (Bull.) P. Kumm	Agaricaceae
69. <i>Lepista personata</i> (Fr.) Cooke	Tricholomataceae
70. <i>Leucoagaricus leucothites</i> (Vittad.) Wasser	Agaricaceae
71. <i>Lycoperdon mammiforme</i> Pers.	Lycoperdaceae
72. <i>Lycoperdon perlatum</i> Pers.	Lycoperdaceae
73. <i>Lycoperdon pratense</i> Pers.	Lycoperdaceae
74. <i>Macrolepiota mastoidea</i> (Fr.) Singer	Agaricaceae
75. <i>Macrolepiota procera</i> (Scop.) Singer	Agaricaceae
76. <i>Macrolepiota rhacodes</i> (Vittad.) Vellinga	Agaricaceae
77. <i>Marasmius epiphyllus</i> (Pers.) Fr.	Marasmiaceae
78. <i>Marasmius oreades</i> (Bolton) Fr.*	Marasmiaceae
79. <i>Marasmius rotula</i> (Scop.) Fr.	Marasmiaceae
80. <i>Melanoleuca melaleuca</i> (Pers.) Murrill	Tricholomataceae
81. <i>Meripilus giganteus</i> (Pers.) P. Karst.	Meripilaceae
82. <i>Morchella esculenta</i> (L.) Pers.*	Morchellaceae
83. <i>Mycena capillaripes</i> Peck	Mycenaceae
84. <i>Mycena pelianthina</i> (Fr.) Quél.	Mycenaceae
85. <i>Mycena polygramma</i> (Bull.) Gray	Mycenaceae
86. <i>Mycena pura</i> (Pers.) P. Kumm.	Mycenaceae
87. <i>Mycena rosea</i> Gramberg	Mycenaceae
88. <i>Omphalotus olearius</i> (DC.) Singer	Omphalotaceae

89. <i>Paralepista flaccida</i> (Sowerby) Vizzini	Tricholomataceae
90. <i>Paxillus involutus</i> (Batsch) Fr.	Paxillaceae
91. <i>Peniophora quercina</i> (Pers.) Cooke	Peniophoraceae
92. <i>Pleurotus ostreatus</i> (Jacq.) P. Kumm.	Pleurotaceae
93. <i>Pluteus cervinus</i> (Schaeff.) P. Kumm.	Pluteaceae
94. <i>Pluteus petasatus</i> (Fr.) Gillet	Pluteaceae
95. <i>Psathyrella pseudogracilis</i> (Romagn.) M.M. Moser	Psathyrellaceae
96. <i>Pseudoclitocybe cyathiformis</i> (Bull.) Singer	Pseudoclitocybaceae
97. <i>Pseudosperma rimosum</i> (Bull.) Matheny & Esteve-Rav.	Inocybaceae
98. <i>Radulomyces molaris</i> (Chaillet ex Fr.) M.P. Christ.	Radulomycetaceae
99. <i>Rhodocollybia butyracea</i> (Bull.) Lennox	<i>Omphalotaceae</i>
100. <i>Russula atropurpurea</i> (Krombh.) Britzelm.	Russulaceae
101. <i>Russula lepida</i> Fr.	Russulaceae
102. <i>Russula nigricans</i> (Pers.) Fr.	Russulaceae
103. <i>Russula pectinatoides</i> Peck	Russulaceae
104. <i>Russula rosea</i> Pers.	Russulaceae
105. <i>Russula vesca</i> Fr.	Russulaceae
106. <i>Sarcoscypha coccinea</i> (Jacq.) Lambotte	Sarcoscyphaceae
107. <i>Schizophyllum commune</i> Fr.	Schizophyllaceae
108. <i>Scleroderma citrinum</i> Pers.	Sclerodermataceae
109. <i>Stereum hirsutum</i> (Willd.) Pers.	Stereaceae
110. <i>Stereum ochraceoflavum</i> (Schwein.) Sacc.	Stereaceae
111. <i>Stereum subtomentosum</i> Pouzar	Stereaceae
112. <i>Suillus granulatus</i> (L.) Roussel	Suillaceae
113. <i>Trametes cinnabarina</i> (Jacq.) Fr.	Polyporaceae
114. <i>Trametes gibbosa</i> (Pers.) Fr.	Polyporaceae
115. <i>Trametes hirsuta</i> (Wulfen) Lloyd	Polyporaceae
116. <i>Trametes versicolor</i> (L.) Lloyd	Polyporaceae
117. <i>Tubaria furfuracea</i> (Pers.) Gillet	Tubariaceae
118. <i>Typhula filiformis</i> (Bull.) Fr.	Typhulaceae
119. <i>Verpa bohemica</i> (Krombh.) J. Schröt.	Morchellaceae
120. <i>Xerocomellus chrysenteron</i> (Bull.) Šutara	Boletaceae
121. <i>Xerocomus badius</i> (Fr.) E.-J. Gilbert	Boletaceae
122. <i>Xerocomus rubellus</i> Quél.	Boletaceae

123. <i>Xerocomus subtomentosus</i> (L.) Quél.	Boletaceae
124. <i>Xylaria hypoxylon</i> (L.) Grev.	Xylariaceae
125. <i>Xylaria polymorpha</i> (Pers.) Grev.	Xylariaceae

* Zaštićena vrsta

** Strogo zaštićena vrsta

Stanište, kao funkcionalna celina koju čine zajednice biljaka, životinja, gljiva i mikroorganizama, predstavlja osnovu za očuvanje biološke raznovrsnosti [5]. Šumarci, drvoredi i pojedinačna drveća u Spomen-parku "Kragujevački oktobar" predstavljaju značajne komponente šumskog pejzaža. Posebno su istaknute šume i šumarci bele vrbe i topole, šume sladuna i cera, kao i šumarci lužnjaka i graba. Ovi širokolisni mezofilni šumarci doprinose biološkom diverzitetu, dok šumski zasadi autohtonih lišćara i četinara, kao i voćnjaci, dodatno obogaćuju šumski ekosistem. Žbunje, koje obuhvata širokolisne higrofilne žbunjeve, kserofilne šibljacke i različite zasade žbunastih biljaka, takođe igra ključnu ulogu u očuvanju biološke raznovrsnosti Spomen-parka. Istraživanje ekosistema i staništa u Spomen-parku "Kragujevački oktobar" doprinelo je identifikaciji ključnih aspekata biodiverziteta i zaštite prirodnih karakteristika ovog područja. Očuvanje prirodnih karakteristika Spomen-parka "Kragujevački oktobar" važno je ne samo za lokalnu zajednicu već i za očuvanje nacionalne i međunarodne biološke raznovrsnosti.

4. ZAKLJUČAK

Spomen-park „Kragujevački oktobar” predstavlja značajnu prirodnu oazu i igra ključnu ulogu u urbanom ekološkom pejzažu Kragujevca, nudeći značajan biodiverzitet unutar istorijskog i kulturnog dobra. Prisustvo raznovrsnih ekosistema u okviru Spomen-parka „Kragujevački oktobar“ naglašava značaj urbanih zelenih površina u očuvanju biodiverziteta. Rezultati analize zemljišnog pokrivača pružaju ključne podatke za urbano planiranje i očuvanje, naglašavajući potrebu održavanja i potencijalnog proširenja šumskih područja u urbanim sredinama. Uticaj invazivnih vrsta je zabrinjavajući, jer ugrožavaju stabilnost i funkcionisanje ekosistema. Prisutnost retkih i zaštićenih vrsta gljiva dodatno naglašava potrebu za očuvanjem prirodnih staništa unutar Spomen-parka.

Istraživanje prezentovano u ovom radu potvrdilo je važnost ovog područja i neophodnost njegove zaštite. Dobijeni podaci o ekosistemima i njihovom biodiverzitetu omogućiće da se primene mere zaštite i upravljanja koje će doprineti održivom razvoju Spomen-parka. Buduće strategije treba da se fokusiraju na upravljanje invazivnim vrstama, obnovu staništa i edukovanje javnosti i lokalnog stanovništva, kako bi se podstakla održiva koegzistencija između urbanog razvoja i očuvanja prirode.

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BIODIVERSITY IN AN URBAN CONTEXT: PRELIMINARY STUDY OF ECOSYSTEMS AND HABITATS IN THE MEMORIAL PARK "KRAGUJEVAČKI OKTOBAR"

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ABSTRACT:

This study aims to assess ecosystem diversity, invasive plant species, and fungi in the Memorial Park "Kragujevački Oktobar" (Kragujevac, Serbia), a protected cultural asset that commemorates the suffering and death of thousands of innocent civilians in World War II. Aside from its historical, national, and cultural significance, this area has exceptional natural values. Field research was carried out from 2016 to 2023, covering various vegetation periods. The factors such as anthropogenic impact and invasive plant species were investigated to determine their potential negative impact on the biodiversity of this area. A detailed analysis of the land cover using the CORINE Land Cover database revealed the presence of seven land cover categories: urban green areas, meadows, agricultural areas with a significant portion of natural vegetation, deciduous forests, and water bodies. Using pan-European data (The High Resolution Tree Cover Density), various levels of density were identified, and a significant area of the park with a density of woody vegetation over 30% was observed, indicating relatively well-preserved forest ecosystems. The presence of nine highly invasive plant species with well-established populations has been identified as a threat to autochthonous biodiversity, natural ecosystem functioning, the economy, and human health. Furthermore, 125 fungi species have been identified, including one strictly protected and three protected species. These findings help to deepen our understanding of the park's ecosystem and habitat structure, emphasizing the importance of preserving them. The collected data can be used to help preserve biodiversity and manage this unique area in a sustainable manner.

Keywords: ecosystems, fungi, habitats, invasive species, nature conservation.

THE SIGNIFICANCE AND APPLICATION OF PHOTOCATALYSIS FOR REMOVING MOULDS AND MYCOTOXINS IN WATER

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ABSTRACT:

*Moulds are widely distributed heterotrophic organisms present in aquatic ecosystems, including oceans, freshwater, and drinking water. Over the past 30 years, an increased presence of moulds has been documented in European waters, which can have adverse effects on human health and water quality. Water analyses often show the presence of moulds, including *Penicillium*, *Cladosporium*, *Aspergillus*, and other species, which can cause blockages in water pipes, alter the taste of water, and trigger allergic reactions. Moulds, such as *Aspergillus* spp., have even been found in hospital water systems, raising concerns about possible fungal infections. Mycotoxins, as secondary metabolites of moulds, lead to a range of health effects and thus pose an additional problem if found in the aquatic environment. Photocatalysis have shown great potential in removing moulds and mycotoxins from the aquatic environment. With the use of materials such as TiO₂ and other nanoparticles, a large number of moulds and their secondary products can be effectively removed. Additionally, studies have shown that a combination of UV radiation and hydrogen peroxide can be effective for this purpose. Different combinations of catalysts and light sources show varying effectiveness in degrading mycotoxins. This paper provides an overview of methods and evaluates the effectiveness of photocatalytic treatments to improve water quality for the protection of human health.*

Keywords: *moulds, mycotoxins, photolysis, photocatalysis, advanced oxidation processes*

1. INTRODUCTION

Moulds are ubiquitous, heterotrophic organisms that can be found in oceans, freshwater, and drinking water [1]. Over the past 30 years, the presence of a large number of moulds has been recorded in European waters, including surface water, groundwater, and tap water [2]. Filamentous moulds, in particular, can proliferate in water to such an extent that they can affect public health or have negative effects on water quality, making it crucial to monitor and study water quality [3]. Regarding drinking water, results have shown that 75% of analyzed samples in the drinking water network tested positive for moulds, ranging from 1-3000 CFU/mL [4]. The most commonly isolated moulds in drinking water include

Penicillium citrinum, *P. glabrum*, as well as other *Penicillium* species, *Cladosporium cladosporioides* [5], *Aspergillus* spp. [6], *Cladosporium*, *Rhizopus*, *Phoma*, *Acremonium*, *Alternaria*, *Exophiala*, *Mucor*, *Trichoderma* [7]. Filamentous moulds in the drinking water distribution system lead to:

- i) blockage of water pipes;
- ii) changes in the organoleptic properties of water;
- iii) acting as pathogens or allergens; and
- iv) causing water contamination with mycotoxins [8].

The appearance of potentially pathogenic fungal species, such as *A. fumigatus*, in 49% of hospitals in Oslo, in drinking water, has raised questions about whether the hospital water system can serve as a transmission route for fungal infections. Several studies have focused on analyzing water in hospital systems for the presence of moulds. Increased levels of *A. flavus* and *Fusarium* have also been found in hospital environments after the start of showers. It is presumed that moulds become aerosolized in the air, meaning they float, rather than settle under the influence of gravity, when water passes through plumbing installations, and then come into contact with patients [9]. Pereira et al. [10] investigated the presence of moulds in spring waters, with the most commonly isolated species being *Aspergillus* spp., *Fusarium* spp., *Penicillium* spp., *Trichoderma* spp., *Mucor* spp., and *Rhizopus* spp. Other studies have used raw water, treated water, water from private homes, and hospitals. Sammon et al. [11] collected samples from different entrances, parts of bottled water treatment plants, where they examined the presence of moulds. *Candida*, *Aspergillus*, *Cladosporium*, *Fusarium* spp., *Penicillium* spp., and *Trichoderma* spp. were found in that study. The appearance and identification of moulds in this type of water have been linked to sensory defects related to taste, odor, and some allergic reactions [12]. It is believed that they can transform 2,4,6-trichlorophenol into 2,4,6-trichloroanisole, leading to these sensory changes, and an "electronic nose" is used for their detection [13].

An additional problem with the appearance of moulds in water can be the production of their secondary metabolites, namely mycotoxins. Also, mycotoxins can as secondary metabolites of mold reach natural waters through atmospheric leaching from contaminated agricultural land. Mycotoxins are considered metabolites because they are not necessary for fungal growth and occur as products of primary metabolic processes. The function of mycotoxins has not been fully established to date, but it is believed that they play a role in eliminating other microorganisms in the same environment and help parasitic moulds invade host tissues [14]. Although all mycotoxins are produced by moulds, not all toxic products of moulds are mycotoxins [15]. The most important mycotoxins (Fig. 1) are produced by toxigenic moulds from five genera: *Aspergillus*, *Alternaria*, *Claviceps*, *Penicillium*, and *Fusarium* [16]. Moulds are naturally present in crop microflora and animal feed, but factors influencing mycotoxin production can be divided into physical (relative humidity, temperature, moisture, and mechanical damage), chemical (CO₂, O₂, substrate composition, pesticides, and mouldscides), and biological (plant variety, stress, insects, spores, damage). The combination of these factors creates a favorable environment for mold growth [17]. Environmental conditions have the greatest impact on mold synthesis and mycotoxin production, with fungal infections most commonly occurring in the field and/or during storage [18].

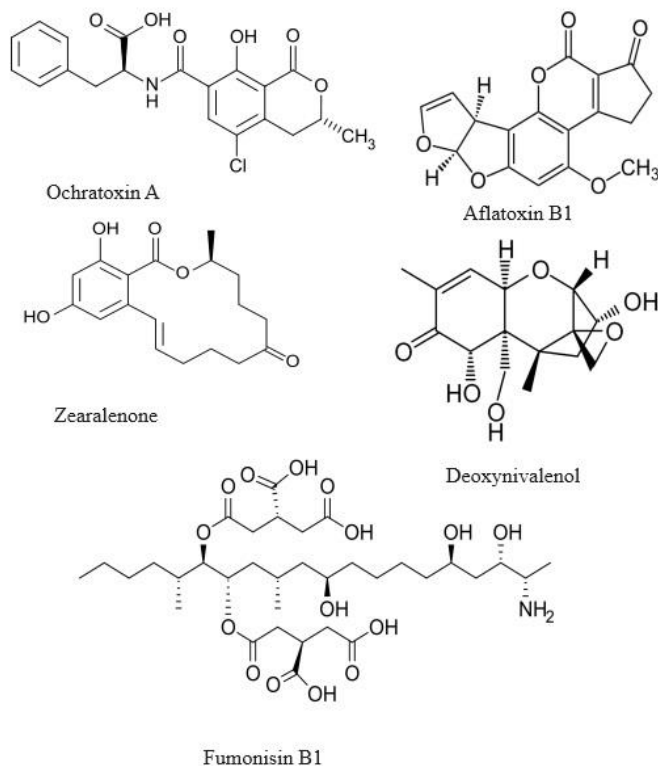


Fig 1. Chemical structures of mycotoxins

In recent years, the process of photocatalysis has shown great potential as a cheap, environmentally friendly, and sustainable method for treating environmental components because it has the ability to remove persistent organic compounds and microorganisms in water [19, 20]. In the following text, an overview of the application of this treatment in the removal of moulds and their secondary metabolites in the aquatic environment will be provided.

2. APPLICATION OF PHOTOCATALYSIS FOR REMOVAL OF MOULDS AND MYCOTOXINS IN AQUATIC ENVIRONMENTS

In the field of water treatment, there has been a development of oxidative degradation processes known as Advanced Oxidation Processes (AOPs). Examples of AOPs commonly used for removing pollutants from wastewater include O_3/H_2O_2 , UV/O_3 , $UV/O_3/H_2O_2$, UV/H_2O_2 , $UV/S_2O_8^{2-}$, Fenton reaction, photo-Fenton, and electro-Fenton reaction, sonolysis, γ -radiolysis, heterogeneous photocatalytic reactions using TiO_2 , and others [21, 22]. AOPs are characterized by the formation of highly reactive species such

as hydroxyl radicals ($\cdot\text{OH}$), superoxide radicals ($\text{O}_2^{\cdot-}$), ozone (O_3), hydrogen peroxide (H_2O_2), which are capable of oxidizing and mineralizing any organic molecule, yielding CO_2 and inorganic ions [23]. Photocatalysis is one of the AOPs methods that is attracting increasing attention as a "green" method for water disinfection [24], showing great potential for removing organic pollutants [19, 25]. Photocatalytic reactions on semiconductor powders have attracted great attention due to the efficient degradation of a large number of active pharmaceutical ingredients (antibiotics, analgesics, steroids, hormones, psychoactive substances, etc.), alkanes, haloalkanes, aliphatic alcohols, carboxylic acids, alkenes, aromatic and haloaromatic compounds, polymers, surfactants, pesticides, dyes, etc., using sunlight radiation [26]. Moreover, heterogeneous photocatalysis has also begun to be used for the degradation of mycotoxins [27]. Many nanomaterials, including nano-Ag, nano-Zn, nano- TiO_2 , and nano- Ce_2O_4 , exhibit antimicrobial properties without strong oxidation, thus having a lower tendency to form by-products. Nanomaterials have a large specific surface area and easily accessible surface, leading to high-quality catalytic activity [28]. Photodegradation of mycotoxins implies the influence of radiation on double bonds and their breaking. This leads to the breaking of the lactone rings and obtaining a new chemical structure that loses its toxic properties. Namely, by studying the mechanism of degradation of aflatoxin B₁ (AFB₁) in water, it was concluded that the double bond of the terminal furan ring and the lactone ring in AFB₁ (Fig. 1) are the key active sites acting as the main toxicological groups to hepatic cells [29, 30].

In the study by Rajaa [31], the efficiency of photocatalysis combined with light (mercury lamp, 160W) was investigated on the formation of colony-forming units (CFU) and biomass of *Fusarium oxysporum* during the photocatalytic reaction, over various exposure periods. The results showed that TiO_2 in combination with light caused a significant reduction in the number of colonies: 65; 66; 12.66; 4; 4.66; /0.5 ml after 30, 60, 90, 120 minutes of irradiation, compared to the dark control without TiO_2 , while TiO_2 alone had no effect on CFU compared to the dark control. The combination of TiO_2 and light resulted in the survival ratio reduction into 1.93 and 2.2 % after 90 and 120 min. Additionally, a significant reduction in biomass was observed in this combination. Sunlight with the addition of TiO_2 exhibits a more effective moldicidal effect than sunlight alone. This study investigated the effect of solar and solar photocatalytic (TiO_2) disinfection on the inactivation of fungal pathogens. Photocatalytic disinfection was performed on 5 strains of the *Fusarium* genus (*F. equiseti*, *F. oxysporum*, *F. anthophilum*, *F. verticillioides*, and *F. solani*). After 1-6 hours, it is possible to achieve nearly complete inactivation of moulds starting from 103 CFU/mL using solar photocatalysis. Degussa TiO_2 was used as the photocatalyst, with a concentration at which 99% extinction occurs being 35 mg/L [23]. In the study by Polo-López et al. [32], it was shown that the best inactivation rate of *F. solani* was achieved with other treatments such as photo-Fenton treatment (10/20 mg/L $\text{Fe}^{2+}/\text{H}_2\text{O}_2$) at pH 3, followed by $\text{H}_2\text{O}_2/\text{Solar}$ (10 mg/L), and finally $\text{TiO}_2/\text{Solar}$ was the slowest.

When it comes to the application of photocatalysis in the removal of mycotoxins, adding TiO_2 to water samples containing AFB₁, deoxynivalenol (DON), ochratoxin A (OTA), and zearalenone (ZEA) in combination with UVC radiation has shown significant efficiency in degrading these mycotoxins. For example, ZEA (3 mg/dm³) is completely degraded in

the presence of TiO₂ within 30 minutes of applying UVC radiation. Slightly lower efficiency of photocatalysis was observed in the degradation of AFB₁ (94%) and OTA (97%) [33]. For the removal of AFB₁, several catalysts were applied, but ZnO@NPC core-shell photocatalyst and graphene oxide/Cu₃(BTC)₂/Fe₃O₄ were found to be the most effective [34,35]. TiO₂ Wackherr has proven to be an efficient photocatalyst in degrading fumonisins B₁ and B₃, with the removal of B₃ being slightly more efficient than fumonisin B₁ [36]. Using UV/Zn₂SnO₄ treatment for the removal of fumonisin B₁ in different types of water (Danube, groundwater, tap, and ultrapure water), it was found that the degradation efficiency of this mycotoxin was highest in ultrapure water (67% in 30 minutes), likely due to matrix effects [37]. A hybrid graphene/ZnO was used as a photocatalyst for the degradation of 15 ppm DON under UV radiation at 254 and 365 nm. The results showed that at a wavelength of 254 nm (UVC radiation), the photocatalytic activity of the graphene/ZnO hybrid was 3.1 times higher than that of pure ZnO, and 99% of DON was degraded within 30 minutes. The newly synthesized graphene/ZnO hybrid exhibited high photocatalytic activity and simple application for the removal of mycotoxins and environmental protection [38]. In addition to UV radiation, applied similar solar irradiation with upconversion nanoparticles@TiO₂, and α-Fe₂O₃ were also applied for the photocatalytic degradation of DON [39, 40]. Treatment with UV/0.5Ce-TiO₂ showed low efficiency in DON removal [41].

3. CONCLUSION

Filamentous moulds in water can significantly impact human health and water quality, so it is crucial to monitor and study water quality. In addition to their direct effects on water quality, moulds produce secondary metabolites known as mycotoxins, which pose a serious threat to human and animal health, causing a range of adverse effects. When it comes to removing moulds and mycotoxins from the aquatic environment, photocatalysis emerges as a potential solution. The application of photocatalysts such as TiO₂ and graphene/ZnO hybrids has shown great potential in removing mycotoxins from the water, opening the door for future research and application of this technology in practice. Because of all these factors, considerable attention is being devoted to finding new methods for removing moulds and mycotoxins from water without altering its structural and sensory characteristics.

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THE MACROINVERTEBRATE COMMUNITY COMPOSITION IN SOME WATER ECOSYSTEMS IN STARA PLANINA MOUNTAINS (SOUTHEAST SERBIA)

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ABSTRACT:

Due to its geographical location and paleogeographic history, the Stara Planina Mountains are one of the six biodiversity hotspots in Europe. This study aims to depict the composition of the aquatic macroinvertebrates situated on the Serbian side of the Stara Planina Mountains. Aquatic macroinvertebrates were collected at six sites: Jelovičko Spring, Dojkinačka, Visočica, Temštica, and Rakitska rivers, and the spring of Bigar Stream. We recorded 1974 specimens within 97 taxa and ten systematic groups. Insects dominated the macroinvertebrate community, comprising 82.5% of the total density. Specifically, Diptera (23.5%), Ephemeroptera (19.8%), and Trichoptera (19.3%) were the most abundant. Trichoptera was the most diverse group, represented by 27 taxa, followed by Diptera (25 taxa) and Ephemeroptera (15 taxa). The diversity of macroinvertebrate communities, expressed as the Shannon index of general diversity, varied spatially from 3.17 (Dojkinačka River) to 1.72 (spring of Bigar Stream), while Simpson's Diversity Index ranged from 0.73 (spring of Bigar Stream) to 0.95 (Rakitska River). This study contributes to filling knowledge gaps about benthic communities in rivers and streams in the Stara Planina Mountains, which is essential for evaluating the vulnerability of freshwater ecosystems.

Keywords: macroinvertebrate diversity, sensitive taxa, rivers, springs

1. INTRODUCTION

Freshwater ecosystems are considered one of the most important providers of ecosystem services in terms of economic value, culture, science, and education. They also contain about 10% of all described animal species, making these habitats among the most productive ecosystems on earth (Nieto et al., 2017). At the same time, these ecosystems are the most threatened worldwide; therefore, freshwater organisms require more attention for their conservation. Macroinvertebrates are a part of every freshwater ecosystem in the

world and often exhibit high diversity. Aquatic macroinvertebrates can have an important impact on nutrient cycling, primary productivity, decomposition, and translocation of material (Wallace and Webster, 1966). Because of their long life cycles (generally one year, most of which is spent in the water) and relative immobility, aquatic macroinvertebrates are good indicators of stream health, and therefore, their survival is directly linked to their habitat (Agouridis et al., 2015; Parmar et al., 2016).

Regions of the Stara Planina Mountains have always attracted attention because of the vast diversity of landforms and heterogeneous habitats. At the suggestion of the Serbian Institute for Nature Conservation, the western Stara Planina Mountains were placed under strict protection in 1997 as a "natural merit of the first class". Due to their geographical position and paleogeographical history, the Stara Planina Mountains are one of the six biodiversity hotspots in Europe (Stojanović et al., 2017).

A literature survey of the biota on the Serbian side of this mountain yielded a high number of different scientific works. However, there have been limited and sporadic investigations concerning aquatic macroinvertebrates (Živić et al., 2005). Therefore, the study focused on the macroinvertebrate assemblage in the selected localities of the Stara Planina Mountains to expand our knowledge of macroinvertebrate diversity in this biodiversity hotspot.

2. MATERIALS AND METHODS

2.1. Study area

Field research of aquatic macroinvertebrates of Stara Planina Mountain was performed at six sites. A detailed description of the sites, including geographical coordinates, altitudes, and the date of sampling, is provided in Table 1.

Table 1. Characteristics of the studied sites.

Name of sites	Site code	Date of sampling	Geographic coordinates	Elevation
Jelovičko Spring	JEL	28.05.2022.	43°11'00.2"N 22°50'00.1"E	756 m
Dojkinačka River	DOJ	29.05.2022.	43°14'27.1"N 22°46'42.2"E	866 m
Visočica River	VIS	29.05.2022.	43°09'23.9"N 22°48'27.2"E	705 m
Rakitska River	RAK	18.11.2022.	43°20'39.0"N 22°40'38.9"E	729 m
Temštica River	TEM	22.03.2023.	43°15'47.6"N 22°33'01.8"E	388 m
Bigar Stream	BIG	22.03.2023.	43°20'42.7"N 22°26'21.7"E	537 m

2.2. Sample collection and processing

At each site, three subsamples of macrozoobenthos were gathered from the most dominant substrate types using a Surber sampler with a 250 mm mesh. These subsamples were combined into a single sample, promptly preserved in a 96% alcohol solution, transported, and stored at the Institute of Biology and Ecology, Faculty of Science, University of Kragujevac, Republic of Serbia. The collected materials were analyzed using a Nikon Szm 800 stereomicroscope equipped with a Leica camera and a Nikon Eclipse E100 microscope. Taxonomic identification was conducted utilizing available literature (Rozkošný, 1980; Nilson, 1997; Eiseler, 2005; Waringer & Graf, 2011). Macroinvertebrate community composition and diversity were assessed across sampling sites, including the number of individuals, taxon richness, and Shannon (Shannon, 1948) and Simpson (Simpson, 1949) diversity indices.

3. RESULTS AND DISCUSSION

During our study, we recorded 1974 individuals and 97 taxa, of which 73 were identified at the species level, 24 at the genus level, and one at the family level. The highest numbers of taxa were collected at the Temštica River (45 taxa), followed by the Dojkinačka River (40 taxa). Trichoptera was the most diverse group, represented by 27 taxa, followed by Diptera (24 taxa), Ephemeroptera (15 taxa), and Plecoptera (12 taxa) (Table 2).

Table 2. Qualitative and quantitative analysis (absolute number of individuals) of macroinvertebrates from the investigated water ecosystems

TAXA	JEL	DOJ	VIS	RAK	TEM	BIG
Turbellaria						
<i>Dugesia gonocephala</i> (Duges, 1830)	0	0	0	0	2	0
<i>Dugesia</i> sp.	13	0	0	4	0	0
<i>Polycelis felina</i> (Dalyell, 1814)	0	0	0	0	0	8
<i>Polycelis</i> sp.	27	0	0	0	0	0
Oligochaeta						
<i>Eiseniella tetraedra</i> (Savigny, 1826)	0	0	0	0	1	0
<i>Lumbriculus</i> sp.	0	0	0	0	0	0
<i>Psamoryctides barbatus</i> (Grube, 1860)	0	0	2	0	0	0
<i>Stylodrilus heringianus</i> Claparède, 1862	0	1	1	0	0	1
Gastropoda						
<i>Ancylus fluviatilis</i> (O. F. Müller, 1774)	6	2	6	8	1	0
<i>Bythinella dispersa</i> Radoman, 1976.	0	0	0	0	0	136
Amphipoda						
<i>Gammarus balcanicus</i> Schaferna, 1922	19	0	0	0	18	85
Decapoda						
<i>Austropotamobius torrentium</i> (Schrank, 1803)	2	2	1	1	0	0
Ephemeroptera						
<i>Baetis alpinus</i> (Pictet, 1843)	0	0	0	0	4	0
<i>Baetis lutheri</i> Müller-Liebenau, 1967.	2	8	9	0	0	0
<i>Baetis rhodani</i> (Pictet, 1843)	7	27	59	0	19	6
<i>Baetis</i> sp.	2	3	0	0	0	1

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<i>Ecdyonurus helveticus</i> Gr. Eaton, 1883	0	0	0	0	0	7
<i>Ecdyonurus</i> sp.	8	7	6	4	3	0
<i>Epeorus assimilis</i> Eaton, 1865	0	21	46	9	29	0
<i>Ephemera danica</i> Müller, 1764	0	4	1	5	0	0
<i>Ephemerella mucronata</i> (Bengtsson, 1909)	0	9	6	0	0	0
<i>Ephemerella</i> sp.	0	1	0	0	0	0
<i>Paraleptophlebia submarginata</i> (Stephens, 1835)	0	0	0	0	3	0
<i>Paraleptophlebia wernerii</i> Ulmer, 1919	0	0	4	0	0	0
<i>Rhithrogena semicolorata</i> (Curtis, 1834)	0	15	35	0	24	0
<i>Seratella ignita</i> (Poda, 1761)	0	0	0	0	2	0
<i>Torleya major</i> (Klapálek, 1905)	0	0	2	0	0	0
Plecoptera						
<i>Brachyptera risi</i> (Morton, 1896)	1	0	0	0	10	0
<i>Dinocras megacephala</i> (Klapálek, 1907)	0	3	0	0	0	0
<i>Isoperla grammatica</i> (Poda, 1761)	0	0	5	0	1	0
<i>Isoperla tripartita</i> Illies, 1954	51	6	0	0	0	0
<i>Leuctra pseudosignifera</i> Aubert, 1954	0	0	0	0	3	0
<i>Leuctra</i> sp.	0	0	0	9	0	0
<i>Nemoura erratica</i> Claassen, 1936	2	0	0	0	0	14
<i>Perla burmeisteriana</i> Claassen, 1936	0	0	0	0	5	0
<i>Perla marginata</i> (Panzer, 1799)	0	11	8	7	12	0
<i>Protonemura nitida</i> (Pictet, 1836)	95	3	0	0	2	0
<i>Protonemura</i> sp.	0	0	1	0	0	0
<i>Taeniopteryx schoenemundi</i> (Mertens, 1923)	0	0	0	0	1	0
Trichoptera						
<i>Athripsodes albifrons</i> (Linnaeus, 1758)	0	0	1	0	0	0
<i>Chaetopteryx villosa</i> (Fabricius, 1798)	0	0	0	0	0	8
<i>Cheumatopsyche lepida</i> (Pictet 1834)	0	2	29	0	0	0
<i>Drusus</i> sp.	1	0	0	0	0	0
<i>Glossosoma</i> sp.	0	2	0	0	1	0
<i>Lepidostoma basale</i> (Kolenati, 1848)	0	0	0	0	4	0
<i>Oligopteryx maculatum</i> (Fourcroy, 1785)	0	0	0	0	1	0
<i>Odontocerum albicorne</i> (Scopoli, 1763)	0	1	0	0	1	0
<i>Helicopsyche bacescui</i> Orghidan and Botosaneanu, 1953	0	0	0	0	0	6
<i>Halesus digitatus</i> Curtis, 1834	0	17	4	0	0	0
<i>Hydropsyche botosaneanui</i> Marinković-Gospodnetić (1966)	0	0	0	0	6	0
<i>Hydropsyche instabilis</i> (Curtis, 1834)	0	2	24	14	0	0
<i>Hydropsyche</i> sp.	0	4	4	0	0	0
<i>Micrasema morosum</i> (McLachlan, 1868)	0	0	0	0	6	0
<i>Potamophylax luctuosus</i> (Piller & Mitterpacher, 1783)	3	41	5	0	4	0
<i>Polycentropus</i> sp.	0	0	0	5	0	0
<i>Philopotamus montanus</i> (Donovan 1813)	0	0	0	13	1	0
<i>Psychomyia pusilla</i> (Fabricius, 1781)	0	0	41	0	0	0
<i>Rhyacophila laevis</i> Pictet, 1834	0	0	0	0	3	0

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<i>Rhyacophila tristis</i> Pictet, 1834	0	0	0	0	1	0
<i>Rhyacophila</i> sp.	12	2	13	0	1	1
<i>Silo piceus</i> (Brauer, 1857)	0	2	0	9	30	0
<i>Silo</i> sp.	0	0	1	1	0	0
<i>Sericostoma flavicorne</i> Schneider, 1845	0	2	1	0	0	0
<i>Sericostoma personatum</i> (Kirby & Spence, 1826)	0	3	2	0	11	0
<i>Thremna anomalum</i> McLachlan, 1876.	0	0	0	0	0	2
<i>Wormaldia occipitalis</i> (Pictet, 1834)	0	0	0	0	1	0
Diptera						
<i>Antocha vitripennis</i> (Meigen, 1830)	0	2	7	1	0	0
<i>Atherix ibis</i> (Fabricius, 1798)	0	1	0	0	0	0
<i>Berdeniella</i> sp.	5	0	0	0	0	0
<i>Bezzia</i> sp.	0	0	2	0	0	0
<i>Dicronata bimaculata</i> (Schummel, 1829)	0	0	0	0	2	0
<i>Dixa</i> sp.	0	0	0	1	0	0
<i>Ibisia marginata</i> (Fabricius, 1781)	0	0	0	3	0	0
Chironomidae	0	10	0	7	0	3
<i>Brillia flavifrons</i> (Johannsen 1905)	0	0	0	0	2	0
<i>Brillia modesta</i> (Meigen, 1830)	0	0	0	0	1	0
<i>Diamesa insignipes</i> Kieffer, 1908	0	0	0	0	9	0
<i>Diamesa</i> sp.	17	0	0	0	1	0
<i>Eukiefferiella fittkau</i> Lehmann, 1972	116	12	0	0	0	0
<i>Eukiefferiella</i> sp.	0	0	0	2	0	0
<i>Micropsectra</i> sp.	0	0	0	0	0	5
<i>Nilotanypus dubius</i> (Meigen, 1804)	0	5	0	0	0	0
<i>Orthocladius thienemanni</i> Kieffer, 1906	0	0	0	0	187	0
<i>Orthocladius frigidus</i> (Zetterstedt 1838)	0	0	0	0	2	0
<i>Orthocladius</i> sp.	20	0	0	0	13	1
<i>Parametriocnemus stylatus</i> (Spärck, 1923).	0	1	0	3	0	0
<i>Polypedilum convictum</i> (Walker, 1856)	0	15	0	0	0	0
<i>Thienemanniella majuscula</i> (Edwards, 1924)	0	2	0	0	0	0
<i>Tvetenia calvescens</i> (Edwards, 1929)	3	0	0	0	3	1
<i>Tvetenia discoloripes</i> (Goetghebuer & Thienemann, 1936)	2	21	3	9	1	0
<i>Tanytarsus</i> sp.	0	4	0	0	0	0
Coleoptera						
<i>Pomatinus substriatus</i> (Müller, 1806)	0	0	1	3	1	0
<i>Hydraena gracilis</i> Germar, 1823	0	0	2	11	0	0
<i>Elmis</i> sp.	3	5	15	12	3	29
<i>Limnius volckmari</i> (Panzer, 1793)	0	0	3	0	0	0
<i>Limnius</i> sp.	0	2	7	0	0	0
<i>Orectochilus villosus</i> (O. F. Müller, 1776)	0	3	21	0	1	0
Number of taxa	23	40	37	23	45	17
Number of individuals	417	284	381	141	437	314

Looking at the absolute number of individuals, the most representative groups are Diptera (25.6%), Ephemeroptera (20.2%), Trichoptera (17.8%), and Plecoptera (12.7%). Other groups were numerically poorer, with an average percentage of less than 10% (Figure 4). The Chironomidae family (18 taxa) accounts for 95.2% of all individuals within the Diptera order.

Diversity indices for studied sites are shown in Table 2. The diversity of macroinvertebrate communities, measured by the Shannon index of general diversity, showed spatial variation ranging from 3.17 (Dojkinačka River) to 1.72 (Bigar Stream spring). Meanwhile, Simpson's Diversity Index exhibited a range from 0.73 (Bigar Stream spring) to 0.95 (Rakitska River) (Table 3).

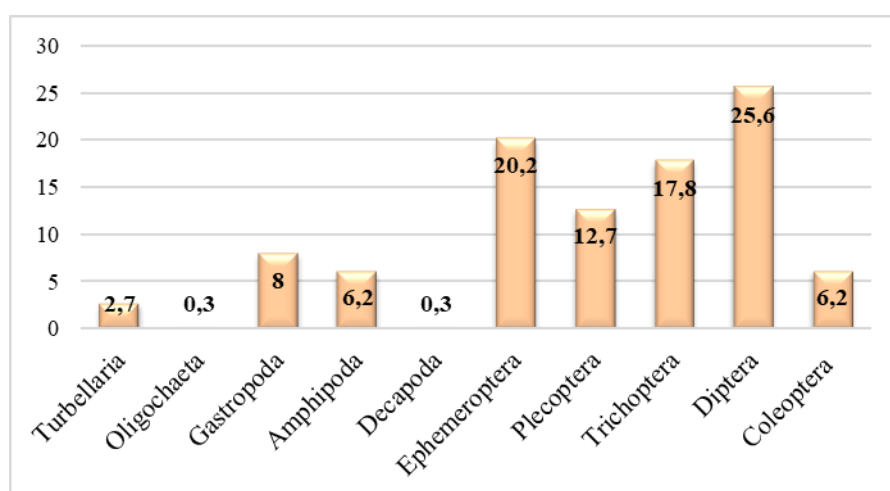


Figure 1. Percentage of individuals in each taxonomic group at the studied rivers and streams.



Figure 2. Macroinvertebrate diversity in the investigated sites is presented as the number of individuals, taxa richness, Shannon and Simpson's diversity indices.

The Stara Planina Mountains are recognized as one of Europe's most important biodiversity hotspots. However, the biogeographic patterns of its freshwater fauna, especially for macroinvertebrates, are poorly understood due to the lack of basic data on distribution and ecology, particularly for the Serbian side. We investigated the diversity of aquatic macroinvertebrates in the six watercourses on the Serbian side, recording 97 taxa. The observed community composition was as expected for this type of watercourse and is not significantly different from that typically found in hilly-mountainous rivers in the Balkan Peninsula region (Živić et al., 2005; Paunović et al., 2006; Petrović et al., 2015). The bottom fauna of these investigated watercourses is characterized by taxonomic richness and a vast diversity of insects. This is quite typical because these macrozoobenthos groups dominate highland rivers and streams. The water resources of the Stara Planina Nature Park are mostly preserved and represent water sources of high quality (class I or II), which are of national and regional importance for Serbia. This is supported by the recorded high level of Ephemeroptera, Plecoptera, and Trichoptera (EPT groups) taxa, which are sensitive to physical, chemical, and hydromorphological degradation (Moog et al., 2017). In the spring of the Jelovička River, insects dominated, such as *Protonemura nitida*, *Isoperla tripartita*, and *Eukiefferiella fittkai*, which are mostly cold-water stenothermal species that normally inhabit these habitats. In addition to insects, the benthic fauna in the studied springs was dominated by amphipods (*Gammarus balcanicus*) and gastropod (*Bythinella dispersa*) taxa, such as was the case in many other springs in Serbia and neighbors' regions (Marković et al., 1999; Dumnicka et al., 2007). The recorded abundant populations of *B. dispersa*, pollution-sensitive snails at the spring

of Bigar Stream, indicate favorable habitat conditions and a low level of anthropogenic pressures. The great diversity of insect larvae indicates that habitat conditions at the investigated sites (shallow and fast streams with a rocky and stony bed cover and minimum human impact) are more favourable for insects than for any other macrozoobenthic groups. This significant diversity is matched by relatively uniform and high Shannon and Simpson indices values on the Temštica, Visočica, Dojkinačka, and Rakitska rivers. The dominant species in the upper reaches of these four rivers were *Epeorus assimilis*, *Baetis rhodani*, *Rhithrogena semicolorata*, *Perla marginata*, as well as species of the genus *Rhyacophila* and *Hydropsyche*. Vánca et al. (2011) examined the Ephemeroptera fauna on the Bulgarian side of the Stara Planina Mountain, and their findings align with ours. Following the Appendix of the Book of Regulations regarding the identification and conservation of protected and strictly protected wild species of plants, animals, and fungi (Anonymous, 2010), we recorded the presence of three strictly protected species (*Austropotamobius torrentium*, *Thremma anomalum*, *Helichopsyche bacescui*).

The taxonomic richness and high diversity of macroinvertebrates in the Visočica and Temštica rivers were previously documented by Živić et al. (2005), recording the presence of 102 taxa. Compared to our study, the greater number of recorded taxa is attributed to sampling macroinvertebrates across a larger number of localities and throughout more seasons. Therefore, this one-time study should be extended to encompass a broader range of habitats and a longer observation period.

3. CONCLUSION

During our investigation, we documented a fauna typical of hilly-mountainous rivers and streams in the Balkan Peninsula region, with the domination of insects in both qualitative and quantitative community composition. Understanding the composition, distribution, and abundance of macrozoobenthos in mountain rivers is essential for effective river management and conservation efforts. Monitoring these organisms provides valuable data for assessing the impacts of human activities and climate change on freshwater ecosystems.

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COMPARATIVE VALIDATION OF THE GROUNDWATER LEVEL DETERMINATION METHOD

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ABSTRACT:

In this paper, a comparative validation of the method of determining the level of underground water was performed, using a tape level meter and a level meter with a sensor electrode, whose performance is in accordance with the criteria from AOAC (Association of Official Analytical Chemists) and Eurachem. Piezometer at Nikola Tesla Airport Belgrade Serbia and the piezometer at the location of the Sunoko sugar factory in Pećinci Serbia were chosen as measuring points for the validation of the method and the assessment of the measurement uncertainty of the groundwater level measurement. Based on the elements of validation such as repeatability, reproducibility, the contribution of the error of the measuring equipment, the accuracy of the calibrated scale, it was determined that the tape level meter has a measurement uncertainty of 3.36 %, while the sensor electrode level meter has a measurement uncertainty of 2.93%.

Keywords: *method validation, measurement uncertainty, groundwater level, level meter, field measurement*

1. INTRODUCTION

Groundwater is water that exists underground in saturated zones below the land surface. The upper surface of the saturated zone is called groundwater. Contrary to popular belief, groundwater does not form underground rivers. It fills the pores and cracks in underground materials such as sand, gravel and rocks and other materials, in the same way that water fills a sponge ie porous material. If groundwater flows naturally from the rock materials or if it can be removed by pumping (in useful quantities), and can be found in wells, underground tanks, underground reservoirs, piezometers, etc. places [1]. A piezometer is a vertical cylindrical object for regime observations of groundwater. In other words, it is a well of small diameter used for measuring the level of underground water, sampling water for physico-chemical tests. In addition to being observation objects during hydrogeological research for water supply needs, piezometers are often used in research and remediation of polluted sites [2]. Groundwater level measurement can be done using

a level meter. Water level indicators aka level meter are used to measure groundwater level and temperature in piezometric and well constructions. These instruments consist of a cable mounted on a reel containing a signal circuit and batteries, so that they are easily portable. A connector placed at the lower end of the cable, in contact with the water, closes the circular flow that activates the sound and light signal or it can be a tape with a precisely calibrated scale expressed in mm, cm and m. The validation elements are repeatability, reproducibility, error of the measuring equipment (bias) and the accuracy of the calibrated scale [4, 5, 6].

2. METHOD REQUIREMENTS AND RESULTS

As a requirement of the method in terms of precision, it is taken from A High-Accuracy and Power-Efficient Self-Optimizing Wireless Water Level Monitoring IoT Device for Smart City, <https://doi.org/10.3390/s21061936> [3] so the precision requirements are as follows:

Table 1. Maximum deviation of the estimated distances

Estimated Distance (cm)	Maximum Deviation (cm)	Percentage
100	0.8	0.8%
150	1.2	0.8%
200	1.6	0.8%
350	1.8	0.51%
400	2.6	0.65%
500	3.4	0.68%

The validation of the method was done in two days, by field measurement of the groundwater level at the locations Belgrade Airport and Pz Sunoko Pećinci. The following parameters were used to validate the method: precision in terms of repeatability and reproducibility. The following laboratory equipment was used during field measurement: level meter LABP-101 (sound level meter) and level meter LABP-102 (tape level meter) (Fig. 1 and Fig. 2). No chemicals were used in the verification process. The measurement results are directly read in cm and m.



Fig. 1. Level meter LABP-101 (sound level meter)



Fig. 2. Level meter LABP-102 (tape level meter)

Accuracy (in terms of repeatability) was done by measuring the level of underground water at the locations Belgrade Airport - Fuel Storage, 20.286485E 44.815835N. In order to determine the water level, it is necessary to make a minimum of 10 measurements (larger number of individual measurements). Using the same equipment and in a short period of time and received RSDr in % is:

Table 2. Precision in terms of repeatability

Level meter	RSDr (%)	Criterion (%)
LABP-101	0.25	0.68
LABP-102	0.20	0.68

Precision (in terms of reproducibility) was made on the basis of 10 parallel measurements at the location Pz Sunoko Pećinci - 19.9514854E 44.8882795N. Two field analysts were measuring the water level in 10 measurements each and the value of the relative standard deviation RSDr:

Table 3. Precision in terms of reproducibility

Level meter	RSDR (%)	Criterion (%)
LABP-101	0.50	0.80
LABP-102	0.54	0.80

The analysis of the contribution of all factors to the measurement uncertainty of the method, as well as the calculation of the combined and extended measurement uncertainty includes the contributions from Table 4:

Table 4. Evaluation of measurement uncertainty

Level meter	RSDr (%)	RSDR (%)	u (scale error) (%)	U Bias (%)	Uc (%)	U (%)
LABP-101	0.25	0.50	1.59	0.01	1.68	3.36
LABP-102	0.20	0.54	1.35	0.01	1.46	2.93

3. CONCLUSION

Based on the obtained validation results, it can be concluded:

- both level meters meet the criteria for RSD for repeatability and reproducibility
- the reading error from the scale of both level meters contributes the most to the combined measurement uncertainty
- bias originating from scale calibration and scale precision have the smallest share in the combined measurement uncertainty
- the tape level meter has a lower uncertainty than the sound level meter

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EMPIRICAL FORMULAS FOR DETERMINING THERMOPHYSICAL PROPERTIES OF PARAFFIN: A COMPARATIVE STUDY WITH EXPERIMENTAL DATA

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ABSTRACT:

This study delves into the empirical determination of thermophysical properties of paraffin, specifically focusing on its significance in latent heat energy storage applications. Inspired by similar methodologies employed in fuel oil studies, the research emphasizes the vital role of physical and chemical characteristics in engineering applications, impacting processes such as equipment design and material balances. Petroleum properties, particularly those of its fractions, are conventionally classified into two groups: those independent of temperature and those temperature-dependent, encompassing critical parameters like density, characteristic temperatures, and vapor pressure. Paraffin, derived from crude oil through extensive processing, stands out among these fractions due to its application in various industrial sectors, including energy, heating, and transportation. In this work, we present uncomplicated methodologies for calculating fundamental properties of unspecified petroleum fractions, with a focus on paraffin, a complex mixture primarily composed of hydrocarbons. The properties under consideration include molar mass, density, heat capacity, thermal conductivity, critical parameters, and boiling point. These calculations leverage easily measurable or commonly known parameters, such as standard density and normal boiling temperature, often expressed in terms of API density and Watson's characterization factor. Given the growing importance of paraffins in latent heat energy storage, this study aims to contribute significantly by 1) comparing empirical expressions for determining their thermophysical properties with experimental and literature data and 2) developing thermodynamic tables for paraffins based on selected expressions and data. The accurate knowledge of these properties is imperative for optimal functioning in production facilities within the petroleum industry, and this research aims to provide practical and efficient methods to enhance the engineering analysis and design of processes involving paraffins.

Keywords: energy storage, paraffin, thermal properties

1. INTRODUCTION

Paraffins, a type of hydrocarbon, are known for their ability to store latent heat energy efficiently. Their molecular structure allows them to undergo phase changes, such as solid to liquid and vice versa, while absorbing or releasing significant amounts of energy in the process. This property makes paraffins ideal candidates for latent heat energy storage applications, where they can store thermal energy during melting and release it upon solidification. Various studies have highlighted the effectiveness of paraffins in latent heat storage systems due to their high latent heat of fusion and wide range of melting temperatures. Moreover, research, such as that referenced in [1] and [2], has demonstrated the viability of utilizing paraffins for thermal energy storage in diverse applications ranging from solar heating to building climate control, offering sustainable and efficient solutions for managing energy demand and enhancing overall system performance.

2. MATHEMATICAL MODEL

The provided mathematical model presents a comprehensive framework for understanding hydrocarbon fluids' thermophysical properties, with a focus on density and its relation to crucial parameters like boiling temperature. Density, pivotal in industrial processes such as oil refining, varies with temperature, pressure, and composition. The model characterizes standard density, typically referenced at temperatures like 15°C or 60°F, alongside specific gravity (SG) for material comparison, often against water. Equations within the model facilitate SG calculation and its conversion to API degree, a standard measure in the petroleum industry. Additionally, the model addresses boiling temperature's significance, offering equations to predict it based on molar mass and density. This enables precise manipulation of fluid behavior across temperature ranges, aiding engineers and researchers in their endeavors.

2.1. Parameters for modeling thermophysical properties

The first important parameter is the relative density of hydrocarbon, which is determined by the following expression [3,4]:

$$SG = \frac{\rho_{15^\circ}}{\rho_{w15^\circ}}, \quad (1)$$

Based on the water properties, it amounts to:

$$SG = \frac{\rho_{15^\circ}}{998.95}.$$

Density according to the API degree is determined by the expression [3,4]:

$$^\circ API = \frac{SG}{141.5} - 131.5 \quad (2)$$

Watson characterization factor is an indicator of the proportion of aromatic hydrocarbons in a mixture, where higher factor values correspond to higher content of saturated and paraffinic components. The value of k_w is usually in the range of 10 to 13, but smaller and

larger values are not uncommon. For example, benzene has a characterization factor $k_w=10.0$, while hexane has a value of $k_w=12.8$.

For an unknown composition of hydrocarbons, the following expression can be used [3,4,5]:

$$k_w = \frac{(1.8 \cdot T_b)^{1/3}}{SG}, \quad (3)$$

where "T_b" denotes the boiling temperature in K.

2.2. Molar Mass

For calculating the molar mass (M, kg/kmol) in the range of T_b = 38 to 455°C and M = 70 to 300 kg/kmol, an equation is provided in reference [6].

$$M = 1.66069 \cdot 10^{-4} \cdot T_b^{2.1962} \cdot SG^{-1.0164}, \quad (4)$$

In reference [7], it was established that equation (4) provides good results even for higher temperatures. Reference [8] states that correlation (4) is accurate for heavy fractions (C₅₀) with M=200÷700 kg/kmol. According to [9], in the range of T_b=300÷850K and M=70÷700 kg/kmol, an equation is provided.

$$M = 42.965 \cdot T_b^{1.26007} \cdot SG^{4.98308} \cdot \exp(2.097 \cdot 10^{-4} \cdot T_b - 7.78712 \cdot SG + 2.08476 \cdot 10^{-3} \cdot T_b \cdot SG), \quad (5)$$

or according to [10]

$$M = 12277.6 + 9486.4 \cdot SG + (8.3741 - 5.9917 \cdot SG) \cdot T_b + (1 - 0.77084 \cdot SG - 0.02058 \cdot SG^2) \cdot (0.7465 - \frac{222.466}{T_b}) \cdot \frac{10^7}{T_b} + (1 - 0.80882 \cdot SG + 0.02226 \cdot SG^2) * \left(0.3228 - \frac{17.335}{T_b}\right) \cdot \frac{10^{12}}{T_b^3}. \quad (6)$$

Other reserachers suggested the relations [1]:

$$M = \frac{0.01077 \cdot T_b^m}{\rho_{20} / \rho_{w,4}}, \quad (7)$$

$$m = 1.52896 + 0.06486 \cdot \ln\left(\frac{T_b}{1078 - T_b}\right), \quad (8)$$

Watson's characterization parameter can also be determined based on the known molar mass [12]:

$$k_w = 4.5579 \cdot M^{0.15178} \cdot SG^{-0.84573}. \quad (9)$$

3. NORMAL BOILING TEMPERATURE

For the case of a known composition of a mixture of n components, the volumetric average boiling temperature can be determined through the mass fractions of individual components x_i as [3,4]:

$$t_b = \sum_{i=1}^n x_i \cdot t_{b,i}. \quad (10)$$

The boiling temperature can also be determined based on the known molar mass and density for heavy fractions as [6,13]:

$$T_b = 9.3369 \cdot M^{0.5369} \cdot SG^{-0.7276} \exp(1.6514 \cdot 10^{-4} \cdot M + 1.4103 \cdot SG - 7.5152 \cdot 10^{-4} \cdot M \cdot SG), \quad (11)$$

and

$$T_b = 10.7128 - 9.417 \cdot 10^4 \cdot M^{-0.03532} \cdot SG^{3.266} \exp(-4.922 \cdot 10^{-3} \cdot M - 4.7685 \cdot SG + 3.462 \cdot 10^{-3} \cdot M \cdot SG). \quad (12)$$

These methods will be used for the confirmation of the molar mass value.

3.1. Determining thermophysical properties.

This article will present equations for calculating the following liquid properties:

- Density;
- Thermal conductivity (λ , W/(m·K));
- Kinematic viscosity (ν , m²/s);
- Specific heat capacity (c_p , J/(kg·K));
- Enthalpy of vaporization (Δh , kJ/kmol).

3.3. Density

The density of hydrocarbons for different temperatures can be determined by the expression [14]:

$$\frac{\rho_t - \rho_{15^\circ}}{t - 15} = -(2.34 - 0.0019 \cdot \rho_t). \quad (13)$$

3.4. The coefficient of thermal conductivity

The coefficient of thermal conductivity depending on temperature can be determined using the known density at 15°C from the expression [15]:

$$\lambda = \frac{117}{\rho_{15^\circ}} \cdot (1 - 0.00054 \cdot t). \quad (14)$$

and [16],

$$\lambda = 0.164 - 1.277 \cdot 10^{-4} \cdot T. \quad (15)$$

In recent times, equation has emerged in [17]:

$$\lambda = 2.54 \cdot \left(\frac{SG}{T}\right)^{0.5} - 0.0144. \quad (16)$$

which the authors correlated for mixtures in the range $T_b=347.6\div 749.8$ K and $SG=0.7310\div 1.1733$.

The deviations in the values for the thermal conductivity coefficient are determined by the maximum possible deviations obtained based on other methods for determining thermophysical properties provided by the literature.

3.5. The kinematic viscosity

The kinematic viscosity of hydrocarbons (ν) in [mm²/s] depending on temperature can be determined from the following expression If the viscosity ν_{ref} (in mm²/s) is known at the temperature T_{ref} (in K) [3,4,18]:

$$\ln \ln(\nu + 0,8) = \ln \ln(\nu_{ref} + 0,8) - 3,7 \cdot \ln\left(\frac{T}{T_{ref}}\right). \quad (17)$$

For the case when only the boiling point is known, the expression is given by [4,8]

$$\ln \ln(\nu + 0,8) = 0.3408 \cdot T_b^{0,5} + 13.4729 - 3.7 \cdot \ln(T), \quad (18)$$

or also [4,18]:

$$\ln \ln(\nu + 0,8) = 4.3414 \cdot (T_b \cdot SG)^{0,2} + 6.6913 - 3.7 \cdot \ln(T). \quad (19)$$

The deviation for the value of kinematic viscosity is determined by the maximum possible deviation obtained based on the above two mentioned methods.

3.6. Specific heat capacity

The specific heat capacity of hydrocarbons depending on temperature is determined from the equation [19]:

$$c_p = \frac{1684 + 3.389 \cdot t}{\sqrt{SG}} \cdot 10^{-3}. \quad (20)$$

In [5], the following equation is provided:

$$c_p = (2916 - 1331 \cdot SG + (6.142 - 2.306 \cdot SG) \cdot t) \cdot (0.055 \cdot k_w + 0.35), \quad (21)$$

and also [4,16],

$$c_p = A_1 + A_2 \cdot T + A_3 \cdot T^2 \quad (22)$$

Where coefficients A_1 , A_2 and A_3 are determined in the function of k_w and SG . The deviations for determining the values of specific heat capacity are determined by the maximum possible deviations obtained based on other methods for determining thermophysical properties provided in the literature.

3.7. The heat of vaporization

The heat of vaporization or condensation according to Trouton's rule states that the heat of vaporization Δh is equal to [3,4]:

$$\Delta h = 0.88 \cdot T_b \quad (23)$$

in kJ/kmol.

According to [9], the heat of vaporization or condensation in the range of $T_b = 27 \div 343^\circ \text{C}$ and $M = 70 \div 300 \text{ kg/kmol}$ is:

$$\Delta h = 9.76157 \cdot T_b^{1.14086} \cdot SG^{0.00977089} \quad (24)$$

A more recent source [20] states that for the range of $T_b = 231.3 \div 722.8 \text{ K}$ and $M = 44.094 \div 422.82 \text{ kg/kmol}$, a more suitable equation is:

$$\Delta h = T_b(9.549 + 14.811 \cdot \ln T_b + 12.346 \cdot \frac{T_b}{M} - 0,06662 \frac{T_b^2}{M} + 7.833 \cdot 10^{-5} \cdot \frac{T_b^3}{M} + 19.334 \cdot \ln SG) \quad (25)$$

3.8. Flashpoint temperature

The flashpoint temperature of a pure hydrocarbons can be estimated from the equation [21,22]:

$$t_F = 0,683 \cdot t_b - 71,7 \quad (26)$$

In 1988, a general correlation was proposed by Patil for estimation of closed cup flash point of organic compounds from their normalboiling points [23]:

$$T_F = 4.656 + 0.844 \cdot T_b + 0.000234 \cdot T_b^2 \quad (27)$$

Hshieh developed a correlation for closed cup flashpoint with normal boiling points for organic compounds after analysing data for 494 compounds [22,24]:

$$t_F = -54.5377 + 0.5883 \cdot t_b + 0.00022 \cdot t_b^2 \quad (28)$$

The correlation coefficient is 0.966 with standard error of estimate is 11.66°C .

3.8. Pour point temperature

The pour point of a [liquid](#) is the [temperature](#) below which the liquid loses its flow characteristics. It is defined as the minimum temperature in which the oil has the ability to pour down from a beaker. In [crude oil](#) a high pour point is generally associated with a

high [paraffin](#) content, typically found in crude deriving from a larger proportion of plant material. The pour point can be estimated as [25]:

$$t_{pp} = 234.85 \cdot SG^{2.970566} \cdot M^{0.61235-0.473575 SG} \cdot \nu^{0.310311 - 0.32834 SG} \quad (29)$$

Where the pour point of petroleum fraction is in R, SG is at 60 F/60 F and kinematic viscosity is at 100 F in cst.

4. RESULTS

Paraffin wax refers to a mixture of alkanes (saturated hydrocarbons) with the general molecular formula C_nH_{2n+2} . For Paraffin wax usually, n is within a range of 18 – 32, and the solidification point for hard Paraffin wax is between 50-60°C [26].

For the analysis and comparison the following properties of paraffine were adopted (Tab. 1).

Table 1. Thermal and physical properties of observed of paraffine EC 232-315-6 [26-30]

	Sources value	Adopted
Density at 15°C ρ [kg/m ³]	790-940	860
Boiling temperature t_b [°C]	>300, >370	>370°C
Kinematic viscosity ν at 99°C [mm ² /s]	2.70-5.82	2.70
Flesh point t_f [°C]	113-240	176
Specific heat capacity c [kJ/kgK]	2.14-2.9	2.52
Melting point t_M [°C]	50-60	60
M [kg/kmol]	300-550	352

The average value of the molar mass calculated according to the eq. is $M=307.8$ kg/kmol, with standard deviation of 14.7 i.e. under 5%. The recalculated value of by. eq (3) and (11) and (12) and t_b is in the range 369.9 to 382°C which confirms the methodology for molar mass.

The following properties of the paraffin were calculated above the melting point at the temperatures above 60°C.

Table 2. Thermophysical properties

t [°C]	ρ [kg/m ³]	Pr [-]
60	825.3	85.3
100	788.4	41.3
150	731.8	22.6

Table 3. Thermal conductivity [W/(mK)]

t [°C]	Method 1	Method 2	Method 3	Av.	St. Dev [%]
60	0.121	0.131	0.115	0.123	6.95
100	0.116	0.129	0.108	0.118	9.02
150	0.110	0.125	0.100	0.112	11.2

Table 4. Kinematic viscosity [mm²/s]

t [°C]	Method 1	Method 2	Method 3	Av.	St. Dev [%]
60	4.92	5.66	7.73	6.10	23.9
100	2.34	2.61	3.29	2.75	17.8
150	1.25	1.36	1.62	1.41	13.4

Table 5. Heat capacity [kJ/(kgK)]

t [°C]	Method 1	Method 2	Method 3	Av.	St. Dev [%]
60	2.09	2.11	2.03	2.08	1.9
100	2.26	2.28	2.18	2.24	2.4
150	2.47	2.49	2.36	2.44	2.8

Table 6. Latent heat [kJ/kmol] and [kJ/kg]

Method 1 [kJ/kmol]	Method 2 [kJ/kmol]	Method 3 [kJ/kmol]	Av. [kJ/kmol]	Av. [kJ/kg]	St. dev
56.6	58.1	68.4	61.0	0.19	10.6

Table 7. Closed cup flashpoint temperature [°C]

Method 1	Method 2	Method 3	Av.	St. Dev
181	193.2	177.5	183.9	8.3

The determined flashpoint temperature calculated for clean substance according to eq. 27 to 29 is 183.9°C which is close to value in Tab 1.

5. DISCUSSION

The analysis of diverse models for predicting paraffin wax properties offers crucial insights into hydrocarbon fluid behavior, vital for industries like cosmetics and pharmaceuticals. Density and boiling temperature values align with paraffin wax norms, with a calculated average molar mass of 307.8 kg/kmol showing consistent reliability, albeit within a standard deviation of 14.7. Recalculated boiling temperatures validate molar mass accuracy, affirming model robustness.

Thermophysical properties at temperatures above the melting point (60°C) depict expected trends, with density decreasing and thermal conductivity, kinematic viscosity, and specific

heat capacity showing consistent variations. Despite low variability in predicted values, kinematic viscosity presents slightly higher deviation. Method 3 aligns well with candle wax properties, while methods 1 and 2 lean towards paraffin viscosity's lower limits.

Average latent heat (61.0 kJ/kmol) calculated through different methods indicates minimal variability, suggesting high model agreement. These results furnish comprehensive insights into paraffin wax behavior, crucial for industries reliant on it, such as manufacturing and product development, facilitating process optimization and quality enhancement.

Flashpoint values are consistent, but pour point estimation (21°C) diverges significantly from expected values (50-60°C), indicating potential adjustments in molar mass and viscosity predictions to better align with empirical data.

6. CONCLUSIONS

Practical applications of the model are demonstrated through the analysis of paraffin wax properties. By comparing adopted values with experimental data, the efficacy of the model in predicting thermophysical properties is validated. The calculated values show good agreement with data from the literature from, confirming the reliability of the model for industrial applications for determining paraffine properties, although some additional observations considering pour point, *i.e.* viscosity and molar mass should be conducted.

In conclusion, the mathematical model presented in this paper offers a robust framework for understanding and predicting the thermophysical properties of hydrocarbon fluids. Its comprehensive approach to characterizing fluid behavior facilitates informed decision-making in various industrial processes, particularly in the oil and gas industry. Further research and application of the model hold promising potential for advancing paraffine analysis and their application as heat storages.

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***MEDICAL, BIOMEDICAL AND PHARMACEUTICAL
SCIENCES***

INVESTIGATION OF THE INHIBITORY ACTIVITY OF FURANOCOUMARIN DERIVATIVES IN KAMPO EXTRACT MEDICINES ON THE ENZYME VITAMIN K EPOXIDE REDUCTASE RESPONSIBLE FOR ANTICOAGULANT EFFECT

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ABSTRACT:

The present study aimed to evaluate the inhibitory effect of natural furanocoumarin coumarin derivatives, namely isoimperatorin (IsoIMP), oxypeucedanin (OXY), oxypeucedanin hydrate (OXYh), imperatorin (IMP), heraclenin (HERn) and heraclenol (HERl) which were isolated from Kampo Extract Medicines, on human enzyme Vitamin K epoxide reductase (VKOR) through molecular docking simulation. VKOR is a crucial enzyme located in the endoplasmic reticulum (ER) membrane. It plays a vital role in the carboxylation process of blood coagulation enzymes, which is dependent on vitamin K. Warfarin (WF) is a commonly used oral anticoagulant that belongs to the category of vitamin K antagonists (VKA). Based on the values of Gibbs binding energies (ΔG_{bind} , kcal mol⁻¹), the inhibitory potential against the VKOR enzyme decreases in the following order: isoIMP (-8.61) > HERn (-8.46) > OXY (-8.43) > IMP (-8.33) > OXYh (-8.24) > HERl (-7.18). All investigated compounds exhibit almost identical, although slightly lower, inhibitory effects towards the VKOR enzyme in comparison to WF (-9.71). Upon comparing the characteristics of the ADMET (Absorption, Distribution, Metabolism, Excretion, and Toxicity) analysis, it is evident that the investigated compounds, which exhibited the potent inhibitory effect against VKOR enzyme, possess a superior pharmacological profile in comparison to WF. In summary, the examined compounds exhibit a strong inhibitory activity to the VKOR enzyme, low toxicity levels, and have a structural similarity to commercial anticoagulants. These characteristics make them suitable for further research and potential use as commercial anticoagulants.

Keywords: anticoagulant, furanocoumarins, ADMET, molecular docking, Kampo Medicines

1. INTRODUCTION

Blood coagulation, a fundamental process crucial for wound healing, can pose significant health risks if not properly regulated. The formation of blood clots, while essential for preventing excessive bleeding, can lead to severe complications such as deep vein thrombosis, pulmonary embolism, stroke, or heart attack when occurring improperly [1-3]. To manage clot-related conditions and prevent their progression, anticoagulants play a pivotal role in clinical practice. These drugs target various aspects of the coagulation cascade, including the activity of key enzymes like thrombin and the function of clotting factors [3].

Among them, Vitamin K epoxide reductase (**VKOR**) stands out as a critical enzyme responsible for the posttranslational modification of coagulation factors. **VKOR**, primarily targeted by oral anticoagulants known as Vitamin K antagonists (**VKA**), plays a central role in the activation of vitamin K-dependent clotting factors [4]. One of the most widely used **VKAs** is warfarin (**WF**), which inhibits **VKOR**, thereby disrupting the formation of functional vitamin K-dependent receptors and rendering coagulation factor molecules inactive [5]. This mechanism underscores the importance of understanding the inhibitory effects of various compounds on **VKOR** activity, particularly in the context of developing new anticoagulant therapies.

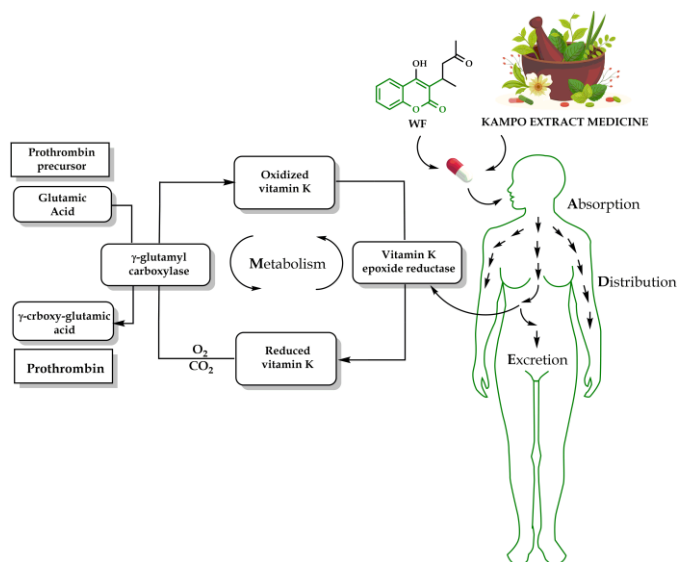


Fig. 2. Illustrative presentation of the role of key pharmacokinetic parameters in the framework ADMET (*Absorption, Distribution, Metabolism, Excretion, and Toxicity*) analysis and inhibitory effect (disruption of vitamin K cycle) of Warfarin (**WF**) according to Vitamin K epoxide reductase (**VKOR**)

Coumarin derivatives, including furanocoumarins, are known for their diverse biological activities, including their role in anticoagulation in the pharmaceutical industry. These derivatives are often present in plants of the *Rutaceae* and *Umbelliferae* families [6]. Some herbal remedies in the *Umbelliferae* family, such as *Byakushi*, *Kyokatsu*, *Boufu*, and *Hamaudo*, are used as components of Kampo extract medicines [7]. *Kampo* medicines were approved for use by the National Health Insurance System in Japan in 1976 and are widely utilised for treating various conditions, including cancer, dementia, metabolic diseases like obesity and diabetes, hypertension, neuralgia, and dysmenorrhea [8]. While *Kampo* medicines are increasingly embraced in medical practice, their therapeutic effects have not been thoroughly understood, warranting a greater accumulation of information to promote evidence-based medicine.

Therefore, the main objective of this study is to evaluate the inhibitory potential of natural furanocoumarin coumarin derivatives: isoimperatorin (**IsoIMP**), oxypeucedanin (**OXY**), oxypeucedanin hydrate (**OXYh**), imperatorin (**IMP**), heraclenin (**HERn**) and heraclenol (**HERl**), isolated from Kampo Extract Medicines, on human **VKOR** through molecular docking simulation (Figure 2) [9]. All furanocoumarins utilized in this research were obtained from herbal remedies (*Kyokatsu*, *Byakushi*, and *Boufu*) and purified in-house, ensuring a purity level exceeding 99%. *Senkyu-cha-cho-san* and *Sokei-kakketsu-to*, granule Kampo extract medicines containing herbal remedies from the *Umbelliferae* family, were sourced from Tsumura and Co. (Tokyo, Japan) [9]. At the same time, other reagents were commercially available and of analytical grade.

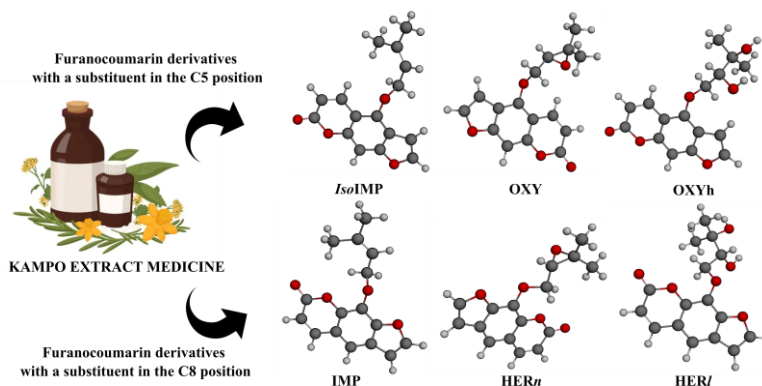


Fig. 2. Three-dimensional representation of geometries of investigated compounds isolated from KAMPO extract medicine. Legend: grey - carbon, red - oxygen, white - hydrogen.

By evaluating the binding energies of these compounds, the study aims to identify promising candidates for further research as potential anticoagulants. Through a comprehensive analysis of their inhibitory effects and pharmacological profiles, the study sheds light on the potential of these compounds as alternative anticoagulant agents. The findings not only contribute to our understanding of **VKOR** inhibition but also offer insights into the development of safer and more effective anticoagulant therapies.

2. METHODOLOGY

To determine the binding affinity and inhibitory potential of the investigated compounds towards the **VKOR** protein Autodock 4.2 software in combination with the Lamarckian Genetic Algorithm was used [10]. The parameters determined for the LGA method were the following: maximum of 250000 energy evaluations, 27,000 generations, and mutation and crossover rates of 0.02 and 0.8, respectively. The Kollman partial charges and polar hydrogens were added using AutoDockTools. The flexibility of the ligands/complexes was taken into account, while the protein remained a rigid structure. Molecular docking investigations consist of several sequential stages, including protein identification and preparation, ligand preparation, and grid formation. The structures of the studied compounds were optimized using the *Gaussian 16* software package [11] in combination with the B3LYP-D3BJ method and the 6-311++G(d,p) basis set [12]. The 3D X-ray crystallographic structure of **VKOR** (PDB code 6WV3) [13] receptor with warfarin was retrieved from the RCSB Protein Data Bank. Before performing a molecular docking study of investigated compounds with the receptor structures, the co-crystallized water molecules as well as ligands from the binding sites were removed using Discovery Studio 4.0 [14]. The search space of **VKOR** was restricted to a grid box size of 40 × 40 × 40 Å following the XYZ dimensions: -9.827 × 26.818 × 55.760 with a grid spacing of 0.375 Å. The other docking parameters were selected using the standard protocols which are further described in our previous research [15,16]. ADMETlab 2.0 web [17] server was used to determine the toxicity profile and important pharmacokinetic properties of ADMET (Absorption, Distribution, Metabolism, Excretion, Toxicity) analysis

3. RESULTS AND DISCUSSION

3.1. Inhibitory activity against VKOR enzyme- molecular docking study

Table 2 presents the obtained results of the thermodynamic parameters of interest, derived from the molecular docking study.

Table 1. Important thermodynamic parameters (kcal mol⁻¹) for the most stable conformations of investigation compounds in the active site **VKOR** determined after molecular docking simulation

Comp.	ΔG_{bin} <i>d</i>	K_i (μ M)	ΔG_{inter}	ΔG_{vdw+h} <i>bond+desolv</i>	ΔG_{elec}	ΔG_{total}	ΔG_{tor}	ΔG_{unb}
VKOR– IsoIMP	-8.61	0.49	-9.51	-9.46	-0.05	-0.53	0.89	-0.53
VKOR– OXY	-8.46	0.66	-9.33	-9.26	-0.07	-0.41	0.89	-0.41
VKOR– OXYh	-8.24	0.91	-10.03	-9.90	-0.13	-1.84	1.79	-1.84

VKOR-IMP	-8.33	0.78	-9.22	-9.20	-0.02	-0.77	0.89	-0.77
VKOR-HER_n	-8.46	0.63	-9.36	-9.28	-0.08	-0.50	-0.89	-0.50
VKOR-HER_I	-7.18	5.42	-8.97	-8.86	-0.11	-2.20	1.79	-2.20
VKOR-WF*	-9.71	0.76	-11.20	-11.05	-0.16	-1.03	1.49	-1.03
*Ref. [18]								

Through the analysis of thermodynamic parameters, especially Gibbs binding energies (ΔG_{bind} , kcal mol⁻¹), it becomes evident that the inhibitory potential against the **VKOR** enzyme diminishes in the subsequent sequence: **isoIMP** (-8.61 kcal mol⁻¹) > **HER_n** (-8.46 kcal mol⁻¹) > **OXY** (-8.43 kcal mol⁻¹) > **IMP** (-8.33 kcal mol⁻¹) > **OXY_h** (-8.24 kcal mol⁻¹) > **HER_I** (-7.18 kcal mol⁻¹). All tested compounds exhibit similar inhibitory activity to the standard, effective, and commercially utilised anticoagulant **WF** (-9.71 kcal mol⁻¹).

Figure 3 illustrates the structures of the most stable conformations of the investigated compounds within the **VKOR** enzyme. Analyzing the binding modes and interactions of these compounds in the active site of the **VKOR** enzyme is crucial for comprehending the inhibitory activity of the investigated furanocoumarin derivatives. The amino acid residue A:ASN 222 forms a conventional hydrogen bond with the oxygen atom of the compounds **IsoIMP** (1.93 Å), **OXY** (1.89 Å), **IMP** (2.12 Å), and **HER_n** (2.05 Å) through the hydrogen atom of the -NH₂ group. Additionally, amino acid residues A:SER 165, A:SER 223, A:LEU 262, and A:TYR 281 contribute to the stabilisation of the studied compounds **OXY_h** and **HER_I** in the active site of **VKOR** enzyme by forming conventional hydrogen bonds with the polar oxygen atoms of these compounds.

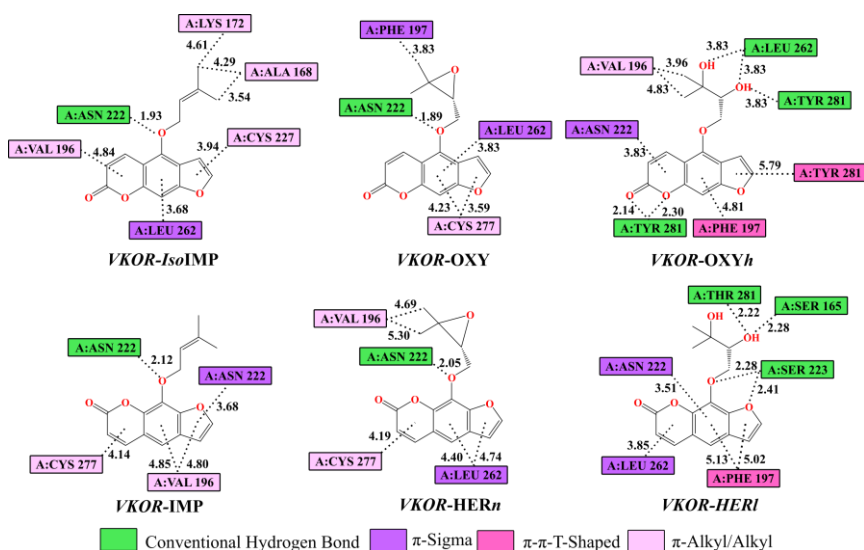


Fig. 3. Two-dimensional depiction of interactions between investigated compounds and amino acid residues in the active site of the Vitamin K Epoxide Reductase (**VKOR**, PDB code: 6WV3) with interatomic distance (Å) obtained after molecular docking simulation. Different colours represent various types of interactions as shown in the legend.

Aside from conventional hydrogen bonds, hydrophobic interactions also significantly contribute to the binding affinity of the investigated compounds to the enzyme's active site. Amino acid residue A:ASN 222 forms π -sigma interactions with the aromatic rings of compounds **OXYn** (3.83 Å), **IMP** (3.68 Å) and **HERI** (3.51 Å). A specific π - π -T interaction occurs between the aromatic rings of the amino acid A:PHE 197 and the compounds **OXYn** (4.81 Å) and **HERI** (5.02 and 5.13 Å). Finally, the investigated compounds form hydrophobic π -Alkyl/Alkyl contacts with amino acid residues A:ALA 168, A:LYS 172, A:VAL 196 and A:CYS 277 in the enzyme's active site of the **VKOR** enzyme. These contacts have larger interatomic distances and make a smaller contribution to the overall stabilisation and affinity of the compounds for active sites.

3.2. ADMET analysis

ADMET analysis is a crucial component of the process of discovering and developing drugs. It involves studying the absorption, distribution, metabolism, elimination, and toxicity of a drug. Pharmacokinetics and pharmacodynamics are assessed to evaluate the viability of a compound for drug development. ADMET analysis is a thorough examination of the compound's "fate" in the organism, encompassing its administration, delivery, breakdown, and elimination.

The absorption of a potential drug denotes its entry into the systemic circulation of the organism. To reach this stage, an oral drug must traverse intestinal cell membranes through passive diffusion, carrier-mediated processes, or active transport. Human colon adenocarcinoma (Caco-2) cell lines, serving as a surrogate for human intestinal epithelium, are commonly employed to assess *in vivo* drug permeability due to their morphological and functional resemblance. A compound with a Caco-2 value exceeding -5.15 cm/s is deemed to possess good permeability through epithelial cells. All compounds tested in this study demonstrate favourable penetration through Caco-2 cell epithelium, with the investigated isolated derivatives **OXYh** and **HERI** exhibiting superior penetration compared to the standard anticoagulant **WF** (Table 2).

The Madin-Darby Canine Kidney Cells (MDCK) model serves as an *in vitro* test for assessing drug permeability in biomedical research, representing a benchmark for evaluating absorption efficiency. A compound is deemed to exhibit good permeability if its value exceeds 2×10^{-6} cm/s. Based on this criterion, all investigated compounds show favourable absorption in the human body, with compounds **OXY**, **HERn**, and **HERI** showing better permeability than **WF** (Table 2).

Human Intestinal Absorption (HIA) is a crucial determinant of an oral drug's effectiveness. HIA values range from 0 to 1, with compounds scoring 0-0.3 considered to possess good intestinal absorption (> 30%). The isolated compounds demonstrate superior intestinal absorption compared to **WF** (Table 2).

The distribution of a drug in the body, a crucial aspect of ADMET analysis, is typically characterized by parameters such as plasma protein binding (PPS%), fraction unbound (Fu), and volume distribution (VD). Drug distribution primarily involves binding to serum proteins and transport throughout the body. A PPS% value exceeding 81.85% indicates high protein association, prompting further investigation into specific transport proteins like Human Serum Albumin (HSA).

Volume distribution (VD) is a theoretical concept relating the administered dose of a drug to its concentration in circulation, crucial for understanding *in vivo* distribution. An optimal VD value falls within the range of 0.04-20 L/kg, indicating efficient distribution throughout the organism. All compounds, except **OXYh**, exhibit higher distribution based on the VD parameter (Table 2). A higher VD value compared to **WF** offers several potential advantages. It facilitates wider distribution, leading to faster therapeutic onset and reduced risk of accumulation and side effects. Additionally, a shorter duration of action results in milder and shorter-lasting side effects, potentially enhancing safety and patient tolerance.

Table 2. Estimated parameters of ADMET analysis – absorption and distribution of investigated compounds

Comp.	Absorption					Distribution		
	Caco-2p (cm s ⁻¹)	MDCK (cm s ⁻¹)	HIA	F _{20%}	F _{30%}	PPB %	Fu %	VD (L kg ⁻¹)
IsoIMP	-4.761	2.1×10 ⁻⁵	0.006	0.02	0.99	83.98	10.70	0.978
OXY	-4.775	2.6×10 ⁻⁵	0.005	0.03	0.98	87.81	10.37	0.941
OXYh	-4.914	2.2×10 ⁻⁵	0.032	0.22	0.94	84.55	15.43	0.664
IMP	-4.693	2.0×10 ⁻⁵	0.008	0.01	0.70	81.85	10.73	0.903
HERn	-4.671	2.6×10 ⁻⁵	0.007	0.01	0.69	85.49	9.02	0.947
HERl	-4.939	2.5×10 ⁻⁵	0.033	0.03	0.36	82.86	13.39	0.823
WF*	-4.862	2.2×10 ⁻⁵	0.036	0.01	0.07	96.08	6.75	0.740
*Ref. [18]								

The metabolism of the investigated compounds is a crucial aspect of ADMET analysis (Table 3). The human cytochrome P450 family, comprising 57 isoenzymes primarily located in the liver, metabolizes a significant portion of pharmaceuticals. The main enzymes involved, including 1A2, 3A4, and 2C9, handle the metabolism of over 80% of drugs. All compounds exhibit activity towards these key enzymes, indicating their involvement in the metabolic pathways (Table 3). Generally, all investigation compounds demonstrate superior inhibitory properties compared to WF, whereas WF serves as a better substrate for these enzymes. The half-life of a drug (T_{1/2}) combines clearance and volume of distribution effects, with values in the range of 0.0-0.3 indicating rapid elimination from the body. However, all compounds show slow elimination based on the values in Table 3.

Table 3. Estimated parameters of ADMET analysis - metabolism and elimination of investigated compounds

Comp.	Metabolism; P450						Elimination	
	1A2		3A4		2C9		T _{1/2} h	CL mL min ⁻¹ kg ⁻¹
	I	S	I	S	I	S		
<i>IsoIMP</i>	0.986	0.522	0.644	0.202	0.623	0.843	0.180	13.699
OXY	0.976	0.795	0.303	0.459	0.416	0.616	0.191	10.730
OXY_h	0.921	0.573	0.058	0.327	0.140	0.702	0.388	11.209
IMP	0.989	0.240	0.660	0.148	0.669	0.638	0.497	14.685
HER_n	0.969	0.693	0.587	0.258	0.344	0.139	0.442	12.520
HER_l	0.894	0.336	0.283	0.205	0.417	0.279	0.707	11.919
WF*	0.881	0.958	0.061	0.368	0.541	0.933	0.791	0.554
*Ref. [18]								

The toxicity assessment of newly synthesized compounds is the final step in ADMET analysis. The hERG gene-encoded voltage-gated potassium channel is crucial for cardiac depolarization and repolarization. Blockade of hERG can lead to cardiac disorders such as palpitations, fainting, or even sudden death. All investigated compounds exhibit identical values within the 0.0-0.3 interval, indicating no cardiotoxic effects (Table 4).

Drug-induced liver damage poses a significant risk to patient safety, often resulting in the withdrawal of drugs from the market. Values greater than 0.3 for H-HT suggest potential hepatotoxicity for all compounds including **WF** (Table 4).

The AMES test, assessing mutagenic potential by detecting mutations in bacterial DNA, is indicative of carcinogenicity. All tested compounds, except **IMP** (0.364), have values ranging from 0.0 to 0.3 and do not exhibit mutagenicity.

Table 4. Estimated parameters of ADMET analysis toxicology of investigated compounds

Comp.	hERG	H-HT	AMES
<i>IsoIMP</i>	0.08	0.907	0.069
OXY	0.19	0.170	0.065
OXY_h	0.09	0.173	0.024
IMP	0.037	0.952	0.364
HER_n	0.032	0.435	0.191
HER_l	0.024	0.341	0.150
WF*	0.012	0.811	0.028
*Ref. [18]			

3. CONCLUSION

The molecular docking study and comprehensive ADMET analysis conducted in this study provide valuable insight into the potential of various furanocoumarin derivatives isolated from Kampo extract medicines as potential anticoagulant agents. Thermodynamic parameters obtained from molecular docking reveal their inhibitory potential against the **VKOR** enzyme, with *isoIMP* showing the highest affinity. Structural analyses elucidate key binding modes and interactions within the enzyme's active site, essential for understanding their inhibitory activity. Notably, hydrogen bonding and hydrophobic interactions play significant roles in compound binding. In addition, the investigation of absorption, distribution, metabolism, and elimination highlights favourable pharmacokinetic properties of the compounds. They demonstrate good permeability through intestinal epithelial cells and absorption in the human body, with enhanced distribution compared to the standard anticoagulant, warfarin (**WF**). Metabolism studies indicate involvement with key cytochrome P450 enzymes, suggesting potential metabolic pathways. Despite slow elimination, the compounds show no cardiotoxic effects but raise concerns regarding hepatotoxicity. In conclusion, the investigated furanocoumarin derivatives exhibit promising inhibitory activity against the **VKOR** enzyme, favourable pharmacokinetic profiles, and acceptable toxicity profiles, positioning them as potential candidates for further development as anticoagulants. However, further studies, particularly *in vivo* evaluations, are warranted to confirm their efficacy and safety for clinical use.

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COMPARATIVE ANALYSIS OF THE CHEMICAL COMPOSITION OF POTENTILLA REPTANS L. AERIAL PART AND RHIZOME

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ABSTRACT:

Potentilla reptans L. belongs to the Rosaceae family, genus Potentilla, and is a native species of Eurasia. The most common compound found in the rhizome is catechin, while the aerial parts contain chinic acid, caffeic acid and 5-O-caffeocholic acid, along with other constituents that contribute to its unique composition. Potentilla species have been traditionally used for the treating purulent facial eczema and buccal ulcerations. They are applied topically for mouth ulcers, throat inflammation and wound-healing, and are also used internally for jaundice and dysentery. In traditional medicine Potentilla species have been employed for the treatment of hepatitis, rheumatism, scabies, diarrhea, viral infections and as a remedy for detoxification in cases of purulent facial eczema and buccal ulcerations.

The aim of this study was to compare the chemical compositions of aqueous extracts from the rhizome and aerial part of P. reptans collected during the summer in central Serbia. We determined the content of several major groups of components in both herbal samples, including total flavonoids, phenols, and total procyanidins. The levels of total phenols and procyanidins were found to be higher in the rhizome compared to the aerial part. These findings suggest that the characterization of aqueous extracts from different parts of P. reptans confirms that traditional medicinal uses of this plant which should not be disregarded.

Keywords: *Potentilla reptans L, flavonoids, phenols, procyanidins*

1. INTRODUCTION

Potentilla reptans (*P. reptans*) is one of approximately three hundred *Potentilla* species that belong to the *Potentilla* Genus, within the Rosaceae family. The *Potentilla* genus is primarily characterized by perennial, and more rarely biennial or annual herbaceous plants (1). *P. reptans* is a perennial herbaceous plant with an erect rhizome. The stem is herbaceous, thread-like, creeping, and can grow up to 100 cm in length, while the leaves have five or seven lobes. This species is typically found near shores, in wet meadows, and in flood-prone areas (2). *Potentilla* species have long been integrated into the traditional medicinal practices and cultures across Europe, Asia and North America. For example, *Potentilla erecta* is officially recognized in the pharmacopoeias of various European countries and was historically utilized to treat purulent facial eczema and oral ulcerations. These plants were predominantly prepared as water or alcoholic extracts, applied topically for mouth sores, throat inflammation, and wound healing, or administered orally for jaundice and dysentery. Traditional medicine, and also sporadically employed *Potentilla* species to address hepatitis, rheumatism, scabies, diarrhea, viral infections, and as detoxifying agent (1). Moreover, *P. erecta*, *P. anserina* and *P. reptans* were included in homeopathic pharmacopoeias for the production of homeopathic remedies. Despite this widespread traditional usage, a comprehensive investigation of the phytochemistry and pharmacology of this genus remains incomplete. Clinical studies on *P. erecta* rhizome extracts have, however, yielded positive results in the treatment of ulcerative colitis and viral diarrhea in children (2,3). Some compounds, primarily flavonoids, phenolic acids, especially catechin in rhizome and chinic acid, caffeic acid and 5-O-caffeoylquinic acid, have been identified in the aerial parts of *P. reptans* (1). Animal models have been utilized to assess the antibacterial and antioxidant activities of *P. reptans*, yet data concerning the chemical composition and pharmacology of its underground parts are lacking (4,5). The aim of this study was to compare the chemical composition of *P. reptans* aerial part and rhizome grown in Serbia.

2. MATERIAL AND METHODS

P. reptans was collected from the Sumadija region of Serbia during the period between June - August 2023 (for the aerial parts) and in August of the same year (for the rhizome). Extracts of the aerial part and rhizome were obtained using the Soxhlet method (6). The collected plant material was dried in the shade. Separate aqueous extracts were prepared by extracting the aerial parts and rhizome of *P. reptans*. Fifty grams of dried, milled plant parts were extracted using 500 mL of distilled water (6). The dry extracts were then obtained by evaporation under reduced pressure (RV05 basic IKA, Germany).

2.1. Determination of the total phenols

The determination of the total phenol content was performed according to the standard method described by Singleton et al. (7). The reagents used included Folin-Ciocalteu's reagent (FC) (from Fisher Scientific, UK), anhydrous Na₂CO₃ (from Analytika, Czech Republic) and gallic acid (from Sigma Aldrich, Germany) as the standard. The absorbance was measured at 760 nm after 120 min of sample preparation. The total phenol compound content in the examined extracts was expressed as mg of gallic acid equivalents (GA) per gram of dry extract weight.

2.2. Determination of procyanidins

The content of procyanidins was calculated using the method described in the European Pharmacopoeia 6.0 (10) and expressed as equivalents of cyanidin chloride. The reagents used were butanol (BuOH) (from POCH, Poland) and cyanidin-chloride (from Carl Roth, Germany). The absorbance was measured at 550 nm by spectrophotometer (Cecil CE 2021) (8). The procyanidin content the extracts was expressed as mg of cyaniding chloride equivalents (C) per gram of dry extract weight.

2.3. Determination of flavonoids

The flavonoid content was calculated using the aluminum chloride colorimetric method the reagents used were AlCl₃ X 6H₂O, CH₃COONa X 3H₂O (from Centrohema, Serbia), quercetin (from Sigma-Aldrich, Germany), and methanol (MeOH) (from J.T. Baker, USA) (9). Quercetin was used as the standard. The absorbance was measured at 415 nm after 30 min. All samples were prepared in triplicate and the mean values for flavonoid content were expressed as milligrams of quercetin equivalents per gram (Q) of dry extract weight calculated according to the standard calibration curve.

2.4. Evaluation of antioxidative activity

The investigated plant extracts were tested using the DPPH assay according to the method described by Soler-Rivas et al. (10). The materials used included DPPH (from Fluka, Switzerland), butylated hydroxytoluene (BHT) (from Alfa Aesar, USA), butylated hydroxyanisole (BHA) (from Merck, Germany), dimethyl sulfoxide (DMSO) (from SigmaAldrich, Germany). The absorption at 515 nm was measured using a microplate reader after 60 min (Multiskan Spectrum, Thermo Corporation). Synthetic antioxidants (BHT, BHA, PG, quercetin and rutin) were used as positive control. The radical-scavenging capacity (RSC) was calculated by the equation:

$$\text{RSC} = 100 - (A_a - A_{\text{corr}}) / A_{\text{control}} \times 100$$

where A_a = average absorbance of the probes for a given concentration sample level; A_{corr} = correction of extract absorbance (with no reagents); A_{control} = absorbance of the DPPH

radical (with no extract). The extract concentration which causes 50% of DPPH inhibition (IC₅₀), was calculated from the RSC concentration curve.

3. RESULTS AND DISCUSSION

We have identified the contents of the three main components phenols, flavonoid, and procyanidin in both samples.

Quantitative phytochemical analysis of major compounds found in the rhizome and aerial part of *P. reptans* is presented in Table 1

Table 1. Quantitative phytochemical analysis of aqueous extracts of *P. reptans* rhizome (PR) and aerial part (PA) (the mean value ± SD of three measurements).

Active constituents	PA	PR
Total phenols (mg of GA _a /g)	278.0 ± 0,25	732.4 ± 0,8
Flavonoid content (mg of Q _b /g)	35.5 ± 0,8	14 ± 0,3
Procyanidin content (mg of C _c /g)	5,8 ± 0.35	120.4 ± 0,3

„GA = gallic acid, „Q = quercetin, „C = cyanidin chloride

Table 2. DPPH free radical scavenging activity of the *P. reptans* extracts aerial part (PA) and rhizome (PR).

Sample	IC _{50a} (∞g/mL)
PA	15.28 ± 0.358
PR	4,89 ± 0.572
BHT	10.75 ± 1.255
BHA	2.31 ± 0.128

„The mean value ± SD of three measurements

Both examined extracts showed DPPH activity. The rhizome showed better activity than the aerial part, weaker than the BHA standard, while it was better than BHT standard. The aerial part showed the weakest activity among all the tested samples.

Phenolic and flavonoid compounds play a key role in the expression of antioxidant properties of plants. The presence of these groups of compounds actively participates in the therapy and prevention of many diseases such as cancer, cardiovascular diseases, etc. The rhizome extract of *P. reptans* is two and half times richer in total phenols than aerial part of the same plant, while the flavonoid content is twice as high in the aerial part compared to the rhizome (table 1). The amount of procyanidins is significantly higher in the rhizome of the plant than in the aerial part. Also, the rhizome of *P. reptans* has a higher amount of procyanidins (120.4 g/kg of dry weight) than the rhizome of *P. alba* (80 g/kg of dry weight). Comparing our results with the results of other plants of the *Potentilla* species, we found that the aerial part of *P. reptans* is richer in total phenol content than *P. fruticosa*, while the same sample has the lowest amount of procyanidins among the compared species (11). The DPPH method is one of the most commonly used methods in defining antioxidant activity (12). The rhizome of *P. reptans* has three times greater activity than the aerial part, as well as a slightly higher activity than the BHT standard. The DPPH analysis values show that the aerial part has the weakest activity among all the analyzed

standards. Previous studies have shown that total phenols affect antioxidant activity, which is also confirmed by our research (13,14). It is noticeable that the presence of procyanidins, which have lately attracted the attention of nutrition and medicine as potent protective antioxidants for human health, may also contribute to the antioxidant action of the rhizome since a significantly higher content of procyanidins was found in the rhizome of *P. reptans* than in the aerial part (15).

4. CONCLUSION

The study showed that the aerial part and rhizome of *P. reptans* are a good source of secondary metabolites such as total phenols, flavonoids, and procyanidins. The rhizome is richer in total phenols and procyanidins, while the aerial part is richer in flavonoids. Both extracts showed moderate antioxidant activity. The results obtained by characterizing the aqueous extracts of the rhizome and aerial part of *P. reptans* confirm the traditional medicinal use of this plant.

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REPRESENTATION OF BACTERIAL INFECTIONS IN THE HUMAN POPULATION OF MACVA DISTRICT

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ABSTRACT:

The aim of this study was to determine the most common bacterial infections in the human population on the territory of the Mačva district and to examine the existence of antibiotic resistance among them. Due to their frequency, the necessary use of antibiotics and the increased costs of treatment, bacterial infections represent a current and one of the most prevalent problems in modern medicine. According to microbiological analyzes conducted in the Health Laboratory in Šabac, during 2022, various causative agents of human infections were registered. The presence of bacteria was determined in different types of materials, using standard microbiological methods. A total of 107700 samples were analyzed, of which 60.92% of the isolates were from population of Mačva district.

In 67.24% of punctate samples, were present coagulase-negative staphylococci, Enterococcus spp. (20.69%) and Naisseria spp. (12.07%). Staphylococcus aureus had dominant participation in infections of the throat (56.06%), skin (37.96%), nose (36.32%), wounds (24.43%), sputum (21.66%) and tongue (19.92%). A high rate also has a Klebsiella spp. Which were recorded in sputum (34.47%), oral swabs (73.33%) and wound swabs (14.15%). In addition, Streptococcus pneumoniae, Haemophilus spp., Escherichia coli and beta-hemolytic streptococci were also important causes of bacterial infections in the human population.

The results of the disc diffusion antibiogram method showed resistance to ampicillin, penicillin G and amoxicillin in the range of 19.8% - 33.2%, in Staphylococcus aureus isolates.

Keywords: antibiotics, bacteria, infection, resistance.

1. INTRODUCTION

The high frequency of bacterial infections represents a major threat to public health problem worldwide especially for immunocompromised people. Bacterial infections are health issues that result from the growth and activity of bacteria or their toxins within various parts of the human body. These infections can manifest in various forms, such as urinary tract infections, bloodstream infections, skin, throat, nose, ear, or sinus infections, bacterial pneumonia, food poisoning, and some sexually transmitted infections. Bacterial toxins can penetrate tissues and cells, potentially causing damage to organs and, in severe cases, even death. Disease can be caused by the organism itself or by the body's response to its presence. Bacteria are transmitted to humans through air, water, food, or living vectors (Doron & Gorbach, 2008). There are five principal modes by which bacterial infections may be transmitted: contact, airborne, droplet, vectors, and vehicular (contaminated objects such as food, water, and fomites).

It is crucial to identify and treat bacterial infections promptly to prevent complications and protect overall health.

All of the human organs are susceptible to bacterial infection. It is well known that toxins produced by bacteria can cause damage to tissues, cells, and organs, leading to severe health consequences or even death in some cases. It should be emphasized that not all bacterial infections will have a fatal outcome. The severity of an infection depends on various factors, including the type of bacteria, the patient's immune system, and the presence of any underlying health conditions. Early detection and appropriate treatment can significantly reduce the risk of severe complications. According to Šuljagić & Mirović (2006), the death rate of patients with bacterial blood infections included in the study was 44.9%. Milovanović & Nikolić (2017) showed that the incidence of bacterial infections is 4 to 5 times higher in patients with liver cirrhosis compared to the general population, while mortality is 3.75 times higher in patients who develop a bacterial infection. By reviewing the most common causes of bacterial infections, Jarvis & Martone (1992) determined that five pathogenic species were most often associated with the occurrence of viral infections: *Escherichia coli* (13.7%), *Staphylococcus aureus* (11.2%), *Enterococcus* spp. (10.7%), *Pseudomonas aeruginosa* (10.1%) and coagulase-negative staphylococcus (9.7%). A survey of the prevalence of infection-related deaths in 2019 worldwide reported that 7.7 million deaths were associated with 33 bacterial pathogens. Five leading pathogenic species - *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus pneumoniae*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* - were responsible for 54.9% of deaths among the bacteria studied [GBD 2019]. In 2019, most deaths occurred as a result of bacterial lower respiratory tract infections, bloodstream infections, and peritoneal and intra-abdominal infections.

Among the top causes of mortality in the world, lower respiratory infection is the third most common and diarrhea is the sixth. Both are often caused by bacteria. Tuberculosis is the seventh most common cause of death. Prevention is especially important in this age of increasing antibiotic resistance, because treatment can be so difficult to achieve. There are three major principles of control of bacterial infection: Eliminate or contain the source of infection, interrupt the chain of transmission, and protect the host against infection or disease. In addition, there is increasing recognition that the elimination of important cofactors, such as air pollution from vehicles or indoor cooking, can markedly reduce the

incidence of bacterial infections. Which measure is most effective often depends on the reservoir for the infection. Prevention of infection, e.g., through a vaccine, is generally called primary prevention, treatment of infected people to prevent symptomatic infection is called secondary prevention, and treatment of infected people to prevent transmission to other humans is called tertiary prevention.

This study presents comprehensive estimate presence of bacterial infections highlighting their importance and impact.

2. MATERIAL AND METHOD

The research was conducted by collecting the results (from January to December 2022.) of microbiological analyses, which included the isolation and identification of bacterial pathogens of different materials and the determination of their sensitivity to antibiotics using the antibiogram method. The analysis was performed in the Zdravlje Health Microbiology Laboratory in Šabac based on instructions from the primary level health care institution. The research included bacterial isolates that were isolated using standard microbiological methods from a urine culture, throat swab, nose swab, wound swab, tongue swab, oral cavity swab, sputum and punctate. Antibiotic susceptibility testing was performed using the disk-diffusion method on Mueller-Hinton agar (antibiogram method). The inoculum is prepared by diluting an 18-24-hour pure bacterial culture in a saline solution. The suspension is vortexed and then the density of the suspension is adjusted by comparison with the 0.5 McFarland standard for turbidity. After that, the inoculum is sown on the surface of the substrate and then antibiogram tablets or discs are placed on the surface using a dispenser or sterile tweezers. Growth inhibition zones were read according to the recommendations of Eucast (European Committee on Antimicrobial Susceptibility Testing). Susceptibility to: penicillin G, ampicillin, amoxicillin, amoxicillin-clavulonic acid, cephalexin, cefazolin, cefaclor, ceftriaxone, tetracycline, tigecycline, erythromycin, clindamycin, gentamicin, amikacin, tobramycin, ofloxacin, ciprofloxacin, levofloxacin, trimethoprim-sulfonamide, cefprozil was tested. , cefuroxime, cefadroxil nitrofurantoin, ampicillin sulfbactam, meropenem, fosfomycin, colistin, piperacillin, imipenem, ceftazidime, piperacillin-tazobactam, vancomycin and aztreonam. The obtained results were processed using descriptive statistics of the Microsoft Excel program.

3. RESULTS AND DISCUSSION

The results of the research, which included 107.700 patients, in the period from January to December, 2022, are shown in Table 1.

Table 1. Microbiological findings of samples of human origin

	Samples type	Number of analyzed samples	Percentage of samples from Mačva district
1.	Throat swab	6286	3555 (56,55%)
2.	Nose swab	16095	9058 (56,28%)
3.	Wound swab	12218	8083 (66,16%)
4.	Oral cavity swab	68	45 (66,18%)
5.	Tongue swab	1267	758 (59,83%)

6.	Skin swab	2769	1420 (51,28%)
7.	Urine cultures	67449	41697 (61,82%)
8.	Sputum	1490	937 (62,88%)
9.	Punctate	58	58 (100%)
Total:		107700	65611 (60,92%)

Based on the data shown in the table, it can be seen that the representation of samples from Mačva district in the total number of analyzed samples was 60.92%. Urine cultures had the highest representation in the total number of tested samples with 62.62%, of which 61.82% of the samples were from the territory of the Mačva district.

The smallest representation in the total number of tested samples was punctate samples with 0.05%. All of these samples (100%) were from the territory of Mačva district.

The results shown on Fig. 1 represent the most frequently isolated pathogens from urine cultures: *Enterococcus* spp. (10.55%), *Escherichia coli* (57.92%) and *Klebsiella* spp. (13.80%). Our results are comparable to the results of the study by Đorđević et al., 2016, who analyzed the frequency of outpatient urinary tract infections. The most frequently isolated causative agents of urinary infections among them were *E. coli* (56.6%), followed by *Klebsiella* spp. (16.2%), *Proteus* spp. (14.68%), *Enterococcus* spp. (5.3%) and *Pseudomonas aeruginosa* (3.7%). Similar results on the presence of bacteria in urine cultures were published by Lazarević et al., 2022, based on which the bacterium *E. coli* was more often isolated in women (82.7%), while *P. aeruginosa* was more present in men (76.1%). *Klebsiella* spp. and *Enterococcus* spp. occurred almost equally in both sexes (Lazarević et al., 2022). The results of Marković et al., 2007, show that *E. coli*, as the most common causative agent, was represented by 53.24% in urine samples, while *Klebsiella pneumoniae* was isolated from 7.71% of urine samples.

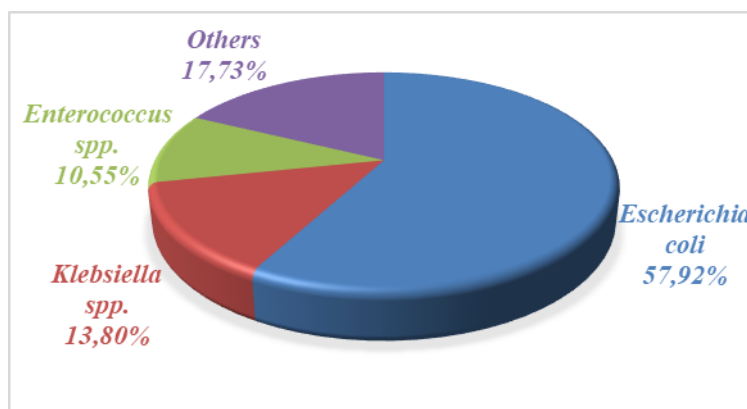


Fig. 1. The most common isolates from urine culture

The study of the oral cavity swab samples (Fig. 2) showed that *Klebsiella* species were present in the highest proportion, accounting for 73.33% of the cases. *Escherichia coli* was found in a lower prevalence of 26.67%. These findings provide valuable information

about the microbial composition in the oral cavity and may contribute to better understanding oral health and associated issues.

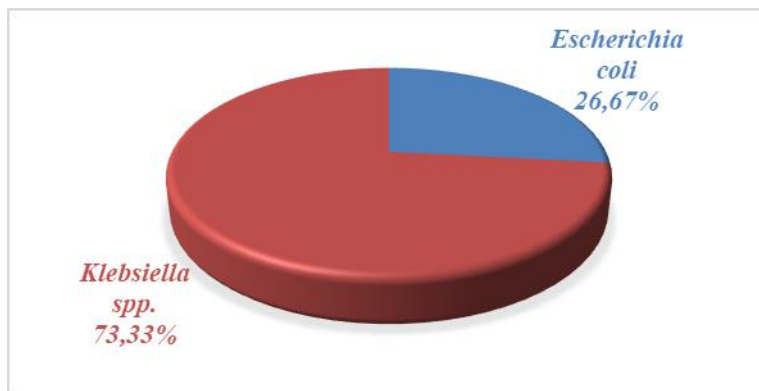


Fig. 2. The most common isolates from swab of the oral cavity

Based on the information provided through the Fig. 3, *Staphylococcus aureus* appears to be the most common bacterial species among the isolates, making up 58.70% of the total samples. This highlights its importance in studied materials. Additionally, beta-hemolytic streptococci (SBH) are also found in significant quantities, representing 36.93% of the bacterial population.

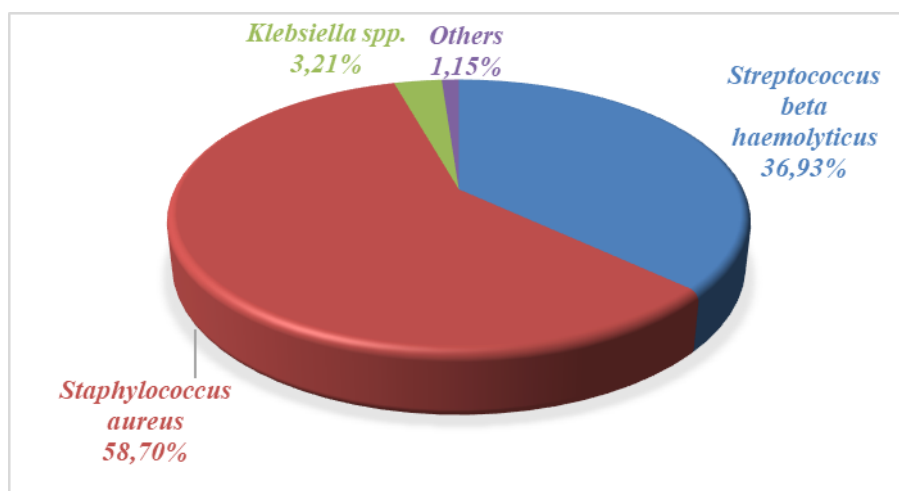


Fig. 3. The most common isolates from throat swab

S. aureus is probably the most important pathogenic species because of its intrinsic virulence, its ability to cause a variety of life-threatening infections, and its adaptive capacity to adapt to different environmental conditions (Lowy 1998; Waldvogel 2000).

Mortality as a result of bacteremia caused by *S. aureus* has remained at a level of 20-40% on average, despite the availability of effective antibiotics (Mylotte et al. 1987). Similar results were obtained by analyzing the presence of bacterial infections in nasal swabs (Fig. 4). In addition to *S. aureus* (36.32%), representatives of *Streptococcus pneumoniae* (15.51%) and *Haemophilus* spp. (13.22%).

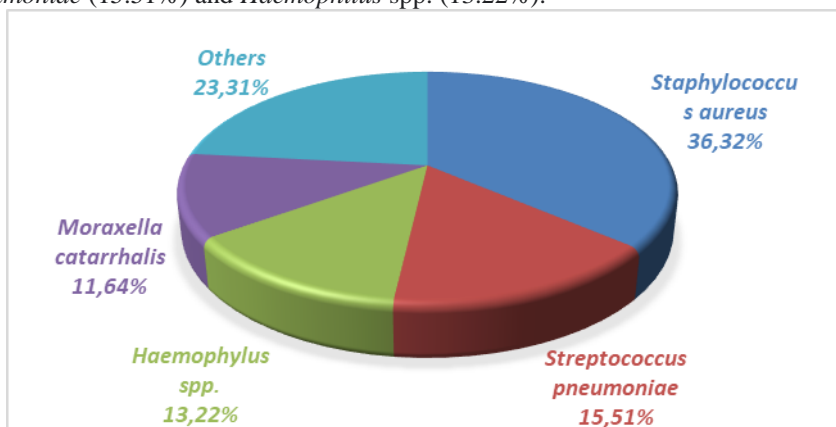


Fig.4. The most common isolates from nasal swabs

The results of the examination of bacterial infections in wound swabs are shown in Fig. 5. The most prevalent pathogens in wound swabs in the examined period were: *S. aureus* (24.43%), *Klebsiella* spp. (14.15%), *Escherichia coli* (9.38%) and *Enterococcus* spp. (8.84%).

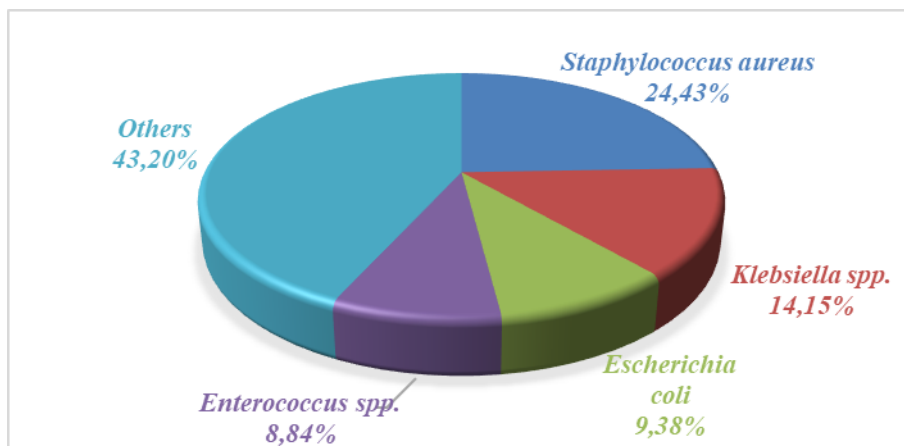


Fig. 5. The most common isolates from wound swabs

Numerous data from the literature indicate the presence of different bacterial species in wound swabs (Bowler 2007; Bessa et al. 2015; Ilić 2020). Research on the most common causes of wound infections has shown that the most common contaminants are bacteria

from the genus *Staphylococcus* (Ilić A. 2020), while the results of Bessa et al. 2015 show that the most frequently detected bacteria are *S. aureus* (37%), followed by *Pseudomonas aeruginosa* (17%), *Proteus mirabilis* (10%), *Escherichia coli* (6%) and *Corynebacterium* spp. (5%). Widespread opinion in practice is that pathogenic representatives such as *Staphylococcus aureus*, *Pseudomonas aeruginosa* and beta-hemolytic streptococci are primarily responsible for impaired healing and infections in acute and chronic wounds (Bowler et al. 2002). According to Jarvis & Martone, 1992; John & Barg 1996, *S. aureus* is the most common cause of surgical site infections, followed by respiratory tract infections (16.1%) and blood infections (16.5%).

As with other causes of bacterial infections, *S. aureus* has developed resistance to antibiotics over time. In this sense, the most important strains today are those that are less sensitive to methicillin (MRSA) and vancomycin (VRSA) (Šuljagić & Mirović, 2006). The most frequently isolated bacterial species from skin swabs (**Fig. 6**) were *Staphylococcus aureus* (37.96%) and coagulase-negative staphylococci (23.38%).

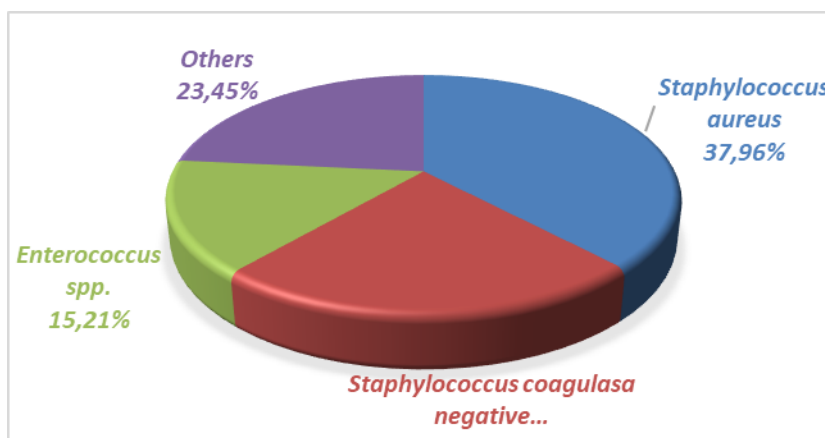


Fig. 6. The most common isolates from skin swabs

The most frequently isolated bacterial species from tongue swabs (**Fig. 7**) were *Klebsiella* spp. (30,74%), *E. coli* (23,09%) and *Staphylococcus aureus* (19,92%).

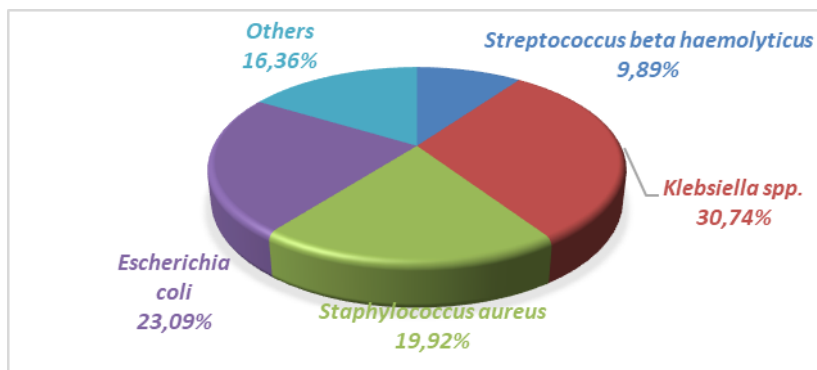


Fig. 7. The most common isolates from tongue swabs

Analysis of the results to determine the presence of certain bacterial species in sputum resulted in **Fig. 8**. The most frequently isolated pathogens from sputum are: *Klebsiella spp.* which were represented by 34.47%, *S. aureus* 21.66% and *E. coli* 20.17%.

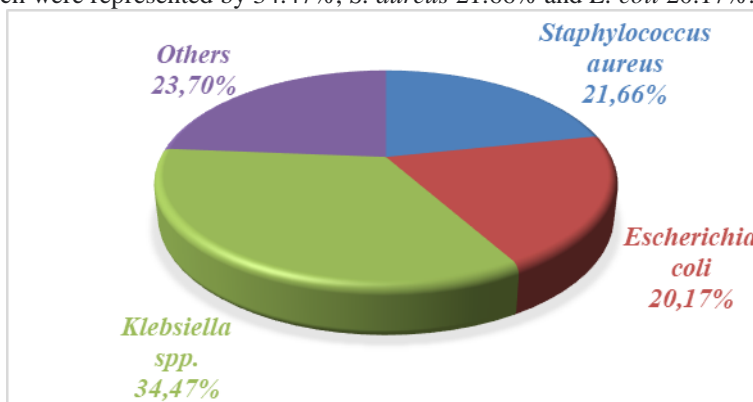


Fig. 8. The most common isolates from sputum

The results obtained by examining the presence of bacteria in the punctate (**Fig. 9**) show that the most frequently isolated causative agents of the disease from this material are coagulase-negative staphylococci representatives (67.24%), *Enterococcus spp.* (20.69%) and *Neisseria spp.* (12.07%).

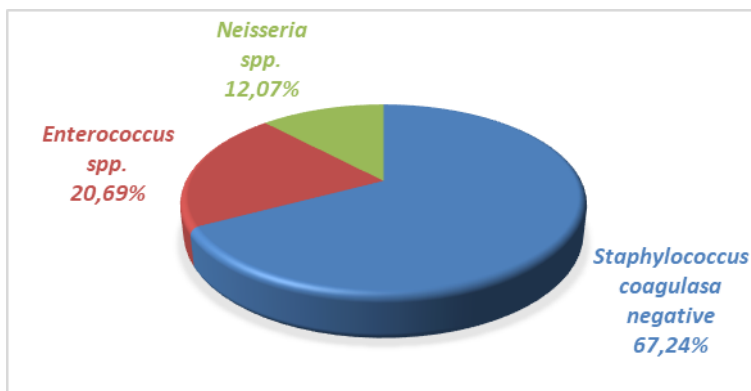


Fig. 9. The most common isolates from punctate

From the presented results it can be seen that the causative agents of bacterial infections were determined in all types of analyzed materials.

In this study, the most common bacterial isolates were: *S. aureus*, *Escherichia coli*, *Enterococcus spp.* and *Klebsiella spp.*

Staphylococcus aureus, which people typically carry on their skin or mucus membranes, often causes skin and soft tissue infections, but also spreads readily throughout the body via the bloodstream and can cause infection of the lungs, abdomen, heart valves, and almost any other site. The disease can be caused by the destruction of the body's cells by the organism or the body's immune response to the infection. Antibiotics may be of little or no use when the disease manifestations are a result of the body's attempts to rid itself of the bacteria. Systemic inflammatory response syndrome (SIRS), usually caused by a bacterial infection, is an overwhelming inflammatory response to infection, manifested by the release of large numbers of cytokines and presenting with signs of infection and early signs of hemodynamic instability. If allowed to progress, SIRS patients can go on to develop sepsis, with multiorgan failure and death. Once the cascade of events has begun, even the strongest antibiotics are often powerless to stop this progression. Our results of the disc diffusion antibiogram method showed resistance to ampicillin, penicillin G and amoxicillin in the range of 19.8% - 33.2%, in *Staphylococcus aureus* isolates.

3. CONCLUSION

Bacterial infections have a large impact on public health. Infections of the urinary and upper respiratory tract, as well as wounds, had the highest prevalence in the observed period. *Enterococcus spp.*, *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella spp.* are the most frequently isolated bacteria.

Bacterial infections have long been an underestimated cause of global health burden, calling for urgent strengthening of prevention strategies. The study puts in spotlight the crucial importance of access to treatment with effective antibiotics for all health systems.

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INTERACTION OF DINUCLEAR PLATINUM(II) COMPLEXES WITH PHENANTHROLINE AS A BRIDGING LIGANDS WITH HUMAN SERUM ALBUMINE

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ABSTRACT:

Mononuclear platinum(II) complexes used in medicine as antitumor agents showed a number of different problems in the application such as toxic effect, the appearance of resistance and a limited spectrum of action. Because of that, polynuclear platinum(II) complexes are under current investigation as a new class of antitumor agents with potential clinical applications. Two dinuclear Pt(II) complexes with 1,7-phenanthroline (1,7-phen) and 4,7-phenanthroline (4,7-phen) as the bridging ligands and ethylenediamine (en) as bidentate coordinated diamine ligand, $[\{Pt(en)Cl\}_2(\mu-1,7-phen)]^{2+}$ and $[\{Pt(en)Cl\}_2(\mu-4,7-phen)]^{2+}$, were synthesized and their *in vitro* cytotoxic activity were tested [1]. Results of investigation of cytotoxic activity against two tumor cell lines (human breast carcinoma (MDA-MB-231) and mouse breast carcinoma (4T1) cells), and one healthy cell line (human fibroblasts cells (MRC-5)) showed that platinum(II) complexes had good cytotoxic activity. Complex $[\{Pt(en)Cl\}_2(\mu-1,7-phen)]^{2+}$ had stronger selectivity toward MDA-MB-231 and 4T1 breast carcinoma cells in comparison to cisplatin [1]. Further, in this paper interactions of $[\{Pt(en)Cl\}_2(\mu-1,7-phen)]^{2+}$ and $[\{Pt(en)Cl\}_2(\mu-4,7-phen)]^{2+}$ complexes with human serum albumin (HSA) were investigated by UV-Vis spectrophotometry and fluorescence spectroscopy. Results indicate that investigated platinum(II) complexes bind to HSA through dynamic process. Also, competitive interactions between platinum(II) complexes and site markers ibuprofen (IB) and eosin Y were performed.

Keywords: platinum(II) complexes, phenanthroline, HSA, ibuprofen, eosin Y

1. INTRODUCTION

The antitumor effect of cisplatin is conditioned by the binding of the complex to DNA nucleobases which is followed by tumor cell apoptosis [1]. Therefore, the attention of scientists were focused on polynuclear platinum(II) complexes because of their ability to form products with DNA that are structurally different from those formed by cisplatin and similar mononuclear platinum(II) complexes [2]. These complexes contain two or

more metal ions in their structure, which are connected to each other by bridging ligands. Earlier results of investigation showed that some of the dinuclear platinum(II) complexes with *N*-heterocycles bridging ligands are more effective *in vitro* than cisplatin in several tumor cell lines [3–5].

Bridging ligands, flexible polyamines or different rigid *N*-heterocycles are mostly used [6–9]. Phenanthroline is a class of chelating bidentate ligands for transition metal ions that has played an important role in the development of coordination chemistry [10,11]. They are rigid, planar, hydrophobic heteroaromatic systems, whose differently placed nitrogen atoms are good structural features for coordinating metal ions [12]. Previously *in vitro* investigation of two dinuclear platinum(II) complexes, $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-1,7-phen})](\text{ClO}_4)_2$ (**Pt1**) and $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-4,7-phen})](\text{ClO}_4)_2$ (**Pt2**), where 1,7-phen (1,7-phenanthroline) and 4,7-phen (4,7-phenanthroline) are the bridging ligands while en (ethylenediamine) is bidentate coordinated diamine ligand, showed that these platinum(II) complexes have good potential to be antitumor agents [13]. In order to investigate the transport of novel platinum(II) complexes, important characteristics of antitumor agents, in this paper we investigated interactions of **Pt1** and **Pt2** complexes with HSA by UV-Vis and fluorescence spectroscopy. Also, competitive experiments with site markers (eosin Y and ibuprofen) were performed to determine the preferred site of the **Pt1** and **Pt2** complexes to which they bind to the HSA.

2. EXPERIMENTAL

2.1. Chemicals

The dinuclear platinum(II) complexes, $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-1,7-phen})](\text{ClO}_4)_2$ (**Pt1**) and $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-4,7-phen})](\text{ClO}_4)_2$ (**Pt2**), were synthesized by procedure published in the literature [1] Phosphate buffered saline (PBS, 10 mM, pH = 7.4; 2.7 mM KCl and 137 mM NaCl), human serum albumin (HSA), ibuprofen and eosin Y were purchased from the Aldrich Chemical Co (Merck). Stock solutions of HSA and investigated complexes were prepared in 10 mM PBS buffer at pH = 7.4 concentration 2 μM based on its molecular mass and kept in a refrigerator at 4 °C.

2.2. Absorption Measurements

The UV-Vis spectra were recorded on a Shimadzu double-beam spectrophotometer equipped with thermostated 1.00 cm quartz Suprasil cells over the wavelength range of 200–500 nm. Electronic absorption spectra of HSA were recorded in the presence and absence of **Pt1** and **Pt2** complexes at room temperature. The concentration of HSA was constant (8 μM) while concentration of investigated Pt(II) complexes increased from 0 - 120 μM . Binding constant (K_{app}) was calculated by the Benesi-Hildebrand equation [14]:

$$\frac{(A_{\infty} - A_x)}{(A_x - A_0)} = 1 + \frac{1}{(K_{\text{app}} \cdot [\text{Pt}])} \quad (1)$$

where A_{∞} is the absorbance of the fully bound form of the complex with BSA, A_0 is absorbance of BSA at 278 nm in absence and presence of investigated **Pt1** and **Pt2** complexes, and $[\text{Pt}]$ is concentration of dinuclear Pt(II) complexes. Binding constant (K_{app}) can be calculated from the ratio of the intercept to the slope in the linear plot of $(A_{\infty} - A_0)/(A_x - A_0)$ versus $1/[\text{Pt}]$.

2.3. Measurements of the fluorescence spectra

Fluorescence measurements were carried out on a RF-1501 PC spectrofluorometer (Shimadzu, Japan). The experiments involving interaction of **Pt1** and **Pt2** complexes with HSA were performed at room temperature in 10 mM PBS buffer solution (pH = 7.40) to keep the physiological conditions. The concentration of HSA was fixed at 8 μM while concentration of investigation Pt(II) complexes increase up to 160 μM ($r = 0 - 20$). The fluorescence emission spectra of HSA were recorded in the scanning range 300–500 nm at an excitation wavelength of 295 nm in the absence and presence of different concentrations of **Pt1** and **Pt2** complexes. The dinuclear platinum(II) complexes did not show fluorescence under the applied conditions.

The fluorescence quenching data were analyzed using the Stern–Volmer equation [15]:

$$I_0/I = 1 + K_{sv}[\text{Pt}] = 1 + k_q\tau_0[\text{Pt}] \quad (2)$$

where I and I_0 are the fluorescence intensities of HSA with and without a quencher (platinum(II) complexes), respectively, k_q is the quenching rate constants of the biomolecule, K_{sv} is the dynamic quenching constant, τ_0 is the average lifetime of the biomolecule without a quencher (around 10^{-8} s) and $[\text{Pt}]$ is the concentration of **Pt1** and **Pt2** complexes.

The binding constant of the complex with BSA was calculated by the Scatchard equation [15]:

$$\log[(I_0 - I)/I] = \log K_a + n \cdot \log[\text{Pt}] \quad (3)$$

where K_a is the association binding constant and n is the number of binding sites which have been obtained from the plot of $\log[(I_0 - I)/I]$ versus $\log[\text{Pt}]$.

2.4. Job's method

The method of continuous variation is a very useful method for the characterization of the complex formed by an interaction of the two species. The stoichiometry of interaction dinuclear platinum(II) complexes was calculated by Job's method. This method involves the preparation of a series of solutions in which the sum of the total molar concentration of HSA and Pt(II) complex is constant while the ligand mole fraction X is varied from 0-1. Solutions of HSA and investigated complexes were prepared in 10 mM PBS buffer at pH = 7.4 concentration 8 μM . Fluorescence spectra of HSA/Pt(II) complex were recorded from 300 to 500 nm at an excitation wavelength of 295 nm. Defining the concentration of the formed complex as:

$$[\text{C}] = [\text{P}]_0 - [\text{P}] \quad (4)$$

and it can be shown using equation [16]:

$$[\text{C}] = \frac{F_0 - F}{F_0} \cdot [\text{P}]_0 \quad (5)$$

2.5. Site marker competitive experiments

Competitive experiments were carried out using two site markers (ibuprofen as site marker for site binding II and eosin Y as site marker for site binding I) by keeping the concentration of HSA and the site markers constant at 8 μM . The concentration of dinuclear **Pt1** and **Pt2** complexes gradually increased so that molar ration (r) be from 0 to 10. Fluorescence spectra of the above systems were recorded from 300 to 500 nm at an excitation wavelength of 295 nm.

3. RESULTS AND DISCUSSION

Dinuclear complexes $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-}1,7\text{-phen})](\text{ClO}_4)_2$ (**Pt1**) and $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-}4,7\text{-phen})](\text{ClO}_4)_2$ (**Pt2**), in which 1,7-phen (1,7-phenanthroline) and 4,7-phen (4,7-phenanthroline) are bridging aromatic *N*-heterocyclic ligands, en (ethylenediamine) is bidentate coordinated diamine ligand (**Fig. 1**), have been synthesized by procedure published in the literature [1] and their interactions with HSA were investigated by UV-Vis and fluorescence spectroscopy measurements.

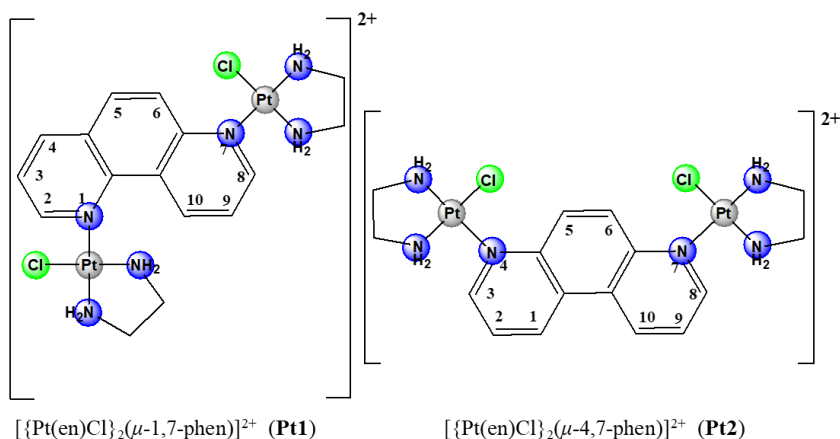


Fig. 1. Structural formula of dinuclear platinum(II) complexes **Pt1** and **Pt2**. Carbon atoms in the phenanthroline are labeled in accordance with the IUPAC rules.

3.1. Absorption measurements

Interaction of **Pt1** and **Pt2** complexes with HSA was investigated by electronic absorption spectroscopy. The UV-Vis spectra of HSA in the presence and absence of **Pt1** and **Pt2** complexes are shown in **Fig. 2**.

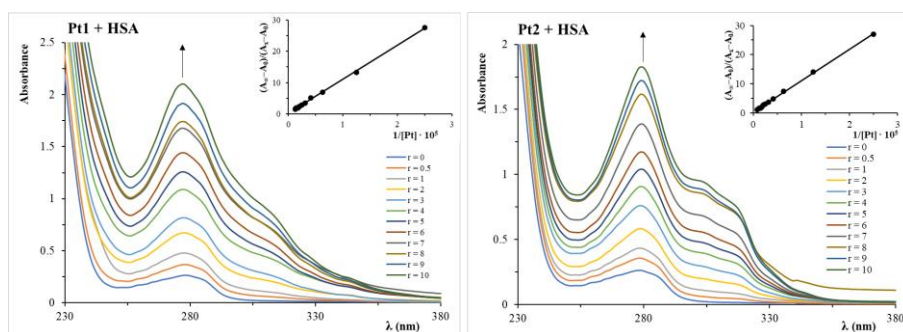


Fig. 2. UV-Vis absorption spectra of HSA in the absence and in the presence of increasing amounts of **Pt1** and **Pt2**

The weak absorption band at 278 nm is mainly caused by the transition $\pi-\pi^*$ of Trp, Tyr and Phe acid residues in HSA [17]. If the formation of a ground-state complex between fluorophore and quencher is due to static quenching, there are no changes in the spectra. But if the formation of the ground state complex is due to dynamic process comes to perturbation of the absorption spectra of the fluorophore [18]. From **Fig. 2**, it can be observed that with increasing amounts of **Pt1** and **Pt2** complexes added to the HSA solution, the intensity of the absorption peak of HSA at 278 nm increases. In UV-Vis spectra of HSA and Pt(II) complexes there are no wavelength changes of absorption maximum, so it can be concluded that the interaction of formation ground state complex goes via static process. Binding constant (K_{app}) was calculated by the Benesi-Hildebrand equation (equation 1). The calculated value of K_{app} for **Pt1** and **Pt2** complexes is $1,0 \cdot 10^4 \text{ M}^{-1}$. It can be concluded that different positions of nitrogen atoms in bridging ligands 4,7-phen and 1,7-phen do not affect the strength of the interaction investigated complexes with HSA.

3.2. Fluorescence measurements

Fluorescence spectroscopy was used to investigate the quenching mechanism, mode, and strength of the interaction of HSA with **Pt1** and **Pt2** complexes. Fluorescence emission spectra of the HSA in the absence and presence of **Pt1** and **Pt2** complexes is shown in **Fig. 3**. The strong fluorescence properties of albumin are due to the aromatic amino acids tryptophan (Trp), tyrosine (Tyr) and phenylalanine (Phe) residues. The intrinsic fluorescence intensity of HSA when excited at 295 nm mainly comes from the tryptophan residues, located in the depth of subdomain IIA, because the fluorescence of tyrosine is almost completely quenched if it is ionized or in the vicinity of an amino group, a carbonyl group, or a tryptophan residue while phenylalanine quantum yield is very low quantum yield [19].

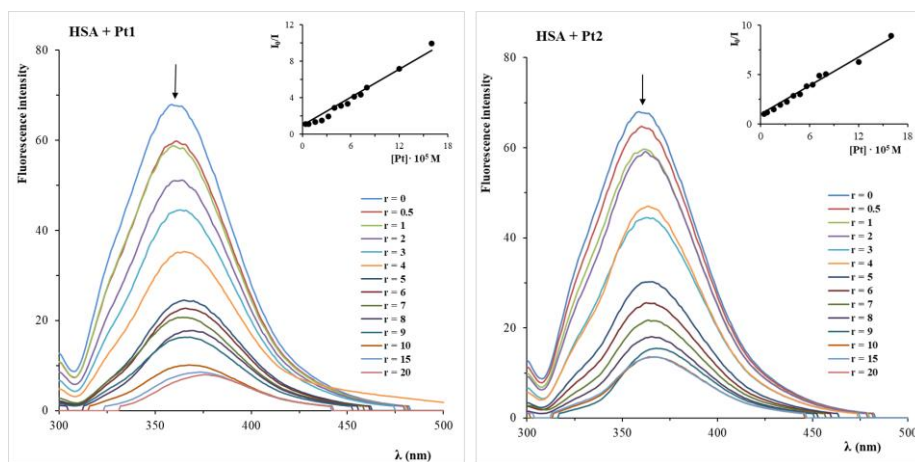


Fig. 3. Emission spectra of the HSA in the absence and in the presence of increasing amounts of **Pt1** and **Pt2** complexes in 10 mM PBS at pH 7.40 and room temperature

As can be seen from **Fig. 3** the addition of the **Pt1** and **Pt2** complexes to a solution of HSA provoked a decrease in the fluorescence intensity of HSA, with a slight shift in the position of the maximum emission wavelength. It can be concluded that binding of **Pt1** and **Pt2** complexes to HSA leads to concentration-dependent quenching of Trp-214 fluorescence. To investigate the quenching mechanism between the Pt(II) complexes and HSA, the dynamic quenching constant K_{sv} and quenching rate constants of the biomolecule k_q were calculated using equation 2 (**Table 1**).

Table 1. The dynamic quenching constant (K_{sv}), the quenching rate constant of the biomolecule (k_q), the association binding constant (K_a) and the number of binding sites (n) of HSA derived for **Pt1** and **Pt2** complexes.

Complex	$K_{sv} \cdot 10^4$ (1/M)	$k_q \cdot 10^{12}$ (kJ/mol)	$K_a \cdot 10^6$ (1/M)	n
Pt1 + HSA	6.0	6.0	6.0	1.5
Pt2 + HSA	5.7	5.7	4.0	1.5
Pt1 + HSA/ibuprofen	7.4	7.4	0.2	1.1
Pt1 + HSA/eosine Y	0.5	0.5	0.8	1.2
Pt2 + HSA/ibuprofen	5.8	5.8	0.4	1.2
Pt2 + HSA/eosine Y	1.2	1.2	1.0	1.4

The values of K_{sv} for the interaction of **Pt1** and **Pt2** complexes with HSA indicate a good HSA-binding tendency of the complexes. The difference between K_{sv} for **Pt1** and **Pt2** complexes is small so it can be concluded that differences in structure of bridging ligands does not effect on strength of the interaction of investigated Pt(II) complexes with HSA. The k_q values for **Pt1** and **Pt2** complexes are higher than for different kinds of quenchers for biopolymer and points evidently to the presence of a static quenching. The calculated K_a value indicated that a strong affinity existed between HSA and dinuclear platinum(II) complexes. The value of n was 1.5, which suggested that there was one or two classes of binding sites on HSA for investigated platinum(II) complexes.

3.3. Job's method

Considering that binding number obtained in fluorescence measurements were 1.5 for both dinuclear Pt(II) complexes, the stoichiometry of interaction Pt(II) complexes with HSA was investigated by Job's method. In the continuous variation method, the total molar concentration $T_o=[HSA]+[complex]$ is held constant, but their mole fractions are varied. A measurable parameter, that is proportional to HSA concentration, is plotted against the mole fraction of one of these two components. A special point is determined from the plot. The Job plot for both platinum(II) complexes results are the same as one presented in **Fig. 4**. The maximum of the Job's curves occurs at 0.5 and indicates the existence of a complex with a 1:1 stoichiometry for both investigated platinum(II) complexes [16].

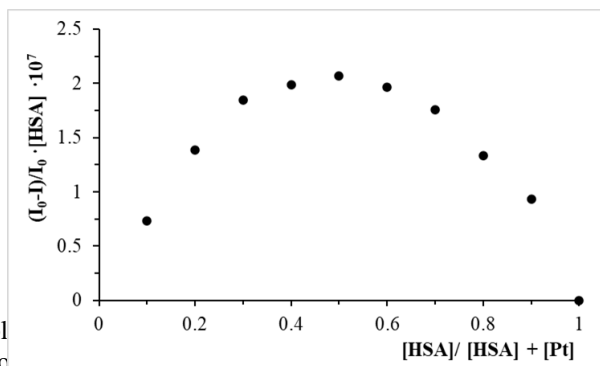


Fig. 3. Job plot showing the relative fluorescence intensity ($I_0 - I$)/ $I_0 \cdot 10^7$ versus the molar ratio $[HSA]/([HSA] + [Pt])$ for the complex. The concentration (T_0) of HSA was $8 \mu M$, in phosphate buffer, pH 7.4, and the concentration of the platinum complex was $8 \mu M$. The excitation wavelength was 295 nm .

3.4. Site marker competitive experiments

The fluorescence quenching titration was used to determine the binding constants of **Pt1** and **Pt2** complexes in interaction with HSA in presence of ibuprofen and eosin Y as site probes for sites I and II. Concentrations of HSA and site markers were set at $8 \mu M$, while the concentration of **Pt1** and **Pt2** complexes gradually varied between 0 and $80 \mu M$. Emission spectra were recorded in the range of $300\text{--}500 \text{ nm}$ with an excitation wavelength of 295 nm (Fig. 4).

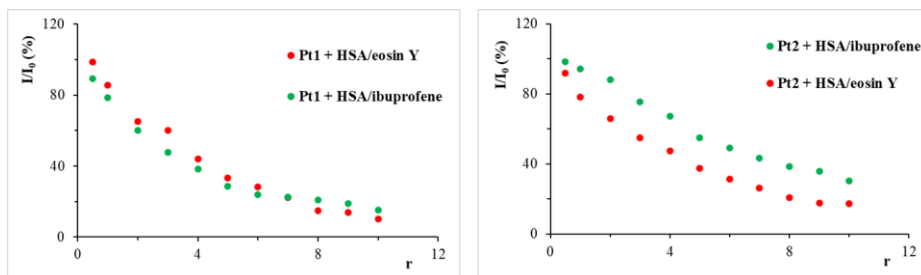


Fig. 4. The relative intensity of the fluorescence emission of HSA/eosin Y or HSA/ibuprofen in present of **Pt1** and **Pt2** complex.

As it can be concluded from Fig. 4, the increasing concentration of investigated platinum(II) complexes leads to fluorescence intensity of HSA/eosin Y or HSA/ibuprofen system decrease. According to experimental results, binding constants were determined by using equations (2) and (3) and presented in Table 1. When compare binding constants from Table 1 for investigated platinum(II) complexes, it can be concluded that there was a competitive interaction between complexes and eosin Y. Decrease in the K_a value found in the presence of eosin Y when compared to the K_a value of native HSA indicated that that primary interaction **Pt1** and **Pt2** complexes and HSA is at site I [20].

3. CONCLUSION

In this paper interaction of two dinuclear platinum(II) complexes, $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-}1,7\text{-phen})](\text{ClO}_4)_2$ (**Pt1**) and $[\{\text{Pt}(\text{en})\text{Cl}\}_2(\mu\text{-}4,7\text{-phen})](\text{ClO}_4)_2$ (**Pt2**), with HSA were investigated by UV-Vis and fluorescence spectroscopy. UV-Vis measurements showed that investigated platinum(II) complexes bind to HSA via static process. The calculated value of K_{app} for both dinuclear platinum(II) complexes are the same, so it can be concluded that **Pt1** and **Pt2** complexes bind with the same strength to albumin. Also, results obtained from fluorescence measurements confirm that **Pt1** and **Pt2** complexes bind to HSA via static process with no difference in strength of bond between investigated platinum(II) complexes. The number of binding sites (n) obtained by fluorescence measurements were proved by Job's method and it can be concluded that stoichiometry of interaction **Pt1** and **Pt2** complexes with HSA is 1:1. Competitive experiments with two site markers eosin Y and ibuprofen as site probes for sites I and II showed that investigated platinum(II) complexes bind to HSA at site I. This paper can be helpful to understand the influence of bridging ligands in dinuclear platinum(II) complexes on their fate in organisms.

4. LITERATURE

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ZNAČAJ PRODAJNO-MARKETINŠKIH AKTIVNOSTI ZA RAZVOJ INDIVIDUALNOG DOBROVOLJNOG ZDRAVSTVENOG OSIGURANJA U REPUBLICI SRBIJI

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SAŽETAK: Dobrovoljno zdravstveno osiguranje se u zemljama zapadnog Balkana godinama iza nas pozicioniralo kao najperspektivnija grana osiguranja, pre svega jer omogućava značajno viši kvalitet zdravstvene zaštite i značajne uštede u plaćanju medicinskih usluga u privatnim zdravstvenim ustanovama. Postojeći trend razvoja je vezan za obezbeđivanje dobrovoljnog zdravstvenog osiguranja kao benefita zaposlenih u kompanijama, sa tek par procenata tržišnog učešća individualnih i porodičnih polisa ove vrste osiguranja. Ono što zabrinjava osiguravajuće kompanije je izostanak profitabilnosti, a kao razlog su targetirani s jedne strane izuzetno visoki troškovi sprovođenja osiguranja, a sa druge strane dampingovanje cena proizvoda dobrovoljnog zdravstvenog osiguranja zarad većeg tržišnog učešća. Međutim, na profitabilnost je pozitivno ocenjen uticaj ugovaranja individualnih i porodičnih polisa, zbog čega se u narednom periodu očekuju značajne prodajno-marketingne aktivnosti na popularizaciji ove vrste potencijalnih ugovaranja. Cilj rada je upravo da pokaže jedan od modela koji bi mogao da doprinese boljoj prodaji i profitabilnosti individualnog dobrovoljnog zdravstvenog osiguranja.

Ključne reči: zdravstvena zaštita, individualno dobrovoljno zdravstveno osiguranje, osiguravajuće kompanije, prodajno-marketingne aktivnosti

1. UVOD

Svet na početku XXI veka možda nije bio najidealnije mesto za život, ali je svakako pružao veći osećaj sigurnosti i održivosti za čoveka kao pojedinca i svaku državu kao teritorijalnu i/ili nacionalnu tvorevinu.

Pandemija COVID-19, a zatim i globalna politička i ratna kriza na istoku Evrope su drastično promenile sliku o čoveku, humanosti, odgovornom ponašanju i činjenju.

Zaboravljeni su mnogi principi koji su postojali pre ovih događaja, a fokus ovom prilikom stavljamo na zdravstvena osiguranja, pre svega na individualno dobrovoljno zdravstveno osiguranje.

Zdravstveno osiguranje je vrsta osiguravajuće zaštite koja pokriva medicinske troškove prouzrokovane lečenjem nastalih bolesti. Ono je jedan od mehanizama finansiranja zdravstvenih sistema u mnogim zemljama. Objedinjuje rizike i omogućava finansijsku zaštitu korisnika zdravstvenog osiguranja od visokih troškova lečenja, koji mogu nastati usled nastupanja bolesti ili povrede.

Dobrovoljno zdravstveno osiguranje (DZO) je dodatni ili dopunski vid zdravstvenog osiguranja koji si uplaćuje od strane poslodavca kao benefit za zaposlene (ovaj vid DZO-a se ujedno zove i kolektivno dobrovoljno zdravstveno osiguranje) ili ga može ugovoriti pojedinac za sebe i članove svoje porodice (individulano i porodično DZO).

DZO nema preterano dugu tradiciju u Republici Srbiji, iako se formalno vodi da su prve polise nastale krajem XX veka, prva polisa individualnog zdravstvenog osiguranja nastala je u januaru 2007.godine i osigurana suma je bila 100.000 evra. Poseban kuriozitet je da je ova polisa i dalje aktivna, obnavlja se svake godine, što ukazuje na činjenicu da kvalitet koji je prepoznat traje, bez obzira na cenu koštanja. O ozbiljnijem razvoju DZO-a govorimo tek od 2012.godine, kada se u Republici Srbiji masovnije otvaraju privatne zdravstvene ustanove, koje su kao takve mogle da ponude bržu dostupnost medicinskim uslugama, naročito sofisticiranoj dijagnostici (MRI, MSCT i sl.), odličan kvalitet i rasprostranjenost na većem delu teritorije, a ne samo u velikim gradovima.

Kada je u pitanju individualno DZO, tek tu imamo kratak istorijski period razvoja i on je usko vezan za pandemiju COVID-19 kada su se građani masovnije upoznali sa privatnim zdravstvenim sistemom u Republici Srbiji (zbog zauzetosti državnih medicinskih kapaciteta borbom sa corona virusom) i njegovim mogućnostima u lečenju i kontroli hroničnih i drugih bolesti.

Masovnost prodaje i značajan rast premije u DZO-u, za razliku od drugih linija osiguranja, u ovom slučaju nisu doneli i profitabilnost za osiguravajuće kompanije. Detaljnom analizom ustanovljeno je da su osiguravajuća društva u borbi za klijente formirali izuzetno niske cene koje nisu opravdale troškove sprovođenja osiguranja i zbog toga dugi niz godina u ovom biznisu posluju sa negativnim rezultatom.

Tražeci izlaz iz ove situacije, odustajanje od proizvoda nije bila alternativa, shvatili su da je rezultat kada su u pitanju individulane polise DZO veoma dobar i da na ovoj prodaji treba insistirati. Loša situacija je ta što ova vrsta polisa u ukupnom broju osiguranika čini tek nekih 5% od ukupne premije na godišnjem nivou.

Zaključak je da je neophodno izraditi marketinško-prodajne modele koji će podspešiti prodaju individualnih polisa DZO, jer bez rasta ovog segmenta i dostizanja bar 30% tržišnog učešća u ukupnoj premiji po DZO-u, ne može se govoriti o stabilnoj profitabilnosti ove grane osiguranja.

Ovo istraživanje upravo predstavlja jedan od takvih modela, u kom smo nastojali da segmetacijom tržišta u domenu korisnika privatnih zdravstvenih ustanova opredelimo i definišemo koje bi marketinško-prodajne aktivnosti bile najadekvatnije za njihovu konverziju u klijente dobrovoljnog zdravstvenog osiguranja.

2. DOBROVOLJNO ZDRAVSTVENO OSIGURANJE U REPUBLICI SRBIJI

Dobrovoljno zdravstveno osiguranje u Republici Srbiji čini nekoliko podkategorija, pre svih vanbolničko i vanbolničko i bolničko lečenje (ova dva segmenta su bila predmet

našeg istraživanja), kao i teže bolesti i hirurške intervencije (ova vrsta DZO-a je rezervisana za kolektivna/kompanijska ugovaranja i neće biti predmet rada).

Dobrovoljno zdravstveno osiguranje se finansira uplatom mesečnih ili godišnjih premija, uobičajeno polise se sklapaju na godinu dana (postoji mogućnost i višegodišnjih ugovaranja), dok se visina premije određuje na osnovu procene rizika (Rakonjac-Antić, 2018.). Iznos premije zavisi od nekoliko faktora rizika, a pre svega od starosne dobi potencijalnih osiguranika, vrste posla kojim se klijent bavi, kao i zdravstvenog stanja sa kojim osiguranik ulazi u osiguranje. Do 31.12.2022.godine na procenu rizika je uticao i pol klijenta, ali na osnovu Uredbe Narodne banke Republike Srbije i preporuke koju je dao poverenik za rodnu ravnopravnost Republike Srbije, ovaj kriterijum je eliminisan i osiguravajuća društva od tada primenjuju unisex tarifu. Iako ovo pravilo nije primenjeno na području EU, niti se na njemu insistira od strane briselske administracije, nadležni organi u Republici Srbiji su se drugačije opredelili.

Osnov za sprovođenje dobrovoljnog zdravstvenog osiguranja predstavljaju Zakon o osiguranju i Zakon o zdravstvenom osiguranju. Ova akta definišu da polise dobrovoljnog zdravstvenog osiguranja mogu se ugovoriti sa pravnim (kao benefit za zaposlene) ili fizičkim licima. Posebna pogodnost koja važi za građane Republike Srbije je da je u slučaju obezbeđivanja benefita DZO za zaposlene, poslodavac oslobođen plaćanja poreza i doprinosa do finansijskog iznosa koji se usklađuje na godišnjem nivou (Uredba o DZO-u, 2008.).

Proizvodi vanbolničkog i vanbolničkog i bolničkog lečenja definišu određena pokrića i sumu osiguranja koja se može koristiti u periodu na koji je osiguranje zaključeno. Kada su u pitanju sume osiguranja one se kreću od 1.000-100.000 evra pokrića na godišnjem nivou. Medicinske usluge mogu biti pružene pre svega u osnovnom pokriću koje je obavezno da se ugovori i tu spadaju zdravstvene usluge poput specijalističkih pregleda, dijagnostike, laboratorijskih analiza, mentalnog zdravlja, komplementane medicine i sl. Od dodatnih ili dopunskih pokrića, na raspolaganju su sistematski pregled, lekovi, fizikalna terapija, stomatološke usluge, oftalmološke usluge i sl. Sva dopunska pokrića predstavljaju izbor, potrebu, želju i mogućnost da budu ugovorena.

2.1. Zakonska regulativa kojom se uređuje dobrovoljno zdravstveno osiguranje

Shodno odredbama Zakona o zdravstvenom osiguranju pravo da organizuje, uređuje i sprovodi dobrovoljno zdravstveno osiguranje, povereno je Republičkom fondu za zdravstveno osiguranje, kao i pravna lica koja su registrovana za delatnost osiguranja. Dobrovoljno zdravstveno osiguranje ne može biti zaključeno na kraći period od 12 meseci, gde je mogućnost dužeg vremenskog perioda definisana na način kako to predviđa svaki osiguravač svojim osnovnim i posebnim uslovima osiguranja.

Prema Zakonu o zdravstvenom osiguranju (član 174) definisane su vrste dobrovoljnog zdravstvenog osiguranja i to:

- 1) dopunsko zdravstveno osiguranje je osiguranje kojim se pokrivaju troškovi zdravstvene zaštite koji nastaju kada osiguranik ostvaruje zdravstvenu zaštitu koja je obuhvaćena obaveznim zdravstvenim osiguranje na način i po postupku koji su drugačiji od načina i postupka ostvarivanja prava iz obaveznog

zdravstvenog osiguranja koji je propisan zakonom kojim se uređuje zdravstveno osiguranje i propisima deonetim za sprovođenje tog zakona;

- 2) privatno zdravstveno osiguranje je osiguranje lica koja nisu obuhvaćena obaveznim zdravstvenim osiguranjem ili koja nisu uključena u obavezno zdravstveno osiguranje;
- 3) dodatno zdravstveno osiguranje je osiguranje kojim se pokrivaju svi troškovi nastali u cilju rešavanja zdravstvenog problema osiguranika, a nisu obuhvaćeni pravima iz obaveznog zdravstvenog osiguranja. Osim pruženih medicinskih usluga, ovim osiguranjem je obuhvaćena i finansijska nadoknada za troškove nastale po tom osnovu;

Društva za osiguranje mogu sprovesti sva tri oblika dobrovoljnog zdravstvenog osiguranja, dok Republički zdravstveni fond nema mogućnost sprovođenja privatnog zdravstvenog osiguranja.

Sredstva za finansiranje dobrovoljnog zdravstvenog osiguranja se akumuliraju na osnovu izračunatih i plaćenih premija osiguranja, a sve je definisano ugovorom, tj. polisom dobrovoljnog zdravstvenog osiguranja.

2.2. Pregled tržišta dobrovoljnog zdravstvenog osiguranja u R. Srbiji

Svi učesnici na tržištu osiguranja u obavezi su da sačinjavaju i dostavljaju Izveštaje o godišnjim rezultatima, tako da na osnovu Izveštaja RFZO-a, za 2022. godinu zaključene su 16.177 polise dobrovoljnog zdravstvenog osiguranja, što predstavlja rast od 76,28% u odnosu na prethodnu godinu. U poređenju sa društvima za osiguranje, rast je za oko 50% veći, ali treba uzeti u obzir tržišno učešće RFZO u odnosu na ostala društva za osiguranje. Zarađena premija je iznosila 19,616 miliona dinara, dok su troškovi sprovođenja osiguranja iznosili 6,14 milion dinara (Izveštaj o finansijskom poslovanju RFZO za 2022.godinu).

Kada su u pitanju osiguravajuće kompanije u Republici Srbiji, ukupna premija dobrovoljnog zdravstvenog osiguranja (isključena putna asistencija) u 2022.godini je iznosila 9.873.454 hiljade dinara, a ukupan broj osiguranika u ovoj kategoriji je bio 3.310.271 osiguranik. Ako se posmatra samo vanbolničko i vanbolničko i bolničko lečenje, broj osiguranika je iznosio 247.982. Posmatrano premijski i po broju osiguranika zabeležen je rast u odnosu na 2021.godinu za oko 27% (Izveštaj Narodne banke R Srbije: pregled broj osiguranja, broj osiguranika i premije po vrstama i tarifama osiguranja za Srbiju u 2022.godini). Slična stopa rasta se očekuje i u Izveštaju za 2023. godinu, a uzlazni trend se nastavlja i u 2024.godini.

Evidentni rast dobrovoljnog zdravstvenog osiguranja je posledica boljih makroekonomskih prilika, činjenica da osiguranicima omogućava lakši put do izabranog lekara, savremenih metoda lečenja i kvalitetnijeg načina života. Takođe, dobrovoljno zdravstveno osiguranje dodatno medicinski edukuje građane Republike Srbije, što ima za posledicu smanjenje prekomernog korišćenja medicinskih usluga, a samim tim većih investicija u zdravstveni sistem i optimizaciju na relaciji potrebnih i pruženih zdravstvenih usluga (Kočović et al, 2013, prema Rakonjic-Antić, 2012). Ovim razvojem pruža se viši nivo zdravstvene zaštite, bolja slika zdravlja nacije, jer paralelnim zdravstvenim

sistemima (državnim i privatnim) obezbeđuje se širok dijapazob zdravstvenih usluga, što je dodatni razlog da se dobrovoljno zdravstveno osiguranje još bolje razvija.

3. UTICAJ RAZLIČITIH FAKTORA NA DALJI RAZVOJ DOBROVOLJNOG ZDRAVSTVENOG OSIGURANJA

Kada se posmatra uticaj rauličitih faktora generalno na razvoj određenih privrednih i društvenih prilika, prvo od čega se kreće je analiza životnog standarda građana. Dobrovoljno zdravstveno osiguranje ne odstupa od ove logike i algoritma ponašanja, s obzirom da je veoma mali procenat korisnika individualnog DZO-a koji su u rangi prosečnih ili ispod prosečnih primanja u Republici Srbiji. Upravo je ovo jedan od glavnih razloga što je proces razvoja individualnog DZO-a veoma spor jer upravo prati unapređenje životnog standarda naših građana.

U tom smislu, dostupni podaci u Republici Srbiji svedoče o sledećem: prosečna plata krajem 2022.godine je iznosila 75.757,00 dinara, dok je prosečna potrošačka korpa dostigla vrednost u tom periodu od čak 92.231,00 dinara, a minimalna vrednost od 48.147,56 dinara. Ako se posmatra isti period prehodne godine govorimo o prosečnom rastu primanja od oko 13%, dok je vrednost potrošačke korpe porasla za oko 17%.

Ovi podaci, gde potrošačka korpa brže raste od prosečne plate, ukazuju da građani Republike Srbije teško mogu da izdvoje sredstva za polise dobrovoljnog zdravstvenog osiguranja. Trend u 2023. i 2024. godini se menja i ako se ovako nastavi, zadržaće se kurs manje inflacije čime će se stvoriti ekonomski povoljniji uslovi za brži razvoj DZO-a.

U prilog ovoj činjenici govore i podaci rasta cena proizvoda na malo i usluga lične potrošnje, gde su iste povećavane tokom 2022.godine za nešto manje od 2% na mesečnom nivou (Republički zavod za statistiku R Srbije). U 2023. godini ovaj procenat je gotovo prepolovljen što je dodatna pozitivna karakteristika daljeg rasta.

Bitan faktor je i procenat nezaposlenosti u Republici Srbiji, koji pre desetak godina bio gotovo 20%, dok je tokom 2022. godine iznosio oko 8,8%. Međutim to je još uvek iznad svetskog proseka koji se za posmatrani period kreće oko 6,7% (Trading Economics Statistics).

Zaključujući o daljim trendovima ekonomskih prilika u Republici Srbiji potrebno je izanalizirati i bruto domaći proizvod. Kao prava mera za to je poređenje sa zemljama u okruženju i u tom smislu u 2021.godini Slovenija je ostvarila GDP po glavi stanovnika u iznosu od 28.104 dolara, Hrvatska 16.247 dolara, Crna Gora 9.545 dolara i Srbija 8.748 dolara (International Monetary Fund). Takođe, još jedna bitna varijabla životnog standarda je i kupovna moć građana. Taj pokazatelj u Sloveniji je 49.967 dolara, u Hrvatskoj 37.546 dolara, u Srbiji 27.100 dolara i u Crnoj Gori 26.032. dolara. Ovi podaci pokazuju da u Republici Srbiji još dosta treba da se poboljšaju ekonomske prilike da bi se stigle zemlje u regionu i kako bi dobrovoljno zdravstveno osiguranje imalo stabilan i brži trend razvoja.

Svi analizirani faktori predstavljaju fundamentalne osnove za razvoj dobrovoljnog zdravstvenog osiguranja, s tim da se algoritamski u sve ovo dosta upleo uticaj izazvan pandemijom COVID-19. Naime, u periodu kada su državni kapaciteti bili potpuno zauzeti saniranjem posledica pandemije, kako drugi zdravstveni problemi nisu nestali, građanima je ostalo da zdravstvenu zaštitu potraže u privatnim medicinskim ustanovama. Shvatajući prednosti koje pružaju, ali i značajna sredstva koja treba izdvojiti za lečenje u istima,

građani su tražeći različite alternative, masovno „otkrili“ dobrovoljno zdravstveno osiguranje. Ovo je uticalo i na povećanje zdravstvene pismenosti pojedinca, sposobnost i motivaciju da se razumeju i primene informacije o zdravlju, kako bi se donosile adekvatne odluke vezane za poboljšanje kvaliteta života (Sorensen et al, 2015).

Naravno, osim zdravstvene pismenosti za bolje funkcionisanje dobrovoljnog zdravstvenog osiguranja, neophodno je pružiti bolju u potpuniju promociju usluga koja bi uticala na približavanje karakteristika ove vrste osiguranja potencijalnim korisnicima (Kočević et al, 2013).

4. MARKETINŠKO-PRODAJNI MODEL ANALIZE POTENCIJALNOG KLIJENTA DOBROVOLJNOG ZDRAVSTVENOG OSIGURANJA

Dugo se bez naučne i analitičke osnove pretpostavljalo, a onda se na osnovu relevantnih prodajnih i marketinških pokazatelja ispostavilo potpuno tačnim da dinamičan razvoj i rast tržišta dobrovoljnog zdravstvenog osiguranja u Republici Srbiji definitivno više nije upitan.

Godišnji rast broja klijenata DZO od oko 27% bio je dovoljna inicijacija da najveći broj osiguravajućih kompanija otpočne sa prodajom ovog proizvoda, bazirajući svoju marketinšku i poslovnu politiku na targetiranju korporativnih klijenata.

Upravo ova okolnost ima za posledicu da najveći broj društava za osiguranje ostvaruje negativne rezultate u ovoj grani biznisa i da sve preduzete mere na sanitaciji portfolija ne daju očekivane, da ne kažemo gotovo nikakve rezultate.

Zaključak je da *osiguravajuće kuće za bolje rezultate moraju pronaći alternative u novim marketinško-prodajnim nastupima, pre svega kada je u pitanju sama struktura klijenta DZO.*

Ovo je ujedno bilo i **osnovno pitanje u sprovedenom istraživanju** – pronaći novu bazu potencijalnih klijenata koji bi mogli da obezbede profitabilnost DZO u budućem periodu.

U tom smislu opredeljeno je da istraživanje bude sprovedeno među *korisnicima usluga privatnih zdravstvenih ustanova iz urbanih područja*, s obzirom da oni mogu prepoznati potrebu za DZO-om, jer imaju dovoljno razvijenu zdravstvenu svet, koriste mrežu privatnih medicinskih ustanova, a ujedno imaju i dovoljno finansijskih sredstava da bi kupili polisu DZO.

Dakle, istraživanje nas je odvelo u pravcu individualanih klijenata i inicijaciji njihove potrebe da za sebe i članove svojih porodica obezbede kvalitetnu i kompletnu zdravstvenu zaštitu, koristeći proizvode DZO.

Da bi inicijacija bila sadržajna, kvalitetna i ciljana, jer za razliku od korporativnih klijenata koji su se unapred opredelili da obezbede DZO kao benefit za svoje zaposlene, kada su u pitanju individualni korisnici, tu u prodajno-marketinškom smislu imamo samo jednu šansu. Ta jedna šansa mora biti iskorišćena na pravi način, u smislu da se potencijalnom klijentu da dovoljno informacija o proizvodu DZO i kod njega stvori potreba da ga kupi. Imajući u vidu momenat ličnog u kupovini (radi se o proizvodu koji tretira na određeni način emotivnu crtu klijenta), neophodno je obezbediti pravi i efikasan način pristupa.

Navedeno je i definisalo *cilj istraživanja*, izraditi studiju o navikama i stavovima potencijalnih individualnih klijenata DZO, njihova identifikacija na tržištu, kao i prepoznavanje njihovih želja i potreba.

Kao metod istraživanja korišćen je upitnik (u istraživanju je učestvovalo 1143 ispitanika), a uzorak je bio reprezentativan po polu i regionima i obuhvatio je ispitanike 25-55 godina.

Statističkom obradom prikupljenih podataka izvršili smo segmentaciju tržišta i dobili tri kategorije u koje smo svrstali ispitanike i to:

- **Skeptici** (52% segmenta), **Bezbrizni** (26%) i **Vizionari** (22%)



Slika 1: Kategorije ispitanika (slikoviti prikaz)

Segmentacijom tržišta i formiranjem pomenutih klastera, kao i prikupljenim podacima došlo se do osnovnih zaključaka o svakoj od kategorija, o njihovim navikama, željama, potrebama i sl., a sve u pravcu i dodiru sa zdravstvenom zaštitom, osiguranjem itd.

Naime, u tom smislu zaključeno je da recimo **Skeptici** stavljaju naglasak na sigurnost svojih najbližih, žele život bez trzavica, naročito u domenu finansija. S druge strane, **Bezbrizni** su preokupirani trenutnim momentom življenja i uglavnom se najbitniji sami sebi. Uklapaju se u razmišljanja i stavove većine i recimo spremni su da na "prestizne" stvari troše mnogo novca. Za razliku od njih **Vizionari** mnogo rade, a veći deo njih je zaposlen u privatnom sektoru. Bitno im je lično usavršavanje, što manje prepreka na tom putu, što znači da preferiraju stabilnost i odustvo neizvesnosti u svim segmentima, pa i zdravstvenom.

Ovo su samo neke od karakteristika koje smo dobili od ispitanika u ovim kategorijama i svakako utiču na buduće kreiranje prodajno-marketinškog targetiranja. Ove osobnosti će ujedno pomoći i pri segmentaciji potencijalnih klijenata i njihovom svrstavanju u jedan od klastera.

Formiranjem segmenata, dalji svoj fokus je stavljen na prepoznavanje bitnih karakteristika svakog od njih koje mogu uticati na strategiju pravilne inicijacije.

U tom smislu ustanovljeno je da među **Skepticima** preovlađuju žene (63%), dok je ova zastupljenost među **Bezbriznim** i **Vizionarima** značajno manja i kreće se od 42-48%. Kada su u pitanju finansijski prihodi, **Skeptici** beleže najmanji mesečni prihod koji je 10% niži od prosečnih primanja u R Srbiji, dok se **Bezbrizni** malo iznad proseka, a **Vizionari** beleže mesečna primanja veća za oko 15% od proseka.

Posmatrajući godine života, **Skeptici** su prosečno najmlađi (36 godina), a **Vizionari** najstariji (48 godina).

Dalji podaci po segmentima prikupljeni su i obrađeni teritorijalno, obrazovno, porodični status i sl., dakle sve što je targetirano kao potencijalno bitno za određivanje nastupa ka svakoj od ovih kategorija.

Nakon dobijanja “fotorobota” svakog segmenta, neophodno je bilo da je shvate njihove navike, želje, opredeljenja, a sve sa aspekta i onoga što je u vezi sa zdravstvenim osiguranjem.

U tom smislu, za svaki od segmenata je analiziran kako recimo provode slobodno vreme (**Skeptici** vole udobnost svog doma, **Bezbrizni** imaju mnogo prijatelja od kojih su dosta njih stekli putem društvenih mreža, vole putovanja, dok **Vizionari** imaju manji broj odabranih prijatelja, nekoliko mesta za izlazak i uživaju u različitim događajima zatvorenog i ciljanog tipa), šta su im postulati vrednosti (zanimljivo je da sve tri kategorije visoko cene lično zdravlje, dok je kod **Skeptika** zdravlje ukućana izuzetno bitno).

Takođe, analiziran je i način informisanja (kod **Skeptika** je dominantan TV, pa čak i novine i to štampana izdanja, **Bezbrizni** očekivano sve prate putem interneta i društvenih mreža, dok za **Vizionare** mnogo znače zaključci određenih foruma i društvenih grupa u kojima učestvuju stručnjaci iz oblasti medicine).

Na osnovu ovoga, iz prikupljenih podataka je bilo važno zaključiti: *Pa kome onda veruju pripadnici ove tri kategorije kada je u pitanju zdravlje i zdravstvo?*

Kod **Skeptika** je izražena preporuka članova porodice i bliskih prijatelja (92%), za **Bezbrizne** je mnogo bitan stav online zajednice i oni više vrednuju dobru ocenjenost određenih osiguranja ili zdravstvenih sistema, nego pojedinačne lekare ili razvijenost određenih grana biznisa u okviru osiguravajuće kuće (to znači ako automobil osiguravaju u jednoj kompaniji, verovatno će i DZO tu kupiti, ne ulazeći u analizu kako je ta kompanija u ovom biznisu pozicionirana na tržištu). Na **Vizionare** najveći uticaj će ostaviti struka, želeće da čuju ljude iz osiguravajućih društava specijalizovane za DZO, ali svakako će im značiti i mišljenje eminentnih lekara o nekoj osiguravajućoj kompaniji.

5. ZAKLJUČAK

Na kraju izveden je zaključak na koji način bi bilo najbolje pristupiti potencijanom klijentu DZO nakon što se ustanovi kom segmentu pripada i na osnovu toga dobije projekcija njegovih očekivanja, želja i potreba kada je DZO u pitanju. U tom smislu, definisali smo način i metod kako privući i zadržati potencijalnog klijenta DZO.

Kada su u pitanju **Skeptici**, oni od samog proizvoda DZO očekuju sigurnost za sebe i članove porodice i potpunu posvećenost i lični pristup. To znači da u kontaktu sa ovom kategorijom potencijalnih klijenata neophodno je obezbediti lični kontakt, tačnije potpuno edukovanog prodavca koji će moći da odgovori i da pojašnjenja na sva pitanja iz ove oblasti. Za **Bezbrizne** sa druge strane treba obezbediti brzu, jednostavnu i razumljivu komunikaciju i ponuditi proizvod sa što manje “ali”. To znači da i njegovo korišćenje treba da bude jednostavno i bez suvišnih protokola na relaciji klijent-lekar-osiguravajuća kompanija. **Vizionari** posebnu pažnju posvećuju kvalitetu i sveobuhvatnosti proizvoda. Žele pokrivenost svih opcija potencijalnih zdravstvenih izazova i posebno ocenjuju izvesnost izlečenja. U tom slučaju cena ne igra nikakvu ulogu kod njih (primer je mogućnost pokrivanja lečenja u inostranstvu).

Takođe, kroz istraživanje zaključci su izvedeni i u pravcu načina komunikacije proizvoda DZO i kako ih zainteresovati (marketinški nastup prema svakom segmentu), šta sve učiniti kako bi se steklo poverenje i dugoročno ugovaranje polise DZO, kao i šta sve mogu biti potencijalni reputacioni izazovi i kako ih prevenirati.

Generalni zaključak je da lični pristup prema klijentu mora postojati, bez edukovanih prodavaca nema izvesne prodaje, a komuniciranje proizvoda DZO mora definitivno biti targetirano prema kategoriji klijenata kojoj se obraćamo.

Profit iziskuje napor kada je u pitanju DZO, taj napor bar za sada je veći od željenog i očekivanog.

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THE IMPORTANCE OF SALES AND MARKETING ACTIVITIES FOR THE DEVELOPMENT OF INDIVIDUAL VOLUNTARY HEALTH INSURANCE IN THE REPUBLIC OF SERBIA

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ABSTRACT: *Voluntary Health Insurance (VHI) has recently become the most perspective branch of insurance in the Western Balkans countries mostly because it provides considerably high quality of health protection and significant savings when it comes to payment of medical services in privately funded health institutions. The current development trend is in correlation with ensuring VHI as a part of the employees benefits packages, with only a few percentage market share of individual and family health insurance policies of this kind. The lack of profitability that stems from extremely high costs of insurance implementation on one hand and VHI price damping with purpose of higher market share on the other hand is what raises most concern among insurance companies. Nevertheless, individual and family policy contracts have had positive impact on profitability due to which considerable sales and marketing activities so as to popularize potential contracts of this kind are expected in foreseeable future. The aim of this paper is to introduce one of the models with might contribute to better sale and profitability of VHI.*

Keywords: *health insurance, individual voluntary health insurance, insurance companies, sales and marketing activities*

***ECONOMY, MANAGEMENT, TOURISM AND
HOSPITALITY***

HERCEG NOVI: ANALIZA EKONOMSKIH I KOMUNIKACIJSKIH ASPEKATA KULTURNOG NASLEDA IZ PERSPEKTIVE STAVOVA GRAĐANA

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SAŽETAK:

Herceg Novi svojom bogatom kulturom građanom kroz vekove, predstavlja jednu od najznačajnijih turističkih destinacija Južne Evrope. Cilj rada je da se sagleda potencijal kulturnog nasleđa grada kao i mogućnost njegovog povezivanja sa ekonomskim i medijskim aspektima. Metod istraživanja započinjemo proučavanjem naučne i medijske javnosti zemalja čiji su narodi ostavili traga u formiranju kulture Boke Kotorske. Vršimo analizu na koji način te zemlje promovišu sopstvene kulturne vrednosti. Takođe ispitivani su stavovi građana Herceg Novog prema realizaciji formiranja festivala kulturnog nasleđa i načinima njegove prezentacije. Korišćene su kombinovane istraživačke metode u obliku ankete, intervjua kao i analize medijskih sadržaja iz oblasti kulture i ekonomske politike. Rezultati istraživanja pokazuju da su potrebne nove strategije u razvoju lokalne kulture i jačanja turističkog potencijala grada.

Ključne riječi: Herceg Novi, kulturno nasleđe, promocija

1. UVOD

Celokupno kulturno nasleđe Herceg Novog ne može se sagledati i tumačiti isključivo kao ekskluzivitet regije kojoj pripada. Ono višestruko prevazilazi granicu lokalnih razmera, i bez sumnje, doseže do veoma visoke pozicije na kulturnoj mapi Starog kontinenta. Raspon i obim kvaliteta istorijskog nasleđa, raznovrsnost i uticaj potpuno različitih kulturnih tradicija obezbedilo je gradu smeštenom u Bokokotorskom zalivu status veoma značajnog kulturnog centra. Na osnovu faktografije i istraživanja javnog mnjenja koje prezentujemo u radu obuhvaćeni su precizno svi segmenti kulturnih vrednosti, što potvrđuje široku panoramu zaostavštine ovog životnog prostora.

U monografiji „Herceg Novi“ Lazara Seferovića, višegodišnjeg istraživača i poznavaoca hercegnovske sveukupne kulturne baštine prezentovani su podaci sertifikovani na osnovu visokih kriterijuma vredonosnog sistema [1]. Sa svojim osobenostima i specifičnostima grad obiluje velikim brojem srednjovekovnih građevina koje svoje mesto treba da nađu na festivalskoj mapi Evrope.

2. KULTURNI POTENCIJAL HERCEG NOVOG

Kategorizacijom spomenika kulture upisanih u registar Republičkog zavoda za zaštitu spomenika Crne Gore obuhvataju opseg od crkvi, manastira, utvrđenja, sakralnih kompleksa, kula, tvrđava, zidina, starogradskog jezgra, episkopskih rezidencija, kuća od kulturne vrednosti, zadužbina, bisti podignutim u slavu pisaca, pesnika i istorijski značajnim ličnostima, sve do česmi na teritoriji gradske opštine. Prema ovom registru,

koji je pedantno zabeležio Seferović, na teritoriji Herceg Novog zavedene su 94 crkve, 32 spomen obeležija iz različitih vremenskih dekada, impozantan broj od 62 arheoloških lokaliteta, uz deset pomorskih lokaliteta posebne istorijske vrednosti, tri spomenika prirodne baštine, na kraju i 12 postavljenih bisti velikim piscima i pesnicima. Iznete brojke dovoljno snažno ilustruju vrednost u istorijskom, kurtuloroškom, ekonomsko-turističkom, društvenom, socijalnom, geopolitičkom, verskom, religioznom, duhovnom i umetničkom dijapazonu, i nesumljivom “*par excellence*” uticaju na formiranje kulturnih obrazaca, kako na prostoru Crne Gore, tako i van granica zemlje kojoj pripada. Insistiranje na permanentnom podsticaju afirmacije i upoznavanja sa svim potencijalima koje Herceg Novi poseduje, podrazumeva pojačanu kulturu sećanja i pamćenja.

3. PODIZANJE SVESTI GRAĐANSTVA O ZNAČAJU KULTURE HERCEG NOVOG

U ovom delu bavimo se potrebama građanstva da više učestvuju u kulturnom životu grada, kao i nužnosti podizanja svesti građanstvu o vrednostima u kojima stvaraju i bitstvuju. Izgrađujući habitus na temeljima nasleđa od neprocenjive vrednosti, svaki subjekt ponaosob formira svoj stav prema kulturi i istoriji u kojoj se razvija. Međutim, neophodno je kao znak savesti istaći sledeće priznanje i suočavanje sa istinom, oporom i paradoksalnom, da sve što je gore istaknuto kao kulturni resurs, čak ni žiteljima ovoga grada nije dovoljno dobro poznato, još manje prezentovano na način koji zahteva potpuno drugačiji koncept savremenog kulturnog poimanja pre svega u marketinškom smislu. U skladu sa vremenom i novim mogućnostima od stalnog medijskog prisustva, vizuelizacije, otvaranje različitih potencijala koje su u dobroj meri danas marginalizovani. Uočljiv je nedostatak strategija koja ne tolerišu improvizaciju, niti “ad-hoc” aktivnosti. Nedostak ideja i u medijskoj sferi, interaktivnost sa zahtevima potencijalnih konzumenata, novih kreativnih rešenja, i potpuno neutralisanje pasivnosti kako bi se projektni zadaci realizovali sa visokim stepenom efikasnosti, naravno u sintezi svih aktera, pre svega u kordinisanim akcijama između turističkih i ekonomskih poslanika i usaglašene generalne kulturne politike. To bi gradu omogućilo trostuku korist:

A. Animaciju kroz prezentacije kulturno-istorijskog nasleđa, i komercijalnu dobit, a u viskom procentu preoblikovalo turističku klijantelu. U ovom kontekstu nameće se pitanje stimulisane naučno - istraživačkih timova kako bi se šira javnost upoznala sa tako obimnim kulturnim nasleđem. Transparentnost i aktiviranje zapostavljenim, i gotovo konzerviranim kulturnim vrednostima, kakvi su bez sumnje arheološki i pomorski lokaliteti, čijom bi se izloženošću turistima, otvorilo novo polje delovanja i ukupno poboljšanje kvaliteta turističke ponude. Iluzorno je na ovom mestu praviti paralele između gradova sa ograničenim i znatno manjim kulturnim kapacitetima, koji zahvaljujući marketingu, odnosima sa medijima i javnošću permanentno i efikasno animiraju i usmeravaju ciljne potrošačke grupe ka otvorenosti, čak i onih ograničenih ili skučenih vrednosti koje u istorijskom smislu ne predstavljaju značajnu kulturnu vrednost i sadržaj. Istorijski, gotovo tektonski poremećaji, globalni i lokalni ratovi, krize, prirodne nepogode, klimatske promene, otežavajuće okolnosti koje pogađaju turističku sferu, teškoće u održavanju visokog kvaliteta saobraćajnih komunikacija, nesigurnost, pojačan rizik, sa kojima se suočavaju kulturne i turističke destinacije, podrazumeva fleksibilnost i raznovrsnost novih koncepata kao bi se ova privredna grana uopšte održala. Herceg Novi

je od osnivanja sa širokim rasponom razumevanja mnogobrojnih istorijskih tokova izgrađivao sebe na način koji jedino nije podrazumevao gubitak slobode, identiteta i misli. Ali je zbog urođenog kosmopolitizma svaku kulturu koja je proklamovala različite namere i ciljeve upravo integrisao kao prolaznike koje mogu da ostave makar kulturni pečat gradeći tako poziciju koja će ga učiniti raznovrsnim i kulturno jasno određenim. Tomo K. Popović u „Istorijskim bilješkama“, period od 1382. do 1797. godine, piše da je bosanski kralj Stjepan Tvrdko I, sedam godina prije Kosova, dakle 1382. g, počeo da zida novi grad, dogradio ga je, proširio i uljepšao sinovac mu Herceg Stjepan- Vukčić Kosača, otuda mu i ime Herceg Novi [2]. Svaka vrsta uticaja koja je diktirala i usmeravala civilizacijski točak, hercegovljani su razumeli kao doprinos i vrednost. Ne samo područja na kojem je grad nicao, već i u širem kontekstu značaja koji bi mogao da dobije u budućnosti kreiranu i stvaranu i iz različitih istorijskih interesa. Ali sa zajedničkim imeniteljom od osnivanja, preko Mlečana, Feničana, Španaca, Austrougarske, Osmanlijske Turske, sve do današnje, oblikovane agende u kojoj kultura i kulturna dobra zauzimaju visoku poziciju i kategoriju osobenosti vredne pažnje.

B. Upravo iz ove spoznaje rad sadrži i segment koji analizira i komunikacione magistrale kako bi se na planu odnosa sa javnošću, drugačijim medijskim prisustvom, originalno koncipiranjem novih turističkih sadržaja aktera uključenih u kompaktan timski angažman povezalo u jednu celinu. Tako bi Herceg Novi, otvoren i transparentan, u punom kapacitetu afirmisao novu razvojnu kulturnu i kroz nju turističku politiku. To bi u konačnom zbiru doprinelo dalekosežnim benefitima koje bi iz novog strateškog opredeljenja, značajno povećalo kredibilitet, osnažilo prepoznatljivost i uticaj na globalnom ekonomskom, turističkom i socijalnom planu. U takvoj simbiozi delovanja prema široj javnosti u kontinuitetu bi se prezentovala sva kulturna, sada izolovana i sakrivena bogastva, (primer gotovo zarasle i oku posmatrača nevidljive tvrđave Španjola), i mnogih drugih, koja su nažalost sada daleko od javne pozornosti, i sa atributom neiskorišćenih, praktično marginalizovanih potencijala. To podrazumeva korenite promene u shvatanju i razumevanju neophodnosti preoblikovanja prezentacije turističkih usluga. Između ostalog, i zbog ogromne ekspanzije i konkurencije koja se i u takvim okolnostima veoma brzo transformiše i prilagođava inovativnim turističkim trendovima, kakvi su bez sumnje primeri specijalizovanih, i po osobenosti veoma poželjnih segmenata iskorišćenih iz različitih društvenih oblasti. Tome najbolje svedoče ubrzane transformacije unutar zdravstvenih sistema, prilagođavajući angažmane prema specifičnosti ove privredne grane u odnosu prema turističkim i drugim sadržajima. Kao i sve jasniji definisan primat na oslobađanju i širokoj otvorenosti ka kulturnim dobrima prema ljudima koji žele da se uz bazičnu ponudu upoznaju i sa kulturnim vrednosti zemlje i grada u kojem borave određeno vreme. Moderan čovek, ne mora po definiciji biti predstavnik elite, već kao pasionirani ljubitelj kulturnih vrednosti, traži vrstu izlaska iz nametnutog turističkog obrasca i monotonog klišeja zbog neaktivnosti lidera da kreiraju i nametnu nove sadržaje. Zahtev drugačije ponude mora da implementira i kreira novu sintezu od već mnogo puta doživljenog sa aspekta turističke ocene onoga što mu se nudi. A takav pristup doprineo bi razvijanju novih mogućnosti da boraveći u Herceg Novom stekne potpuniju sliku, sadržajnije i živopisnije od uobičajne ponude. Trenutak u kojem se svet nalazi zahteva, strateški precizno utvrđen red poteza kako bi se dve društvene oblasti, ekonomska i turistička, pojavili kao nosioci modernije i probitačnije animacije i strategije za

osvajanjem novih tržišta povezujući ih u sinhronizovanu celinu, i u opštem interesu, kako na planu afirmacije dobara, tako i komercijalizacije.

C. I treći aspekt podjednako važan podrazumeva obaveznost medijske kampanje i cele lepeze marketinških alata koje nosiocima ovih aktivnosti stoje na raspolaganju. Vreme neoliberalnog koncepta kapitalizma izraženo kroz konzumentarizam, podrazumeva bitnu promenu strategija kada su u pitanju novi modeli, kako bi se potencijalnim korisnicima ovako nematerijalno bogastvo prezentovalo i učinilo dostupnim, kroz sažimanje istorijsko - kulturnih i geopolitičkih paralela što bi Herceg Novom osnažilo poziciju stečenu na kulturnoj mapi između “Istoka i Zapada”. Spoj samo na prvi pogled nespajivih kulturnih osobenosti i specifičnosti, upravo bi podigao kulturni sadržaj i identitetsku ličnu kartu Herceg Novog. Direktna uticaj različitih civilizacijskih kulturnih narativa i paradigmi oblikovao se kroz protok vremena u ekstremno harmonizovanu celinu, čija je spona kroz vekove egzistirala kako na materijalnom, tako i na duhovnom planu, što je retka dragocenost na mapi svetske kulturne baštine. Zalag za ovakav stav bazira se na već sve opštim faktima, jasno određenim prema podacima o broju kulturnog i religijskog blaga smeštenog, kako u centralnoj gradskoj zoni, tako i u određenom skladu duž cele hercegnovske rivijere i njene zaleđine. Praktično svako selo duž hercegnovske rivijere poseduje mnogobrojne skrivene kulturološke riznice, određene devastirane, ali u u istorijskom kontekstu veoma važne kao dokaz kulturnog kapitala i tradicija u kojem su nastajale. Živo svedočanstvo kulturnih epoha sa obrascem ispisivanim kao jedinstvo suprotnosti, ljudske i kulturne raznolikosti, koja je dospevala do najudaljenijih tačaka planete kroz vremenske dekade. Determinisali su ih sa različitih aspekata i opšte prihvaćene neprevaziđene vrednosti i sa karakteristikama koje su se manifestovale u mnogobrojnim društvenim segmentima u afirmaciji grada. Ako kroz aspekt sadašnjosti posmatramo i istražujemo korene hercegnovske multikulturalnosti, latili bi se zadatka koji je sam po sebi, zbog obima i značaja, pretenciozan. Ali ono što je nesporno, u svakom smislu treba težiti takvom naumu, jer je on stvaran, realan i opiljivo, živ sam po sebi. Da li je reč o turističkim i kulturnim stratezima, to je pitanje prve vrste o kojem se mora ozbiljno razgovarati kako bi se profilisale strategija na kojim bi se pokazala održivost i praktičnost korišćenja kulturnih mogućnosti sa ciljem oblikovanja grada sa drugačijim polazištem od većine koji svetu određuje prefiks unisonosti i favorizovanja masovnosti. Značajnija i jača upotrebna vrednost kulture, samo bi podigla nivo i dodatni kvalitet. Jer, kultura nema granica, što bi onda jedan grad sa takvom kulturnom baštinom ograničavao sopstvene ideje, zadovoljavajući se sa konceptom koji je u priličnoj meri prevaziđen. Za tako nešto potrebno je učiniti čitav niz koraka kako bi se u praktičnom smislu osetili rezultati dobro osmišljene strategijske kampanje.

4. NAUČNA JAVNOST I FESTIVALI KULTURNOG NASLEĐA

U ovom delu izvršićemo kvalitativnu analizu određenog broja naučnih radova koji se dotiču festivalskih formi prezentacije kulturnog nasleđa. Prvenstveno se oslanjamo na naučnu javnost zemalja koje su svoju kulturu utkale u istoriju grada Herceg Novog. Napomenućemo da su festivali kulturnog nasleđa prisutni na raznim svetskim lokacijama. Velika većina tih festivala nalazi se i na mediteranu. Metodološki posmatrano uvek se može početi od mogućnosti ekonomske postave održivosti samog festivala. O tome govore i

španski autori koji se bave nematerijalnim kulturnim nasleđem. Oni navode nekoliko komponenata u ekonomskoj održivosti kulturnih projekata, a to su izdvajanje sredstava od imućnih poslovnih pojedinaca, kao i sredstava od kompanija, zatim ekonomskih uticaja na regiju u kojoj se održava festival kao i ulog institucija lokalne samouprave [3]. Grčki autori idu dalje u razmatranjima kako što bolje unaprediti festivale kulture. Oni napominju važnost ekonomske politike i ekonomske kreativnosti, koja može imati uticaj i na sam razvoj zemlje [4]. Istraživanje ovih autora takođe pokazuje da postoje i društvene grupe koje su senzibilnije prema ovakvim festivalima (uglavnom je to prema istraživanjima obrazovanja i ekonomski imućnija grupacija žena). Ovakvo istraživanje idu u prilog komunikološkoj teoriji o socijalnoj segmentiranosti masovne publike, koja se upravo bavi društvenim grupama i njihovim reagovanjem na medijske sdržaje [5]. Ova teorija ukazuje da pripadnici masovne publike, istog pola, obrazovanja, starosti, reaguju slično na kulturološke sadržaje, koji se plasiraju putem medija ili festivalskih formi. Kada govorimo o italijanskim istraživačima, zapažamo njihovu zainteresovanost ka festivalu kulturnog nasleđa u južnoj Italiji, regija Apulija. Sa Barijem kao glavnim gradom ova regija poseduje festival pod nazivom *Nocte della Taranta*, koji promovise modernu i tradicionalnu muziku. Festival je prožet nizom istorijsko-kulturoloških događaja. Takođe ovaj festival je povezan sa univerzitetima u Italiji i u inostranstvu, jer se kroz akademske institucije dublje proučavaju lokalne kulture i način kako da se unaprede u festivalske forme. Tako je istraživanje pokazalo da festival u Apuliji poseti 230 000 posetilaca, te da on progresivno, ekonomski i lokalno napreduje [6]. Istraživači sa Malte idu dalje u svojim razmišljanjima. Oni navode da festivali kulturnog nasleđa na mediteranu moraju da prate nove svetske tokove, kao jednu vrstu izazova, kao i da promocija lokalne kulture zasigurno doprinosi ekonomskom napredku društva ali ima i svoju edukativnu dimenziju kroz digitalizaciju medija [7].

5. REZULTATI ISTRAŽIVANJA

Istraživanje je sprovedeno od juna do avgusta 2023 godine na teritoriji opštine Herceg Novi. Upitnik je formiran radi procene stavova građana Herceg Novog prema očuvanju kulturnog nasleđa. Korišćen je upitnika trostepene Likertove skale [8]. U ovom radu izdvajamo tri pitanja bitna za ovaj segment naučne delatnosti. Ostala pitanja biće iskorišćena za druge naučne zamisli i radove u okviru unapređenja kulture grada Herceg Novog.

Tabela 1: Stavovi građana Herceg Novog prema formiranju festival kulturnog nasleđa

Pitanja	Pozitivan stav	Negativan stav	Bez stava
1. Da li ste zadovoljni medijskom prezentacijom i otvorenošću kulturnog nasleđa Herceg Novog	20 %	70%	10 %

2. Da li smatrate da je Herceg Novom u turističkoj ponudi potreban festival kulturnog nasleđa	80 %	15 %	5%
3. Koliko ste zadovoljni odnosom gradske vlasti prema održavanju i očuvanju kulturnog bogatstva	20%	65 %	15 %

Iz priloženog se vidi (tabela 1.), da građani Herceg Novog velikom većinom (80 %) imaju pozitivan stav prema formiranju festivala kulturnog nasleđa u njihovom gradu. Negativan stav je iskazan prema medijskoj prezentaciji kulturnog nasleđa (70 % ima negativan stav), kao i njegovom očuvanju na lokalnom nivou (65 % ima negativan stav). Istraživanje sličnog tipa, rađeno je i u regionu. Naime velika većina mladih ljudi u Srbiji smatra da mediji vrlo malo izveštavaju o značaju srednjovekovnog kulturnog nasleđa kao i o njegovom očuvanju [9].

6. ZAKLJUČAK:

Na osnovu analiza: a- kulturnih vrednosti grada Herceg Novog, b- naučne javnosti mediteranskih zemalja koje temeljno izučavaju potencijale kulturnih vrednosti svojih regija, c- sprovedenog empirijskog istraživanja (stavova građana Herceg Novog prema kulturnim vrednostima), smatramo da je potrebno sprovesti sledeće ekonomske, komunikološke (medijske) i kulturološke strategije:

1. Ostvariti kontinuitet u implementaciji i realizaciji projektovanih ideja. To jedna od najznačajnijih strateških odrednica. Kampanjsko delovanje neće doprineti i ostvariti dugoročni efekat.

2. Drastično pojačavanje aktivnosti na medijskom planu, podrazumeva upotrebu savremenih medija, korišćenje raznovrsnih medijskih sredstava, od tradicionalnih do najnovijih, kakve su društvene mreže, internet, portali, elektronska izdanja, itd. Sve mora biti osmišljeno prema potrebama i željama korisnika, uz jasno i precizno vođene i osmišljene reklamne kampanje, izdavanje publikacija, vodiča, flajera, propagandnog materijala, organizovanja kulturnih simpozijuma, okruglih stolova, debatnih sesija, i svih ostalih komunikacijskih sadržaja.

3. Saradnja sa svim PR licima iz oblasti kulture i turizma, stvaranja čvrstih veza, kako bi se realizovali međusobni interesi i na najbolji način obavestavalo javno mnjenje i pospešivao interes na svim nivoima, što bi dodatno valorizovalo vrednost kulturne baštine.
4. Dinamična distribucija informacija, podizanje vrednosti kulturnog PR-a.
5. Funkcionalnije delovanje kulturnih organizacija prema medijima.
6. Direktna harmonizacija odnosa između kulturnih i turističkih poslanika.
7. Intenzivna saradnja sa svim relevantnim činiocima od lokalnog do međunarodnog nivoa (prvenstveno medijskih produkcija iz inostranstva koje se bave kulturom).
8. Permanentno lobiranje i povezivanje sa najreprezentativnijim predstavnicima iz različitih kulturnih oblasti.
9. Personalizovanje određenih kulturnih vrednosti kroz aktivnosti grupa i pojedinaca koji su opšte poznati i prihvaćeni od javnog mnjenja.
10. Intezivan rad na kreiranju određenih brendova iz kulturnog miljea, poboljšanje reputacionog kapaciteta ukupne kulturne i turističke tradicije, kao i jačanje imidža koji je grad stekao na kulturnoj mapi.
10. Rad na pripremi javnih nastupa kulturnih poslanika sa jasnim ciljem i porukom koju upućuju javnosti
11. Konačno jedan od glavnih strategijskih ciljeva je kulturološka integracija grada Herceg Novog sa mediteranskim gradovima koji gaje festivale kulturnog nasleđa (gostovanje umetnika iz tih gradova na budućem festivalu kulturnog nasleđa grada Herceg Novog).

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HERCEG NOVI: ANALYSIS OF ECONOMIC AND COMMUNICATION ASPECTS OF CULTURAL HERITAGE FROM THE PERSPECTIVE OF CITIZENS' ATTITUDES

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SUMMARY:

Herceg Novi, with its rich culture built over centuries, is one of the most important tourist destinations in Southern Europe. The goal of the work is to look at the potential of the city's cultural heritage as well as the possibility of connecting it with economic and media aspects. We start the research method by studying the scientific and media public of countries whose peoples left their mark in the formation of the culture of Boka Kotorska. We analyze how those countries promote their own cultural values. The attitudes of the citizens of Herceg Novi towards the realization of the cultural heritage festival and the ways of its presentation were also examined. Combined research methods were used in the form of surveys, interviews, as well as analysis of media content from the fields of culture and economic policy. The research results show that new strategies are needed in the development of local culture and the strengthening of the tourist potential of the city.

Keywords: *Herceg Novi, cultural heritage, promotion*

DOES THE ACCOUNTING DEPARTMENT PROVIDE TAX COMPLIANCE OF COMPANIES?

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ABSTRACT:

In general, company owners and its legal representatives are responsible for tax payments of the company and possible tax evasion. On the other hand, tax compliance usually depends on the bookkeeping records made by the accounting department. In many cases, accountants are asked to solely decide on the tax treatment of certain transaction, while in others they may have a help from the legal department of the company. In addition, tax treatment of certain transactions is decided after the consultations with external tax consultants, which employ both accountants and lawyers. Case studies from the Republic of Serbia presented in the paper show that accounting departments are mostly responsible for deciding on tax treatments of transactions, while legal departments in companies are usually responsible for drafting the contracts, collaboration with attorneys and preparation for court proceedings. Such findings imply that accountants should have a wide knowledge on various types of taxes in order to ensure tax compliance. While professional accounting organizations have already included tax modules in their education programs, most faculties in developing countries dealing with accounting issues are yet to implement it. Therefore, higher education institutions should strive to fill this gap in order to harmonize their education programs with the requirements of the accounting labor market.

Keywords: *accounting, law, tax, tax compliance, tax evasion, education*

1. INTRODUCTION

Tax Accountant, Accounting and Tax Manager, Accounting, Tax and Compliance Specialist, Associate for Accounting and Tax are only few of many working positions in modern companies that require both accounting and taxation knowledge. In fact, many job interviews for the accounting working positions assume various questions about company taxation – calculation of taxes, tax rates, deadlines for filing tax returns etc.

Such circumstances imply that accountants are important for ensuring tax compliance of the company. Belnap et al. (2024) find that both accountants in the company and external accounting companies are important in ensuring tax compliance of the company. In fact,

company owners and its legal representatives are responsible for tax payments of the company. However, accountants often advise company owners on their taxation issues (Boll, 2014).

Taxes are interdisciplinary issue that may be viewed, *inter alia*, from both accounting and law aspect (Lamb & Lymer, 1999). In this regard, it is often questioned whether accountants or lawyers should be responsible for tax compliance. Graduated lawyers should have knowledge from the *Tax Law* courses, while accountants often finish their studies without separate taxation course. On the other hand, accountants record business transactions in general ledger and need significant tax knowledge as it is hard to imagine transaction without any impact on the current and/or future tax payments of the company.

Subject of the paper is ensuring tax compliance in companies and the responsibility for it. Traditionally, tax compliance is regarded as the main objective of the tax management of the company. In the last few decades, companies also strive to minimize their tax burden and to present themselves as socially responsible companies (in terms of paying taxes) in the public – however, the tax compliance remains a basic task of the tax management.

The main objective of the paper is to examine whether accountants are responsible for ensuring tax compliance in the companies. Usually, only accountants and lawyers are educated in taxes during their studies and deal with the tax issues in companies. Therefore, in the paper is compared the role of accountants and lawyers in ensuring tax compliance in companies in the Republic of Serbia.

Besides introduction and conclusion, the paper is consisted of three parts. The first part briefly reviews the relation between accounting and taxation. In the second part, we have compared the responsibility of accountants and lawyers in securing tax compliance of companies. In the third part of the paper, we have analyzed the tax knowledge that accountants gain during the studies.

2. ACCOUNTING-TAXATION NEXUS

A growing number of companies in developing countries publishes job advertisement for positions that cover both accounting and taxation issues in which candidates with degree in accounting, finance or related fields have a strong competitive advantage. *Tax Accountant* is probably the most widely used name for such position in these companies. Job description of such positions indicates that a candidate is expected to be responsible, *inter alia*, for:

- value-added tax (VAT) – for instance to distinguish whether VAT is payable for specific transaction, to select adequate VAT rate, to deal with VAT on the import of goods and services, to manage data in electronic invoice system etc;
- corporate income tax – for instance to calculate and submit tax liability, control book-tax differences, manage tax benefits in line with the tax law and deal with the withholding tax;

- property tax – for instance to calculate, submit and bookkeep property taxes and ensure compliance with relevant regulation and, in some cases
- personal income tax – though this type of tax is often the responsibility of payroll department of the company.

Some prior research (Seida & Wempe, 2004; Jacob & Schutt, 2020) clearly shows that taxes have a strong influence on investment and financing decisions of companies. For instance, they may influence the managers to invest more in fixed assets or current assets, or to finance the business with equity or debt. In addition, taxes may strongly influence dividend policy, management compensation policy, risk management, corporate restructuring and legal form choice (Shackelford & Shevlin, 2001; Graham, 2003).

The main focus of the prior research is on the corporate income tax, both in countries with high and low corporate tax rates, due to the influence of the US-oriented literature (Zhang et al., 2021) as corporate tax rates in the US have been traditionally high. However, other tax types such as personal income tax and property tax should not be neglected (Lazar & Istrate, 2018). Despite the fact that accountants often rank value-added tax as a most complex tax type, the microeconomic research on it is relatively minor. Zhang et al. (2021) explain that neglecting value-added tax in prior research is due to the fact that some of the most developed countries (such as the USA) does not implement this type of tax.

Although often neglected in the microeconomic research, taxes in the real world are of the first-order importance for accounting and finance sectors of companies. It is hard to imagine any operating, investing or financing transaction without the implications on the tax position of the company. Some transactions result in tax payments or tax savings in the current tax period, while some lead to the tax payments or tax savings only in future periods. As a result, accountants should recognize tax consequences of transactions in order to conduct appropriate bookkeeping records.

Despite the fact that accounting and taxes are highly related, they often impose different rules to the companies. Probably the best example may be found in the corporate income tax as most countries implement different rules for the calculation of accounting income and taxable income (Hung, 2000). Some differences between these types of income result in the calculation of deferred corporate income tax.

Accountants often label taxes as highly complex. For instance, accountants in Serbia argue that deferred corporate income tax is one of the most complex accounting issues (Obradović et al., 2018). In this regard, accountants often use third-party services in order to comply their bookkeeping records with the tax regulation – companies often acquire professional literature and/or external services from professional tax consultants to help accountants to implement the complex tax regulation.

External services from professional tax consultants are often acquired not only to ensure tax compliance, but also to enhance tax planning and tax avoidance (Hogan & Noga, 2015). Due to their well-known reputation, accounting companies from the Big 4 group

(Deloitte, EY, KPMG and PwC) are often marked as the most-frequent tax consultants (Sikka, 2015), though some companies decide to acquire services from local consultants as they might be better and narrowly specialized for a certain domestic market.

Larger companies decided not only to acquire external services from professional tax consultants, but also to organize internal tax departments. Mulligan & Oats (2016) argue that internal tax departments are primarily organized in large companies with multinational presence. Such departments are usually organized under the chief financial officer, together with accounting, controlling, treasury finance and similar departments.

Organizing such departments within legal department of the company is significantly less frequent. However, internal tax departments employ both accountants and lawyers that are responsible for the tax compliance, tax planning and tax avoidance, the collaboration with other sectors of the company and with the external tax consultants. Hogsden (2018) adds that these departments should, besides tax compliance, tax planning and tax avoidance, strive to eliminate negative public reactions to the implemented strategies of tax avoidance.

3. REAL WORLD EXPERIENCES

We have examined the role of accountants in ensuring tax compliance in two companies in Serbia. In each company, we have interviewed an employee that deals with the tax compliance issues. These companies are engaged in different industries, located in different cities and are of different size, thus enabling us to study possible differences regarding tax compliance in companies with different specific features.

The first company is a smaller company that is primarily engaged in the hotel and hospitality industry. This company owns many hotels, motels and restaurants in one of the largest cities in Serbia. In addition, this company employs chief financial officer, two senior accountants and two accountants. Each of five mentioned employees has bachelor degree or secondary school degree in the field of economy. Legal department of the company employs only one person, with bachelor degree in the field of law.

In this company we have interviewed a female senior accountant with bachelor degree in the field of economy. She responded that accounting department is fully responsible for most types of taxes – they do not deal only with the personal income tax and social security contributions, since they are responsibility of the payroll department. However, payroll often consults accounting department regarding relevant changes in the tax law. Among other tax types that are responsibility of the accounting department, she labelled VAT as the most challenging tax type.

Regarding the role of legal department in this company, interviewed accountant responded that lawyer is primarily responsible for drafting contracts, while he is not familiar with the tax regulation. For instance, she witnessed that the lawyer is not familiar even with the basics of the corporate income tax calculation. She furtherly responded:

“The lawyer primarily drafts the contracts. He tells us that he is willing to change the contract provisions if it is necessary due to unfavorable tax treatment of current version of the contract.”

Accounting department in this company is responsible for deciding on the tax treatment of every-day transactions, but also of some less frequent and more challenging transactions. For instance, the company belongs to the consortium that bought the assets of the bankrupt hotel from Serbia. The contract for this transaction was drafted by the lawyer, but tax implications (primarily regarding the property tax) of this transaction were the responsibility only of the accounting department.

Such dilemmas on the tax treatment of specific transactions are solved by the chief financial officer and the accounting department, but the company is also subscribed to a professional magazine that deals with accounting and taxation. The company also uses consultations (through e-mail and telephone) with company that publishes the professional magazine.

The lawyer of the company is not even included in some fully legal aspects of taxation. For instance, in one month the company missed to meet the deadline for filing VAT return. In this case the accounting department had to calculate and pay default interest for delayed VAT payment. Accounting department also had to communicate with the national tax authorities. In addition, the accounting department have to cooperate with national tax authorities during the tax audits.

Regarding the tax education of interviewed accountant, she had only *Public Finance* as a tax-oriented course during the studies. In addition, she obtained the *Certified Accountant* license from the Association of Accountants and Auditors of Serbia – among other exams, she had *Tax System* within this program.

The second company is a larger company that is primarily engaged in manufacturing, though it operates in several other industries, such as real estate and hospitality. This company is headquartered in one of the largest cities in Serbia. The company has, under the chief financial officer, separate departments of accounting, controlling, taxation and treasury finance. Tax department employs only one female employee (that we have interviewed), with bachelor degree in the field of economy.

Interviewed employee responded that she closely collaborates with the accounting department. These departments are jointly responsible for tax compliance of the company. Tax and accounting departments are not responsible only for the personal income tax and social security contributions, as they are the responsibility of the payroll sector, organized within the legal and human resources department.

Regarding the role of the legal department in the company, interviewed accountant responded that lawyers are not responsible for tax compliance, as they primarily draft the contracts and send them to the chief financial officer for the approval. Lawyers also collaborate with attorneys and prepare documents for court proceedings. On the other

hand, tax and accounting departments should closely collaborate with the legal department. However, some problems in such collaboration may occur. The interviewed employee explained one of the past problems:

“The legal department registered a change of the purpose of some company’s land from the agricultural to the construction land. However, they did not note us about this change, as they did not know that such change has the important tax implications. As a result, we have paid property tax in less amount than we should have paid.”

Regarding previous example, it may be added that companies in Serbia should pay property tax on the agricultural land in significantly smaller amount compared to the property tax on the construction land.

To ensure tax compliance, tax and accounting department of this company invest significant funds in external tax consulting. In this regard, they use services of professional tax consultant and are subscribed to two professional magazines that deal with the accounting and taxation. They also use additional consultations (through e-mail and telephone) with the companies that publish these professional magazines.

External tax consultants are usually highly helpful in solving tax dilemmas in the company. However, in some cases they produce even more questions regarding the certain tax treatment. The interviewed employee explained one of the cases:

“We purchased some services from a supplier, but we were not sure whether these services belong to the construction services or not, since (under certain criteria) for such services VAT should be calculated using reverse-charge mechanism. Through e-mail communication with the external tax consultant, he explained that these services belong to the construction services. However, after we called him to get further explanation, he changed his opinion.”

Similarly to the first mentioned company, the interviewed employee responded that tax and accounting department had to cooperate with national tax authorities in case of any tax audit. In addition, this interviewed employee also had only *Public Finance* as a tax-oriented course during the bachelor studies and has *Certified Accountant* license from the Association of Accountants and Auditors of Serbia.

4. TAX EDUCATION OF ACCOUNTANTS

Complexity of the tax regulation has significantly increased during the last few decades. Owens & Hamilton (2004) stress that complexity of tax regulation may prevent understanding and managing tax liabilities. Such circumstances may lead to the unintentional mistakes in the calculation of tax burden, but also to the intentional tax evasion. Therefore, if the accountants are asked to ensure tax compliance of their companies, they should be adequately tax-educated.

In this regard, professional accounting organizations that certify accountants and issue professional licenses have already included tax courses as obligatory courses in the professional education. For instance, the Association of Chartered Certified Accountants from the Great Britain included the course *Taxation*, while the Association of Accountants and Auditors of Serbia included the course *Tax System* for two professional licenses (*Accountant* and *Certified Accountant*).

However, faculties in Serbia that offer accounting and finance modules still struggle to comply with the requirements of the accounting labor market, particularly regarding the tax knowledge of graduated students. Therefore, we have analyzed curriculums (for the bachelor studies) of the state-owned faculties of economics that offer accounting-based modules. Regarding taxation, we find that:

- the first faculty has *Public Finance* as mandatory course in the seventh semester and *Tax Accounting* as optional course in the eighth semester;
- the second faculty has only *Public Finance* as mandatory course in the third semester;
- the third faculty has *Public Finance* as optional course in the fifth semester and *Budgetary and Tax Accounting* as optional course in the sixth semester;
- the fourth faculty has *Monetary and Public Finance* as mandatory course in the third semester and *Tax Accounting* as mandatory course in the eighth semester and
- the fifth faculty has *Monetary and Public Finance* as mandatory course in the fourth semester and *Tax Accounting* as optional course in the eighth semester.

This brief review of curriculums shows that taxation courses are primarily macroeconomic-oriented (public finance courses) and consider taxes as a state revenue, rather than the company expense. Microeconomic-oriented courses (tax accounting and tax management courses) are not offered at some faculties, while at most of them are only optional.

The situation is even worse at the master studies level (considering master studies in Serbian language). Out of the five mentioned state-owned faculties, no one faculty offers master program with “tax” or “taxation” in its name. In addition, no one faculty offers any tax-oriented course within accounting and finance master programs.

In addition, state-owned faculties that offer accounting-based modules suffer from the lack of taxation issues in other courses. For instance, at some faculties *Financial Accounting* or *Financial Bookkeeping* courses are lectured without covering VAT and corporate income tax issues – therefore, transactions are recorded in a general ledger ignoring most of the taxes. Some faculties offer courses on the accounting of financial institutions (banks and insurance companies) and also ignore taxation issues – for instance, VAT, corporate income tax and non-life insurance premium tax.

The important step forward was made by one state-owned faculty (first mentioned in our brief review of curriculums) as this faculty made an agreement with the state-owned faculty of law to jointly organize master program *International Master in Taxation* in English language, lasting one or two years. Each mandatory course of this master program

is tax-oriented (macroeconomic, microeconomic and law). One of the mandatory courses is *Tax Accounting*.

Regarding study programs and courses that deal with accounting and financial aspect of taxation, state-owned faculties in Serbia are lagging behind some faculties in neighboring countries. For instance, state-owned faculties in Croatia offer various tax courses besides *Public Finance* and *Tax Accounting*. In this regard, we point out to the curriculum of the two faculties in Croatia:

- the first faculty organizes two-years program *Accounting, Financial Reporting and Auditing*, in which *Accounting Aspect of Company Taxation* is the obligatory course in the first semester. In addition, they organize (in duration of one year or one and a half year) program *Accounting and Taxes*, in which *Tax System of Croatia* is the obligatory course, while *Calculation and Filing Taxes* is the optional course. Program *Accounting and Auditing* in English language is also organized with *Tax Accounting* as the optional course.
- the second faculty organizes two-years program *Financial Management*, in which they organize *Tax Management* as obligatory course in the second semester and *Fiscal Policy* as obligatory course in the fourth semester. On another one-year program *Accounting, Auditing and Analysis*, they organize *Tax Forensics* as obligatory course. In addition, they organize the *Public Finance* course at the undergraduate studies level.

Microeconomic aspect of taxation is also well represented at some faculties in Bosnia and Herzegovina. First, one state-owned faculty organizes master program *Accounting and Taxes*, lasting one or two years. Regardless of the studies duration, two important courses are part of this master program – *Tax Accounting* and *Tax System of the European Union*. Both courses are obligatory. This faculty also has a course *Taxes and Corporations* at the undergraduate studies.

Second, another state-owned faculty has two obligatory courses for students of accounting and finance. *Tax system of the Bosnia and Herzegovina* is the obligatory course in the seventh semester, while *Tax Accounting* is the obligatory course in the eighth semester.

5. CONCLUSION

The concepts of tax compliance and tax avoidance are as old as taxes themselves. Therefore, ensuring tax compliance is an ever-present issue in companies. In this regard, we have studied the responsibility for ensuring tax compliance within the companies with particular focus on the role of the accountants.

Our research showed that accountants are most responsible for ensuring tax compliance in companies. They should (often solely) decide on the tax treatment of business transactions, while, in some specific cases, they use external tax consultants to ensure tax compliance. Some larger companies organize separate tax department within the company and mostly employ accountants in it. Interviewed accountants responded that the role of

accounting in ensuring tax compliance is significantly larger than the role of legal department of the company as company's lawyers are primarily responsible for drafting the contracts.

Our research points out at the imbalance between the requirements of the accounting labor market and the knowledge that the accountants gain during their education. In general, companies require important tax knowledge from the accountants, while the accountants are not enough tax-educated during their studies.

Such imbalance has important implications on various stakeholders. First, creators of the accounting programs (at faculties and within professional organizations) should be aware of the lack of tax education for students of the accounting and finance. This implies that students of accounting and finance should be equipped with more tax-oriented knowledge, which may be conducted in at least two ways: introducing completely new tax-oriented courses (for instance *Tax Accounting*, *Tax Consulting*, *Tax Management* etc) or deepening the tax knowledge within the current courses (for instance *Financial Accounting*). Second, companies should be prepared to finance further tax education of their accountants as a result of the insufficient tax knowledge that accountants gained during the education.

Presented attitudes should be considered in the light of certain limitations. Our research is based on the interview method, covering only two accountants from only one country. In this regard, the future research may develop a larger sample and cover more developing countries. In addition, the answers from the interviewed accountants may be quantified, thus enabling the statistical analysis.

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TEHNOLOŠKI RAZVOJ I INOVACIJE KAO TEMELJ EKONOMSKOG PROGRESA SRBIJE

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SAŽETAK:

Savremeni svet oslikan je neprestanim promenama, u kojima ključ ekonomskog uspeha leži u sposobnosti njihovog razumevanja i optimalnom prilagođavanju novonastalom poslovnom okruženju. Promene se događaju tolikom brzinom i takvim intezitetom da ih je veoma teško pratiti. Jedan od osnovnih principa za rast i razvoj zemalja, kao i za celokupni društveno-ekonomski napredak jeste razvoj nauke i tehnologije.

Savremeni privredni tokovi u svetskoj privredi, a pogotovo kretanja u okviru tehnološkog razvoja, postaju sve dinamičnija. U današnjem svetu samo one države koje su u stanju da ulažu u istraživanje i razvoj mogu da se nadaju ekonomskom napretku i prosperitetu.

Konstantne tehnološke promene utiču i na povećanje dinamičnosti uslova poslovanja, čineći ih neizvesnim i nepredvidivim. Modernizacija tehnologije, rast i razvoj u okviru tog sektora direktno utiču na rast privrede. Opšte usmeravanje preduzeća u pravcu razvoja, rezultiralo je sve većoj inovativnosti. Cilj rada je da se ukaže na značaj i kompleksnost uticaja tehnološkog razvoja na savremene uslove poslovanja i da pokaže da je upravo strateški kurs Srbije ulaganje u razvoj nauke i tehnologije, kao i podsticanje razvoja poslovanja preduzeća u tom pravcu.

Ključne reči: tehnološki razvoj, inovacije, društveno-ekonomski napredak, Srbija

1. UVOD

U uslovima brojnih globalnih izazova, znanje predstavlja pouzdan temelj za budući ekonomski napredak. Razvoj privrede i društva danas se sve više zasniva na znanju kao ključnom resursu, a broj svakodnevnih društvenih izazova koji se mogu rešiti samo novim znanjem, se konstantno uvećava.

Potreba za znanjem i naukom sve više je izraženija. Može se reći da je nauka važna komponenta razvoja svakog društva, pa tako i Srbije. Na moći nauke da stvori, proširi i primeni znanje počivaju tehnološki napredak, bezbednost, obrazovanje i nacionalni identitet.

Srbija se, kao i druge države, suočava sa brojnim društvenim izazovima, među kojima su ekonomske krize, klimatske promene, migracije, demografski trendovi i bezbednost. Uprkos ekonomskom razvoju Srbije, svi ti izazovi predstavljaju određene pretnje za razvoj, a mogli bi delimično i da uspore napredak Srbije. Zbog toga, nauka i tehnologija očigledno igraju važnu ulogu u pripremanju odgovora na takve izazove. Neophodnost otkrivanja i primene naučnog znanja upravo u takvim momentima izraženija je nego inače, a time se pokazuje ispravnost uverenja da je snaga jednog društva srazmerna znanju kojim raspolaže.

Jedan od osnovnih principa za rast i razvoj, kao i za celokupni društveno-ekonomski napredak jedne zemlje, jeste razvoj nauke i tehnologije. Srbija će upravo kroz Strategiju naučnog i tehnološkog razvoja, u narednom periodu ojačati još više naučnoistraživački i inovacioni sistem. Na taj način Srbija će biti progresivnija u prilagođavanju izazovima, kojih je svakim danom sve više, a uz prepoznavanje postojećih potencijala, biće u mogućnosti da održi kontinuitet reformi i približi se zemljama EU.

2. NAUČNO-TEHNOLOŠKI I INOVACIONI SISTEM U FUNKCIJI RAZVOJA

Nauka i istraživanje predstavljaju sistematski stvaralački rad koji se preduzima radi stvaranja novih znanja, s ciljem podizanja opšteg civilizacijskog nivoa društva i korišćenja tih znanja u svim oblastima društvenog razvoja. Nauka i istraživanje kao delatnost, danas su od posebnog značaja za sveukupni razvoj Srbije. [6]

Naučnoistraživački i inovacioni sistem u Srbiji danas predstavlja jedan dinamičan sektor, koji je tesno povezan sa obrazovanjem, privredom i društvom. On sa sobom nosi brojne prednosti, ali i velike izazove.

Naučno-tehnološki i inovacioni sistem doprinosi ubrzanom razvoju Srbije kroz poboljšanje kvaliteta i efikasnosti nauke, tehnološki razvoj i inovacije i dalju integraciju u

Evropski istraživački prostor, čime se pomaže da se dostignu standardi razvijenih ekonomija. [2] Srbija postaje okruženje koje podržava razvoj novih inovativnih projekata, istraživanja i rešenja. Rad na stimulativnom pravnom okviru, kao i povećanje finansijskih sredstava za ulaganje u istraživanje i razvoj, razlog su zašto Srbija napreduje i pozicionira se kao ekonomski uspešna i inovativna zemlja. [6]

U doba digitalizacije, Srbija želi da poboljša i ojača svoju poziciju inovatora kroz sprovođenje podsticajnih mera poput lakšeg započinjanja poslovanja, lakšeg zapošljavanja, stvaranje novih podsticaja za istraživanje, razvoj i stvaranje intelektualne svojine, kao i drugih mera za olakšano digitalno poslovanje. U cilju podsticanja istraživanja, razvoja i stvaranja intelektualne svojine i inovacija, osnovani su Fond za inovacionu delatnost Republike Srbije i Fond za nauku Republike Srbije koji pružaju finansijsku podršku naučnoistraživačkim organizacijama i privredi za razvoj inovacija. [6] Ova dva fonda finansiraju naučna istraživanja iz različitih oblasti koji doprinose razvoju nauke, ali i njenoj praktičnoj primeni u svakodnevnom životu.

Kroz sistem finansiranja nauke daje se doprinos jačanju naučnoistraživačkih organizacija i finansiranju naučnoistraživačkih rezultata, što ima pozitivan uticaj na dalji razvoj Srbije. [7]

Finasiranje ima za cilj unapređenje naučnoistraživačke aktivnosti pojedinačnih istraživača, zaposlenih u naučnoistraživačkim organizacijama, kao i povećanje kvaliteta istraživanja kroz rad naučnoistraživačkih organizacija. Takođe, ima za cilj jačanje saradnje između tih organizacija i privrednog sektora, kao i postizanje većeg efekta primene rezultata istraživanja sa ciljem povećanja konkurentnosti na domaćem i inostranim tržištima. [7]

Kroz sistem finansiranja nauke i istraživanja, omogućava se i uključivanje mladih istraživača u rad naučnoistraživačkih organizacija, u cilju sprečavanja odliva mladih talenata, a isto tako se afirmiše i povratak istraživača iz inostranstva da prenesu stečena znanja, kroz njihovo uključivanje u rad naučnoistraživačkih organizacija.

Radi planiranja i ostvarivanja dugoročnih strateških ciljeva, prioriteta i pravaca naučnog i tehnološkog razvoja, Vlada Srbije usvojila je Strategiju naučnog i tehnološkog razvoja za period od 2021. do 2025. godine – Moć znanja. Strategija počiva na doktrini da će Srbija biti snažna, prosperitetna i ugledna srazmerno znanju kojim raspolaže. [8] U uslovima brojnih globalnih izazova, ova Strategija prepoznaje znanje kao pouzdan temelj za budući ekonomski napredak, razvoj obrazovanja i očuvanje zdravlja, bezbednosti i nacionalnog identiteta u Srbiji.

Na osnovu detaljne analize prethodnog stanja, Strategija naučnog i tehnološkog razvoja Republike Srbije za period od 2021. do 2025. godine predviđa razvoj okruženja u kome akteri naučnoistraživačkog i inovacionog sistema mogu načiniti iskorak u kvalitetu i uticaju. [8] Na temelju ovog mehanizma, definisan je opšti cilj Strategije da se razvoj Srbije ubrza kroz unapređenje kvaliteta i efikasnosti nauke, tehnološkog razvoja i inovacija i dalje integracije u Evropski istraživački prostor.

3. POKAZATELJI USPEHA U TEHNOLOŠKOM RAZVOJU I MEĐUNARODNOJ SARADNJI U SRBIJI

Srbija daje veliku podršku u oblasti inovacija i tehnološkog razvoja. Stanje tehnološkog razvoja u Srbiji može se sagledati kroz finansijske rezultate aktera u inovacionim sistemima. Rezultati postignuti u IT sektoru ukazuju na evidentno jačanje visokotehnoloških kompanija. Srbija je ostvarila izuzetan porast izvoza IT usluga i proizvoda sa 127 miliona evra 2010. godine, na 1422 miliona evra 2019. godine. Ostvareni suficit u razmeni IT usluga od približno 802 miliona evra u 2019. godini je predstavljao oko 80% suficita ukupnog izvoza usluga Srbije. [9]

Srbija, kroz razne projekte utiče na povećanje inovacionih kapaciteta i tehnološke spremnosti kompanija. Programi koji su namenjeni razvoju inovacija; Program ranog razvoja - u fazi rasta, Program sufinansiranja inovacija, kao i za saradnju sa naučnoistraživačkim organizacijama u vidu konzorcijuma - Program saradnje nauke i privrede, dali su odlične rezultate. [6]

Kompanije koje su finansirane u okviru Programa ranog razvoja pokazale su značajan rast u prihodima od prve godine finansiranja do navršene četiri godine nakon završetka projekta. [4] Zbirni prihod posmatranih kompanija je uvećan sa 3,46 na 8,73 miliona evra, dok je prosečan godišnji prihod po kompaniji uvećan sa 60.500 na 264.500 evra. [7]

Primetno je povećanje inovacionih kapaciteta i tehnološke spremnosti malih i srednjih preduzeća, kao i jačanje veze između privatnog sektora i akademske zajednice.

Tabela 1. Inovacioni kapaciteti i tehnološka spremnost malih i srednjih preduzeća 2020. – 2026. godine

Naziv	Jedinica mere	Bazna vrednost 2020.	Ciljna vrednost u 2024.	Ciljna vrednost u 2025.	Ciljna vrednost u 2026.
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Broj malih i srednjih preduzeća koji su dobili finansiranje	broj	0	114	114	114
Broj novih proizvoda/usluga koji su plasirani na tržište	broj	0	30	50	60

Kompanije beleže i prilično visoku stopu preživljavanja, gde čak 39% podržanih mladih kompanija beleži godišnje prihode od više od 50.000 evra. Sličan trend pokazuju i kompanije finansirane u okviru Programa sufinansiranja inovacija, kod kojih su prihodi udvostručeni, sa prosečnih 0,6 na 1,17 miliona evra godišnjih prihoda, tri godine nakon završetka projekta. [7]

Međutim, da bi se strateški analizirao inovacioni sistem i njegovo stanje unapredilo, nije dovoljno meriti samo finansijski aspekt. Nužno je uporediti različite indikatore stanja u Srbiji sa drugim državama. Merenje inovativne efikasnosti je vrlo kompleksno, ali i značajno, jer se na taj način ukazuje na položaj jedne zemlje. [1] Na listi 131 zemlje sveta, mereno Globalnim indeksom inovativnosti iz 2020. godine, Srbija je pozicionirana na 53. mesto. [8]

Prema sumarnom indeksu inovativnosti, Srbija je u odnosu na zemlje Evropske unije viđena kao umereni inovator, ali je istovremeno i zemlja sa brzim rastom i razvojem inovacionog ekosistema. Naime, indeks kvaliteta porastao je za 24,4% svoje vrednosti, u periodu od 2012. do 2019. godine, ali je ostao relativno nizak u odnosu na razvijene evropske zemlje, čemu doprinose značajne strukturalne razlike između Srbije i članica EU. [5]

Povećanje broja inovatora dodatno svedoči o unapređenju stanja inovacionog sistema. Zahvaljujući sistemskoj i infrastrukturnoj podršci, postignut je značajan porast u broju inovacionih organizacija. Prema podacima Ministarstva prosvete, nauke i tehnološkog razvoja od trenutka formiranja Registra, početkom 2006. godine, registrovano je: 69 inovacionih organizacija (7 inovacionih centara, 18 istraživačko-razvojnih centara i 44 razvojno-proizvodna centra), 11 inovacionih organizacija za infrastrukturnu podršku inovacionoj delatnosti (poslovno-tehnološki inkubatori i naučno-tehnološki parkovi) i 95 fizičkih lica inovatora. Ako se posmatra samo mreža naučno-tehnoloških parkova u Srbiji, a prema podacima dostavljenim od strane pojedinačnih naučno-tehnoloških parkova u 2020. godini, ukupno je poslovalo 144 razvojne i startup kompanije, koje upošljavaju 1295 zaposlenih. [6]

Tabela 2. Zastupljenost inovativnih poslovnih subjekata 2020. – 2026. godine

Naziv	Jedinica mere	Bazna vrednost 2020.	Ciljna vrednost u 2024.	Ciljna vrednost u 2025.	Ciljna vrednost u 2026.
Ukupan procenat inovativnih poslovnih subjekata	%	54,79	56	58	60

Srbija, takođe ostvaruje značajne rezultate u međunarodnoj saradnji kroz učešće u multilateralnim, regionalnim i bilateralnim programima. Jedan od razloga za uspeh u međunarodnoj saradnji je odlična međunarodna povezanost srpskih istraživača. Najvažniji multilateralni programi su Horizont 2020, COST i EUREKA. Regionalni programi se ostvaruju putem implementacije Strategije EU za Dunavski region, Jadransko-jonsku inicijativu i Centralno-evropsku inicijativu, a bilateralna saradnja obavlja se sa velikim brojem država, uključujući i strateške partnere. [3]

Tabela 3. Međunarodne multilateralne, bilateralne i regionalne saradnje i uspostavljanje partnerstva 2020. – 2026. godine

Naziv	Jedinica mere	Bazna vrednost 2020.	Ciljna vrednost u 2024.	Ciljna vrednost u 2025.	Ciljna vrednost u 2026.
Broj odobrenih multilateralnih, bilateralnih i regionalnih projekata za finansiranje	broj	170	175	180	185
Broj razmenjenih istraživača	broj	200	250	260	270

Tabela 4. Učešće Srbije u programu COST i EUREKA 2020. – 2026. godine

Naziv	Jedinica mere	Bazna vrednost 2020.	Ciljna vrednost u 2024.	Ciljna vrednost u 2025.	Ciljna vrednost u 2026.
Broj Eureka projekta	broj	3	10	10	10

Procenat učešća naših istraživača u tekućim COST akcijama	%	93	93,5	93,6	93,7
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Važno je spomenuti da se kroz razne programske aktivnosti vrši i nagrađivanje učenika srednjih škola za postignute rezultate na republičkim i međunarodnim takmičenjima i dodeljuju se stipendije studentima na studijama u zemlji i inostranstvu. Realizacijom ovih aktivnosti se doprinosi realizaciji ciljeva Nacionalne strategije za mlade usmerenih na pružanje podrške mladim talentima u akademskom i profesionalnom usavršavanju.

Tabela 5. Stipendije, nagrade i finansirani projekti 2020. – 2026. godine

Naziv	Jedinica mere	Bazna vrednost 2020.	Ciljna vrednost u 2024.	Ciljna vrednost u 2025.	Ciljna vrednost u 2026.
Broj studenata na univerzitetima u zemlji i inostranstvu kojima je dodeljena stipendija	broj	2100	2300	2300	2400
Broj učenika srednjih škola kojima su dodeljene novčane nagrade za postignute uspehe na republičkim i međunarodnim takmičenjima	broj	1530	1530	1700	1800
Finansirani projekti iz oblasti inovacija, nauke i umetnosti	broj	0	10	12	15

4. ZAKLJUČAK

Srbija mora biti spremna za novu eru koja zahteva efikasnije i podsticajnije upravljanje novim tehnologijama i inovacijama. Nove tendencije i svakodnevni izazovi stavljaju pred

Srbiju potrebu da prepozna nove tehnološke procese i inovacije, kao nepohodan uslov za dalji rast i razvoj.

Nauka i istraživanje, kao delatnost, su od posebnog značaja za sveukupni razvoj Srbije. Zasnovana na znanju, iskustvu i veštinama, zajedno sa visokim obrazovanjem, nauka je glavni pokretač privrednog i društvenog razvoja, i predstavlja deo međunarodnog naučnog, obrazovnog, kulturnog i umetničkog prostora.

Danas su institucije nauke i tehnološkog razvoja generatori prosperiteta, ojačane do nivoa da budu međunarodno prepoznatljive, osposobljene da samostalno rešavaju probleme i da odgovaraju na društvene izazove.

U uslovima brojnih društvenih izazova, znanje predstavlja pouzdan temelj za budući ekonomski napredak. Skrivenе snage našeg naučnoistraživačkog i inovacionog sistema na ove izazove mogu da odgovore stvaranjem novog znanja, i tako omoguće rast standarda građana, razvoj obrazovanja, očuvanje bezbednosti i nacionalnog identiteta u Srbiji.

Društveno-ekonomske promene, koje prate ubrzan naučno-tehnološki razvoj, posebno ekspanzija modernih tehnologija, zahtevaju visoko obrazovane ljude koji su u stanju da efikasno funkcionišu u društvenim procesima i koriste raspoloživu tehnologiju. Preduzeća i nacionalne ekonomije konkurentsku prednost, upravo baziraju na znanju i iskorišćavanju potencijalnih šansi i mogućnosti. Zbog toga su osnovni razvojni ciljevi najrazvijenijih zemalja povećanje ulagnja u nauku i tehnologiju, kao i u inovativne aktivnosti, kroz kontinuirano učenje i obrazovanje ljudskih resursa.

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TECHNOLOGICAL DEVELOPMENT AND INNOVATION AS THE FOUNDATION OF SERBIA'S ECONOMIC PROGRESS

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ABSTRACT:

The contemporary world is characterized by constant changes, in which the key to economic success lies in the ability to understand them and optimally adapt to the newly emerging business environment. Changes are happening at such a speed and intensity that it is very difficult to keep track of them. One of the basic principles for growth and development of countries, as well as for the overall socio-economic progress, is the development of science and technology.

Contemporary economic trends in the world economy, especially the trends in technological development, are becoming more and more dynamic. In today's world, only those countries that are capable to invest in research and development can hope for economic progress, advancement and prosperity.

Continuous technological changes also affect the boost in the dynamics of business conditions, making them uncertain and unpredictable. Modernization of technology, growth and development within that sector, has a direct impact on the growth of the economy. The general orientation of companies in the direction of development has resulted in ever increasing innovation. The aim of this study is to indicate the significance and complexity of the impact of technological development on modern business conditions and to demonstrate that the strategic pathway for Serbia is investing in the development of science and technology, as well as encouraging the development of business operations in that direction.

Keywords: *technological development, innovation, socio-economic progress, Serbia*

THE ROLE OF DIGITAL DISRUPTIVE AND NON-DISRUPTIVE INNOVATION IN THE BUSINESS ECOSYSTEM DEVELOPMENT

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ABSTRACT:

The paper presents the different roles of disruptive and non-disruptive innovations in modern business. Consequently, their impact on stakeholders and ecosystems is different. Today we are witnessing the transforming effects of cloud technology, machine learning, mobile devices, social media, which are unstoppably and galloping changing the business environment. Desk research has shown that organizations planning to create and introduce innovations must be curious and open to the challenges in permacrisis. In addition to the art of anticipating and designing changes, they also need to know how to implement them. Digital disruption indicates the continuation of a technological and economic paradigm that requires the re-design of markets, strategies and value itself. On the one hand, digital transformation coupled with business model innovation creates new value and new opportunities for organizations to make an impact and innovate. On the other hand, established norms are in danger due to the inapplicability of traditional industrial definitions and the formation of new ecosystems. To prepare for a radically different tomorrow, those thriving under digital disruption should continually redefine strategy in terms of how best to open up to external influences, collaborate with new ecosystems and partners, and how they can manage change and drive digital transformation through organization. The question is, what can organizations start doing today to prepare for a completely different business environment tomorrow? Is it necessary and required for innovation to be disruptive? As a concept, non-disruptive innovation represents the continuous creation of new industries and new jobs without destroying existing ones, in order to achieve productivity, economic growth and sustainability.

Keywords: *disruptive innovation, non-disruptive concepts, digital transformation, added value, sustainable ecosystem*

1. INTRODUCTION

According to Accenture global survey of more than 3,400 C-suite executives, conducted from October 2023 to November 2023, across 20 countries, 19 industries to compare their perceptions of change with the analysis of business disruption, [1] it was found out that only half of C-suite leaders are confident their companies are prepared heading into 2024. Almost 89% respondents plan to reallocate budgets in 2024 considering the accelerating

change disrupting business. About 52% respondents say they are not fully prepared to respond to the changes they will face in the 2024 business environment. Nearly 43% respondents plan to do so to improve efficiency to manage through changes in the business environment. A majority believe the combination of technology and talent change will be the most disruptive to their organizations in 2024. For 42% respondents the skills shortage is one of the top three challenges that would hold back their organizations' ability to change. The number one action organizations are taking to manage through change is increasing investments in new technologies. [1]

Exceptionally evolving technologies, from artificial intelligence to smart machines, alongside emerging market dynamics, have compelled companies to become more innovative and adopt a strategy of change through continuous innovation of their products and services. In the era of permacrisis, the design of business models needs to shift from traditional static models tailored for stable environments towards radically new business models selected and implemented at the level of individual business units rather than across the entire organization. [2] Management within companies that fail to adopt and adapt their business models finds itself in an unfavorable position.

According to Joseph Bauer and Clayton Christensen [3], the change in creating new markets and needs results from reallocating resources from known customer needs in existing markets to markets and customers that are either scarce or non-existent, a task impossible through rational, analytical investment processes. An excellent example of the disruption cycles is evident in the transition from horses to mass production of automobiles. As with any paradigm shift, it was not an easy process. Henry Ford pursued his vision of high-quality, affordable automobiles. Numerous obstacles hindered the realization of this vision: skepticism towards automobiles, the lack of a transportation ecosystem, and even securing investments in his company. An investor in the Ford company was advised by the president of a savings bank not to invest in Ford because the horse was there to stay, but the automobile was merely a novelty or whim. Such an atmosphere prevailed at a time when decisions of such magnitude were not made. Ford's famous quote, "If I had asked people what they wanted, they would have said faster horses", epitomizes this sentiment. Asking someone who is familiar only with horses how to improve the product, they would request a "faster horse".

2. WHAT DOES DISRUPTIVE INNOVATION MEAN

The term "disruption" derives from the Latin "*dis*" ("apart") and "*rumpere*" ("to break"), signifying "to break apart". Historically, the term carried a negative connotation, only in the past three decades gaining a positive spin. In the realm of business, the term gained prominence with the concept of "disruptive innovation", coined by Harvard Business School professor Clayton Christensen in the early 1990s. Christensen's "The Innovator's Dilemma" [4] significantly influenced business strategy and innovation thinking. The book's central question is: Why do companies fail? Illustrated through examples like Nokia, according to Christensen, the root cause is a lack of understanding of innovation application. Disruption offers users the opportunity to obtain a significantly higher-quality product or service for a generally lower price, leading to large companies losing their market position, while small ones become leaders.

Sustainable technologies represent incremental improvements that large companies adeptly manage (examples include Nokia, Kodak, Blockbuster, Britannica, Sears). In contrast, disruptive technologies are often simpler, more accessible, and initially less appealing to existing customers (examples include Netflix, Apple, Google, Wikipedia, Uber, Tesla, Spotify). While Nokia focused on hardware, Apple and Google developed new operating systems and created an ecosystem of applications around their products. Users increasingly shifted towards smartphones over conventional phones, rendering Nokia non-competitive. Nokia overlooked market changes when users started using the iPhone differently from conventional phones, as it replaced computers rather than traditional phones. Through this transformation and innovation, the market was disrupted as existing and long-standing competitors were threatened.

Creating disruptive business strategies requires the integration and combination of multiple methodologies and tools. Each has its own function and application, from those that support in concept thinking to those that support in designing multiple options for potential solutions to strategic challenges. [5] [6] [7] [8] [9] Disruptive innovation is a business concept that describes the introduction of a new product, service, or technology that significantly alters the existing market landscape, displacing unavoidable competitors and creating new market dynamics. It often begins by addressing underserved needs or neglected customer segments with a simpler, more accessible solution and gradually evolves to challenge and surpass existing products or services. Disruptive innovations typically leverage new technologies, business models, or approaches, leading to a fundamental shift in industry norms and customer preferences. [10]

Disruptions can be triggered by various factors, among which five specific dimensions can be identified:

- cost – new technologies and/or processes reduce old ones non-competitive in terms of production costs, as the new ones are so inexpensive that the old ones become unprofitable;
- quality – new technologies and/or processes elevate the quality of products or services to a level that diminishes the old ones non-competitive;
- customers – significant changes in consumer or business user preferences make previous products or services unattractive compared to new ones;
- regulation – new laws or regulations no longer permit old ways of operation, such as environmental regulations or labor protection laws designed to improve social conditions,
- resources – previously vital resources are no longer easily accessible for various reasons, from exhaustion of natural resources to trade blockades.

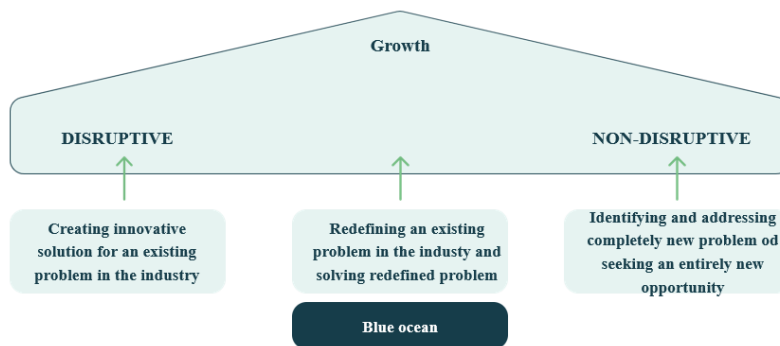
There are now more Netflix subscribers than there were previously DVD rentals at Blockbuster. Growth is achieved through a prism of victories and defeats because the success of disruptors comes at the direct expense of existing players and markets. Amazon not only disrupted the operations of 1,200 Borders stores, along with countless independent book sellers, but also took a significant portion of sales from Barnes & Noble. In addition to disruptive innovations, the authors of the book “Beyond Disruption, Innovate and Achieve Growth without Displacing Industries, Companies, or Jobs”, W. Chan Kim and Renée Mauborgne [11], emphasize the significant role of non-disruptive concepts in the development of organizations and society. According to them, “For what purpose?” is a vital question that should be continuously asked when undertaking any

initiative that is disruptive. In light of the need for change, the answer “Because things need to change” is not satisfactory. Disruption and creation without disruption have different roles and specific consequences. Disruption occurs when a new market is created within the boundaries of existing industries, as Amazon did by threatening book sellers and retail, or as Uber did in the taxi industry. Creation without disruption occurs when you create an entirely new market beyond the boundaries of existing industries, where there are no defined players or markets to replace.

2. THE DIFFERENCE BETWEEN DISRUPTIVE AND NON-DISRUPTIVE INNOVATION

David L. Rogers, author of “The Digital Transformation Playbook”, states: “Digital transformation is not just about upgrading technology, but about upgrading your strategic thinking”. [12] Over the past few years, the concept of disruption has gained popularity, referring to the understanding and relation to technology and innovation. The implication is the discontinuity of previous technology and/or methods that are no longer sustainable. This perspective is broader than Christensen's in The Innovator Dilemma [4], who seeks to limit the use of the term 'disruption' to a specific mechanism and evolutionary path of innovation. By making the product accessible and easy to use, disruptive innovation involves bringing into the “game” those who have not previously used the product, known as “non-consumers” [13] [14]. The concept is based on the idea that disruption is a measurable outcome not only of its process but also of its results.

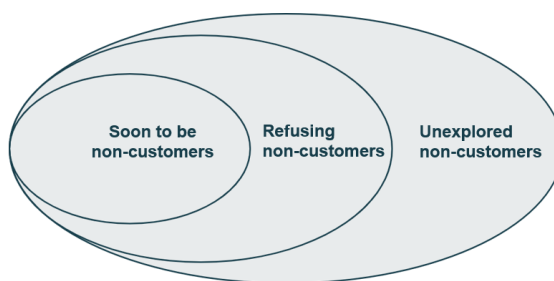
Illustration 1. Differences between Disruptive and Non-disruptive Innovation by W. Chan Kim and Renée Mauborgne (2023)



In the 2023 Interbrand report, the top five positions are held by technology companies (Google, Apple, Amazon, Microsoft, Samsung), which disrupt industries they compete in through digital approaches [15]. Some examples of business models are the result of digital disruptions: Airbnb rents properties without owning any, Alibaba does not own products despite being one of the largest selling platforms, Uber is a taxi service that does not own any vehicles, and Facebook is a media organization that does not create content.

There is a whole spectrum of innovations in the market, ranging from creating entirely new markets to introducing absolute novelty, while at the other end lies “non-disruptive” innovation, creating new jobs and profitable growth without jeopardizing existing companies. The concept of non-disruptive innovation differs from existing innovation concepts and can be defined as “creating an entirely new market beyond the boundaries of existing industries.” This means that no existing market or existing market players are disrupted and fail, and businesses and working places are not lost.

Illustration 2. Non-customers in the Blue Ocean Strategy by Renée Mauborgne and W. Chan Kim (2004)



3. EXAMPLES OF DIGITAL DISRUPTIVE INNOVATIONS

Digital disruption refers to the change in expectations and behaviors caused or expressed by digital capabilities, channels, or means, which radically transforms culture, markets, industries, or processes. Digital disruption has led to the redefinition of traditional business models. New market entrants, disruptors, are often technology-driven startups that rapidly disrupt established industries by offering innovative solutions and more efficient business models. [16] Digital technologies have raised customer expectations in terms of speed, convenience, practicality, and personalization of services. Digital disruption motivates companies to continually invest in digital tools and platforms to enhance the customer experience in order to retain their customers. The evolution of customer behavior is closely monitored.

The escalating demand for sustainable transportation alternatives has led to the emergence of electric vehicles as a response to this market gap:

- electric vehicles – these vehicles reduce exhaust emissions but have historically been limited in performance (particularly in terms of battery longevity) and more expensive than conventional counterparts,
- autonomous vehicles – the commercial introduction of driverless vehicles based on artificial technology and advanced control systems with the potential of enhancing traffic flow and reduce the need for private cars in urban environments,
- smart city management – systems that can optimize traffic flows in real-time using big data analytics,
- mobile technologies – smartphone-based applications.

The growth and development of technology involve:

- concerns about pollution and overcrowding – growing public concern in developing economies where economic growth has led to high levels of pollution, as well as ongoing concerns in advanced countries;
- increased self-employment – lifetime careers are evolving into short-term careers due to technology, leading to greater economic pressure and a willingness to become self-employed, for example, as Uber drivers, delivery couriers, and local transport providers;
- aging population - in the coming decades, the proportion of the population with special mobility needs will increase in almost every country, as well as the number of those who are no longer fully capable of driving;
- regulation of motor manufacturers – led by climate change agreements and environmental sustainability pressures, manufacturers are under strong pressure to improve fuel efficiency and emissions with conventional fossil fuel-based technologies (gasoline, diesel), which are likely to be increasingly restricted.

Technologies such as the Internet of Things (IoT), blockchain, and artificial intelligence (AI) are transforming supply chains, making them more efficient and transparent. Companies are adopting these technologies to optimize their supply chain processes, reduce costs, and improve overall performance. The availability of vast amounts of data and advanced analytical tools has enabled enterprises to make decisions based on more sophisticated information. The presence of digital disruption has motivated companies to use data analytics to gain and maintain a competitive edge by understanding customer preferences, market trends, and operational efficiency. Digital disruption has facilitated global connectivity, allowing companies to conduct business on a larger scale and expand their audience. E-commerce enables companies to broaden their customer base and data beyond geographical boundaries. Automation and AI technology have led to the replacement of some jobs, but new roles requiring digital skills are emerging. Consequently, companies are investing in upskilling and reskilling their workforce to navigate effectively in the digital environment. Digital disruption fosters collaboration and partnerships between traditional and technological companies. The result of such collaborations is the ability for companies to leverage advantages and remain competitive in the evolving digital landscape.

Cryptocurrency is a disruptive digital innovation that has revolutionized the financial industry. Operating on decentralized blockchain technology, it offers numerous advantages such as faster transactions, lower fees, enhanced security, and increased accessibility. By eliminating the need for intermediaries like banks, cryptocurrencies enable peer-to-peer transactions, challenging traditional financial systems. This disruptive technology has the potential to transform not only finance but also other industries through the development of decentralized applications and smart contracts. The disruptive innovation of cryptocurrency is reshaping the perception and utilization of money, opening new possibilities for the future of finance.

The launch of Chat-GPT is considered to be the greatest disruption in education since the start of calculators has occurred. Efficiently finding mostly accurate information has enabled time savings and the creation of an initial database of information for further research. However, if education does not view Chat-GPT as an assistant, it becomes a risk because even the most diligent student may be prone to incomplete information. Addressing new challenges requires transforming not only the education system by

introducing new forms of learning and assessment [17], and digital transformation focused to customers in other industries should be included. [18]

Luxury eyewear brand Ray-Ban, founded in 1936, collaborated with Meta (Facebook) company to launch the Meta smart glasses. These smart glasses retain the iconic shape of Ray-Ban eyewear while incorporating Meta technology, enabling features such as recording and live streaming directly from the glasses, controlled by fingerprint scanning. RTFKT is a digital fashion brand that creates virtual sneakers and certain fashion accessories. At the core of their business is blockchain technology (a disruptor) for authentication and ownership of digital products. On the other hand, Nike is a multinational corporation that manufactures clothing, footwear, and sports equipment with a significant presence in the sports and fashion industries. RTFKT's products align with the trends of the growing crypto community, and Nike has found a way to respond to the emerging trend and the need to connect virtual and physical products. In December 2021, Nike acquired RTFKT Studios for one billion dollars. Despite being a traditional company, Nike is investing in expanding its offerings and enhancing its products to meet the emerging needs of customers. Although they are digital products, these items are becoming mainstream and widely accepted by consumers. Nike assessed the situation and made a good decision, as it generated \$185 million in profit from digital apparel sales in the first year, surpassing any fashion brand that attempted similar endeavors after Nike.

4. EXAMPLES OF NON-DISRUPTIVE INNOVATIONS

W. Chan Kim and co-authors claim that business and society can progress together through the application of non-disruptive concepts, despite the fact that many employees may lose their jobs or need to requalify. [19] By creating without disruption, options are opened for achieving economic growth and creating new jobs without causing social disruption from lost jobs and vulnerable communities toward a sustainable future. There are three basic steps common to organizations and individuals who have created and conquered a new market that is not disruptive. This includes identifying opportunities for creation, analyzing opportunities, and transforming opportunities into high-value, low-cost solutions. In the last 20 years, “disruption” has been the primary requirement in business, starting from the theory of disruption by Christensen to examples of digital disruptors such as Spotify, Tesla, Apple. Thus, corporate leaders were constantly expected to innovate, disrupt markets, or the company itself.

Crowdsourcing comes from the combination of the words "crowd" and outsourcing. It can be seen as a process that enables an organization to work with many people, to perform services or to generate ideas or content; it can also be useful as a means of gathering opinions, money and information. Kickstarter is a public benefit corporation launched in 2009 as a result of the realization that there are many people with interesting and creative projects that have started or need to be launched but lack capital. Since most of these individuals are not from the business world, their goal is to realize the idea itself rather than generate a return on investment. Kickstarter, as an online crowdfunding platform, did not enter the existing financial market or threaten a certain number of existing investors. Participation in presented projects is not obligatory, but investing is done for symbolic acknowledgment of the website or product, a thank-you note, or some promotional material. This has actually created a new set of investors who are interested in creative

work and want to support individuals in realizing their dreams. As a corporation, Kickstarter became profitable after three years of its inception, raising \$7.7 billion according to the data from November 2023, and about 600 thousand projects have been supported, resulting in the growth of part-time jobs. Over 15 thousand new companies and non-profit organizations have been launched. These facts testify that due to the non-disruptive concept such as Kickstarter, no one lost their job, no company ceased operation, but rather a positive impact was achieved.

Microfinance is an innovation that has transformed the lives of many people as financial services have become accessible to those with low incomes. Before the arrival of microfinance, banks or other financial institutions were not ready to provide such services, considering the low-income population unsuitable candidates for loans. However, Muhammad Yunus, the founder of Grameen Bank, enabled people who were denied access to initial capital to create new small businesses, entrepreneurial ventures, and achieve a higher standard of living. Microfinance is a multi-billion-dollar industry with excellent loan repayment rates of 98%, leaving room for future growth. Another non-disruptive concept is business and life coaching, which has created a completely new opportunity for people to improve their professional and personal lives that never existed before, unlocking a new industry. It has offered strong, profitable growth and thousands of new jobs, without the need to oppose or replace any existing industry or market participants.

5. CONCLUSION

There is a whole spectrum of innovations in the market, ranging from creating entirely new markets to introducing absolute novelty, while at the other end lies “non-disruptive” innovation, creating new jobs and profitable growth without jeopardizing existing companies. The concept of non-disruptive innovation differs from existing innovation concepts and can be defined as “creating an entirely new market beyond the boundaries of existing industries.” This means that no existing market or existing market players are disrupted and fail, and businesses are not lost. On one hand, there is a social factor in understanding the role of disruption. To disrupt the market, a leap in value is required, typically emphasized by a new business model, otherwise, the industry will not be “disrupted” and customers, whether they are businesses or consumers, will have no reason to switch from the existing offering to the new one. On the other hand, the economic factor considers the allocation of society's resources where they are believed to be better utilized.

Therefore, the approach to modern challenges also requires from everyone different tools, experiences, and readiness to learn, unlearn and be a lifelong learner. Virtual reality, augmented reality, new forms of gaming, virtual property, and Web3, open up marketing and business opportunities, especially for the new generation. Every company will benefit from being involved in new trends, that's why it is very important to be informed and learn, so that both individuals and companies are ready in time for new ways of doing business. In spite of the fact that non-disruptive innovation has long been overshadowed by the corporate world and media's obsession with disruption, it has clear benefits to stakeholders such as societies and organizations in building sustainable ecosystems.

6. LITERATURE

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FUZZY AHP ASSESSMENT OF BALKAN WINERIES FROM A TOURIST ATTRACTION PERSPECTIVE

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ABSTRACT:

In many modern tourist destinations, wineries represent increasingly popular facilities attracting many visitors. Since the end of the 20th century, with the transformation from primarily production facilities to facilities that integrate the concepts of production and tourism, wineries have become significant strongholds of wine culture. The development of wineries in the Balkans experienced expansion at the beginning of the 21st century, along with the end of the transition process. In the last ten years, visiting wineries has become an indispensable activity of wine tourism. Many factors determine the attractiveness of a winery among potential visitors. This paper aims to evaluate selected wineries from the Balkans, built after 2000, based on defined indicators that influence the attractiveness of wineries by applying multi-criteria analysis. Ten modern wineries were selected for the research. The indicators were ranked by importance using the fuzzy AHP approach, followed by the selected wineries. The results indicate the most critical factors determining contemporary wineries' attractiveness. The results may impact the future processes of building wineries in the Balkan region.

Keywords: multi-criteria decision-making, fuzzy AHP approach, contemporary wineries, tourism, Balkan region

1. INTRODUCTION

Although the roots of wine tourism activities can be traced back to the 18th century, with the opening of taverns next to wine cellars and the gathering of people to taste wine [1], the development of wine tourism as an economic branch is officially linked to the post-WWII period. The second half of the 20th century brought numerous social changes, such as the rise of middle-class leisure activities and the increase in international travel, that directly or indirectly impacted the transformation of the wine industry and wine production facilities and influenced the development of wine tourism. People are becoming more interested in consuming wine and learning about the production process and wine culture traditions. Along with constructing new wineries, wine schools were founded to educate sommeliers, future winegrowers, and winemakers. Wine has become a reflection of lifestyle and has been promoted in the media [2]. Many magazines discussed the pairing of wine and food and the benefits that wine has on health and mood. In this way, wine consumption becomes a trend.

Due to globalization, wine as an industrial product was becoming widespread and financially accessible to everyone [3]. The creation of the opportunity to market wine worldwide and reach a significant number of consumers has caused the need to adjust the offer of wine producers to people's preferences. Given the expansion of wine production, a high degree of competition has occurred in the wine market. To find a way to stand out from other producers, more attention has been paid to experimentation with wine and investing in marketing. At the same time, during the 50s, the first wine festivals were organized in California, where visitors could taste wine [1]. Soon, wine festivals became places for producers to compete and important annual manifestations that gather wine lovers, places to socialize, meet and exchange experiences.

The 60s marked a turning point in the evolution of wine tourism. Numerous wineries opened their doors to visitors, offering a unique experience of tasting wine at its origin [4]. This expansion of tourist offerings, which now included tasting and the opportunity to witness the production process first-hand, significantly boosted the producers' economic income. The on-site sale of wine and the word-of-mouth recommendations from visitors expanded the sales network, presenting a promising growth opportunity for the industry. For this reason, wine producers started investing in the architecture of winery facilities.

Since the end of the 20th century, the architecture of wineries has wholly transformed from former industrial facilities into a kind of stronghold of wine culture and tourism by introducing a range of public content for visitors [5]. Wine tourism and industry sectors have become inseparable, whereby contemporary wineries, in addition to tasting rooms, often include restaurants, wine bars, viewpoints, and guest rooms. Architectural design of wineries becomes part of the wine industry's strategy to attract tourists, sell wine and create the appropriate brand in the global market [6].

The paper examines the attractiveness of wineries from the perspective of tourists in the 21st century. Due to the complexity of the attractiveness in the wine industry, the research focuses exclusively on architecture as a factor contributing to wineries' attractiveness. The primary goal of the conducted research is to identify the most significant indicators of the attractiveness of contemporary wineries using multi-criteria analysis. The research's methodological framework also includes applying the case study. Ten wineries from the Balkan countries are selected to analyze examples of modern wine production facilities.

In this sense, the research simultaneously aims to determine the wineries from the Balkans that can be considered the most attractive from the aspect of architectural design. The triangular fuzzy Analytical Hierarchical Process (fuzzy AHP) method was applied in the multi-criteria analysis and decision-making domain for this research.

2. TOURIST ATTRACTION TO CONTEMPORARY WINERIES

The allure of a winery is intricately tied to the tourists' drive to explore it. In our unique approach, we delve into the attractiveness of wineries, not just in terms of their location, market position, staff, and services, visual appeal, room layout, and material usage [7,8]. For this study, we adopt indicators from the architectural design perspective, offering a fresh take on the motivations for visiting wineries.

Based on the results of previous research, indicators of the attractiveness of contemporary wineries are divided into four main groups: location (L), contents and use (C), exterior design (E), and interior design (I). Table 1 provides an overview of the primary groups of indicators, sub-indicators and alternatives.

Table 1. Overview of indicators related to the attractiveness of contemporary wineries

	Sub-indicators	Alternatives
Location (L)	Accessibility and infrastructure (L ₁)	Good traffic connection to urban centres (L ₁₁)
		Distance from cultural/natural heritage sites (L ₁₂)
		Visible approach to winery (L ₁₃)
		Possibility to park cars in the winery site (L ₁₄)
	Authenticity of wine landscape (L ₂)	Long tradition of viticulture (L ₂₁)
		Existence of historical cellars (L ₂₂)
		Authentic geographical conditions (L ₂₃)
		Authentic topography of terrain (L ₂₄)
	Winery position concerning vineyards and terrain slope (L ₃)	In urban/suburban areas far from vineyards (L ₃₁)
		On slight slope terrain surrounded by vineyards (L ₃₂)
On the top of the hill surrounded by vineyards (L ₃₃)		
Integrated partially into surrounding (L ₃₄)		
Completely buried into the ground (L ₃₅)		
Contents (C)	Degustation (C ₁)	Wine degustation in tasting hall (C ₁₁)
		Wine degustation in wine cellar (C ₁₂)
		Outdoor wine degustation (C ₁₃)
	Education about wine production (C ₂)	Tour in vineyard (C ₂₁)
		Workshops related to production and tasting (C ₂₂)
		Tour in the wine cellar and old wine museums (C ₂₃)
	Recreation (C ₃)	Wine festivals and other events in the winery (C ₃₁)
		Relaxing in views (C ₃₂)
		Walking in the vineyard (C ₃₃)
	Services (C ₄)	Pairing wine and food in the restaurant (C ₄₁)





		Oversleeping - hotel (C ₄₂)	
		Wine bars, cafe bars (C ₄₃)	
Exterior design (E)	Exterior form (E ₁)	Covered partially or entirely by ground (E ₁₁)	
		Modern sculptural and expressive forms (E ₁₂)	
		Minimalistic simple forms (E ₁₃)	
		Associative forms (E ₁₄)	
		Traditional forms (E ₁₅)	
Materials and colours in exterior (E ₂)		Dominantly use of glass (E ₂₁)	
		Dominantly use natural or recycled material (E ₂₂)	
		Dominantly use of concrete or brick (E ₂₃)	
		Mixed use of materials and colours (E ₂₄)	
		Use of innovative, flexible materials (E ₂₅)	
		Dominantly use of one colour (E ₂₆)	
Exterior design (E)	Entrance design (E ₃)	Minimalistic design with no specific elements (E ₃₁)	
		Expressive canopy (E ₃₂)	
		Long frontal axial path to entrance (E ₃₃)	
		Monumental stairs (E ₃₄)	
		Entrance gates or walls (E ₃₅)	
	Design of outdoor space (E ₄)		The roof on the top with outdoor stairs (E ₄₁)
			The roof on the top with indoor stairs (E ₄₂)
			A terrace on one of the floors (E ₄₃)
			Groundfloor garden (E ₄₄)
			Outdoor walkways between volumes (E ₄₅)
Interior design (I)	Walking through wine space (I ₁)	Specific stairs connecting wine space (I ₁₁)	
		Pedestrian bridges above wine space (I ₁₂)	
		Console plateaus above wine space (I ₁₃)	
		Only by directly walking through the wine space (I ₁₄)	
	Visual connection with wine space (I ₂)		By galleries (I ₂₁)
			By glass portals (I ₂₂)
			By glass opening in the wall (I ₂₃)
			By glass opening in floor (I ₂₄)
			Only by directed approach in wine space (I ₂₅)
	Interior form (I ₃)		Simple, minimalistic forms (I ₃₁)
			Emphasized form of walls (I ₃₂)
			Akcent on constructive elements (I ₃₃)
	Materials and colours in interior (I ₄)		Dominantly use of glass-transparent walls (I ₄₁)
			Dominantly use of one material (I ₄₂)
			Mixed use of materials and colours (I ₄₃)
Dominantly use of one colour (I ₄₄)			
Shadows and light (I ₅)		Lantern penetration of natural light (I ₅₁)	
		Natural light through wall holes (I ₅₂)	
		Artificial ambient lighting point (I ₅₃)	

	Artificial bright lighting (I ₅₄)
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3. THE CASE STUDY OF BALKAN WINERIES

The application of attractiveness indicators is checked using the example of wineries from the Balkans. Wine tourism in this region developed late compared to Western European countries. The construction of private wineries occurs due to the transition process, whereby most wineries built at the end of the 20th century did not foresee separate contents intended for tourists. However, at the beginning of the 21st century, new wineries almost inevitably included tasting rooms and many restaurant spaces. Considering the availability of project documentation, this research selected ten wineries from the Balkans, which will be ranked in terms of attractiveness. The wineries were selected based on the criteria: (1) they represent one of the most visited wineries in the Balkans; (2) they were built in the 21st century; (3) they are oriented towards visitors - include facilities for tourists; (4) they are located in rural areas.

Table 2. Overview of general information on chosen wineries from the Balkan region

Name of the winery	Location: Year	Name of the winery	Location: Year
	Kromidovo, Blagoevgrad Bulgaria		Brestnik, Bulgaria
Orbelus winery	In 2004	Dragomir winery	In 2020
	Podgorica, Montenegro		Gradjani, Montenegro
Mola winery	In 2018	Lipovac winery	In 2014
	Kutjevo, Croatia		Motovun, Istria, Croatia
Galic winery	In 2018	Roxanich winery	In 2019

	Vitezevo, Svilajnac, Serbia		Negotin, Serbia
Virtus winery	2010-2018	Matalj winery	In 2020
	Gradsko, North Macedonia		Palikura, North Macedonia
Stobi winery	In 2010	Lazar winery	In 2020
Source of illustrations: https://www.wineding.com/winery-orbelus-winery_d3499/ ; https://www.gradnja.rs/top-10-najlepse-dizajnerske-vinarije-u-srbiji/ ; https://www.archdaily.com/ ; https://www.lazarwinery.mk/indexEn.html ; https://www.miesarch.com/work/ ; https://lipovacwines.com/index.php/en/			

4. FUZZY AHP ASSESSMENT

Methodologically, the paper relies on a multi-criteria decision-making framework. Given the complexity of the attractiveness of contemporary wineries, this research uses the synergy of the Analytic Hierarchy Process (AHP) method and fuzzy logic assessment to rank previously theoretically defined indicators, sub-indicators and alternatives.

4.1. The AHP algorithm

The AHP algorithm was developed in 1980 by Thomas Saaty as a multi-criteria approach based on structuring the recognized problem through hierarchy [9]. It enables comparison in terms of the priority between each pair of elements on each level of the hierarchy using a number scale from 1 to 9. The AHP algorithm consists of four steps:

- (1) Transposing the research issue into a unique hierarchy with the leading research goal on the top and indicators, sub-indicators and alternatives at lower levels;
- (2) Comparison of the indicators, sub-indicators and alternative pairs at each level of the hierarchy based on the evaluation from the corresponding experts using Saaty's 9-number scale and creation of matrices;
- (3) Calculation of weight coefficients of each element in the hierarchy, where the sum of the weight coefficients for elements at each level is equal to one;
- (4) Final ranking of proposed alternatives using weights of sub-indicators and their normalization [10].

After the creation of comparison matrices, the AHP algorithm in Step (2) also includes an analysis of their consistency, calculating consistency index *CI* and consistency ratio *CR* using the formula [11]:

$$CI = \frac{\lambda_{\max} - n}{n-1}, CR = \frac{CI}{RI}, \quad (1)$$

where λ_{\max} is the maximum eigenvalue of the comparison matrix, n is the dimension of the comparison matrix, and RI is the random index of the comparison matrix. When $CR \leq 0.10$, the matrix is consistent and evaluated elements are accepted.

4.2. The triangular fuzzy AHP algorithm

The practice has shown that it is usually not straightforward to objectively quantify the importance and value of each alternative and indicator precisely. Thus, fuzzy set theory assessment can be of great support.

Let $H = \{(x, m_H(x)), x \in R\}$ represents a fuzzy set of fuzzy numbers where $m_H: R \rightarrow [0,1]$ is a continuous function. For the triangular fuzzy number (TFN) presented as $\tilde{T} = (l, m, u)$ and $\tilde{T} \in H(R)$, the membership function of TFN is [11]:

$$m_{\tilde{T}}(x) = \begin{cases} \frac{x-l}{m-l}, & x \in [l, m] \\ \frac{u-x}{u-m}, & x \in [m, u] \\ 0, & \text{otherwise.} \end{cases} \quad (2)$$

In Equation 2, u is the upper value, l is the lower value, and m is the modal value of \tilde{T} . If there are two triangular fuzzy numbers $\tilde{T}_1 = (l_1, m_1, u_1)$ and $\tilde{T}_2 = (l_2, m_2, u_2)$, then their arithmetic operational laws are:

$$\begin{aligned} (l_1, m_1, u_1) + (l_2, m_2, u_2) &= (l_1 + l_2, m_1 + m_2, u_1 + u_2) \\ (l_1, m_1, u_1) * (l_2, m_2, u_2) &= (l_1 l_2, m_1 m_2, u_1 u_2) \\ k * (l_1, m_1, u_1) &= (k * l_1, k * m_1, k * u_1) \\ (l_1, m_1, u_1)^{-1} &= (1/u_1, 1/m_1, 1/l_1) \end{aligned} \quad (3)$$

In Equation 3, k is scalar and $k > 0, k \in R$. Table 3 gives an overview of the meaning of TFNs using Saaty's 9-number scale.

Table 3. Meaning of triangular fuzzy numbers (TFNs) using Saaty's 9-number scale.

Rating scale	Meaning	Explanation
$\tilde{1} = (1, 1, 3)$	Equal importance	both elements have the same effect
$\tilde{3} = (1, 3, 5)$	Moderate importance	one element has a slight advantage
$\tilde{5} = (3, 5, 7)$	Strong importance	a strong advantage of one element over other
$\tilde{7} = (5, 7, 9)$	Demonstrated importance	one element has a very strong advantage over other
$\tilde{9} = (7, 9, 9)$	Extreme	one element has a full advantage over other

$\tilde{2} = (1, 2, 3)$ $\tilde{4} = (3, 4, 5)$ $\tilde{6} = (5, 6, 7)$ $\tilde{8} = (7, 8, 9)$	Intermediate values	when compromise is needed
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The fuzzy AHP algorithm consists of four steps:

- (1) Creation of a hierarchy with goals, indicators, sub-indicators and alternatives;
- (2) Creation of the fuzzy matrices using the rating scale from Table 3 with consistency checking using Equation 1;
- (3) Applying fuzzification and defuzzification processes as well as calculation of vectors for each element in the hierarchy;
- (4) Final ranking of proposed alternatives using normalization of the weight vectors.

In Step 2, to compare indicators, sub-indicators and alternatives using TFNs, the decision matrix $\tilde{M} = (\tilde{M}_{ij})_{n \times n}$ has been created. Here, \tilde{m}_{ij} represents a fuzzy value used to indicate one alternative's relevance over another.

5. RESULTS AND DISCUSSION

For this research, the indicators, sub-indicators, and alternatives are evaluated by experts from the wine industry, wine tourism, and architectural design. We have applied the averaging approach to calculate the sum of their opinion. The triangular fuzzy AHP method ranks alternatives according to the pessimistic, moderate, and optimistic attitudes toward risk [11]. Table 4 presents the final ranking of the top 20 alternatives related to the attractiveness of contemporary wineries.

Table 4. Final ranking of alternatives using triangular fuzzy AHP method

	$\lambda=0$			$\lambda=0.5$			$\lambda=1$		
	Wsi	Wa	W	Wsi	Wa	W	Wsi	Wa	W
C ₂₃	0.354	0.598	0.088	0.346	0.602	0.090	0.343	0.603	0.091
C ₁₂	0.368	0.559	0.086	0.381	0.577	0.095	0.385	0.584	0.099
I ₁₄	0.400	0.484	0.053	0.375	0.485	0.047	0.365	0.486	0.045
L ₂₃	0.598	0.479	0.046	0.602	0.469	0.048	0.603	0.465	0.049
C ₂₂	0.354	0.253	0.037	0.346	0.262	0.039	0.343	0.266	0.040
C ₁₁	0.368	0.233	0.035	0.381	0.243	0.040	0.385	0.246	0.041
C ₄₁	0.131	0.599	0.032	0.118	0.591	0.030	0.114	0.588	0.029
C ₁₃	0.368	0.207	0.031	0.381	0.178	0.029	0.385	0.168	0.028
C ₃₂	0.145	0.511	0.031	0.153	0.537	0.035	0.156	0.550	0.037
I ₃₃	0.163	0.582	0.026	0.165	0.594	0.025	0.166	0.601	0.025
E ₁₁	0.479	0.336	0.023	0.469	0.346	0.021	0.465	0.350	0.021
C ₃₁	0.145	0.381	0.023	0.153	0.367	0.024	0.156	0.360	0.024
I ₁₁	0.400	0.208	0.023	0.375	0.222	0.021	0.365	0.227	0.021
I ₂₁	0.248	0.336	0.023	0.268	0.332	0.023	0.276	0.330	0.023
C ₂₁	0.354	0.147	0.021	0.346	0.135	0.020	0.343	0.129	0.019
L ₂₁	0.598	0.223	0.021	0.602	0.239	0.024	0.603	0.244	0.025
I ₁₂	0.400	0.194	0.021	0.375	0.187	0.018	0.365	0.185	0.017
L ₂₄	0.598	0.210	0.020	0.602	0.207	0.021	0.603	0.206	0.021
L ₁₃	0.253	0.419	0.017	0.262	0.387	0.017	0.266	0.374	0.017
I ₂₂	0.248	0.230	0.015	0.268	0.243	0.017	0.276	0.249	0.017

The obtained results show that the essential alternatives among indicators groups related to the attractiveness of contemporary wineries for pessimistic attitude are: tour in the wine cellar and old wine museums (C₂₃), wine degustation in wine cellar (C₁₂), direct walking through the wine space (I₁₄), authentic geographical conditions of wine landscape (L₂₃), workshops related to production and tasting (C₂₂), wine degustation in tasting hall (C₁₁) and pairing wine and food in the restaurant (C₄₁). Moderate and optimistic views give the advantage of alternative C₁₂ over C₂₃, L₂₃ over I₁₄, and C₁₁ over C₂₂. Table 5 compares the valorization of the Balkan wineries case study according to the alternatives' weight coefficients. The best ranked are Lazar, Matalj and Roxanich.

Table 5. Valorization of chosen case studies of Balkan wineries and ranking

	Orbelus	Dragomir	Galic	Roxanich	Stobi	Lazar	Mola	Lipovac	Virtus	Matalj
Accessibility and infrastructure	L ₁₁ - L ₁₄	L ₁₁ - L ₁₄	L ₁₁ - L ₁₄	L ₁₁ - L ₁₄	L ₁₁ - L ₁₄	L ₁₁ - L ₁₄	L ₁₁ L ₁₃	L ₁₁ - L ₁₄	L ₁₁ L ₁₃	L ₁₁ - L ₁₄
Authenticity of wine landscape	L ₂₃	L ₂₃	L ₂₁ L ₂₃	L ₂₁ L ₂₄	L ₂₃	L ₂₃	L ₂₃ L ₂₄	L ₂₁ L ₂₄	L ₂₃	L ₂₁ L ₂₃
Winery position	L ₃₂	L ₃₂	L ₃₂	L ₃₃	L ₃₂	L ₃₂	L ₃₅	L ₃₃	L ₃₂	L ₃₃
Degustation	C ₁₁	C ₁₁	C ₁₁	C ₁₁	C ₁₁	C ₁₁ C ₁₃	C ₁₁	C ₁₁	C ₁₁	C ₁₁
Education	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃	C ₂₃
Recreation	C ₃₂	C ₃₂	-	C ₃₂	C ₃₁	C ₃₂	-	C ₃₂	C ₃₂ C ₃₃	C ₃₂
Services	-	C ₄₁	-	C ₄₁ C ₄₂	C ₄₁	C ₄₁	-	C ₄₁ C ₄₂	C ₄₃	C ₄₁
Exterior form	E ₁₄	E ₁₃	E ₁₃	E ₁₂	E ₁₂	E ₁₅	E ₁₁	E ₁₅	E ₁₃	E ₁₃
Materials & colours -exterior	E ₂₂	E ₂₃	E ₂₃	E ₂₄	E ₂₄	E ₂₄	E ₂₂	E ₂₄	E ₂₃	E ₂₃
Entrance design	E ₃₁	E ₃₁	E ₃₁	E ₃₂	E ₃₅	E ₃₁	E ₃₃	E ₃₁	E ₃₁	E ₃₁
Design of outdoor space	-	E ₄₃ E ₄₂	E ₄₄	E ₄₃	E ₄₄	E ₄₄	-	-	E ₄₂ E ₄₄	E ₄₃ E ₄₄
Walking	I ₁₄	I ₁₂	I ₁₄	I ₁₄	I ₁₄	I ₁₄	I ₁₄	I ₁₄	I ₁₄	I ₁₄
Visual connection	I ₂₅	I ₂₁ I ₂₂	I ₂₂	I ₂₅	I ₂₅	I ₂₅	I ₂₃	I ₂₅	I ₂₅	I ₂₂
Interior form	I ₃₂	I ₃₁	I ₃₁	I ₃₂	I ₃₃	I ₃₁	I ₃₁	I ₃₁	I ₃₁	I ₃₁
Materials & colours - interior	I ₄₄	I ₄₃	I ₄₃	I ₄₃	I ₄₃	I ₄₃	I ₄₂	I ₄₃	I ₄₃	I ₄₃
Shadows & light	I ₅₁	I ₅₄	I ₅₃	I ₅₃	I ₅₃	I ₅₃	I ₅₃	I ₅₃	I ₅₃	I ₅₃
Weight	0.3 58	0.3 75	0.3 45	0.4 14	0.4 02	0.4 18	0.3 52	0.3 94	0.3 51	0.4 17
Ranking	7.	6,	10.	3.	4.	1.	8.	5.	9,	2.

6. CONCLUSION

This paper has examined the attractiveness of contemporary wineries in the Balkan region using fuzzy AHP assessment. The conducted research has shown that the most critical factors in the architectural design of wineries for tourist attractions are related to the contents and activities in the facility. The results recognize degustation and education about wine production through approaching the wine cellar as crucial parts of wine tourism. Thus, the use of form, materials, colours, and lights is necessary but not essential in attracting visitors. The obtained insights can be used as guidelines for further designing the wineries.

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VAŽNOST DUE DILIGENCE-A U PROCESIMA MERDŽERA I AKVIZICIJA

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SAŽETAK:

Merdžeri i akvizicije (M&A) predstavljaju kompleksne transakcije koje zahtevaju detaljnu pripremu kako bi se povećale šanse za uspeh u postakvizicionom periodu. Jedna od najznačajnijih pripremnih faza je proces due diligence-a, odnosno detaljno istraživanje ciljne kompanije sa različitih aspekata u cilju identifikovanja potencijalnih rizika, ali i sagledavanja potencijalnih sinergija po okončanju procesa preuzimanja. Proces due diligence-a uključuje sveobuhvatnu analizu i procenu koju preduzimaju kompanije kupci da bi pažljivo ispitali finansijske, pravne, operativne i strateške aspekte potencijalne ciljne kompanije, a pre nego što se upuste u transakciju M&A. Cilj rada je da analizira proces due diligence-a i ukaže na ključne razloge zašto je due diligence jedan od ključnih faktora uspeha M&A. U radu se ukazuje da due diligence doprinosi identifikovanju i ublažavanju rizika povezanih sa transakcijama M&A, poboljšava postakvizicionu integraciju kompanija, omogućava efikasnije pregovaranje o uslovima transakcije, obezbeđujući fer i pravičan ishod za sve uključene strane.

Ključne riječi: merdžeri i akvizicije, due diligence, postakviziciona integracija, stvaranje vrednosti

1. UVOD

Merdžeri i akvizicije predstavljaju strateške transakcije putem kojih kompanije nastoje da ostvare rast, pristupe novim tržištima, povećaju tržišnu moć. Iako kompanije optimistički ulaze u ove transakcije, istraživanja pokazuju da je veliki procenat M&A neuspešan (Homburg and Buceirius, 2006; Tuch & O'Sullivan, 2007). U pokušaju identifikovanja faktora koji doprinose uspehu M&A, studije su otkrivale značaj due diligence-a (KPMG, 1999; Epstein, 2005; Dörrenbächer & Witzmann, 2015; KPMG, 2023). Due diligence predstavlja dubinsku analizu poslovanja ciljnog preduzeća, njegovih snaga i slabosti, njegove konkurentske pozicije, kako bi se sagledali svi potencijalni rizici, ali i potencijal za kreiranje vrednosti.

Due diligence predstavlja jednu od najbitnijih pripremnih faza procesa M&A. Tradicionalno due diligence je obuhvatao finansijski, pravni i komercijalni due diligence, fokusirajući se na istraživanje finansijskih performansi ciljnog preduzeća, analizu ugovora ciljnog preduzeća, kao i analizu konkurentske pozicije preduzeća. U novije vreme, nameće se potreba proširivanja opsega due diligence-a uključivanjem ESG (Environmental, Social and Governance) pitanja. ESG razmatranja su od suštinskog značaja za uspešne M&A. Kompanije koje daju prioritet faktorima ESG-a imaju veću verovatnoću da privuku investitore, imaju veću vrednost i ostvaruju konkurentsku prednost (Mallia-Dare & Kim, 2022).

Rad ima za cilj da sagleda važnost due diligence-a u procesima M&A, naglašavajući pri tome značaj novijeg tipa due diligence-a – ESG due diligence-a. Glavna istraživačka pitanja u radu su: 1) Koje su ključne faze procesa due diligence-a? 2) Koji su ključni tipovi due diligence-a? 3) Kakve su specifičnosti ESG due diligence-a u odnosu na tradicionalni obuhvat due diligence-a? 4) Kakav je značaj due diligence-a u procesima M&A?

U skladu sa opredeljenim predmetom, ciljem istraživanja i definisanim istraživačkim pitanjem, rad je strukturiran na sledeći način. Prvo, dat je pregled literature o procesu due diligence-a koji uključuje tri ključne faze: preliminarni, dodatni i transakcioni due diligence. Drugo, objašnjeni su različiti tipovi due diligence-a, pri čemu je analiziran i ESG due diligence-a i istaknuta njegova specifičnost u odnosu na tradicionalni obuhvat due diligence. Treće, istaknut je značaj due diligence-a u procesima merdžera i akvizicija. Na kraju, data su zaključna razmatranja.

2. PROCES DUE DILIGENCE-A

M&A predstavljaju značajne korporativne događaje koji podrazumevaju temeljan i dinamičan proces koji može da traje od nekoliko meseci do nekoliko godina. Generalno, proces M&A počinje identifikacijom potencijalnih ciljnih kompanija koje bi mogle doprineti ostvarivanju strateških ciljeva kompanije kupca i sprovođenjem *preliminarnog due diligence-a*. U pitanju je preliminarna provera potencijalnih ciljnih kompanija na bazi informacija koje su javno dostupne (Savović, 2018). Osnovna svrha sprovođenja ovog tipa due diligence-a je da kompaniji kupcu obezbedi dovoljno osnovnih informacija o ciljnoj kompaniji kako bi se donela informisana odluka o tome da li da se nastavi sa akvizicijom. *Dodatni due diligence* podrazumeva dubinsku analizu selektovane

ciljne kompanije i otpočinje nakon potpisivanja sporazuma o poverljivosti, kako bi se osiguralo da informacije do kojih se dolazi u procesu due diligence budu sačuvane i ne koriste se u druge svrhe. Due diligence je proces koji uključuje identifikaciju i procenu rizika u okviru procesa M&A, i podrazumeva sprovođenje rigorozne istrage o mogućim rizicima koji će biti prisutni u ovoj transakciji, sa namerom da minimiziraju rizike (Sanz-Prieto et al., 2021). Tokom finalne faze due diligence-a, *transakcionog due diligence-a*, koja počinje nakon potpisivanja sporazuma o preuzimanju, kompanija kupac ima najširi pristup privatnim informacijama i mogućnost da proveriti tačnost primljenih informacija tokom čitavog procesa due diligence-a. Izjave i garancije uključene u ugovor o akviziciji su dizajnirane da olakšaju funkciju provere due diligence-a tako što potvrđuju da su informacije koje ciljna kompanija pruža potpune i materijalno tačne (Wangerin, 2019). Kompanija kupac tokom procesa transakcionog due diligence-a može dobiti najvažnije i najpreciznije informacije o ciljnoj kompaniji. Do kraja procesa due diligence-a, ceo postupak pomaže kompaniji kupcu da stekne uravnotežen pogled kroz jasnoću o prednostima i nedostacima investicione ideje. Otuda, due diligence omogućava kompaniji kupcu da donese racionalnu odluku u vezi sa ulaganjem.

Bazična funkcija due diligence-a je procena koristi i obaveza predložene akvizicije ispitivanjem relevantnih aspekata u prošlosti, sadašnjosti i predvidive budućnosti poslovanja kompanije koja se kupuje (Savović, 2018). Oni koji vrše ovu procenu treba da se fokusiraju na rizik, sprovodeći istragu potencijalne investicije koja služi kao potvrda svih materijalnih okolnosti u vezi sa transakcijom, sa krajnjom svrhom da se kompaniji kupci pruži poverenje u vrednost i rizik poslovanja ciljne kompanije.

Due diligence podrazumeva razvijanje ekstenzivnog razumevanja vrednosti ciljne kompanije kao samostalnog biznisa, kao i vrednosti potencijalnih sinergija. Kao što Cai et al. (2016) ističu, „due diligence nije udvaranje, pregovaranje ili inkvizicija; to je misija utvrđivanja činjenica... poslovni pregled ciljne kompanije postaje prava revizija, sa ciljem da se stekne temeljno razumevanje poslovanja, imovine, obaveza i perspektive ciljne kompanije“. Due diligence tim nastoji da potvrdi pretpostavke ciljne kompanije, ispita sve pravne, regulatorne i probleme usaglašavanja, i potvrdi očekivane sinergije. Svrha due diligence-a je da pruži podršku procesu vrednovanja, pregovaranja i integracije (Savović, 2023). Nakon dobijanja značajnih informacija kroz fazu due diligence-a, počinju pregovori između kompanije kupca i ciljne kompanije u vezi sa cenom, strukturom transakcije i ostalim relevantnim pitanjima. Kada se pregovori završe i kompletira transakcija, kompanije ulaze u završnu fazu – proces integracije dve kompanije.

Od identifikacije partnera za spajanje, preko sprovođenja due diligence-a, vrednovanja i pregovaranja do post-akvizicione integracije, menadžeri se suočavaju sa neizvesnošću tokom čitavog procesa. Ova neizvesnost negativno utiče na prinose kompanije kupca i postakvizicione performanse. Otuda, posedovanje više specifičnih informacija o ciljnoj kompaniji pomaže kompaniji kupcu da poboljša prinos i očekivanu vrednost kombinovanih kompanija.

3. TIPOVI DUE DILIGENCE-A

Due diligence predstavlja kritičnu predakvizicionu aktivnost koja suštinski doprinosi postakvizicionim performansama. Prethodna istraživanja su pokazala da preko 42% procenta profesionalaca koji su bili angažovani na M&A transakcijama smatra da proces

due diligence nije u potpunosti osvetlio kritična mesta neophodna da se identifikuju rizici i budući izvori sinergije i kako ih ostvariti (McKinsey, 2010) Mali doprinos due diligence poslovnim performansama nakon preuzimanja je posledica toga što većina kompanija sprovodi takozvani skraćeni postupak, odnosno radi samo pravni i finansijski due diligence. Na ovaj način potencijalni investitor kroz proces due diligence-a samo identifikuje realnost pravnih i finansijskih činjenica potencijalne mere (Childs, 2007). Ovo je svakako nedovoljno jer due diligence treba da sagleda finansijsku poziciju mete, strategijski i organizacioni potencijal, buduće izvore sinergije, potencijalne rizike i troškove integracije. Tokom ovog procesa je neophodno identifikovati (McKinsey, 2010):

- izvore konkurentске prednosti kompanije koja se preuzima i kako ih očuvati nakon preuzimanja;
- kako ostvariti tradicionalne sinergije: ekonomiju obima i druge oblike poslovne efikasnosti;
- kako ostvariti transformacionu sinergiju koja nastaje sticanjem i izgradnjom novih kompetencija u postupku preuzimanja.

Komercijalna vrsta due diligence je usmerena na analizu tržišne strukture grane, na bazi geografskih kriterijuma, tipova proizvoda i segmenata kupaca. Na bazi informacija o preferencijama kupaca, njihovoj lojalnosti i reakciji na aktivnosti konkurencije kompanija analizira da li su potrebne modifikacije ponude, da li se mogu postojeći proizvodi prodavati kroz preuzete kanale distribucije, da li je moguće ostvariti unakrsnu elastičnost prodaje i slično (Howson, 2006). Due diligence treba takođe da osvetli stanje nematerijalne imovine kompanije koja se preuzima i kako je adekvatno iskoristiti, a time se uglavnom bavi tehnološki due diligence i due diligence usmeren na ljudske resurse. Nematerijalnu imovinu je teško identifikovati i vrednovati, ali kroz ovaj proces treba dati odgovore na neka od sledećih pitanja: koje veštine i tehnologiju poseduje meta, kako će one unaprediti postojeću tehnološku osnovu i da li postoje rizici brzog zastarevanja tehnologije. Na tehnološki due diligence se nastavlja izveštaj o ljudskim resursima koji treba da identifikuje zaposlene koji poseduju strateška znanja, kako ih zadržati i motivisati da svoje znanje podele sa zaposlenim investitora. Takođe, tokom procesa je neophodno identifikovati potencijalne kulturološke razlike i kako one mogu uticati na proces stvaranja i integracije preuzete nematerijalne imovine (Lovallo et al, 2007).

Poslednjih godina se iskristalisao stav da kompanije moraju da prilikom svog poslovanja uvažavaju interese i šire poslovne zajednice (de los Reyes, Scholz & Smith, 2017). U skladu sa tim razvio se koncept *ESG* due diligence koji analizira usklađenost ciljne kompanije sa nacionalnim i međunarodnim propisima kao obavezujućim okvirima, kao i nekodifikovanim normama i očekivanjima stejkholdera u vezi sa ESG-om. U pogledu ekološke (*environmental*) dimenzije, due diligence uključuje postojanje unutrašnje politike, odgovornosti i upravljanja u skladu sa nekoliko ekoloških aspekata (posebno energije, emisije CO₂, materijala, upotrebe vode i otpada) sumirajući ekološki uticaj poslovnog modela. Društvena dimenzija obuhvata politike i odgovornosti koje se tiču društvenih (*social*) aspekata, kao što su ljudska prava, različitost i jednakost. Konačno, dimenzija upravljanja (*governance*) sastoji se od analize rizika sistema upravljanja, poštovanja korporativnih kodeksa ponašanja (protiv mita, antikorupcija itd.) i transparentnosti odluka i naknada odbora direktora i menadžera (Deloitte, 2021).

Ukoliko sprovođenjem ESG due diligence-a uoči postojanje ESG rizika, kompanije kupci mogu da iskoriste dobijene informacije kako bi pregovarale o uslovima preuzimanja ciljne kompanije. One mogu zahtevati nižu procenu vrednosti ciljne kompanije; izdvajanje relevantnog dela posla koji je pogođen, koji će ostati ciljnoj kompaniji; otklanjanje relevantnog rizika tokom postakvizicione integracije i slično. Istraživanja su pokazala da povećanje percipirane korupcije za 1 dovodi do pada plaćenih premija kod međunarodnih preuzimanja za 15% do 27%, što govori u prilog posebne potrebe za ESG due diligence kod transakcija koje se realizuju u zemljama koje se smatraju visoko koruptivnim (Utz & Sjorns, 2006).

Proaktivnim uključivanjem ESG praksi u svoje poslovanje i strategije, kompanije svih veličina i sektora mogu se pozicionirati za ostvarivanje uspeha u dugom roku. Ovo ne samo da koristi samim kompanijama, već i doprinosi održivijem i odgovornijem globalnom poslovnom okruženju. Prihvatanje zakonske perspektive koja se razvija i sve veći naglasak na pozitivnom doprinosu društvu i životnoj sredini može pomoći kompanijama da poboljšaju svoju tržišnu reputaciju i podstiču dugoročno stvaranje vrednosti (Costa, 2023).

4. ZNAČAJ DUE DILIGENCE-A

Svrha due diligence-a je da se minimizira uticaj neizvesnosti koja je prisutna u transakciji ove veličine, jer uključuje ogromne količine finansijskih sredstava. Due diligence je fokusiran na: rigorozan pregled računovodstvenih i finansijskih stavki kako bi se utvrdilo ekonomsko zdravlje kompanije ili poslovne jedinice; razvijanje koherentnih i konzistentnih akcija i strategije sa sistematskim protokom informacija sve do postintegracijskog procesa; identifikovanje i kvantifikovanje sinergija koje se mogu iskoristiti u okviru procesa proširenja radi poboljšanja koristi budućeg poslovanja, identifikovanje bilo koje vrste obaveza (dugova/obaveza) koje je kompanija ili poslovna jedinica stekla, a koje su skrivene; određivanje mogućih nepredviđenih situacija u vezi sa životnom sredinom i radnom snagom (Sanz-Prieto et al., 2021).

Due diligence pruža informacionu osnovu za proces vrednovanja ciljne kompanije, čime pomaže da se odredi cena kompanije, uzimajući u obzir ne samo profitabilnost, profit i koristi koje je kompanija ostvarila, već i potencijalne sinergije koje može da ostvari udruživanjem sa kompanijom koja će izvršiti preuzimanje. Sprovođenje detaljnog procesa due diligence-a povećava šanse za uspeh M&A. Proces due diligence-a doprinosi donošenju odluka na bazi relevantnih informacija. Iz perspektive kompanija kupaca, due diligence povećava sigurnost, dok sprovođenje procesa M&A bez ovog procesa ili uz minorno posvećivanje pažnje procesu značajno povećava rizik.

Važnost due diligence-a iz perspektive kompanije kupca ogleda se u sledećem (Legamart, 2023; Savović, 2023; Savović & Pokrajčić, 2012):

- Identifikovanje i ublažavanje rizika povezanih sa transakcijom M&A. Pažljiv pregled finansijskih izveštaja ciljne kompanije, ugovora, intelektualne svojine, evidencija usklađenosti i druge relevantne dokumentacije omogućava kupcima da steknu sveobuhvatno razumevanje potencijalnih obaveza ili problema koji bi mogli da utiču na transakciju. Određivanjem i procenom rizika u ranoj fazi

procesa, kompanije kupci mogu da donose odluke na osnovu dobrog informisanja i pregovaraju o uslovima relevantnim za transakciju. U određenim slučajevima, otkrivanje značajnih rizika može podstaći ponovnu procenu ili čak potpuno odustajanje od transakcije, čime se štiti kompanija kupca od značajnih finansijskih gubitaka i pravnih komplikacija;

- Poboljšanje postakvizicione integracije. Uspeh transakcije M&A u velikoj meri zavisi od efektivne integracije, a due diligence služi kao ključno sredstvo u postizanju ovog cilja. Pružajući kompanijama kupcima bitne informacije, on utiče na planiranje i izvršenje integracije. Kompanije kupci mogu da otkriju potencijalne sinergije, viškove i operativnu efikasnost temeljnim ispitivanjem sistema, procesa i infrastrukture ciljne kompanije. Pored toga, due diligence pomaže u prepoznavanju kulturoloških razlika i potencijalnih sukoba koji se mogu pojaviti tokom integracije. Rano razumevanje ovih faktora olakšava razvoj strategija upravljanja promenama, podstiče otvorenu komunikaciju i neguje okruženje za saradnju za zaposlene iz obe organizacije;
- Donošenje odluka na bazi informacija. Due diligence je od ključnog značaja za obezbeđenje da kompanije kupci donose odluke koje su potkrepljene informacijama. Kroz sveobuhvatan pregled poslovanja ciljne kompanije, tržišne pozicije, konkurentskog okruženja i izgleda za rast, kompanije kupci mogu proceniti stratešku usklađenost M&A. Oni mogu da procene da li je ciljna kompanija usklađena sa njihovim dugoročnim ciljevima, da li poseduje komplementarne sposobnosti ili sredstva i da li određuje finansijsku održivost transakcije. Štaviše, due diligence omogućava kompanijama kupcima da procene menadžerski tim, kulturu i ljudske resurse ciljne kompanije. Ovaj uvid pomaže u razumevanju potencijalnih izazova i problema kompatibilnosti tokom integracije nakon M&A. Raspoložuci obimnim i značajnim informacijama, kompanije kupci mogu efikasnije pregovarati o uslovima transakcije, na odgovarajući način strukturirani transakciju i razviti mapu puta za uspešnu integraciju;
- Uticaj na cenu transakcije. Due diligence može značajno uticati na naknadu (ili kupovnu cenu) u transakciji M&A. Pažljivo ispitivanje imovine, obaveza, intelektualne svojine i izgleda ciljne kompanije omogućava kompanijama kupcima da donesu odluke sa dobrim informacijama u vezi M&A. Identifikovanje potencijalnih rizika i prilika, zajedno sa određivanjem izjava i garancija ciljne kompanije na osnovu ovih faktora, omogućava kompanijama kupcima da prilagode uslove transakcije i cenu, obezbeđujući fer i pravičan ishod za sve uključene strane. Štaviše, due diligence može otkriti skrivenu ili potcenjenu imovinu, intelektualnu svojinu ili mogućnosti rasta u ciljnoj kompaniji. Ovo otkriće ima potencijal da poveća ukupnu vrednost transakcije, obezbeđujući kompaniji kupcu konkurentsku prednost na tržištu;
- Osiguranje usklađenosti sa propisima. Pomaže kompaniji kupcu da osigura da je ciljna kompanija u skladu sa svim relevantnim propisima i zakonima. Ovo uključuje propise o životnoj sredini, zakone o radu i poreske zakone.

Osiguravajući usklađenost sa propisima, kompanija kupac može izbeći potencijalne pravne i finansijske obaveze.

Odgovarajući due diligence je ključ za obezbeđivanje pozicije kompanije kupca u transakciji M&A. Međutim, proces due diligence-a ne omogućava samo kompaniji kupcu da se oseća ugodnije sa svojim očekivanjima u vezi sa transakcijom, već koristi i ciljnoj kompaniji, jer prolazak kroz rigoroznu finansijsku proveru može, u stvari, otkriti da je fer tržišna vrednost ciljne kompanije veća nego što se prvobitno mislilo. Stoga, nije neuobičajeno da ciljne kompanije same pripremaju izveštaje o due diligence-u pre potencijalnih transakcija (Bernardo, 2024). Due diligence je podjednako neophodan i za ciljnu kompaniju za ublažavanje potencijalnih rizika, identifikovanje pokretača vrednosti i poboljšanje konkurentne pozicije. Neki od najvažnijih razloga zašto je due diligence važan za ciljnu kompaniju su (Legamart, 2023)

- Identifikovanje problema. Sprovođenje due diligence-a omogućava kompanijama prodavcima da otkriju sve potencijalne probleme, kao što su pravne obaveze, kršenja usklađenosti ili finansijske nepravilnosti, koji bi mogli da umanje vrednost njihove kompanije ili ugroze posao. Identifikovanjem i rešavanjem ovih pitanja unapred, kompanije prodavci mogu da ublaže rizike i povećaju svoju pregovaračku moć tokom pregovora;
- Procena kompanije. Kompanijama prodavcima pruža objektivnu procenu njihove kompanije na osnovu njihove imovine, obaveza, prihoda i potencijala rasta. Ovo može pomoći kompanijama prodavcima da odrede realniju cenu za svoju kompaniju i da pregovaraju o boljim uslovima sa potencijalnim kupcima;
- Poboljšanje procesa prodaje. Kompanije prodavci mogu pripremiti sveobuhvatnu dokumentaciju koja detaljno opisuje finansijski i operativni učinak njihove kompanije, pravnu strukturu, ugovore i druge ključne informacije. Ovo može pojednostaviti proces prodaje i smanjiti vreme i resurse potrebne za zaključenje posla;
- Stvaranje osnova za proces pregovaranja. Omogućava kompanijama prodavcima da identifikuju prednosti i slabosti svoje kompanije, kao i potencijalnih kupaca. Ovo znanje može pomoći prodavcima da pregovaraju o boljim uslovima, kao što su viša cena, povoljniji uslovi plaćanja ili smanjen nivo rizika;
- Olakšavanje transakcije M&A. Kompanije prodavci mogu da predvide i reše potencijalne probleme pre nego što postanu prekršioc dogovora. Ovo može pomoći da se olakša transakcija i smanji rizik od sudskih sporova ili sporova nakon zaključenja transakcije.

5. ZAKLJUČAK

M&A predstavljaju jednu od najsloženijih strategija poslovnog restrukturiranja, koja treba da doprinese radikalnoj promeni poslovnog modela ili rastu investitora. Stopa uspešnosti M&A je relativno niska. Veći je broj faktora koji doprinose niskoj stopi uspešnosti M&A, a kao jedan od najčešćih se navode propusti u predakvizicionoj fazi, odnosno propusti prilikom realizacije due diligence. Proces due diligence se odvija kroz tri faze: preliminarni, dodatni i transakcioni due diligence. Kroz proces due diligence-a kompanija

treba da identifikuje potencijalne sinergije koje se mogu realizovati nakon spajanja, troškove koji nastaju spajanjem, kao i rizike koji prate realizaciju sinergije.

Usled potrebe da se bude brži od konkurencije tokom preuzimanja kompanije često sprovode samo bazične vrste due diligence-a, odnosno pravni i finansijski. Kroz ova dva tipa due diligence-a investitor proverava realnost iskazanih finansijskih pozicija, kao i pravnu valjanost materijalne i nematerijalne imovine, obaveza i potraživanja. Međutim ovo nije dovoljno da bi se pokrili svi rizici, zbog čega se sve više insistira na sprovođenju komercijalnog, tehnološkog i due diligence-a usmerenog na ljudske resurse. Komercijalni due diligence treba da odgovori na pitanje tržišne pozicije brendova mete, lojalnosti kupaca i mogućnosti da se iskoriste novo stečeni kanali distribucije za plasman svojih proizvoda. Na kraju, due diligence treba da identifikuje i vrednuje nematerijalnu imovinu mete, ali i da da sugestije kako ova nematerijalna imovina može da unapredi kompetencije investitora, kombinujući se sa nematerijalnom imovinom koju investitor već poseduje. Vremenom se uvidelo da fokusiranje samo na interese vlasnika, a ne i eksternih stejkholdera nije adekvatno za proces due Diligence. Naime, ESG due diligence proverava usklađenost mete ekološkim standardima, formalnim i neformalnim socijalnim normama, i standardima korporativnog upravljanja.

Doprinos due diligence procesu realizacije M&A transakcije je višestruk. Naime, detaljna analiza sprečava kompaniju da uđe u transakciju koja neće stvoriti vrednost vlasnicima. Due diligence treba da identifikuje sve potencijalne rizike transakcije, kako poslovne tako i pravne, obezbedi donošenje odluke na bazi objektivnih informacija, a ne subjektivnih osećaja menadžera, i obezbedi neophodne inpute za sprovođenje procesa integracije mete, nakon preuzimanja. Na ovaj način, due diligence sprečava menadžere da previše plate za preuzimanje ciljne kompanije i eventualno napuste proces nadmetanja, ukoliko cena transakcije postane suviše visoka.

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IMPORTANCE OF DUE DILIGENCE IN MERGERS AND ACQUISITIONS PROCESSES

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ABSTRACT:

Mergers and acquisitions (M&A) represent complex transactions that require detailed preparation in order to increase the success rate in the post-acquisition period. One of the most important preparatory phases is the process of due diligence, i.e. detailed research of the target company from various aspects in order to identify potential risks, but also to consider potential synergies which can be obtained after the realization of M&A. The due diligence process involves a comprehensive analysis and assessment undertaken by acquirers to scrutinize the financial, legal, operational and strategic aspects of a potential target company before engaging in an M&A transaction. The aim of the paper is to analyze the due diligence process and point out the key reasons why due diligence is one of the key factors of M&A success. The paper indicates that due diligence contributes to identifying and mitigating risks associated with M&A transactions, improves post-acquisition integration, enables more effective negotiation of transaction terms, ensuring a fair and equitable outcome for all involved parties.

Keywords: *mergers and acquisitions, due diligence, post-acquisition integration, value creation*

ULOGA I ZNAČAJ BRENDIRANJA ZA TURISTIČKU DESTINACIJU HERCEG NOVI

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Apstrakt: *Da bi destinacija uspešno bila brendirana na turističkom tržištu, neophodno je uskladiti veliki broj faktora. Veoma je važno uključiti u brendiranje sve grupe koje imaju interes u načinu na koji će destinacija biti brendirana. Te interesne grupe su: stanovnici destinacije, posetioci, lokalne i regionalne vlasti, lokalne, regionalne i nacionalne turističke organizacije, kao i sve druge organizacije koje su povezane sa određenom destinacijom. Od marta 2019. godine, Crna Gora se promovise kao atraktivna turistička destinacija, kroz kontinuiranu kampanju od strane organizatora, jednog od najuticajnijih putničkih časopisa, na britanskom tržištu, National Geographic Traveler. To znači da je visoko vreme da se ozbiljno pristupi strateškom planiranju Crne Gore kao turističke destinacije, a time i Herceg Novog. Kada znamo šta je naš turistički proizvod, tada možemo lako definisati ciljnu grupu koja bi trebalo da ga koristi.*

Ključne reči: *brend, destinacije, turizam, organizacije*

1. UVOD

Brendiranje je samo po sebi veoma kompleksan i zahtevan proces kojim turističke organizacije pokušavaju da kreiraju percepciju turističke destinacije onako kako žele da ona izgleda, u stvari da podstaknu u svijesti potrošača asocijacije na zemlju kao atraktivnu turističku destinaciju. To je proces kojim zemlja izdvaja i individualizuje svoju ponudu u odnosu na ponudu konkurentskih zemalja. Brendiranje je postalo moćna sila. Brend čine ime, izraz, simbol, znak, dizajn, kao i kombinacija svih ovih elemenata uz čiju pomoć se prepoznaje proizvod i pomoću koje se vrši diferenciranje u odnosu na konkurenciju.

Predmet istraživanja ovog rada je turistička destinacija i prikaz kako se brendira destinacija i koliko to znači za njenu konkurentnost na tržištu.

Osnovni cilj ovog rada je da prikaže proces brendiranja turističke destinacije, zatim, kako i na koji način se brendira turistička destinacija, koji su elementi i koliki je značaj za

jednu destinaciju brendiranje i na kraju, kroz odgovarajuće primere prikazano je kako se u svetu brendira turistička destinacija Herceg Novi.

2. BREND

Reč brend (engl. brand) izvorno potiče od reči „brand“ što u prevedenom značenju znači goret. Prvenstveno reč brend (brand) značio je žigosanje stoke kako bi se moglo dokazati vlasništvo. 1552. godine po prvi put se navodi i definiše reč brand. „Oxford English dictionary“ definiše „brand“ kao oznaku načinjenu užarenim željezom zbog izričite potrebe za označavanjem stoke i ostale svrhe označavanja. U Antičko doba, ali i pre, proizvođači su označavali svoje proizvode kako bi se razlikovali od drugih proizvođača (posuđe, cigle, oružje i sl.). Proizvodi su se od rane ljudske istorije označavali na određen način kako bi se isticali od drugih odnosno kako bi bili prepoznatljivi.

Označavanje je postalo vrlo važno onog trenutka kada se određeni proizvod počeo prodavati izvan mesta proizvodnje (sajmovi). Znakovi su u prošlosti bili vrlo jednostavni kako bi ih mogli prepoznavati i nepismeni ljudi. Brend je dobio veće značenje tokom industrijske revolucije kada se na tržištu pojavilo sve više proizvođača (Vranešević, 2008). Brend odnosno trgovački brend većinom je služio za prepoznavanje kvaliteta samog proizvoda te je služio udaljenim kupcima (osobe koje nisu imale direktne kontakte s proizvođačima) kao određeno jemstvo (Karamarko, 2009).

Američko udruženje za marketing definiše brand kao ime, pojam, znak, simbol, dizajn, ili kombinaciju istih, usmerenu na identifikaciju proizvoda ili usluga nekog proizvođača ili grupe proizvođača i njihovo razlikovanje od proizvoda ili usluga konkurencije. Brend iznad svega omogućava diferencijaciju u odnosu na konkurente.

Brend je proizvod ili usluga sa dodatim dimenzijama koje ih na izvestan način izdvajaju od ostalih proizvoda ili usluga dizajniranih radi zadovoljenja iste potrebe. Te razlike mogu da budu funkcionalne, racionalne ili opipljive, shodno performansama brenda. One mogu biti i više simbolične, emocionalne ili neopipljive onome šta brend predstavlja (Kotler & Keler, 2006).

2.1. Pojam i definicija brenda

Brend se uglavnom sastoji od naziva i znaka ali i ostalih elemenata a služi kao garancija svim klijentima o kvalitetu samog proizvoda ili usluge. Takođe, brendiranjem proizvoda obaveštava se tržište i potrošači o jedinstvenosti proizvoda na tržištu prema ostalim proizvodima koji se nalaze na tržištu. Brend podrazumeva naziv, simbol i sve karakteristike koji se na neki način povezuju s proizvodom ili uslugama, ali i njihovim funkcionalnostima.

Brend je ime, pojam, dizajn, simbol ili neka druga karakteristika koja identifikuje dobro ili uslugu jednog prodavca i razlikuje ga od drugih prodavaca. Uspešan brand je

proizvod, usluga, osoba ili mesto, koje možemo da identifikujemo i koji su „uvećani“ na takav način da kupac ili korisnik dobijaju relevantne, jedinstvene dodatne vrednosti koje najviše zadovoljavaju njihove potrebe.

Brend predstavlja ime, pojam, znak, simbol, asocijaciju, trgovačku marku ili dizajn i služi za identifikaciju i diferenciranje proizvoda ili usluga proizvođača ili grupe proizvođača od konkurentskih. Brend poseduje funkcionalne i emocionalne elemente koji stvaraju odnos između potrošača i proizvoda ili usluge (Zelić, 2013).

2.2. Pozicioniranje i brendiranje turističke destinacije

Kako će se destinacija pozicionirati na tržištu prvenstveno zavisi od toga kako je doživljavaju i vide budući i sadašnji posetioци, a to se uglavnom odnosi na iskustava i potencijalne koristi koje ona pruža u odnosu na konkurentske destinacije.

Suština pozicioniranja turističkih destinacija ogleda se u činjenici da turističke destinacije imaju određeni položaj, tj. posebnu vrstu opažanja sa kojom ih poistovećuju postojeći i potencijalni potrošači. Mesto koje destinacija zauzima u svesti potrošača predstavlja jedan od osnovnih razloga za izbor konkretne turističke destinacije i njome se direktno anticipira delovanje konkurencije i utvrđuje slobodan prostor na tržištu za konkretan proizvod destinacije (Popesku, 2009).

Strategija pozicioniranja je usmerena prema usklađivanju pozicije destinacije sa potrebama ciljnog tržišta. Potrebno je sve elemente marketing miksa – proizvod, cene, distribuciju i promociju – povezati na takav način da odabrana kombinacija najviše odgovara ciljnom tržištu.

Što se tiče brendiranja turističke destinacije, osnovni vid komunikacije turističke destinacije sa tržištem izvodi se putem vizuelne identifikacije, logotipa turizma jedne zemlje (Đurašević, 2006).

Brend je onaj osećaj koji, o turističkom proizvodu ili turističkoj destinaciji, ima više osoba istovremeno, i upravljati brendom znači upravljati razlikama koje postoje u svesti ljudi (Medek & Banić, 2005).

3. STUDIJA SLUČAJA – BRENDIRANJE TURISTIČKE DESTINACIJE HERCEG NOVI

Kao neka vrsta raskršća između istoka i zapada, Herceg Novi je kroz istoriju bio pod uticajima hrišćanstva sa zapada i islama sa istoka. I upravo takvo istorijsko preplitanje, različitih kultura i vera, u dodiru sa iskonskom lepotom, isklesalo je jedinstvenu sintezu različitih stilova. Na području današnjeg Herceg Novog smenjivale su se različite civilizacijske, odnosno kulturne tekovine, ostavljajući dubok trag na današnji izgled Herceg Novog. Herceg Novi je primorski grad u Crnoj Gori i nalazi se na samom ulazu u Bokokotorski zaliv, u podnožju planine Orjen. Sa mora, pogled na Herceg Novi oduzima dah. Egzotične biljke, drveće i rastinje iz celog sveta je transformisalo Herceg Novi u pravi botanički vrt.

Izgrađen na nivou mora, ovaj grad je savršeno smešten, s pogledom na otvoreno more i dva poluostrva, Lušticu i Prevlaku. Sam grad je izuzetno privlačan za turiste iz raznih krajeva sveta, a blizina dva aerodroma Tivat i Čilipi olakšavajuća su okolnost za dolazak i posetu turista. Grad Herceg Novi, kao i njegova okolina, obiluju arhitektonskim, skulptorskim i slikarskim delima, koja nas neraskidivo vezuje sa bogatom i burnom prošlošću grada. Tu, pre svega, treba istaći preromantičke sakralne spomenike u Bijeloj, Kutima i Sušćepanu (www.hercegnovi.me, 2024).

Herceg Novi svojom lepotom i gostoprimstvom privlači turiste kako iz zemlje i regiona, tako i sa svih svetskih meridijana. Ovaj grad sam sebi je brend, međutim ono što ga izdvaja i brendira van naših granica su svakako, Institut za fizikalnu medicinu, rehabilitaciju i reumatologiju „Dr Simo Milošević“ AD – Igalo, zatim Vaterpolo klub „Jadran“, a takođe i Praznik Mimoze koji se održava u toku meseca februara.

3.1. Institut za fizikalnu medicinu, rehabilitaciju i reumatologiju „Dr Simo Milošević“ Igalo

Danas Institut “Dr Simo Milošević”, pored programa prevencije i rehabilitacije zdravlja nudi wellness i rekreativne sadržaje. Kompleks Faza I (STARI DIO), ** smeštena na samoj obali mora, izlazi direktno na šetalište “Pet Danica”. Institut posjeduje 23 hektara zemlje, 4 smeštajna objekta sa kapacitetom od preko 1200 kreveta u dvokrevetnim, jednokrevetnim, trokrevetnim sobama i nekoliko apartmana, restorana i barova i prostranim terapijskim blokom. Kompleks Faza II (NOVI DIO) ***je raskošno zdanje rasprostranjeno na 50 000 m², u potpunosti klimatizovano, sa 417 komfornih soba i apartmana sa balkonima. Većina soba ima pogled na more. Sve sobe su opremljene klima uređajem sa individualnim podešavanjem, telefonom, TV-om i frižiderom, te svakom gostu pružaju idealne uslove za odmor i rekreaciju (<https://www.planatours.rs/>, 2024).

Pacijenti iz Norveške koji, uglavnom borave u Drugoj fazi Instituta koja je po kvalitetu smeštaja bolja od Prve, u tu ustanovu dolaze već 42 godine i do sada ih je boravilo više od 50.000. Njihov dolazak regulisan je državnim programom, a potpisan je i Sporazum za period od 2019. do 2022. godine. Osim Norvežana, usluge stručnjaka Instituta, doduše

u manjem broju, rado koriste i gosti iz Švedske, Danske i Holandije, a zabežena je i poseta turista iz Grčke, Mađarske i Slovenije.

Prva faza Instituta „rezervisana“ je za goste iz Crne Gore koji dolaze posredstvom Fonda zdravstva i Sindikata, zatim za penzionere, kao i za individualne posete.



Slika 5. Institut „Dr Simo Milošević“ (faza II)

Izvor: (<http://www.caffemontenegro.me/>, 2024)

Sledeći staru evropsku tradiciju prirodnog lečenja, Institut Igalo je postigao međunarodnu reputaciju zbog uspešnog tretiranja klijentele sa širokim spektrom zdravstvenih problema. Zahvaljujući prirodnom lekovitom blatu, Igalo se razvilo u jedno od najvećih peloidnih lečilišta u Evropi.

Institut Igalo, kao jedinstven spoj hotela i zdravstveno-rehabilitacionog centra, uz pomoć neinvazivnih metoda i kroz iskusnu primjenu prirodnih faktora Igala (Ijekovito morsko blato, mineralna voda, blaga mediteranska klima), svakom gostu pristupa kroz individualni medicinski program. Dakle, možemo zaključiti da je Institut „Dr Simo Milošević“ poznat širom Evrope i na taj način reklamira, odnosno brendira Herceg Novi kao turističku destinaciju.

3.2. Vaterpolo klub „Jadran“

U prvim godinama svoga postojanja, kao jedini klub u Boki, Jadran je sve utakmice igrao protiv dubrovačkih klubova, a svoju prvu pobjedu ostvario je protiv, tada već poznatog kluba Građanski, koji je uz komšijski Jug i splitski Jadran, bio jedan od najboljih u tadašnjoj Jugoslaviji. Nastao je u leto 1926. godine povezivanjem tadašnjih divljih

klubova u Herceg Novom – Bijela Vila i Spjata – i kao takav registrovan kod Plivačkog Saveza Jugoslavije.

Današnji “jadranaši”, takođe nižu pobjedu za pobjedom i nastavljaju tradiciju koja klub prati kroz istoriju. Navikli da je sve to normalno i očekivano, ali kada bolje razmislimo i analiziramo sve to je iznad realnog i plod je višegodišnjeg, decenijskog sistematskog rada u klubu.

Učešćima na raznoraznim turnirima i prvenstvima, u raznim gradovima sveta, Jadran reklamira svoj grad, a takođe i svoju državu i kao takvi predstavljaju izuzetan brend za turističku destinaciju kakva je Herceg Novi.

PLIVAČKI VATERPOLO KLUB SWIMMING WATER POLO CLUB



Slika 6. Logo PVK „Jadran“ Herceg Novi

Izvor: <http://www.pvkjadran.com/>

pristupljeno 26.03.2021.

3.3. Praznik Mimoze Herceg Novi

Ovaj praznik osmišljen je i po prvi put organizovan sada već daleke 1969. godine uz pomoć Turističkog saveza Boke Kotorske. Ugled Praznika Mimoze vremenom je rastao i postao jedna od glavnih manifestacija na prostorima bivše Jugoslavije.

„Mimoza“ je 1975. godine imala čast da je svečano otvori tadašnja prva dama Jugoslavije Jovanka Broz a popularne Hercegnovske mažoretke imale su priliku otvoriti 14. Zimske olimpijske igre 1984. godine u Sarajevu. Osim toga, slavu Mimoze pronijele su širom regiona. Njihov karavan je obišao preko 50 gradova, između ostalih i Budimpeštu, Berlin, Kopenhagen...(<http://www.jbapartlounge.me/>, 2024)

Kada neko pomene Mimozu, ne može a da ne pomisli na Herceg Novi. Mimoza je asocijacija na ovaj grad, na novljanje, na njihov duh, tradiciju, stil života i imidž.

Osim Mimoze, i Hercegnovske Mažoretke su zaštitni znak i sinonim za Herceg Novi (skupa sa trombonjerima i gradskom muzikom).

Tradicija „Praznika mimoze“– uključije mnoge fešte karnevalske svečanosti, (velike karnevale za odrasle i decu), smotru mažoretki (mlade djevojke obučene u predivne crvene uniforme i koje izvodeći svoje plesne tačke obavezno svima daruju buket mimoza), karavane mimoze (uključuju gostovanje u gradovima Crne Gore, Srbije, te van granica Crne Gore), koncerti gradske muzike Herceg Novog, kao i „Montenegro mimoza Kup“ najvažniju sportsku priredbu „Praznika mimoze“. Inače, festival „Praznik Mimoze“ član je karnevalskih gradova Evrope od 1991. godine. Toj manifestaciji iz godine u godinu prisustvuje sve veći broj ljudi.



Slika 7. Defile mažoretki kroz Herceg Novi

Izvor: (<https://www.google.com/search>, 2024)

Iz prethodnih primjera možemo zaključiti da Herceg Novi poseduje veoma značajne elemente koji ga brendiraju u inostranstvu i da na taj način postaje sve zanimljivija destinacija za turiste širom Evrope, a i sveta.

4. ZAKLJUČAK

Da bi se jedna destinacija uspešno brendirala na turističkom tržištu, neophodno je stalno istraživanje tržišta. Ovo istraživanje predstavlja prvu fazu procesa brendiranja destinacije. Pod brendiranjem se podrazumeva razvoj sistema standarda i kontinuirano osiguranje kvaliteta. Veoma važne su investicije u smeštajne kapacitete, u javne usluge i bezbednost, kao i u celokupnu infrastrukturu.

Stanovništvo se mora edukovati po pitanju turizma, a ovo se posebno odnosi na zaposlene u trgovinama, restoranima, finansijskim institucijama, javnom i privatnom prevozu, smeštajnim objektima, policiji i javnim preduzećima. Moraju se uskladiti svi parametri da bi se gradio imidž destinacije. Moramo naglasiti da između brenda i turističkog proizvoda postoji značajna razlika i ona se pre svega ogleda u emocionalnoj percepciji. Ta razlika je u dodatoj vrednosti, koja često predstavlja emocionalnu

vrijednost koja se teško definiše. To je vrednost koja u svesti potrošača izaziva osjećaj prestiža. Dodata vrednost brenda može biti posledica iskustva, uticaja referentnih grupa, verovanja da je brend efektivniji, kao i izgleda brenda.

Kada se brendira turistička destinacija veoma važno je razviti obećanje o brendu koje može da ispuni očekivanja i želje svih učesnika. U ovom procesu menadžeri imaju ključnu ulogu i treba da oblikuju brend na osnovu svoje vizije, zaposleni bi učestvovali u kreiranju brenda preko jedinstvene organizacione kulture, da bi stejkholderi na adekvatan način mogli da percipiraju imidž brenda.

Vrednosti od kojih polazi turistička organizacija i vrednost turističke destinacije kao brenda treba uskladiti, one ne smiju biti u suprotnosti jedne s drugima. Treba na kreativan način primeniti odgovarajući miks strategijskih vještina i analitičkog zaključivanja da bi se turistička destinacija pomerila sa nivoa “zanimljive destinacije” na nivo “destinacije koju turisti baš žele da posete”. Da bi turistička destinacija postala brend nije dovoljna samo izjava o misiji, niti diferenciranje proizvoda, ili niska cena, neophodno je uspostaviti veze i sa posetiocima, i sa zaposlenima i sa stanovništvom turističke destinacije, vodeći računa o tome da brend nastaje uzajamnim dejstvom ljudi i organizacione kulture. Destinacija kao brend mora se stvarati iznutra, zaposleni i lokalno stanovništvo moraju biti ambasadori brenda, oni moraju da veruju da je predstava o brendu autentična. Turistička destinacija postaje brend u onom trenutku kada turistima pruža jedinstven doživljaj koji ne postoji na nekom drugom mestu.

Zadatak menadžera turističke organizacije je da strategiju razvoja turističke destinacije prevedu u izraz brenda jer je samo uz pomoć brenda moguće je ostvariti prepoznatljivost njenog turističkog proizvoda, i učiniti da se ona razlikuje od mnoštva sličnih turističkih destinacija. Obzirom da turizam kao privredna grana predstavlja danas najveću šansu za povećanje izvoza, kao i za značajan privredni rast, brendiranje zemlje kao turističke destinacije postaje neophodno.

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THE ROLE AND SIGNIFICANCE OF BRANDING FOR THE TOURIST DESTINATION OF HERCEG NOVI

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Abstract: *In order for a destination to be successfully branded on the tourism market, it is necessary to harmonize a large number of factors. It is very important to include in branding all groups that have an interest in the way the destination will be branded. These interest groups are: people living in the destination, visitors, local and regional authorities, local, regional and national tourism organizations, as well as all those other organizations that are associated with a particular destination.*

Since March 2019. Montenegro has promoted as an attractive tourist destination, through a continuous campaign by the organizers, one of the most influential travel magazines, in the UK market National Geographic Traveler. Which means that it is high time to seriously address the strategic planning of Montenegro as a tourist destination and thus Herceg Novi.

When we know what our tourist product is, then we can easily define the target group that should consume it.

Keywords: *brand, destinations, tourism, organizations*

MANAGING THE CHANGES IN OHRID'S HOTEL OFFER THROUGH BOUTIQUE HOTELS

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ABSTRACT:

Ohrid is the most attractive tourist destination of the Republic of North Macedonia. With its natural and anthropogenic values, it has always been interesting and attractive to tourists, especially foreign visitors. The characteristics and beauties of Lake Ohrid, the cultural-historical heritage as well as the natural, environmental and ethno-social motives are factors that make Ohrid the largest and most famous tourist center of the Republic of Macedonia. Against the significant tourist values, the content of Ohrid's hotel offer is not set as a factor for increasing its competitiveness on the international tourist market.

In this context, changes in the hotel offer are necessary. Managing changes through an innovative approach to the establishment of boutique hotels is a significant strategic direction towards the improvement of hotel services in Ohrid.

Starting from that, this paper will carry out a theoretical and empirical investigation of the concept of boutique hotels and three basic aspects related to them: the brand, the formation of an appropriate organizational structure and the communications that employees make with each other and with guests. For this purpose, an analysis of these elements will be carried out in the SU hotel, one of the most renowned hotels on the Ohrid Riviera. Through the use of the survey technique, emphasis will be placed on researching the suitability of human resources in the hotel, their loyalty to hotel activities and the satisfaction of working in the hotel.

Keywords: *boutique hotel, hotel offer, Ohrid, organizational structure, hotel workers*

1. INTRODUCTION

Although it can be said that competitiveness is not a new concept in the tourism business, however, the complexity and dynamics of the modern environment and all the influences it causes, actualize the high competition in the tourism market as an extremely important challenge of the new century. The main reasons that encourage the competitiveness of the tourist market are: the character of tourist demands expressed through their heterogeneity and elasticity and the possibility of substitution of tourist services with the same or similar ones, as well as the permanent changes in the attitudes, demands, tastes and behavior of tourists. Thus, the modern tourist is constantly looking for something new, unknown and more attractive in all areas of tourist offer. If until a decade ago the motto "It matters where you spend your vacation" was valid, now the motto is "How you spend your vacation". The tourist clientele is oversaturated with worldly resorts, hotels, commercialized summer and winter tourist destinations. A new trend is to get to know new, less known countries, their culture, tradition, return to nature and traditions. Today's tourist is looking for a stay in facilities that will offer him comfort, a pleasant atmosphere, intimacy, in which he will feel their stylistic uniqueness.

Hotel industry, as an essential part of tourism, plays a very important role in creating and satisfying tourist needs. The quality of the accommodation offer, which is determined by the hotel's capacity to provide attractive products, services and solutions for its guests, is a factor that determines the quality of the overall tourist offer. Hotels are not immune to permanent market changes. Therefore, the hotel management is faced with the need to strategically approach the changes and think about finding innovative contents of its offer that will achieve full satisfaction of the guests' expectations.

Innovation is a specialized type of change. It occurs when new ideas and behaviors are accepted in the organization¹, when a developed new idea is translated into a new business, a new product or service, a new process, a new method of work or their improvement. Success in hotel change management depends on the organization's ability to continuously transform knowledge and ideas into new products, processes and systems in order to provide benefits to stakeholders. Innovation in hotels can range from introducing new services with which they break into the market to small, insignificant improvements. But, regardless of that, they represent the most significant area for the improvement of competitive capabilities.

Among the majority of tourist places in Macedonia, Ohrid stands out as the most attractive tourist destination. With its natural and anthropogenic values, it has always been interesting and attractive to tourists, especially foreign visitors. The characteristics and beauties of Lake Ohrid, the cultural-historical heritage as well as the natural, environmental and ethno-social motives are factors that make Ohrid the largest and most famous tourist center of the Republic of Macedonia. However, in contrast to the significant touristic values that it has, the content of the hotel offer is not set as a factor for realizing

¹ Kontić, Lj. (2008): *Inovacije – izazovi za budućnost*, Beograd: Zadužbina Andrejević

the competitiveness of this destination on the international tourist market. The hotel product should be shaped, enriched and improved with new contents and innovations, in order to make the temporary stay of the guests better and more comfortable and Ohrid a more interesting and desirable destination.

2. BOUTIQUE HOTELS AS AN INNOVATIVE FORM IN HOSPITALITY

Innovations in tourism and the hotel industry are determined by the specific character of the tourist product. Considering the nature of the hotel product, innovative changes in the hotel can refer to the creation and successful application of a new product, process, new idea, new form of knowledge, new way of delivering quality or value to the guest, or a combination of all of them. . If changes are implemented according to guest needs, then managers focus on kitchen innovations, room innovations, internet innovations, service innovations that include pets in facilities, etc.¹ Innovation also occurs in the work process of hotels. Although they have a specific technology at work, innovation in its composition can be a significant element for success. Such changes occur in the segmentation of the market and the development of ideas for the product and their materialization, the way of distribution and promotion. The different views of innovation in hospitality point to several key areas in which change can occur in the creation of the hotel offer.²

- Product innovations – represent redesigned or completely new services or products, the novelty of which should be obvious to producers, consumers, suppliers or competitors. Examples of new tourism products developed in recent years are: loyalty programs, facilities for ecologically sustainable accommodation, events based on local traditions, etc.
- Process innovation – tends to increase the efficiency of existing operations by using new or improved technologies or by redesigning the entire production line, e.g. as a result of a reengineering process. Examples of major process innovations in tourism are: computerized tracking systems, cleaning and maintenance robots, self-service appliances, etc.

- Management innovations - it means an innovative approach oriented to the management of the quality of human resources. Tpa consists of the introduction of new jobs, new organizational structures, authority system, internal competence development, team building activities, etc. They are often combined with the introduction of new products, services and production technologies. Through this type of innovation there is a tendency to increase employee satisfaction and loyalty through activity.

¹ Jacob, M. Tintoré, J. Aguiló, E. Bravo, A. Mulet, J. (2003). Innovation in the tourism sector: results from a pilot study in the Balearic Islands. *Tourism Economics*, 9(3), 279-295

² Hjalanger, kaj Radosavljević, G. Borisavljević K. (2011). Inovacije kao faktor preduzetništva u turizmu, Naučni skup Novi metodi menadžmenta i marketinga u podizanju konkurentnosti srpske privrede, 15. oktobar, Palić, Srbija..

•Innovations in logistics, which include the establishment of new commercial links, which can affect the organization's position in the value chain. Innovations in tourism logistics include: vertical linkages in the food and beverage industry, CRS (computer reservation systems) and Internet marketing, improvement of the airport hub system, and so on.

•Institutional innovations are outside the organization that span across the public and private sectors and set new rules of the game. Examples of tourism implications include: reform of financial incentives that restructure the concepts of social or health tourism; destination management systems and units that control access to tourist areas; and establishing or changing credit institutions and changing the conditions for obtaining financial assets.

In practice, there are numerous examples of product and service innovations. In the area of hotel product innovation, the formation of a special type of hotel, such as a boutique hotel, can be emphasized. This type of hotel is due to the growing trend of demand for differentiated hotel products and the wishes of hotel companies to provide more than the usual hotel offer.

A boutique hotel is a type of hotel characterized as a small entity, creating an intimate feeling where every guest is offered personal service. It is an independent hotel or part of a "boutique only" chain. This type of hotel has a special character, design, decor and personalized service. Its specificity is that it remains faithful to the local culture and is usually in the center of the city or in a very attractive place.

As a term, "boutique hotels" haven't actually been around very long. It is considered that it appeared for the first time in the 80s of the last century. However, it is not exactly established because according to some sources Jan Schrager is credited with the term, and other sources announce that the first true boutique hotel was the Clarion Bedford Hotel, opened in San Francisco in 1981, and in 1984 with the opening of the Morgans Hotel in New York, hotelier Jan Schrager and his business partner Steve Rubel actually coined the term boutique hotel.¹ However, from a historical point of view, it is very likely that this type of hotel can be found throughout Europe at the beginning of the 19th century, only that they did not have that name then.

At their core, boutique hotels can be described as personalized, customized, unique and individual. Their most important feature is authenticity and an established unique way of communicating with their target market, breaking the monotony and creating an atmosphere in which guests will feel special. Precisely because of the uniqueness and creativity of the services that make up the offer of boutique hotels, they cannot be unified as a standard product.

However, their essential characteristics are:

¹ https://en.wikipedia.org/wiki/Boutique_hotel; <https://skift.com/history-of-boutique-hotels>

Size: Boutique hotels typically have fewer than 100 rooms, small restaurants or bars, few recreation rooms, and limited meeting space.

Theme: Each boutique hotel has a unique theme, some are historical, some are culinary focused, and some focus on specific elements. The theme is present not only in the aesthetics of the hotel, but perhaps also in its name, staff uniforms, amenities, etc.

Style: The theme cannot be expressed unless the hotel has matching decor and design. Every element of the hotel's appearance should be carefully selected, from the design of the hotel's website, through the hotel's amenities, to the standards of operation.

Service: The small scale and intimate atmosphere allows staff to focus on providing outstanding guest service.

A boutique hotel may or may not be a luxury hotel. Hotels do not become "boutique" by charging high rates or offering premium amenities. In fact, many boutique hotels are affordable and focus more on personalized service than glamorous decor or five-star facilities.

3. ANALYSIS OF THE CONDITION OF THE SU HOTEL AS A BOUTIQUE HOTEL ON THE OHRID RIVIERA

As the most important tourist center in the Republic of Macedonia, Ohrid has a large number of hotels of different sizes and other types of accommodation facilities. Their structural analysis¹ shows that the majority are small and medium-sized hotels and apartments. The small hotel facilities include nine attractive boutique hotels that stand out from the classic offer of other hotels with their offer. Among them, with its extraordinary location, is the SU hotel, a small family hotel where guests can feel cozy and intimate in uniquely designed rooms and suites and enjoy a relaxing time with freshly brewed coffee in the lounge bar. The hotel is located on the shore of Lake Ohrid, in the center of the city so that guests can admire the beauty of the lake and experience Ohrid through the view from its restaurant.

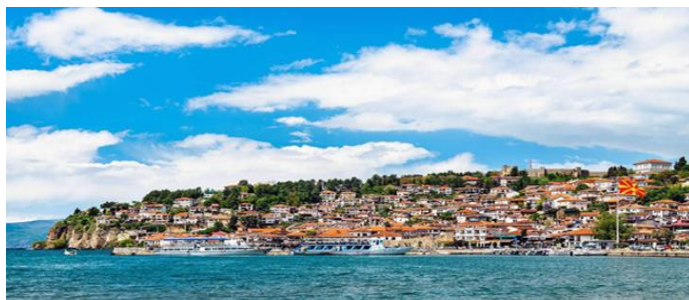


Fig.1. View of the old town of Ohrid

¹ <https://www.booking.com/design/city/mk/ohrid.hr.html>



Fig.2. SU hotel



Fig.3. One of the rooms of SU hotel

However, the ratings of the guests who used the offer of this hotel indicate that there are weaknesses in its operation and actions should be taken to improve the offer. For this purpose, an analysis of two groups of stakeholders of the hotel was carried out:

- the views of the guests through the level of their reputation for separate elements of the hotel's offer expressed on the booking platform.
- the attitudes of the employees through a survey of 36 employees who are not managers and a survey and interview of the 4 managers of the hotel.

Graph 1. Guests' evaluation of the hotel's offer



Source: <https://www.booking.com/searchresults.hr.html>

If the evaluation of hotel Su is compared with the evaluations of other boutique hotels in Ohrid or in the region, it can be noted that this boutique hotel should improve the comfort offered to them. The analysis of the promotional activities through the hotel's website shows weaknesses in the propaganda message, that is, the website lists only the offered values that relate more to Ohrid than to the content of the hotel's offer. The hotel does not use to a sufficient extent the possibilities in strengthening its brand, so that there is no establishment of an emotional connection with which the potential customer would be attracted and choose SU among the large number of hotels that are included in the hotel offer of Ohrid. The website is rarely updated, so there is information that is outdated, inaccurate and irrelevant.

The modern business world in the field of hospitality increasingly emphasizes the loyalty of guests and the loyalty of staff as a factor for competitiveness. In fact, guest satisfaction and hotel performance are influenced by the standards of food and beverage, accommodation and other amenities provided by the hotel. But the qualities of the hotel staff have the same influence. It can be said that the human factor plays the most important role for the hotel's success because guests will be loyal consumers only if they are satisfied with the offer and above all with the expertise and hospitality of the staff. The need for effective and efficient human resources employed in the hospitality industry stems from two vital factors, ie. it is a tourist driven and quality driven industry. Adequate knowledge, skills and expertise of the staff as well as their satisfaction are necessary to attract the guests, to create a pleasant atmosphere of commitment to fully satisfy the guests' requirements and expectations.

In order to gain knowledge about employee satisfaction and their loyalty to the hotel, a survey of the employees of Hotel Su was conducted through their recruitment. The survey was conducted with three types of questions.

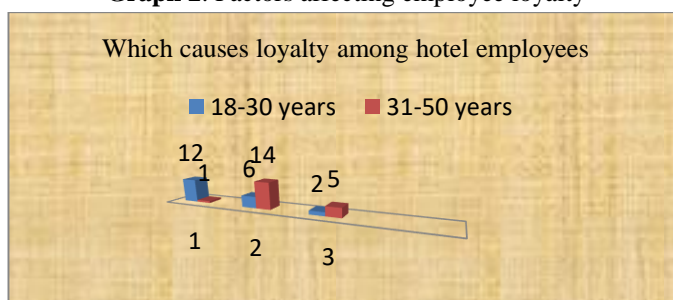
The first type of questions refers to the examination of the factors that influence building the interest of employees in hotel operations. In order to achieve that, two groups of employees were examined, from 18-30 years old and 31-50 years old. Both groups are composed of 20 respondents each.

The survey questions address three basic factors:

1. Salary and other financial incentives
2. Working conditions and promotions
3. Positive working and communication climate in the hotel

The responses received are presented in Graph 2.

Graph 2. Factors affecting employee loyalty



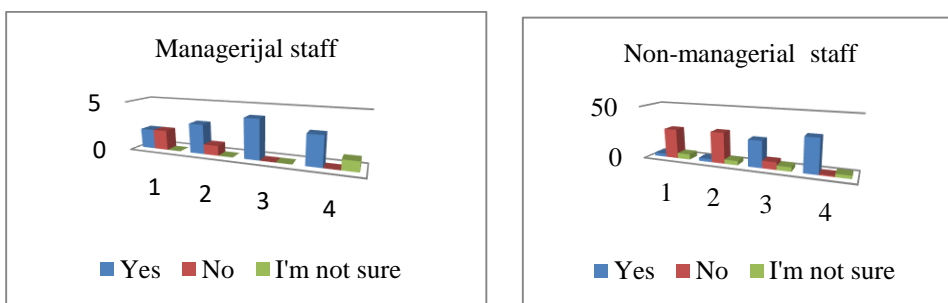
From the results presented, it can be noted that for employees up to 30 years of age, financial compensation has a key impact on their satisfaction with working in the hotel, while for employees over 30 years of age, positive working conditions and the opportunity to improve employees' knowledge and skills are essential. and their promotion.

The second type of question concerns the quality and expertise of the staff. They should be used to determine how appropriate the organizational layout of the hotel is. In order to ensure greater reliability of the obtained results, the same questions were asked to all respondents ie. of managerial and non-managerial staff, namely:

1. Does the structure of employees according to expertise meet the needs?
2. Are there enough employees in each department?
3. Are there enough managers?
4. Would the offer be better if there were more employees?

The results of the received answers are presented in Graph 3

Graph 3. Attitudes of employees about the number and expertise of the staff



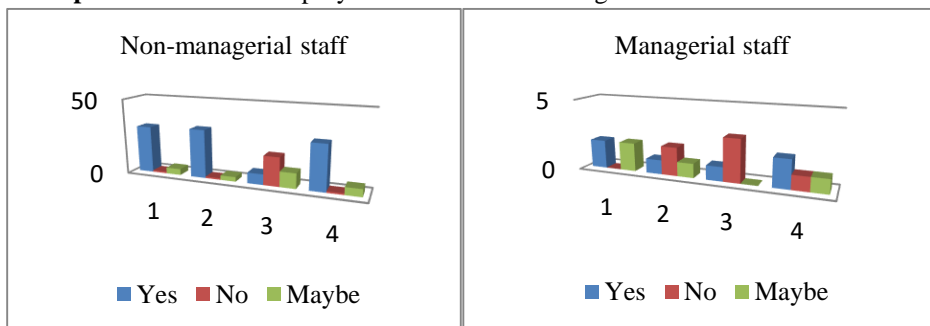
The analysis of the answers points to the conclusion that the expertise of the employees is not at a satisfactory level and needs to be improved. While the managers believe that there is enough staff, other respondents stated that the number of employees should be increased and thus the quality of the offer will be improved.

With the third type of questions, knowledge should be obtained about the organization of work in the hotel. For this purpose, answers were received to the following questions:

1. Is there a need for better organization of work?
2. Are there weaknesses in the transmission of information in the hotel?
3. Do technical means of work meet the needs?
4. Is there a need for teamwork and decision-making?

The results obtained from the survey are presented in the graph that follows.

Graph 4. Structure of employees in relation to the organization of work in the hotel



The received answers point to the conclusion that there is a lack of good organization, leadership and communication system in the hotel. Although the managers are satisfied with the existing organization, their other answers confirm that it is necessary to improve communications and advance leadership through the introduction of a team approach to work.

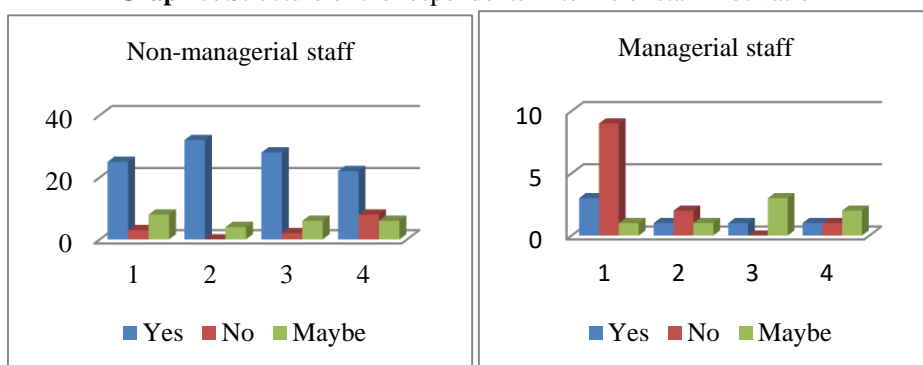
The fourth type of questions aims to determine the motivational climate that exists in the hotel, what is the factor that motivates employees and whether it exists as part of the operation. This was determined by answering the following questions:

1. Is it necessary to maintain annual assessments of individual operations?

2. Is it necessary to include weekly, monthly or quarterly stimulation (reward)?
3. Is it necessary to permanently improve the abilities of employees?
4. Is there a need for improvement in employee-management communication?

The results of the answered questions are as follows:

Graph 5. Structure of the respondents in terms of staff motivation



The received and presented answers indicate that there is a lack of motivation towards the employees in the hotel, and this is due to the inconstant and inadequate communication between the employees and the management, which leads to disharmony in the work. In addition to monetary incentives, employees feel the need for managers to take measures to improve the skills and professional knowledge of employees.

In order to obtain more complete results, an interview with the managers was also conducted on several essential issues, namely:

- Are you satisfied with the sale of the hotel product?
- Are you targeting new markets?
- How important is the opinion of the guests to you?
- Do you examine their satisfaction and how?
- What is your opinion about the image of the hotel among tourists?
- Are you satisfied with the expertise of your staff?
- What is your attitude towards permanent development of employees' abilities?
- Do you think that the employees are rewarded enough?
- Do you cooperate with educational institutions in the field of tourism and catering when hiring staff or on another basis?

4. CONCLUSION

From the conducted survey questionnaires as well as from the managers' answers received from their interviews, certain conclusions can be drawn and some recommendations can be proposed. The following can be stated as essential findings:

- The managers at Hotel Su have their own visions for increasing the turnover and the number of guests and overnight stays by improving the hotel offer. Their intention to

create a positive image of the hotel not only in the region but also in other tourist markets is special.

- They do not make special efforts to research existing and potential tourists, their experience, satisfaction and expectations from the offer.

- The hotel has insufficient staff in terms of number and professional preparation. This applies to all employees, including the management staff. Due to the insufficient number of employees, most of the employees perform two or more roles, especially the management staff. This situation has its influence on the emergence of weaknesses in the organization of work, communication relations in the hotel as well as in the motivational climate that prevails among the employees. Thus, despite the initial enthusiasm of the employees, it has negative long-term consequences on the hotel's financial result.

- The hotel does not have significant communications with the educational institutions of tourism and hospitality from Ohrid or beyond, which contributes to the hiring of inadequate staff for the working positions, which can be said for several other hotels on the Ohrid Riviera. This may be the result of the general situation that prevails in Ohrid's hotel industry, which is the outflow of professional catering staff to work in other tourist countries.

To increase the recognition and attractiveness of the hotel, managers should focus their activities in two directions:

Introduction of an innovative approach oriented to the management of the quality of human resources, which will improve the working climate in the hotel. Their priority must be to motivate their staff both through material rewards and permanent improvement of their abilities so that they can develop their career and commitment to guests. Respecting the professional attitudes and opinions of employees will enable managers to create a positive atmosphere for building staff loyalty to the hotel. Satisfied guests will be loyal promoters of the hotel offer.

Creation of innovative solutions in the content of promotional means and media that present the hotel offer on the tourist market.

This hotel is representative of the small hotels in Ohrid, so the findings apply to all of them to the greatest extent. The possibility of them being built as boutique hotels opens up a wide space to advance the hospitality industry on the Ohrid Riviera.

In that direction is their strategic development through the introduction of various elements in the offer. Bearing in mind the role and importance of the staff in creating the hotel brand, managers must focus on retaining and developing the personnel in them.

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RAZVIJENOST MSP U EU I TRANZICIONIM DRŽAVAMA

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SAŽETAK:

Mala i srednja preduzeća (MSP) u EU i tranzicionim državama su se u 2022. i 2023. suočila, ne samo sa posledicama globalne recesije iz 2020, nego i sa novom ekonomskom neizvesnošću i globalnim turbolencijama (energetska kriza, inflacija, pooštrena monetarna politika), što je znatno pogoršalo uslove njihovog poslovanja. Strah od preduzetničkog neuspeha je povećan u svim zemljama, očekivanja novih preduzetnika usled posledica globalnih recesija su opala. Ključni izazovi i rizici za MSP se odnose na: veliki jaz u produktivnosti MSP u odnosu na velika preduzeća, inflacione pritiske, usporeno osnivanje novih firmi i start-up kompanije, poremećaje u lancu snabdevanja i turbolencije u finansijskom sektoru. Istraživanje u radu je usmereno na analizu strukturnih performansi MSP u tranzicionim i državama EU, sa posebnim akcentom na razvijenost MSP u Srbiji.

Ključne riječi: mala i srednja preduzeća (MSP) u tranzicionim državama, razvijenost i strukturne performanse MSP, konvergencija produktivnosti MSP, izazovi MSP.

1. UVOD

„MSP su okosnica naših ekonomija...industrijska struktura mnogih regiona i gradova – ona su ključ društvene kohezije i pokretač regionalnog otvaranja radnih mesta i blagostanja.“

(A.Gurria, OECD)

Sektor MSP u Evropskoj uniji i u tranzicionim državama se, nakon globalne recesije u 2020, suočio sa novim globalnim potresima i rizicima. Prema GEM istraživanju [7] uslovi za razvoj preduzetništva u 2022-2023. su se znatno pogoršali usled energetske tranzicije, intenzivnih klimatskih promena i smanjenja biodiverziteta (oko 100 biljnih i životinjskih vrsta dnevno nestaje) i rasta siromaštva. Preduzetnički sektor bi trebao da razmišlja na zeleni način: da ne ugrožava životnu sredinu, da koristi reciklirane materijale, da štedi energiju, i dr. Strah od preduzetničkog neuspeha je povećan u svim zemljama, očekivanja novih preduzetnika tokom recesija su opala. Ključni izazovi i rizici za MSP u narednom periodu se odnose na: veliki jaz u produktivnosti MSP u odnosu na velika preduzeća, inflacione pritiske, usporeno osnivanje start-up kompanija, poremećaji u lancu snabdevanja i turbolencije u finansijskom sektoru.

Kao odgovor na rastuće izazove, EU je u novom strateškom pristupu razvoju MSP fokus stavila na tri stuba: (1) izgradnja kapaciteta i podrška tranziciji ka održivosti i digitalizaciji; (2) smanjenje regulatornog opterećenja i poboljšanje pristupa tržištu, kroz implementaciju `mera pozlaćenja MSP`: *prvo misli na male, samo jednom i digitalno podrazumevano*; (3) poboljšanje pristupa finansiranju, koji je od suštinske važnosti za investiranje MSP.

Predmet istraživanja u radu je analiza razvijenosti sektora MSP u EU i tranzicionim državama u periodu 2015-2022, sa akcentom na sektor MSP u Srbiji, dok je cilj istraživanja ukazivanje kreatorima ekonomske politike na neophodnost sprovođenja brzih strukturnih reformi u sektoru MSP.

Istraživanje u radu testira sledeće dve hipoteze:

- H1: Strukturne promene i rešavanje sistemskih problema u sektoru MSP u tranzicionim državama se odvijaju sporom dinamikom, što ga čini nekonkurentnim u odnosu na sektor velikih preduzeća;
- H2: Produktivnost sektora MSP je znatno niža od produktivnosti velikih preduzeća u tranzicionim državama, kao i da je konvergencija produktivnosti MSP ka proseku EU sporija od konvergencije velikih preduzeća.

Metodološki instrumentarijum u radu se bazira na strukturnoj, sektorskoj i dinamičkoj analizi sektora malih i srednjih preduzeća i preduzetnika (MSPP). Rad je strukturiran u tri celine: u *prvoj* je prikazana komparativna analiza razvijenosti sektora MSPP; u *drugoj* je analitički fokus usmeren na ocenu dinamike sprovođenja strukturnih reformi u sektoru MSP u tranzicionim ekonomijama, dok je u *trećoj* analizirana konvergencija produktivnosti sektora MSP i sektora velikih preduzeća u odnosu na prosek EU.

2. RAZVIJENOST SEKTORA MSP U EU I U TRANZICIONIM DRŽAVAMA

Sektor MSP u EU i u većini tranzicionih država je razvijeniji od sektora velikih preduzeća. U EU prosečno 99,8% broja preduzeća su MSP koja zapošljavaju u proseku 2/3 radnika i koja, u proseku, stvaraju 52% bruto dodate vrednosti (BDV) u nefinansijskom poslovnom sektoru (NFPS). Varijacije po državama u broju preduzeća su neznatne, dok su varijacije u strukturi zaposlenih i strukturi BDV приметne.

Tabela 1. Razvijenost MSP u EU i izabranim tranzicionim državama u NFPS¹⁾

	2015						2022					
	Broj (hilj.)	%	Zap. (hilj.)	%	BDV (mlrd. EUR)	%	Broj (hilj.)	%	Zap. (hilj.)	%	BDV (mlrd. EUR)	%
EU-27												
Mikro	21.356,3	92,8	40.057,4	29,5	1.454,0	21,2	22.744,2	93,5	38.790,4	29,4	1.419,4	18,6
Mala	1.378,7	6,0	27.503,4	20,2	1.233,0	18,0	1.332,2	5,5	25.602,3	19,4	1.259,8	16,5
Srednja	224,6	1,0	23.170,4	17,0	1.251,0	18,2	204,8	0,8	20.493,7	15,5	1.266,5	16,6
MSP	22.959,6	99,8	99.731,2	66,8	3.938,0	57,4	24.281,2	99,8	88.464,4	66,8	3.945,8	51,8
Velika	44,5	0,2	45.168,7	33,2	2.924,0	42,6	43,1	0,2	46.919,0	35,6	3.673,8	48,2
Privreda	23.004,1	100,0	135.899,9	100,0	6.862,0	100,0	24.324,3	100,0	131.805,4	100,0	7.619,6	100,0
Austrija												
Mikro	282,6	87,4	694,4	25,4	32,5	18,7	311,2	87,9	741,1	24,0	36,9	15,9
Mala	34,6	10,7	654,7	24,0	36,3	20,9	35,9	10,1	675,4	21,9	45,2	19,4
Srednja	5,2	1,6	513,8	18,8	38,2	22,0	5,5	1,5	542,1	17,6	46,3	19,9
MSP	322,4	99,7	1.863,0	68,2	107,0	61,5	352,6	99,6	1.958,5	63,5	128,4	55,2

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Velika	1,1	0,3	866,9	31,8	67,1	38,5	1,3	0,4	1.124,3	36,5	104,2	44,8
Privreda	323,5	100,0	2.729,9	100,0	174,1	100,0	353,9	100,0	3.082,8	100,0	232,6	100,0
Bugarska												
Mikro	289,0	91,3	574,7	30,1	4,2	21,6	327,6	92,2	607,8	30,6	7,9	18,2
Mala	22,6	7,1	458,1	24,0	4,3	21,8	22,7	6,4	451,9	22,7	8,4	19,2
Srednja	4,2	1,3	417,5	21,9	4,5	22,8	4,2	1,2	418,6	21,1	9,0	20,7
MSP	315,799,8	1.450,375,9	12,966,3	354,599,8	1.478,374,4	25,358,1						
Velika	0,6	0,2	459,5	24,1	6,6	33,7	0,6	0,2	509,6	25,6	18,3	41,9
Privreda	316,4	100,0	1.909,8	100,0	19,5	100,0	355,1	100,0	1.987,9	100,0	43,6	100,0
Hrvatska												
Mikro	138,0	91,9	327,2	30,7	3,9	19,2	178,4	92,4	367,2	32,7	6,3	19,0
Mala	9,9	6,6	198,6	18,6	3,5	17,5	12,5	6,5	236,6	21,1	6,2	18,7
Srednja	1,7	1,1	183,6	17,2	4,0	19,5	1,9	1,0	191,3	17,0	6,2	18,7
MSP	149,099,7709,4	66,611,456,2	192,799,8	795,170,9	18,656,5							
Velika	0,4	0,3	355,9	33,4	8,9	43,8	0,4	0,2	327,1	29,1	14,3	43,5
Privreda	149,4	100,0	1.065,2	100,0	20,3	100,0	193,1	100,0	1.122,1	100,0	32,9	100,0
Mađarska												
Mikro	489,8	94,1	861,3	34,4	9,6	18,1	679,6	95,1	1.070,0	36,6	17,3	20,9
Mala	25,8	4,9	480,0	19,2	8,6	16,3	29,4	4,1	547,4	18,7	14,4	17,4
Srednja	4,1	0,8	404,6	16,2	9,5	18,0	4,4	0,6	433,8	14,8	14,8	17,9
MSP	519,699,8	1.745,969,7	27,752,5	713,499,9	2.051,270,2	46,556,2						
Velika	0,9	0,2	757,7	30,3	25,1	47,5	1,0	0,1	872,7	29,8	36,3	43,8
Privreda	520,5	100,0	2.503,6	100,0	52,9	100,0	714,4	100,0	2.923,9	100,0	82,8	100,0
Češka Rep.												
Mikro	955,0	96,1	1.123,3	31,7	17,9	20,1	1.041,7	96,0	1.174,5	31,0	27,1	19,5
Mala	31,1	3,1	625,1	17,6	12,7	14,3	34,4	3,2	680,1	18,0	20,4	14,7
Srednja	6,4	0,6	668,3	18,9	18,2	20,5	6,8	0,6	697,3	18,4	27,0	19,4
MSP	992,699,8	2.416,768,2	48,854,9	1.082,999,8	2.552,067,4	74,453,5						
Velika	1,5	0,2	1.127,5	31,8	40,1	45,1	1,6	0,2	1.236,6	32,6	64,7	46,5
Privreda	994,1	100,0	3.544,1	100,0	88,9	100,0	1.084,6	100,0	3.788,5	100,0	139,1	100,0
Rumunija												
Mikro	392,2	87,7	903,1	23,5	9,4	15,8	509,0	90,5	1.039,1	25,3	21,7	22,1
Mala	45,4	10,2	883,9	23,0	9,4	15,7	44,3	7,9	879,5	21,4	16,4	16,7
Srednja	7,9	1,8	812,2	21,1	11,0	18,4	7,4	1,3	770,3	18,8	16,2	16,5
MSP	445,599,72.599,2	267,529,849,9	560,799,72.688,9	65,654,355,3								
Velika	1,5	0,3	1.251,6	32,5	30,0	50,1	1,5	0,3	1.411,5	34,4	43,8	44,7
Privreda	447,0	100,0	3.850,7	100,0	59,8	100,0	562,2	100,0	4.100,5	100,0	98,2	100,0
Slovačka Rep.												
Mikro	395,2	96,8	597,1	41,1	8,8	27,0	510,3	97,6	747,5	46,2	11,6	25,8
Mala	10,4	2,6	208,5	14,3	4,4	13,5	10,1	1,9	213,0	13,2	5,8	13,0
Srednja	2,1	0,5	230,8	15,9	5,5	16,8	2,1	0,4	234,5	14,5	7,8	17,2
MSP	407,899,91.036,471,3	18,657,3	522,699,91.195,0	73,925,256,0								
Velika	0,5	0,1	417,1	28,7	13,8	42,7	0,5	0,1	421,6	26,1	19,8	44,0
Privreda	408,3	100,0	1.453,5	100,0	32,4	100,0	523,1	100,0	1.616,6	100,0	45,0	100,0
Slovenija												
Mikro	124,7	94,8	206,9	35,2	4,2	21,8	152,0	94,5	239,6	34,3	8,1	23,8
Mala	5,5	4,2	105,4	17,9	3,6	18,8	7,3	4,5	138,8	19,8	6,9	20,3
Srednja	1,1	0,8	112,5	19,1	4,2	22,0	1,3	0,8	134,1	19,2	7,8	22,8
MSP	131,399,8424,972,2	12,062,6	160,699,8512,673,3	22,866,9								
Velika	0,2	0,2	163,2	27,8	7,2	37,4	0,3	0,2	187,0	26,7	11,2	33,1
Privreda	131,5	100,0	588,1	100,0	19,1	100,0	160,9	100,0	699,6	100,0	34,0	100,0
Srbija												
Mikro	276,3	96,0	351,7	30,9	3,2	22,7	360,4	95,9	398,9	27,1	8,1	22,7
Mala	8,9	3,1	178,0	15,6	2,3	15,4	11,9	3,2	241,2	16,4	5,6	15,7

Srednja	2,0	0,7	209,7	18,4	2,9	19,5	2,8	0,7	286,0	19,4	7,6	21,3
MSP	287,3	399,8	739,3	65,78	457,7	375,0	99,8	926,2	63,0	21,4	59,7	459,7
Velika	0,5	0,2	400,2	34,3	6,4	42,3	0,6	0,2	545,0	37,0	14,4	40,3
Privreda	287,8	100,0	1.139,5	100,0	14,8	100,0	375,6	100,0	1.471,1	100,0	35,8	100,0

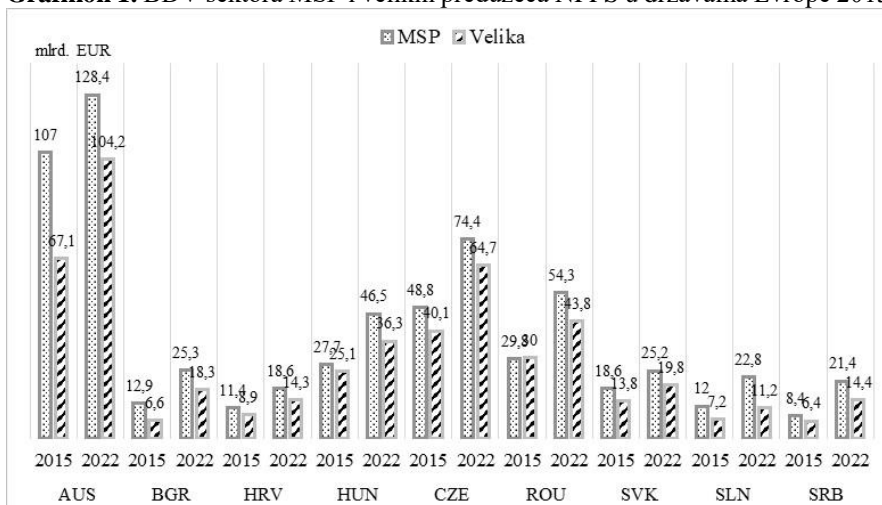
Izvor: Proračun na osnovu Eurostat Structural Business Statistic [5]

¹⁾ NFPS- Nefinansijski poslovni sektor obuhvata sektore B-J, L, M i N (NACE Rev. 2).

Razvijenost sektora MSP u tranzicionim državama još uvek značajno zaostaje za razvijenošću sektora MSP u razvijenim EU ekonomijama. U sektoru MSP Austrije u 352,6 hilj. preduzeća u nefinansijskom poslovnom sektoru (NFPS) radi oko 1.960 hilj. radnika koji su 2022. stvorili 128 mlrd. EUR bruto dodate vrednosti, što je za 42% više od BDV MSP u Češkoj Republici, koji je najrazvijeniji od svih tranzicionih ekonomija.

Od tranzicionih država sektor MSP je najrazvijeniji u Češkoj Republici. Mada je BDV sektora MSP u Srbiji 2015-2022. više nego udvostručen, on je niži od BDV MSP u Češkoj Rep. za 3,5 puta, od BDV MSP Mađarske za 2,2 puta, dok je u odnosu na BDV MSP Austrije niži za 6 puta. Poređenja radi, iste godine, BDP Srbije je bio niži od BDP Austrije 7,4 puta, od BDP Češke Rep. za 4,6 puta i od BDP Mađarske za 2,8 puta. Podsektor mikro preduzeća je najnerazvijeniji u Bugarskoj (BDV 7,9 mlrd. EUR) i Srbiji (8,1 mlrd. EUR). Najviše zaposlenih u sektoru MSP je u Rumuniji (2,7 mil) i Češkoj Rep. (2,5 mil.).

Grafikon 1. BDV sektora MSP i velikih preduzeća NFPS u državama Evrope 2015-2022.



Izvor: Proračun na osnovu baze podataka Eurostata i APR (za Srbiju).

Podsektor srednjih preduzeća u Hrvatskoj stvara najmanji BDV (6,2 mlrd. EUR), slede srednja preduzeća u Slovačkoj Republici, Sloveniji i Srbiji (7,8 mlrd. EUR), što je 6 puta niže od BDV srednjih preduzeća u Austriji (46,3 mlrd. EUR) i 3,5 manje od BDV srednjih preduzeća u Češkoj Republici (27 mlrd. EUR).

3. STRUKTURNE REFORME SEKTORA MSP

Globalno istraživanje uslova za razvoj preduzetništva (GEM) konstatuje da su se uslovi za razvoj preduzetništva u 2022. i 2023. pogoršali usled energetske tranzicije [3], rasta siromaštva i globalne nestabilnosti. GEM ističe da se tržišta menjaju sve većom brzinom i da su lanci snabdevanja sve manje otporni na recesione udare [4]. Ekonomske posledice pandemije COVID-19 se i dalje osećaju širom sveta, prihodi domaćinstava se i dalje smanjuju. Sporost u sprovođenju strukturnih reformi u sektoru MSP najizraženije reflektuje činjenica da je **strah od neuspeha najozbiljnije ograničenje za pokretanje biznisa u svim grupama država**. U brojnim ekonomijama (Brazil, Saudijska Arabija, Katar, Holandija, Portoriko, Poljska i dr.), veliki procenat odraslih se slaže da je pokretanje biznisa relativno lako, kao i da imaju veštine i iskustvo da stvore startup-ove, ali je takvih oko 50% ipak odvrćano od preduzimanja akcije zbog straha od neuspeha. Tome treba dodati da su **očekivanja novih preduzetnika tokom recesija značajno opala** (najviše u Poljskoj, Brazilu i Republici Koreji, ali i u Slovačkoj, Nemačkoj i Švajcarskoj).

Rezultati ocene kvaliteta nacionalnog preduzetničkog okruženja (na osnovu ocene 13 GEM uslova za preduzetništvo) pokazuju da su samo tri ekonomije: Indija, Kina i Indonezija (grupa C) imale devet ili više uslova ocenjenih kao dovoljnim [7]. Ujedinjeni Arapski Emirati su drugu godinu za redom ocenjeni kao najbolje mesto za pokretanje novog posla. Kvalitet nacionalnog preduzetništva (NECI indeks) u državama koje su svrstane u B grupu, u kojoj se nalazi i Srbija, je dosta heterogen: najveći je u baltičkim državama Litvaniji (12 GEM uslova sa ocenom ≥ 5 ; NECI indeks 5,8) i Letoniji (10 GEM sa ocenom ≥ 5 , NECI indeks 5,5), Srbija (5 GEM uslova ≥ 5 i NECI indeksom od 4,6) je bolje rangirana od Rumunije, Hrvatske, Poljske i Slovačke Republike. **Generalan zaključak je da su najsiromašnije ekonomije i najviše pogođene recesionim udarima**. Stope ekstremnog siromaštva su nakon kontinuiranog pada više od dve decenije ponovo u porastu. **Najniže ocene za tranzicione države bile su u oblasti preduzetničkog obrazovanja u školama i na fakultetima (uslovi D1 i D2), opterećenost novih preduzetnika brojnim nametima (B2), slaba povezanost novih poslova i istraživanja i razvoja (E), ali i činjenica da kultura ne promovise preduzetništvo (I)**.

Tabela 2. Ocena GEM uslova u tranzicionim državama 2022.

	SRB	HRV	HUN	ROU	SVN	SVK
A1. Preduzetničke finansije	3,7	4,8	5,3	3,9	4,4	4,9
A2. Lakoća pristupa preduzetničkim finansijama	4,3	4,1	4,8	3,9	4,7	4,6
B1. Vladina politika: podrška i relevantnost	4,1	3,1	4,3	3,0	3,5	4,4
B2. Vladina politika: Porezi i birokratija	6,0	3,7	5,5	4,6	4,2	4,3
C. Vladini preduzetnički programi	5,0	3,9	4,9	3,6	3,9	5,8
D1. Preduzetničko obrazovanje u školi	2,5	2,9	2,2	2,4	2,9	3,0
D2. Preduzetničko obrazovanje na fakultetu	3,5	3,8	4,4	4,7	4,2	4,6
E. Transferi istraživanja i razvoja	3,9	3,4	4,4	3,3	3,2	4,1
F. Komercijalna i profesionalna infrastruktura	5,2	5,0	5,7	5,7	5,7	5,4
G1. Lakoća ulaska: tržišna dinamika	5,4	6,5	4,5	5,5	5,7	6,0
G2. Lakoća ulaska: opterećenja i propis	4,8	3,8	4,7	4,5	4,9	4,6
H. Fizička infrastruktura	7,0	5,5	6,6	5,8	6,6	6,4
I. Društvene i kulturne norme	4,0	3,4	4,1	3,6	3,2	3,9

Izvor: GEM Report 2022-2023. [7]

Implementacija **Akta o malom biznisu za Evropu** (*Small Business Act*) predstavlja jedan od najreprezentativnijih instrumenata za merenje prolaznog vremena strukturnih reformi u sektoru MSP [10]. Najspornije strukturne reforme u tranzicionim državama koje su kandidati za članstvo u EU izražene su u oblastima: Stečaj i druga šansa, MSP u zelenoj ekonomiji, Preduzetničke veštine i Inovaciona politika za MSP. Mada se *Indeks politike MSP* za Srbiju u 2022. [9] povećao (sa 3,68 u 2019. na 3,85, prosek 10 dimenzija), najveći problemi su i dalje locirani u dimenzijama: MSP u zelenoj ekonomiji (ocena 2,53), Stečaj i druga šansa (3,21), Preduzetničke veštine (3,66), Preduzetničko učenje i žensko preduzetništvo (3,78) i Pristup finansijama za MSP (3,89).

Tabela 3. Komparativna analiza Indeksa politike MSP 2022.

	AL B	BI H	MK D	MN E	SR B	TU R	Prose k	
1.	Preduzetničko učenje i žensko preduzetništvo	2,96	3,23	2,39	4,47	3,78	4,37	3,53
2.	Stečaj i druga šansa	2,98	3,38	3,03	3,02	3,21	3,32	3,15
3.	Institucionalni i regulatorni okvir politike MSP	3,89	2,72	3,79	4,16	4,18	4,1	3,80
4.	Operativno okruženje za MSP	4,32	2,49	3,49	3,61	3,98	3,88	3,62
5a.	Usluge podrške za MSP	4,05	3,65	4,03	4,58	4,28	4,78	4,23
5b	Javne nabavke	4,39	3,49	3,97	4,16	4,25	3,73	3,99
.								
6	Pristup finansijama za MSP	3,43	3,34	3,90	3,63	3,89	4,18	3,73
7	Standardi i tehnički propisi	4,02	3,22	3,58	3,94	4,44	4,73	3,98
8a.	Preduzetničke veštine	3,49	2,72	2,26	3,28	3,66	4,35	3,29
8b	Inovaciona politika za MSP	2,58	1,97	3,77	2,99	4,00	4,45	3,29
.								
(1)	MSP u zelenoj ekonomiji	2,07	2,92	3,16	3,65	2,53	4,23	3,09
(2)	Internacionalizacija MSP	3,80	2,72	3,88	3,66	4,00	4,62	3,78

Izvor: OECD, 2022. [10]

Napredak u strukturnim reformama tranzicionih država u oblastima konkurentnosti, dobrog upravljanja, zelene ekonomije, inkluzivnosti, otpornosti i integrisanosti njihovih privreda u 2023. na osnovu reprezentativnih pokazatelja EBRD [5], pokazuje **napredak u oblastima inkluzije i integracije, ali su rezultati u oblasti dobrog upravljanja niži u odnosu na 2022.** Reformski napredak je uglavnom koncentrisan u državama centralne Evrope, baltičkim državama i u državama JIE, dok je pad u tranzicionim državama u južnoj i istočnom mediteranskom regionu, istočnoj Evropi i na Kavkazu. Niske ocene u oblasti **dobrog upravljanja** uzrokovane su uglavnom smanjenom neusklađenošću sa standardima usmerenim na borbu protiv pranja novca, erozijom slobode štampe i povećanjem percipirane korupcije (najveća pogoršanja su u Albaniji, Bosni i Hercegovini, Libanu, Mongoliji i Poljskoj). Rezultati u oblasti **zelene ekonomije** su poboljšani usled povećane proizvodnje obnovljivih izvora energije (OIE) i smanjenja subvencija za fosilna goriva u regionu centralne Evrope. Rezultati **inkluzije** su se poboljšali u mnogim ekonomijama, posebno u Bugarskoj, Estoniji, Mađarskoj, Libanu, Litvaniji i Mongoliji, najviše zbog povećanog učešća u ženske populacije u radnoj snazi, smanjenja nezaposlenosti mladih i povećanja kvaliteta infrastrukture. Rezultati **energetske otpornosti** su skromni, dok je **finansijska otpornost** poboljšana u većini ekonomija (rast adekvatnosti kapitala, niže stope problematičnih kredita, i dr.). Većina ekonomija je poboljšala svoje rezultati **integracije**, uglavnom zbog poboljšanja kvaliteta transportnih i

logističkih usluga, ali oni i dalje značajno zaostaju za naprednim komparatorima. Srbija je najveći napredak ostvarila u oblasti integrisanosti (sa 5,56 na 6,03), dok su najniže ocene u oblasti konkurentnosti (4,93) i zelene ekonomije (5,25).

U oblasti konkurentnosti procenjena su skromna poboljšanja za sve tranzicione ekonomije. Tokom perioda 2016-2023, tranzicione države u regionu JIE su zabeležile značajan napredak u konkurentnosti, uglavnom usled povećanja broja novih preduzeća, poboljšanja logistike usluga, boljeg pristupa finansiranju za MSP, poboljšanih veština, veće produktivnosti rada i sofisticiranosti izvoza usluga [5]. Najkonkurentnije su ekonomije Poljske i Češke Republike, najveći rast konkurentnosti zabeležile su ekonomije Rumunije, Mađarske, Severne Makedonije, Crne Gore, Srbije i Bugarske, dok je najveći pad procenjen za Grčku usled pada kredita privatnom sektoru, pada produktivnosti rada i povećanja državne potrošnje na subvencije.

Tabela 4. Tranzicioni napredak 2016-2023. (vrednosti EBRD indikatora)

Konkurentnost	Dobro upravljanje				Zelena ekonomija				Inkluzivnost				Otpornost		Integrisanost	
	2016	2023	2016	2023	2016	2023	2016	2023	2016	2023	2016	2023	2016	2023		
Češka Rep.			5,88	5,78	7,00	7,41	6,46	7,07	6,68	6,91	7,90	7,87	7,77	7,44		
Slovenija			5,68	5,65	7,19	7,22	6,52	7,15	6,77	7,13	7,61	8,01	6,82	7,21		
Poljska			5,80	5,80	7,36	6,77	6,37	6,74	6,63	6,91	7,78	7,95	6,52	6,83		
Slovačka Rep.					5,59	5,66	6,23	6,36	6,68	7,24	6,41	6,69	7,78	7,89	7,25	7,10
Mađarska			5,34		5,51	5,78	5,97	5,99	6,60	5,82	6,14	6,90	7,23	7,28	7,62	
Hrvatska			5,38		5,35	6,21	6,08	5,83	6,67	6,42	6,73	6,41	6,97	5,95	6,54	
Grčka			5,69		5,34	5,70	5,93	5,79	6,46	6,48	6,57	6,93	7,33	5,81	6,93	
Rumunija			5,34		5,56	5,99	6,16	5,78	6,35	5,84	5,96	6,70	6,94	5,88	6,27	
Bugarska	4,82		4,88		5,83		5,95	5,42	6,27	5,45	5,80	6,16	6,31	6,51	6,66	
Crna Gora	4,87		5,05		5,93		6,34	4,90	5,56	4,98	5,41	5,29	5,48	5,36	5,98	
Srbija	4,82		4,93		5,72		5,94	4,89	5,25	5,11	5,39	5,44	5,58	5,56	6,03	
Sev. Makedonija			4,62		4,78		5,76	5,44	4,75	5,55	4,80	5,01	5,17	5,53	5,18	6,08
Albanija	4,60		4,68		5,28		4,71	4,71	4,71	4,63	5,22	4,60	4,85	4,90	5,05	
BiH	4,38		4,37		4,68		4,09	4,55	5,01	4,85	5,07	5,23	5,32	4,48	4,97	

Izvor: EBRD Transition Report 2023-24. [5]

Napomena: Napredak se ocenjuje na skali od 1 do 10, gde 1 označava najmanji napredak, a 10 odgovara standardima održive tržišne ekonomije.

4. KONVERGENCIJA PRODUKTIVNOSTI SEKTORA MSP U TRANZICIONIM DRŽAVAMA

Komparativna analiza produktivnosti država u EU pokazuje velike razlike u produktivnosti između tranzicionih država i proseka EU, kao i veliki zaostatak država kandidata. Produktivnost MSPP u Bugarskoj u 2022. je na 36,8% proseka EU, Srbije na 38,2%, Rumunije na 43,4%, Slovačke Republike na 45,3%, Mađarske 48,7%, itd. Produktivnost MSPP Slovenije je najbliža proseku EU (95,6%), dok razvijenije ekonomije imaju iznad prosečnu produktivnost u odnosu na EU, produktivnost MSPP

Austrije je 41% iznad proseka EU u 2022. Produktivnost velikih preduzeća značajno zaostaje u svim tranzicionim ekonomijama za prosekom produktivnosti velikih preduzeća u EU, najveći zaostatak je u Srbiji (33,8% proseka EU), Rumuniji (39,7%) i Bugarskoj (45,8%). Generalno, prisutna je blaga konvergencija produktivnosti ka proseku EU u periodu 2015-2022. u svim tranzicionim ekonomijama.

Tabela 5. Trend produktivnosti MSP i velikih preduzeća u izabranim državama EU 2015-2022. (hilj. EUR)

EU	AUS	BGR	HRV	HUN	CZE	ROU	SVK	SVN	SRB	
2015	2022	2015	2022	2015	2022	2015	2022	2015	2022	
MSP	43,446,5	57,465,6	8,917,1	16,123,4	15,922,7	20,229,2	11,520,2	17,921,1	28,244,4	8,917,8
Velika pred.	64,778,3	77,492,7	14,435,9	25,043,8	33,141,6	35,652,3	24,031,1	33,147,0	44,160,1	16,126,5

Izvor: Proračun autora na osnovu podataka Eurostata.

5. ZAKLJUČAK

Oporavak od nedavnih kriza sektora MSP je najviše bio podstaknut oporavkom mikro preduzeća, koja su iskazala snažan rast zaposlenosti [1]. Međutim, u većini tranzicionih ekonomija produktivnost MSP je konstantno niža od produktivnosti velikih preduzeća. Nakon globalne recesije 2020, porast prihoda zabeležila su MSP sa većim stepenom digitalizacije, kao i izvozna MSP. Inflacioni pritisci su bili najveća pretnja poslovanju MSP [6]. Usporeno je osnivanje novih firmi i start-up firmi (u EU pad za 60%), dok je povećan broj gašenja i stečaja. Rizike su povećali poremećaji u lancu snabdevanja, tržištu rada [3] i agregatnoj tražnji [4]. Od procesa digitalizacija i zelene tranzicije se očekuje velike promene u procesu rada, kao i preispitivanje industrijskih sistema i poslovnih modela [6]. MSP će morati da unaprede svoje tehničke i menadžerske veštine i znanja kako bi maksimalno iskoristili digitalizaciju i kako bi mogli da ulažu u dekarbonizaciju.

Najveći izazov za MSP predstavljaju pooštreni uslovi kreditiranja. Naime, procenjuje se da je 25% preduzeća u EU iscrpelo svoje rezerve likvidnosti u 2021, a oko 10% održivih firmi je prešlo u status nelikvidnosti [2]. Pooštavanje monetarne politike kroz rast kamatnih stopa, započeto u 2021. nije međutim, uzrokovalo strožije uslove kreditiranja za MSP u poređenju sa velikim kompanijama. Situacija se promenila u 2022. i 2023. kao refleksija energetske krize. Očekuje se da će obezbeđivanje finansijske ekspanzije biti posebno težak izazov za firme mlađe od 2 godine. Bankarski krediti su ostali najčešći izvor finansiranja. Veće kamatne stope utiču na uslove zaduživanja MSP. Pooštavanje monetarne politike u 2022. povećalo je cenu kredita, potražnja za kreditima je počela da raste kako bi se MSP izborila sa prekidima u lancima snabdevanja. U centralnoj Evropi se procenjuje da je oko 20-25% svih firmi finansijski ranjivo [5], dok se od njih 1/4 (5%) može klasifikovati kao prave zombi firme, što se negativno preliva na cele privrede.

Istraživanje je potvrdilo obe hipoteze u radu. Sektor MSP u tranzicionim državama je suočen sa brojnim problemima, posebno u segmentu jačanja konkurentnosti, produktivnosti i primene novih inovativnih [9] i tehnoloških rešenja. Višedimenzionalnost strukturnih problema i izazova sa kojima se suočavaju MSP se odnosi na neophodnost brzih strukturnih promena u industrijskim ekosistemima u pravcu jačanja njihove izvozne konkurentnosti [8], usklađivanje ponude i tražnje na tržištu rada kao preduslova regionalnog rasta, kao i na ceo spektar reformisanja sistema finansiranja MSP iz poslovnog sektora u skladu sa potrebama preduzetnika.

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SME DEVELOPMENT IN EU AND TRANSITION COUNTRIES

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ABSTRACT:

Small and medium-sized enterprises (SMEs) in the EU and transition countries faced in 2022 and 2023, not only the consequences of the global recession of 2020, but also new economic uncertainty and global turbulences (energy crisis, inflation, tightened monetary policy), which significantly worsened their business conditions. The fear of entrepreneurial failure has increased in all countries, the expectations of new entrepreneurs have fallen due to the consequences of global recessions. Key challenges and risks for SMEs relate to: the large productivity gap between SMEs and large enterprises, inflationary pressures, slow establishment of new firms and start-ups, disruptions in the supply chain and turbulence in the financial sector. The research in the paper is focused on the analysis of the structural performance of SMEs in transitional and EU countries, with a special emphasis on the development of SMEs in Serbia.

Keywords: *Small and Medium-sized Enterprises (SMEs) in Transition Countries, Development and Structural Performance of SMEs, Convergence of Productivity of SMEs, Challenges of SMEs.*

MARKETING MENADŽMENT KAO GENERATOR ODRŽIVOSTI ORGANIZACIJE U UVJETIMA KAOSA

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SAŽETAK:

Radom se analizira utjecaj kriznih razdoblja na tradicionalne poslovne modele, te kako se tržišni kaos manifestira na održivi razvoj poduzeća i sposobnost ostvarivanja stabilnih poslovnih prihoda. Analizira se neophodnost tržišne orijentacije i adaptivnih strategija u kontekstu suvremenog poslovanja poduzeća. Poseban naglasak rada stavljen je na ulogu marketinške funkcije, digitalnu transformaciju poslovnih procesa i ulogu javnih politika u kreiranju otpornijeg gospodarskog okruženja. Radom se produbljuju razumijevanja kompleksnosti suvremenog globalnog tržišnog okruženja i pružaju okviri za bolje razumijevanje izazova s kojima se poduzeća susreću, te ukazuje na potrebe iskorištavanja prilika koje proizlaze iz tih izazova, s ciljem poticanja njihovog prosperiteta i rasta. Težište je na strateškom razmišljanju, inovacijama i prilagodljivosti poduzeća, s osvrtnom na potrebu učinkovitog upravljanja marketinškim strategijama i korištenja tržišnih prilika u svrhu ostvarivanja održivog razvoja u kontinuirano nepredvidljivom globalnom gospodarstvu.

***Ključne riječi:** marketing strategija, transformacija poslovnih procesa, prilagodljivost*

1. UVOD

Poslovanje u uvjetima globalizacije i eskalacije globalnih situacija kaosa poduzeća izlože neprekidnim izazovima koji proizlaze iz dinamičkog i teško nepredvidivog tržišnog okruženja. Globalni trendovi, poput tehnološkog napretka, geopolitičkih promjena, ekonomskih fluktuacija i društvenih transformacija, prijetnja su stabilnosti i kontinuiteta poslovanja poduzeća. Pod ovakvim okolnostima, agilnost i sposobnost poduzeća da se efikasno prilagodi i odgovori na novonastale promjene, pomeće se u imperativ uspjeha i dugoročne održivosti poslovanja. Rad ima za cilj produbiti razumijevanje kompleksnosti koja karakterizira suvremeno globalno tržišno okruženje, te analizirati kako krizni periodi, poput financijskih turbulencija, prirodnih katastrofa, globalnih pandemija i ratnih sukoba izazivaju tradicionalne poslovne modele, te kako tržišni kaos može značajno utjecati na sposobnost poduzeća da održava stabilne poslovne prihode i osigura održivi poslovni rast. Analizira se kako u vremenima kada se tržišne prilike i prijetnje mijenjaju izuzetno brzo poduzeća moraju ne samo preživjeti trenutne krize, već se i strateški pozicionirati i postaviti temelje za budući rast i razvoj. Također, analizira se neophodnost tržišne

orijentacije i adaptivnih strategija u kontekstu modernog suvremenog poslovanja, gdje se naglasak stavlja na ulogu marketinške funkcije, digitalnu transformaciju poslovnih procesa i ulogu javnih politika u kreiranju otpornijeg gospodarskog okruženja. Detaljno se predstavlja kako poduzeća mogu iskoristiti tržišne informacije i uvide u tržišne pokazatelje za oblikovanje fleksibilnih strategija koje omogućuju brzu prilagodbu promjenjivim tržišnim uvjetima. Prezentira se kako digitalna transformacija i napredne tehnologije mogu djelovati kao katalizatori inovacija, poboljšavajući operativnu učinkovitost poduzeća, stvarajući nove prilike za rast. Osim toga, naglasak je kako javne politike i regulatorni okviri mogu pridonijeti stabilnosti samog tržišta, poticati konkurentnost i promovirati održivi ekonomski razvoj [1]. Promatrajući u ovom kontekstu, razmatra se kako pravilno formulisane i implementirane javne politike mogu pružiti okvire unutar kojih poduzeća ne samo da se suočavaju s izazovima današnjice, već i iskorištavaju prilike koje proizlaze iz tih izazova, a sve u cilju poticanja prosperiteta i njihovog rasta. Obuhvaćajući sve navedene aspekte proizašle iz situacija globalnog kaosa, detaljnije se obrađuju navedene teme stavljajući težište na strateško razmišljanje, inovacije i prilagodljivost. Cilj je rada pružiti okvir za analitičko promišljanje navedenih izazova te osigurati strateško razumijevanje o tome kako poduzeća mogu učinkovito upravljati marketinškim strategijama, te iskoristiti tržišne prilike i postići održiv uspjeh u kontinuirano nepredvidljivom globalnom gospodarstvu.

2. TRŽIŠNA ORIJENTACIJA PODUZEĆA KAO IMPERATIV ODRŽIVOSTI

U suvremenom poslovnom svijetu, tržišna orijentacija postaje ne samo poželjna, već i neophodna strategija za preživljavanje i prosperitet poduzeća. Tržišna orijentacija podrazumijeva kontinuirano i sustavno praćenje potreba, želja i očekivanja ciljnih kupaca, kao i brzo i efikasno prilagođavanje proizvoda, usluga i poslovnih procesa zahtjevima globalnog tržišta [2]. U ovom kontekstu, tržišna orijentacija postaje imperativ dugoročne održivosti, osobito u vremenima tržišnog kaosa i nepredvidivih promjena.

2.1. Utjecaj tržišne orijentacije na sposobnost poduzeća da podnesu tržišni kaos

Tržišna orijentacija omogućava poduzećima da postanu agilnija, prilagodljivija i otvorenija prema inovacijama, a upravo to je ključno za dugoročnu održivost u globalno nestabilnim tržišnim uvjetima. Prema istraživanju iz 2020. godine, tržišna orijentacija poduzeća pozitivno utječe na poslovne performanse jer potiče razumijevanje i ispunjavanje kupčevih potreba, što posljedično rezultira većom lojalnosti kupaca, te u konačnici boljom financijskom uspješnošću poduzeća [3].

Poduzeća koja implementiraju tržišnu orijentaciju sposobna su brže detektirati promjene u potrebama, željama i preferencijama kupaca kao i predvidjeti buduće trendove i promjene u pojedinim industrijama. Upravo ovo im omogućuje brzu prilagodbu svojih strategija, proizvoda i usluga, čime se efikasno odgovara na izazove tržišnog kaosa.

Brojni su primjeri poduzeća koja su uspješno prevladala krize zahvaljujući prilagodbi tržišnim uvjetima. Apple Inc. je primjer poduzeća koje stalno inovira i prilagođava svoje proizvode potrebama i željama potrošača. Lansiranjem iPhonea, Apple nije samo ušao na tržište mobilnih telefona, već je stvorio potpuno novu kategoriju pametnih telefona, čime je prouzročio revoluciju cijele industrije i postavio nove standarde. Tržišna orijentacija

Apple omogućila mu je da ostane relevantan i dominantan unatoč brzim i nepredvidljivim promjenama u tehnološkom sektoru [4]. Netflix je primjer poduzeća koje se uspješno prilagodilo promjenjivim tržišnim uvjetima prelaskom s distribucije DVD-ova poštom na streaming usluge. Ova promjena omogućila je Netflixu da se istakne kao lider u industriji online zabave, pružajući sadržaj koji odgovara individualnim preferencijama korisnika, što je posljedično rezultiralo rastom pretplatnika i globalnom ekspanzijom [4]. Amazon se kontinuirano prilagođava i inovira u svojim poslovnim procesima, što je vidljivo kroz diversifikaciju i evoluciju od online knjižare do vodeće globalne e-trgovine i pružatelja cloud usluga. Tržišna orijentacija Amazona usmjerena je na stvaranje iznimnog korisničkog iskustva, brzu dostavu i širok asortiman proizvoda po konkurentnim cijenama, a što ga čini jednim od najvrjednijih poduzeća na svijetu [4]. Na temelju ovih primjera vidljivo je kako tržišna orijentacija nije samo strategija, već ključna komponenta korporativne kulture koja omogućava poduzećima da postignu dugoročni uspjeh i stvaraju dodanu vrijednost i u dinamičnom i nepredvidivom tržišnom okruženju. Integracija tržišne orijentacije u svim aspektima poslovanja od razvoja proizvoda do korisničke službe postaje temelj izgradnje otpornosti i održivosti poduzećima u vremenima krize i nesigurnosti. Marketing je ključan element poslovanja i šire, zahvaljujući suvremenom načinu života, te je stoga važno razumjeti sve njegove aspekte [5]. Kako bi se uspješno suprotstavile tržišnom kaosu, poduzeća moraju ne samo prihvatiti tržišnu orijentaciju kao središnju poslovnu filozofiju, već i kontinuirano ulagati u razumijevanje i predviđanje tržišnih trendova, potreba i želja svojih kupaca te stvoriti fleksibilne i agilne poslovne modele koji mogu brzo reagirati na novonastale promjene. Samo tako poduzeća mogu osigurati svoje mjesto na tržištu, unaprijediti svoju konkurentnost i osigurati dugoročni rast i razvoj [6].

3. ULOGA MARKETINGA U OČUVANJU POSLOVNE STABILNOSTI

U suvremenom poslovnom svijetu uloga marketinga se ne može previdjeti, osobito kada se radi o održavanju poslovne stabilnosti tijekom kriznih perioda. Marketing ne samo da služi za promociju proizvoda ili usluga, već igra ključnu ulogu u izgradnji i održavanju odnosa s klijentima, razumijevanju tržišnih trendova i prilagođavanju poslovnih strategija promjenjivim tržišnim uvjetima.

3.1. Učinak marketinških strategija na održivost prihoda

Studije pokazuju da su poduzeća koja primjenjuju proaktivne marketinške strategije u mogućnosti bolje predvidjeti tržišne promjene i prilagoditi se njima, što rezultira stabilnijim prihodima. Istraživanje provedeno 2020. godine pokazuje da poduzeća sa snažnim brendovima i lojalnim klijentima ostvaruju manje fluktuacije u prihodima tijekom perioda recesija [3], što se može objasniti činjenicom da lojalni kupci ostaju vjerni brandu čak i u teškim vremenima, dok promišljeno uspostavljene marketinške strategije omogućuju poduzećima da efikasno komuniciraju vrijednost svojih proizvoda ili usluga. Jedan od najizraženijih primjera poduzeća koje je uspjelo očuvati svoju bazu klijenata tijekom krize je Apple. Appleova strategija fokusiranosti na inovacije i kvalitetu uz snažan

naglasak na osnaživanje brenda i korisničko iskustvo omogućila mu je da zadrži lojalnost svojih kupaca čak i tijekom značajnih ekonomskih padova. Također, Amazon je primijenio strategiju prilagođavanja svog poslovnog modela i ponude prema promjenjivim potrebama kupaca, što mu je omogućilo ne samo očuvanje postojeće baze klijenata već i privlačenje novih kupaca [7]. Očuvanje baze klijenata zahtijeva razumijevanje potreba i preferencija kupaca, a to uključuje kontinuirano praćenje tržišnih trendova i prilagođavanje ponude sukladno tim trendovima. Tijekom pandemije COVID-19, mnogobrojna poduzeća su brzo prilagodila svoje marketinške apele i ponudu, usmjeravajući se na online kanale prodaje i dostavu na kućni prag [8]. Također, naglasak na personaliziranom marketingu i izgradnji odnosa s klijentima putem društvenih mreža i drugih online kanala pokazao se kao uspješna strategija u privlačenju i zadržavanju kupaca.

Uloga marketinga u održavanju poslovne stabilnosti tijekom kriznih perioda je višestruka i slojevita. Marketinške strategije koje se fokusiraju na izgradnju snažnog branda, razumijevanje i zadovoljavanje potreba kupaca te fleksibilnost i prilagodljivost tržišnim promjenama, ključne su za očuvanje prihoda i kontinuitet poslovanja. Poduzeća koja mogu efektivno implementirati takve strategije u operativno poslovanje postavljaju temelje za dugoročnu održivost i poslovni uspjeh. U današnjem promjenjivom i neizvjesnom poslovnom okruženju marketinške strategije snažno pridonose održivosti prihoda poduzeća. One služe kao čimbenik povezivanja između proizvoda ili usluga i krajnjih korisnika, a njihova efikasnost direktno utječe na tržišnu poziciju i financijsku stabilnost poduzeća. Pravilno strukturirane i implementirane marketinške strategije mogu znatno povećati vidljivost proizvoda, privući nove kupce i zadržati postojeće. Uporaba prilagođenog sadržaja u digitalnom marketingu može stvoriti snažnu veza s ciljanom publikom, te tako povećavajući angažman i lojalnost. Analiza podataka o potrošačima i prilagodba kampanja u skladu s tim informacijama može dovesti do veće konverzije, te u konačnici do rasta prihoda. Tržišta su kontinuirano u promjeni, a istovremeno potrošači postaju sve zahtjevniji pa je stoga ključno kontinuirano analizirati učinkovitost marketinških kampanja i prilagođavati strategije kako bi se osigurala njihova relevantnost i efikasnost. Sposobnost brze prilagodbe na tržišne promjene i inovacije u pristupu kupcima može znatno utjecati na dugoročnu održivost prihoda. Učinak marketinških strategija na održivost prihoda ne smije se zanemariti jer su ključne za izgradnju i održavanje snažne veze s kupcima, razumijevanje i predviđanje tržišnih trendova te osiguravanje kontinuiranog priljeva prihoda. U svijetu gdje se konkurencija i potrošački zahtjevi neprestano razvijaju, agilne i ciljano usmjerene marketinške strategije postaju ne samo alat za uspjeh, već i osnovna komponenta održivosti prihoda i dugoročnog uspjeha poduzeća.

4. DIGITALIZACIJA POSLOVNIH PROCESA KAO ODGOVOR NA KRIZU

Digitalizacija poslovnih procesa igra ključnu ulogu u prilagodbi poduzeća promjenjivim tržišnim uvjetima, posebno u kontekstu krize kao što je pandemija COVID-19. Proces digitalizacije omogućava poduzećima da poboljšaju svoju efikasnost, smanje troškove, povećaju doseg na tržištu i unaprijede korisničko iskustvo. Digitalizacija postaje ključni faktor u prilagodbi poslovnih operacija, što je vidljivo kroz komparaciju uspješnosti

poduzeća koja su implementirala digitalizaciju s onima koja nisu prepoznale ovu priliku. Digitalizacija poslovnih procesa uključuje korištenje digitalnih tehnologija za preoblikovanje poslovnih modela i stvaranje novih načina vrednovanja za korisnike. To ne uključuje samo implementaciju novih tehnologija, već i promjenu načina na koji poduzeća posluju i isporučuju dodanu vrijednost svojim kupcima. Digitalizacija može pomoći poduzećima da postanu agilnija, a to je posebno važno u vremenima krize kada se tržišni uvjeti brzo mijenjaju.

Za vrijeme kriza poput pandemije COVID-19 poduzeća su se suočila s brojnim izazovima, uključujući prekide u lancima opskrbe, pad potražnje i potrebu za prilagodbom novim zdravstvenim i sigurnosnim mjerama [9]. Poduzeća koja su već imala digitalizirane procese bila su u boljoj poziciji da brzo reagiraju na ove izazove [7]. Primjerice, poduzeća s naprednim e-commerce platformama mogla su nastaviti s prodajom proizvoda unatoč ograničenjima u fizičkim trgovinama. S druge strane, poduzeća koja nisu imala digitalizirane procese suočila su se s većim poteškoćama u prilagodbi novim uvjetima i održavanju poslovanja. Digitalizacija također omogućava poduzećima da prikupe i analiziraju velike količine podataka o svojim kupcima i tržišnim trendovima [10]. Upravo ove informacije mogu biti izuzetno vrijedne u kriznim vremenima kada se poduzeća moraju brzo prilagoditi promjenama na tržištu. Analiza podataka može pomoći poduzećima da razumiju promjene u ponašanju kupaca i prilagode svoje proizvode, usluge i marketinške strategije kako bi zadovoljile nove potrebe kupaca. Promatrajući iz drugog aspekta, poduzeća koje nisu implementirala digitalizaciju često su se suočavala s izazovima u prilagodbi svojih poslovnih modela novim uvjetima [11]. Nedostatak digitalne infrastrukture ograničio je njihovu sposobnost da učinkovito komuniciraju s kupcima, upravljaju lancem opskrbe i prilagode se novim marketinškim i prodajnim kanalima, što je za posljedicu imalo da su ova poduzeća češće doživjela veći pad prodaje i profitabilnosti u odnosu na ona koja su uspješno implementirala digitalizaciju u svoje poslovanje.

Primjeri poduzeća koja su uspješno implementirala digitalizaciju tijekom krize pokazuju njihovu značajnu prednost u odnosu na konkurenciju. Maloprodajna poduzeća s razvijenom online trgovinom mogla su nastaviti s prodajom i privlačenjem kupaca unatoč zatvaranju klasičnih maloprodajnih objekata. Proizvođači koji su bili sposobni digitalizirati svoj lanac opskrbe bili su u boljoj poziciji za upravljanje neizvjesnošću i održavanje stabilnog protoka vlastitih proizvoda do krajnjih potrošača. Poslovni uspjeh ovih poduzeća dokazuje da digitalizacija nije samo korisna u vremenima krize, već je i neophodna komponenta modernog poslovanja. Investiranje u digitalna rješenja i tehnologije omogućava poduzećima da budu pripremljena za buduće izazove i da se prilagode dinamičnim tržišnim uvjetima i osiguraju dugoročno održiv rast i razvoj.

Digitalizacija poslovnih procesa igra ključnu ulogu u prilagodbi poduzeća promjenjivim tržišnim uvjetima i predstavlja ključan čimbenik za njihovu sposobnost da se održe u vremenima krize. Poduzeća koja prepoznaju ovu priliku i aktivno ulažu u digitalizaciju osigurat će značajnu prednost u odnosu na

konkurenciju i bit će bolje pripremljena za suočavanje s budućim izazovima i neizvjesnostima.

5. ULOGA JAVNIH POLITIKA U JAČANJU OTPORNOSTI PODUZEĆA

U uvjetima tržišnog kaosa, otpornost poduzeća kao integralnih dionika gospodarstva postaje ključna tema za razmatranje kako od strane vlada tako i od strane poslovne zajednice. U takvim okolnostima uloga javnih politika u poticanju i očuvanju stabilnosti gospodarstva postaje sve važnija [12]. Brojni su načini na koje javne politike i zakonski okviri mogu doprinijeti očuvanju i preživljavanju poduzeća tijekom perioda tržišnog kaosa, gdje se uspješnim političkim inicijativama poduzećima omogućava prevladati krizne periode. Javne politike igraju ključnu ulogu u oblikovanju ekonomskog okruženja u kojem poduzeća posluju [13]. U uvjetima tržišnog kaosa poput finansijskih kriza, prirodnih katastrofa, ratova ili globalnih pandemija, vlade se često suočavaju s izazovom kako brzo reagirati s ciljem minimiziranja negativnih posljedice na gospodarstvo. Efikasne javne politike koje su usmjerene na stabilizaciju tržišta, očuvanje radnih mjesta i podršku poduzećima u teškoćama, mogu značajno doprinijeti otpornosti gospodarstva. U tom kontekstu stabilni i predvidivi zakonski okviri temelj su rasta i razvoja svakog gospodarstva [14]. U vremenima kriza, pravovremeno usvajanje i prilagodba zakonskih regulativa može pomoći u ublažavanju negativnih učinaka tržišnog kaosa. To uključuje mjere kao što su: porezne olakšice poduzećima, potpore za očuvanje radnih mjesta, te fleksibilizaciju tržišta rada. Transparentnost i konzistentnost u implementaciji tih mjera ključne su za očuvanje povjerenja poslovne zajednice u javne institucije i državu. Svjedočili smo brojnim primjerima u kojima su efikasne javne politike pomogle poduzećima da prevladaju krizne periode. Upravo jedan takav primjer je reakcija vlada na globalnu finansijsku krizu 2008. godine. Putem programa kvantitativnog popuštanja, snižavanja kamatnih stopa te finansijskih injekcija u bankarski sektor, vlade su uspjele stabilizirati tržišta i očuvati ključne sektore gospodarstva. Slično tome tijekom pandemije COVID-19 velik broj vlada brzo je reagirao usvajajući pakete mjera za pomoć gospodarstvu, uključujući direktnu finansijsku pomoć građanima, potpore za očuvanje radnih mjesta, te potpore malim i srednjim poduzećima [15].

Javne politike i zakonska regulativa igraju ključnu ulogu u poticanju i očuvanju otpornosti gospodarstva tijekom tržišnog kaosa [8]. Uspješne političke inicijative koje su brzo i efikasno implementirane mogu znatno doprinijeti stabilizaciji tržišta, očuvanju radnih mjesta i podršci poduzećima. Primjeri iz prošlosti nam pokazuju da je proaktivna uloga vlade u oblikovanju javnih politika i zakonskih okvira ključna za preživljavanje poduzeća i oporavak gospodarstva u kriznim vremenima. Stoga je od vitalnog značaja nastaviti s razvojem i prilagodbom javnih politika kako bi se osigurala otpornost gospodarstva na potencijalne buduće izazove.

6. ZAKLJUČAK

U suvremenom poslovnom svijetu tržišni kaos postao je gotovo neizbježna realnost. Promjene se događaju velikom brzinom, a poduzeća koja ne uspijevaju prilagoditi svoje strategije i poslovne procese riskiraju svoj opstanak na tržištu. Promatrajući promjene u tom kontekstu, ključna je sposobnost poduzeća da se prilagode i usvoje tržišno orijentirane marketinške strategije koje će im omogućiti ne samo da prežive, nego da se i razvijaju u turbulentnom okruženju.

Intenziviranje marketinških aktivnosti jedna je od temeljnih sastavnica strategija poduzeća, kojima se mogu diferencirati na tržištu. U vremenu digitalne transformacije ulaganje u digitalni marketing i online prisutnost više nije mogućnost, već poslovna nužnost. Prisutnost na društvenim mrežama, optimizacija za tražilice, email marketing i druge digitalne strategije postaju ključne za privlačenje i zadržavanje kupaca. Osim toga, analize velikih podataka i korištenje naprednih analitičkih alata omogućavaju poduzećima bolje razumijevanje potreba i ponašanja svojih kupaca, što dovodi do stvaranja personaliziranih ponuda i poboljšanja korisničkog iskustva.

Tehnološke inovacije i marketinške strategije ne mogu samostalno osigurati poslovni uspjeh. Ključnu ulogu u tome zauzimaju i proaktivne javne politike, koje stvaraju poticajno okruženje za rast i razvoj poduzetništva. Podrška u obliku poreznih olakšica, potpora, ulaganja u infrastrukturu i obrazovanje kao i razvoj pravnog okvira, koji štiti intelektualno vlasništvo i potiče konkurenciju, neophodna je za izgradnju otpornijeg i dinamičnijeg gospodarstva.

Uloga vlade posebno dolazi do izražaja u kriznim vremenima, kada je potrebno brzo djelovati kako bi se ublažile negativne posljedice krize na gospodarstvo. Mehanizmi kao što su financijski transferi, olakšice za male i srednje poduzetnike te potpore za očuvanje radnih mjesta ključni su za održavanje stabilnosti tržišta i sprječavanje dugoročnih ekonomskih šteta.

Promatrajući s drugog aspekta, poduzeća moraju prepoznati važnost svoje uloge u društvu. Društveno odgovorno poslovanje, održivi razvoj i etički kodeksi postaju ne samo moralna, već i poslovna obveza. Ulaganje u zajednicu, zaštita okoliša i zelene politike, etičko upravljanje lancima opskrbe i transparentnost poslovanja doprinose izgradnji povjerenja i lojalnosti kupaca kao i pozitivnog imidža poduzeća.

Multidisciplinarni pristup, koji kombinira inovativne marketinške strategije, podršku javnih politika i društvenu odgovornost, predstavlja temelj za uspješno suočavanje s tržišnim kaosom. Putem takvog pristupa poduzeća ne samo da se mogu prilagoditi novonastalim promjenama, već mogu i aktivno sudjelovati u oblikovanju pozitivnih trendova u industriji i društvu u cjelini. S obzirom na sve izazove i prilike koje tržišni kaos donosi, očito je da su fleksibilnost, inovativnost i strateško planiranje ključni za dugoročnu održivost poduzeća. S pomoću suradnje privatnog i javnog sektora, te putem kontinuiranog usavršavanja i prilagodbe poslovanja, moguće je ne samo preživjeti, već i razvijati se u dinamičnom i nepredvidivom poslovnom okruženju. Održavanje stabilnosti i kontinuiteta poslovanja u takvim okolnostima zahtijeva konstantan fokus na poslovne procese, brzu prilagodbu i spremnost na promjene, a to će u konačnici rezultirati izgradnjom otpornijeg i uspješnijeg poduzeća, a time i gospodarstva u cjelini.

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MARKETING MANAGEMENT AS A GENERATOR OF ORGANIZATION'S SUSTAINABILITY IN CONDITIONS OF CHAOS

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ABSTRACT:

The paper analyzes the impact of crisis periods on traditional business models and how market chaos manifests itself on the sustainable development of companies and the ability to achieve stable business income. The necessity of market orientation and adaptive strategies in the context of modern business operations is analyzed. Special emphasis of the paper is placed on the role of the marketing function, digital transformation of business processes and the role of public policies in creating a more resilient economic environment. The work deepens the understanding of the complexity of the contemporary global market environment and provides frameworks for a better understanding of the challenges faced by companies, and indicates the need to take advantage of the opportunities arising from these challenges, with the aim of stimulating their prosperity and growth. The focus is on strategic thinking, innovation and adaptability of companies, with reference to the need for effective management of marketing strategies and the use of market opportunities in order to achieve sustainable development in a continuously unpredictable global economy.

Keywords: *marketing strategy, transformation of business processes, adaptability*

INNOVATION IN SMES IN BOSNIA AND HERZEGOVINA: THE ROLE OF GREEN ENTREPRENEURIAL ORIENTATION

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ABSTRACT:

This study investigates the relationship between green entrepreneurial orientation (GEO) and different types of innovation within small and medium-sized enterprises (SMEs) in Bosnia and Herzegovina. A cross-sectional survey method was used to collect data from 257 SMEs. Structural equation modeling was used to test the hypothesis. The results show that GEO plays an important part in different types of innovation. The findings of this research contribute to the existing literature on sustainable business and innovation within the unique context of Bosnia and Herzegovina by not only contributing to the academic discourse on green entrepreneurship but also providing practical insights for SMEs seeking to improve their competitive advantage by integrating green practices and innovations in Bosnia and Herzegovina.

Keywords: *innovation, green entrepreneurial orientation, small and medium enterprises, Bosnia and Herzegovina*

1. INTRODUCTION

In the early 1990s, orientation toward innovation was recognized as one of the priorities companies should include in their corporate strategic planning to be able to cope with a dynamic environment (Saleh & Wang, 1993). Ever since then, innovation has remained one of the strategic tools for gaining and maintaining a competitive advantage for many contemporary businesses (Samsir, 2018). Albeit being examined in various contexts and bodies of literature, from management literature (i.e., on balancing exploitation and exploration or design thinking), over organizational literature (i.e., on learning organization concepts), to strategy literature (i.e., on deliberate and emergent strategy) – the focus of innovation is the same: systematical change and adjusting to change (Ferguson, 2019). Innovation is important not only for firms' and economies' growth and competitiveness but also for national economies (Cantwell, 1999). In fact, the study by Lopes et al. (2021) has shown that the competitive positioning of a certain economy can be explained by a specific innovation strategy.

One of the growing fragments in innovation research is innovation in the small and medium-sized enterprises (SMEs) sector. Innovation is often recognized as an opportunity for SMEs to better position themselves in the market, but it is also critical for their survival in a highly competitive environment. The growing popularity of innovation in the SME sector may be attributable to the adjustable and flexible nature of SMEs. Innovation

outcomes in SMEs are different, mostly dependable on the type of innovation introduced by a firm (Expósito et al., 2019). This is why plentiful innovation types aggravate innovation research and force innovation researchers to specialize and focus on a certain innovation field, which eventually causes innovation to be a highly fragmented research area. That particular fragmentation leads to a disproportion in the existence of research works tackling certain innovation types compared to research works tackling another. For instance, marketing and organizational innovation are being investigated significantly less compared to operational innovation (product and process) (OECD Oslo Manual, 2005; Damanpour et al., 2009). Therefore, the first objective of this study is to check whether an extended approach to classifying innovation works within small and medium enterprises.

In response to increasing concerns surrounding environmental challenges, both governments and businesses are directing their efforts toward fostering more sustainable practices and incorporating them into their core operations (Das and Rangarajan, 2020; Liu et al., 2016). Several studies are pointing out that green entrepreneurial orientation (GEO) can be pivotal in driving the environmental, economic, and social performance of organizations (Asadi et al., 2020; Jiang et al., 2018; Schaefer et al., 2015). That is why recent studies focus on the relationship between GEO and innovation, but primarily the green one (Guo et al., 2020; Muangmee et al., 2021). Considering that in developing countries, the term green innovation has recently been placed on the agenda, the understanding of the concept is still in the early phase. That is why the role of GEO might be more relevant to types of innovation that companies fully understand. Therefore, the second objective of this study is to extend the understanding of GEO's role by investigating its relationship to more traditional types of innovation.

2. THEORETICAL FRAMEWORK

According to West and Farr (as cited in Anderson and Gasteiger, 2008), innovation represents "the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, the organization or wider society" (p. 250). Due to the wide variety of innovation manifests and the nonexistence of unanimity among innovation researchers on innovation antecedents and outcomes, there are many innovation antecedents and outcomes (Saleh & Wang, 1993; Jansen et al., 2006; Aboramadan et al., 2019; Khosravi et al., 2019; Laforet, 2011; Aksoy, 2017; Walker et al., 2010; Laforet, 2013). That again leads to focusing on the most popular innovation antecedents and outcomes, e.g., organizational culture as an antecedent and performance results as an outcome. Consequently, other, less popular innovation antecedents and outcomes remain uninvestigated and might hold a hidden potential for companies to innovate more and more efficiently.

Some authors have found that green innovation is particularly important in micro and SME environments since, besides reducing environmental impact, it can lead to cost savings and increased customer loyalty (Zonna et al., 2023). The term that is often referred to in connection with green innovation is GEO. According to Lumpkin and Dess (1996), entrepreneurial orientation is "a firm's strategic orientation that reflects the entrepreneurial aspects of the styles, methods, and practices of decision-making" (as cited in Silva et al.,

2021, p. 3). In line with this, GEO can be considered as "the strategic approach adopted by businesses towards environmental sustainability and innovation" (p. 5489) whose two main pillars are the integration of environmentally-friendly practices and the development of eco-friendly products and services (Zonna et al., 2023).

In the modern business environment, companies are under enormous pressure to adhere to environmental regulations (Asadi et al., 2020). That is why companies are introducing green strategies that can holistically help organizations respond to market demands (Weng et al., 2015). Derived from theories such as green entrepreneurship and entrepreneurship orientation, GEO supports organizational development through the principle of a triple bottom line (Guo et al., 2020). GEO can be observed through different types of orientations, such as environmental and social (Guo et al., 2020; Cohen & Winn, 2007) or innovative (Becker, 2010). Strategically speaking, GEO contributes to a more green approach to innovation by facilitating the development of green products and services through which it promotes a sustainable organizational system. As greener innovation is a more direct outcome of GEO (Muangmee et al., 2021), there is a notable gap when it comes to concrete innovation typologies. In particular, green innovation tends to reduce the negative impacts on the environment through improving products, processes, organization, or marketing. Therefore, the following hypothesis is proposed:

H1. There is a positive relationship between GEO and different innovation types within the context of SMEs.

3. METHODS

3.1 Participants and procedure

The participants in this study were SMEs following the employee number as a key indicator (10-249). As there is no official database of SMEs in B&H, the convenience sampling method was applied. In particular, the research group used their networks to create a pool of possible participants. Although this type of sampling can raise concerns about sampling bias, to prevent it, the aim of researchers was to reach a large and divergent sample (Vandekerckhof et al., 2019).

The data was collected through a cross-sectional survey design using a questionnaire as the primary instrument. The participants were contacted using various ways, such as face-to-face, social networks, and emails. Together with a questionnaire, the researchers developed a cover letter. The purpose of the study was explained together with instructions on how to fill out a survey and the opportunity to give up at any moment. All responses were anonymous, and there was no trace of any respondents. To participate in the study, individuals had to provide their consent, answer each question, and submit the response.

The data was collected between the last quarter of 2023 and the first quarter of 2024. After closing the data collection, 409 responses were collected. As previously mentioned, there was no official database, so some of the responses were not useful as companies belonged to micro (less than ten employees) or large companies (250 or more employees). After removing them and several others due to missing data, the final sample was 257 SMEs. Regarding the profile of respondents, there were 140 small and 117 medium enterprises.

Furthermore, 46% of them were family businesses, and the average year of existence was 23. Managers were mostly men (77%), while more than half of them were initial founders (52%) with 13 years of experience on average at the position.

3.2 Measurement

Regarding the main constructs of interest, operational innovation was measured by the scale developed by Ar and Baki (2011), organizational innovation by the scale developed by Venkatesh and Bala (2012), and marketing innovation by the scale developed by Naidoo (2010). For EO, the scale of Muangmee et al. (2021) was used. All responses were recorded on a five-point Likert scale (strongly disagree – strongly agree).

4. ANALYSIS AND RESULTS

The analysis part was divided into two stages: pretesting and hypothesis testing. The pretesting stage included reliability, validity, and common method bias checks. Table 1 presents the results.

Table 1. Pre-testing indicators

Variable	M	SD	α	CR	AVE	OPER	ORG	MARK	GEO
OPER	3.801	0.860	0.898	0.899	0.599	(0.774)			
ORG	3.890	0.894	0.851	0.852	0.658	0.661	(0.811)		
MARK	3.930	0.845	0.839	0.851	0.589	0.622	0.764	(0.768)	
GEO	3.323	1.079	0.919	0.896	0.691	0.436	0.383	0.403	(0.831)

Notes. N = 437. M – Mean; SD – Standard Deviation; α – Cronbach’s Alpha; CR – Composite Reliability; AVE – Average Variance Extracted; Square roots of AVE values are in parentheses. All correlation are statistically significant at $p < 0.001$.

The results show that there are no concerns over reliability as both Cronbach’s alpha value and Composite reliability are over 0.7 (Fornell & Larcker, 1981; Taber, 2018). Regarding convergent validity, all AVE values are over 0.50 (Bagozzi & Yi, 1991), while for discriminant, all square roots of AVE values are larger than the mutual correlations between variables (Fornell & Larcker, 1981). In both cases, there are no concerns over validity. Finally, regarding the common method bias, we followed Podsakoff et al.’s (2003) suggestion and performed three tests: Harman’s single factor, common latent factor, and common marker variable. In all cases, the variance was below the common threshold of 0.5.

For hypothesis testing, structural equation modeling was used. Table 2 presents the results.

Table 2. Hypothesis testing

Individual pathways	Std. est.	SE	t	p
GEO → OPE	0.518	0.092	5.641	0.000

GEO → ORG	0.559	0.106	5.265	0.000
GEO → MARK	0.556	0.103	5.403	0.000

Notes. OPE - $R^2 = 0.219$, ORG - $R^2 = 0.180$, MARK - $R^2 = 0.195$.

All relationships tested are positive and statistically significant at $p < 0.001$. Therefore, the results show sufficient evidence to support H1.

5. DISCUSSION AND CONCLUSIONS

The purpose of this study was to check for the application of different innovation types within SMEs while considering the role of GEO. The results showed that there is a significant difference among the three types of innovation (operational, organizational, and marketing), which is an extension of dominantly attractive and popular operational innovation in literature (Damanpour et al., 2009). The results suggest the need for a deeper understanding of innovations, especially in the context of SMEs that, due to their flexibility, are more responsive to market changes. Regarding the results from structural equation modeling, the results were significant for the positive relationship between GEO and adjusted innovation types. This means that GEO not only contributes to “greener processes” (Muangmee et al., 2021) but also concretely increases innovation in different parts of the organization. The study extends the literature that was dominantly focused on the relationship between GEO and green innovation (Shan et al., 2016; Miao et al., 2017). In particular, it can be concluded that GEO has a holistic role in innovation within SMEs.

5.1 Managerial implications

The study provides two main managerial implications. First, it addresses innovation through an extensive model that includes three main components: operational, organizational, and marketing. Considering the significant differences among them, managers have to be careful when analyzing the innovative output of the organization as well as the investments in creating organizational areas. Second, the role of GEO is holistic, which means that GEO plays a multidimensional role in SMEs. Therefore, managers should consider developing GEO within SMEs. Taking GEO into account can be considered as a strategic orientation aimed at integrating environmental sustainability within the organizational process, leadership commitment is essential in fostering a culture of sustainability throughout the whole organization.

5.2 Limitations and future studies

Although the results of the study provide insightful information in theory and practice, there were some limitations that might be considered by future researchers. First, the study takes a very simplistic model of direct relationships between GEO and innovation types. Future studies might consider including moderators (i.e., environment, industry, resources) or mediators (i.e., creativity). Second, the study applied a cross-sectional survey design, preventing the causal conclusions. Therefore, a smaller sample that would allow for measurements at different time periods might be considered in the future. Third, the study included only small and medium enterprises, which makes a limited snapshot of the business environment within the country. In the future, the researchers could consider including micro and large companies and make a comparative study.

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UTICAJ DIMENZIJA NACIONALNE KULTURE NA KUPOVNO PONAŠANJE POTROŠAČA: TESTIRANJE MODERACIJSKIH EFEKATA STILA ŽIVOTA

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SAŽETAK:

Cilj rada je da se testiraju efekti dimenzija srpske nacionalne kulture na ponašanje potrošača u procesu donošenja kupovnih odluka, uz ispitivanje prisustva moderatorskih efekata stila života kada se posmatra relacija između dimenzija kulture i ponašanja potrošača u kupovini. Relacije između dimenzija kulture i ponašanja potrošača u procesu donošenja kupovnih odluka testirane su primenom modela strukturalnih jednačina. Rezultati studije pokazuju da je izbegavanje neizvesnosti najznačajniji prediktor kupovnog ponašanja potrošača a najslabiji distanca moći, dok dimenzija kolektivizam nije ispoljila statistički signifikantne efekte na posmatranu zavisnu varijablu. Dalje, moderacija pokazuje da se sa promenom stila života potrošača menjaju efekti kolektivizma, izbegavanja neizvesnosti i distance moći na kupovno ponašanje potrošača, dok za dimenziju ženske vrednosti nije potvrđen moderacijski efekat. Naučni doprinos studije bazira se na originalnosti istraživačkog modela iste, a mogu se izdvojiti i značajne praktične implikacije rada odnosno njegovih rezultata za formulisanje optimalnih poslovnih strategija, kako generalno za ciljne grupe potrošača, tako i u zavisnosti od psihografskih karakteristika istih.

Ključne riječi: *dimenzije nacionalne kulture, stil života, ponašanje potrošača, proces odlučivanja potrošača o kupovini*

1. UVOD

Kultura se smatra bazičnom determinantom želja i ponašanja pojedinaca kao potrošača. Najšire prihvaćenu definiciju kulture dao je autor Gert Hofstede (Hofstede, 1984, p. 21) prema kojoj se kultura odnosi na kolektivno programiranje uma koje razlikuje članove jedne grupe ljudi od drugih. U kontekstu ponašanja potrošača, Maričić (2011, p. 208) definiše kulturu kao spisak prihvatljivih vrednosti, verovanja, običaja, rituala i mitova koji su svojstveni članovima određenog društva. U zavisnosti od kulturalnog okruženja u kome žive, potrošači će formirati potrebe u skladu sa pravacima koje kultura definiše kao prihvatljive za zadovoljenje istih. Shodno navedenom, potrošači će ispoljavati drugačije ponašanje dok prolaze kroz proces odlučivanja o kupovini kao niz aktivnosti koje

podrazumevaju pažljivu procenu atributa proizvoda ili usluge i racionalan izbor one alternative koja će zadovoljiti identifikovanu potrebu uz najniže troškove (Mothersbaugh & Hawkins, 2016). S tim u vezi, autori Blackwell et al. (2006) ukazuju na efekte koje kultura ispoljava u svakoj od faza procesa kupovine, najpre na definisanje prihvatljivih potreba (na primer, Muslimanima je zabranjeno da konzumiraju svinjsko meso), zatim na način prikuljanja informacija (preporuke porodice, prijatelja ili informisanje putem medija) i značaj atributa prilikom evaluacije proizvoda, takođe na način kupovine i konzumiranja proizvoda i konačno na postupanje sa proizvodom u fazi nakon kupovine (na primer, način odlaganja proizvoda).

Osim činjenice da je kultura najvažnije eksterna determinanta ponašanja potrošača u procesu kupovine, pregledom literature se može uvideti da se stil života izdvaja kao veoma bitna interna determinanta istog. Stil života se najjednostavnije objašnjava kao način na koji osoba živi koji se ogleda u njenim aktivnostima, interesovanjima i mišljenjima. Između kulture, stila života i ponašanja potrošača postoje bliske relacije koje su prvi put prikazane i opisane u radu autora Vilijama Lejzera (Lazer, 1963). Naime, Lazer je prvi u literaturu uveo hijerarhiju razvoja stila života prema kojoj se grupne i individualne vrednosti potrošača formiraju u okviru kulture u kojoj isti živi, da bi se zatim iste prevele u obrasce stila života koji determinišu reakcije potrošača na tržištu (Lawson & Todd, 2002). Nakon rada Lazer-a, Mehrabian & Russell (1974) predlažu model ponašanja potrošača nazvan SOR model po komponentama koje sadrži kao što su Stimulans (eksterna determinanta iz okruženja) koji utiče na Organizam (potrošač odnosno njegove karakteristike) što rezultira Reakcijom poput prihvatanja ili odbijanja stimulansa. Način na koji će potrošač reagovati na stimulanse zavisi upravo od internih karakteristika potrošača. Slično, model autora Hawkins et al. (2004) pokazuje da se potrebe potrošača razvijaju kao posledica delovanja internih i eksternih faktora čija kombinacija generiše iskustva i akvizicije potrošača. Na osnovu formiranih iskustava i akvizicija razvija se lični koncept i stil života koji se prevodi u potrebe i želje potrošača i tako ispoljava efekte na njegovo ponašanje u procesu donošenja odluke o kupovini. Na osnovu navedenih modela može se najpre uvideti značaj kulture kao eksterne determinante kupovnog ponašanja potrošača, a zatim uloga stila života u relaciji između posmatranih varijabli.

Odnos kulture i ponašanja potrošača analiziran je u brojnim empirijskim istraživanjima (Money & Crotts, 2003; Khare, 2013; Yacout & Hefny, 2014; Pandey et al., 2015; Šapić & Golo, 2017; Šapić et al., 2018; Shavitt & Barnes, 2020; Khan, 2022). S druge strane, mali broj studija fokusirao se na analizu efekata koje stil života može imati kada se posmatra odnos kulture i ponašanja potrošača (Pandey & Chawla, 2016; Leonhardt et al., 2020), gde je uočen istraživački gep na kome se zasniva ovaj rad. Predmet rada podrazumeva analizu nacionalne kulture kao antecedente kupovnog ponašanja potrošača, uz uvažavanje moderatorskih efekata koje pritom može imati stil života koji potrošači vode. S tim u vezi, u radu se najpre testiraju uticaji dimenzija nacionalne kulture koje su karakteristične za srpski kulturalni okvir, kao što su prisustvo kolektivism, visoke distance moći, tendencije ka izbegavanju neizvesnosti i dominacije ženskih vrednosti (Hofstede Insights, 2022), na ponašanje potrošača dok prolaze kroz pet faza procesa odlučivanja o kupovini (Engel et al., 1968). Takođe, empirijska analiza obuhvata testiranje moderatorskih efekata stila života u relaciji između dimenzija nacionalne kulture i kupovnog ponašanja potrošača, pri čemu se za merenje stila života potrošača u radu koristi AIO psihografska tehnika autora Wells & Tigert (1971). Struktura rada obuhvata sledeće

delove. Nakon uvodnih razmatranja, prvi deo rada posvećen je definisanju dimenzija nacionalne kulture, teorijskoj analizi odnosa istih sa kupovnim ponašanjem potrošača i moderatorskih efekata stila života u posmatranom odnosu, što će poslužiti kao osnova za formulisanje istraživačkih hipoteza i postavljanje modela istraživanja. Zatim će u drugom delu rada biti opisana metodologija koja je primenjena za prikupljanje i obradu primarnih podataka, da bi se u narednom delu prikazali rezultati koji su dobijeni na osnovu analize tih podataka. Na kraju rada su u okviru zaključnih razmatranja prikazani najznačajniji rezultati do kojih se došlo tokom studije, ukazano je na teorijske i praktične implikacije kao i ograničenja iste, a zatim su date preporuke istraživačima i menadžerima preduzeća.

2. ISTRAŽIVAČKI MODEL I RAZVOJ HIPOTEZA

Pored činjenice da je definicija autora Hofstede jedna od najpoznatijih i najčešće citiranih u literaturi, neosporno je da se u kros-kulturalnim studijama većinom koristi kulturalni okvir koji je razvio upravo ovaj autor (Hofstede, 1980). Navedeni model obuhvata četiri osnovne dimenzije nacionalne kulture označene kao individualizam/kolektivizam, distanca moći, izbegavanje neizvesnosti i muške/ženske vrednosti.

Individualizam/kolektivizam je dimenzija koja pokazuje kako pojedinac vidi sebe u odnosu na druge, odnosno koliko se smatra drugačijim od drugih ili povezanim sa njima (Shavitt & Barnes, 2019, p. 2). U individualističkim društvima ljudi preferiraju opušteni društveni okvir i brinu se samo za sebe i svoje najbliže, dok u kolektivističkim društvima postoji jača saradnja između članova određene grupe kako bi se brinuli jedni o drugima (Ullah et al., 2022). Dimenzija individualizam/kolektivizam može se dovesti u vezu sa prikupljanjem informacija putem medija ili usmene propagande, kupovinom putem interneta, izborom i kupovinom luksuznih proizvoda, automobila, osiguranja i sl. (de Mooij, 2011). Kada se govori o empirijskim studijama koje analiziraju uticaj posmatrane dimenzije na kupovno ponašanje potrošača, rezultati studije autora Nayeem (2012) pokazali su da dimenzija individualizam/kolektivizam determiniše ponašanje potrošača u fazama prikupljanje informacija i evaluacija alternativa. Slično, studija autora Khare (2013) ukazuje na prisustvo efekata kolektivizma na preferencije potrošača prema prodavcima odnosno na izbor trgovinskog formata i stavove prema lokalnim trgovcima. Kada se posmatraju moderatorski efekti stila života u odnosu individualizma/kolektivizma i kupovnog ponašanja potrošača, Leonhardt et al. (2020) su u svojoj studiji došli do zaključka da stil života ima ulogu moderatora kada se posmatra uticaj kolektivizma na generisanje informacija o brendovima kada potrošači donose odluku o kupovini. Na osnovu prethodno iznetih tvrdnji, postavljaju se sledeće istraživačke hipoteze:

H1: Kolektivizam ima statistički značajan utican na ponašanje potrošača u procesu odlučivanja o kupovini.

H1a: Stil života potrošača ispoljava moderatorske efekte u odnosu kolektivizma i kupovnog ponašanja potrošača.

Izbegavanje neizvesnosti se odnosi na stepen u kome društvo oseća strah od neizvesnih situacija i pokušava da ih izbegne kroz pravila i netoleranciju drugačijih ideja i ponašanja (Hofstede, 1980). U kulturama sa tendencijom ka izbegavanju neizvesnosti ne preferiraju se nepredvidive situacije, zbog čega se pojava istih eliminiše brojnim regulativama i pravilima, a pojedinci su emotivni i motivisani unutrašnjom nervozom, dok su osobe koji žive u kulturama gde je niži stepen izbegavanja neizvesnosti tolerantnije po pitanju rizika i različitosti, svode pravila na najmanju moguću meru i nisu sklone ka ispoljavanju

emocija drugima (Hofstede & McCrae, 2004). Dimenzija izbegavanje neizvesnosti se u kontekstu ponašanja potrošača može dovesti u vezu sa prihvatanjem novih proizvoda, izvorima prikupljanja informacija, kriterijumima za izbor proizvoda (na primer, pogodnost ili čistoća) i dr. (Hofstede, 2011). Uloga dimenzije izbegavanje neizvesnosti u ponašanju potrošača analizirana je radu autora poput Money & Crotts (2003) koji su empirijski potvrdili efekte izbegavanja neizvesnosti na ponašanje potrošača u toku prikupljanja informacija i planiranja i kupovine turističkih aranžmana. Slično, Šapić et al. (2018) došli su do rezultata da je izbegavanje neizvesnosti determinanta ponašanja potrošača u procesu odlučivanja o kupovini posmatranom kroz svih pet faza. Kada se relaciji između izbegavanja neizvesnosti i ponašanja potrošača doda stil života, može doći do određenih varijacija u istoj. S tim u vezi, Pandey & Chawla (2016) testiraju uticaj promena stila života, odnosno razvoja savremenog elektronskog stila života, na satisfakciju i lojalnost potrošača koji u procesu kupovine koriste informacione tehnologije, ukazujući pritom na značaj pogodnog dizajna informacija u kulturama sa visokim stepenom izbegavanja neizvesnosti za postizanje satisfakcije i lojalnosti. Shodno prethodno navedenom, u radu će se testirati sledeće:

H2: Izbegavanje neizvesnosti ima statistički značajan utican na ponašanje potrošača u procesu odlučivanja o kupovini.

H2a: Stil života potrošača ispoljava moderatorske efekte u odnosu izbegavanja neizvesnosti i kupovnog ponašanja potrošača.

Distanca moći predstavlja stepen u kome se prihvata i očekuje nejednakost u društvu (Song et al., 2021). Društva sa niskim stepenom distance moći odlikuje smanjivanje nejednakosti između ljudi, svi moraju imati jednaka prava a moć se bazira na formalnoj poziciji i ekspertizi, dok se u društvima gde dominira visoka distanca moći nejednakosti među ljudima smatraju poželjnim i očekivanim, pojedinci koji poseduju moć mogu imati sve privilegije dok su pojedinci koji slabije poseduju moć u zavisnom položaju u odnosu na druge (Hofstede et al., 2010). U pogledu kupovnog ponašanja potrošača, distanca moći utiče na izbor karakteristika za evaluaciju proizvoda (na primer, prestiž kod globalnih brendova), izvore informisanja prilikom prikupljanja informacija kod donošenja odluke o kupovini, izbor i korišćenje brendova koji će jasno istaći status osobe u društvu (na primer, globalni brendovi) i dr. (de Mooij & Hofstede, 2011). Da distanca moći utiče na ponašanje potrošača u procesu odlučivanja o kupovini empirijski su dokazali Yacout & Hefny (2014) posmatrajući efekte dimenzija kulture na izbor izvora informisanja prilikom donošenja kupovne odluke. U studiji koju su sprovedi Šapić & Golo (2017) dokazano je da distanca moći u odnosu na ostale dimenzije kulture ima najjači uticaj na stavove potrošača prema domaćim proizvodima i kupovini istih. Shavitt & Barnes (2020) u svom radu ukazuju na efekte koje distanca moći ispoljava na potrošače u fazama pre i tokom kupovine koji se ogledaju u uticaju poznatih ličnosti na odluku o kupovini, reakcijama potrošača na dizajn i cenu proizvoda, implulsivnoj kupovini i sl. Sledeći isti metodološki pristup kao kod prethodne dve dimenzije kulture, u radu će se ispitati sledeće:

H3: Distanca moći ima statistički značajan utican na ponašanje potrošača u procesu odlučivanja o kupovini.

H3a: Stil života potrošača ispoljava moderatorske efekte u odnosu distance moći i kupovnog ponašanja potrošača.

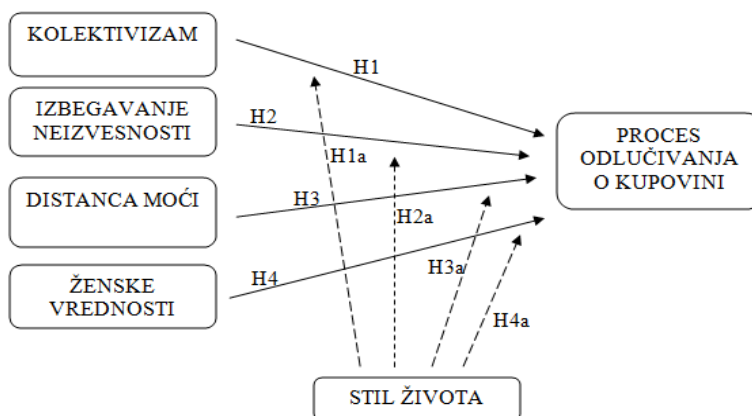
Muške/ženske vrednosti je dimenzija kulture koja se odnosi na stepen u kome su u društvu dominantne muške nasuprot ženskim vrednostima, odnosno tendencija nagrađivanja u

vidu statusa ili bogatstva za uspešne pojedince, školski sistem koji podstiče performanse, žene i muškarci koji prate drugačiji sistem visokog obrazovanja a karijera je uglavnom vezana za muškarce, nasuprot društvu u kome se školski sistem prilagođava društvenim potrebama, postoji briga za životno okruženje, isticanje u odnosu na druge se ne nagrađuje ni materijalno ni društveno a karijeru mogu imati i muškarci i žene (Hofstede, 1984). Posmatrana dimenzija kulture omogućava da se analiziraju razlike u pogledu uloga u porodici (čišćenje ili obavljanje kupovine), izbora i kupovine luksuznih proizvoda, statusnih brendova, nakita i sl. (de Mooij, 2011). Efekte muških i ženskih vrednosti na kupovno ponašanje potrošača empirijski su testirali autori Pandey et al. (2015), koji su ispitivajući uticaj dimenzije kulture na lojalnost kao bitan aspekt postkupovnog ponašanja potrošača došli do rezultata da se muške vrednosti izdvajaju kao najznačajnija determinanta iste, ili Pinna (2019) koji u svom radu potvrđuje postojanje pozitivnog, statistički signifikantnog uticaja ženskih vrednosti na nameru potrošača da biraju i kupuju etičke proizvode, dok je obrnuta situacija kada se posmatraju muške vrednosti. Oslanjajući se na prethodno iznete zaključke, uz uvažavanje metodološkog pristupa u slučaju prethodnih dimenzija kulture, testiraće se sledeće hipoteze:

H4: Ženske vrednosti imaju statistički značajan utican na ponašanje potrošača u procesu odlučivanja o kupovini.

H4a: Stil života potrošača ispoljava moderatorske efekte u odnosu ženskih vrednosti i kupovnog ponašanja potrošača.

Polazeći od prethodno izloženih rezultata empirijskih studija i teorijskih modela ponašanja potrošača (Mehrabian & Russell, 1974; Hawkins et al., 2004) koji dodatno potvrđuju relacije obuhvaćene istraživačkim hipotezama, rad se bazira na istraživačkom modelu (slika 1) koji obuhvata šest varijabli, pri čemu se četiri varijable odnose na dimenzije nacionalne kulture prema klasifikaciji autora Hofstede (1980), dok preostale dve varijable podrazumevaju stil života i proces odlučivanja potrošača o kupovini.



Slika1. Istraživački model

U vezi postavljenog modela istraživanja bitno je napomenuto da se stil života meri kao neponderisana aritmetička sredina šest konstatacija koje se odnose na AIO komponente stila života (Wells & Tigert, 1971), dok varijabla proces odlučivanja o kupovini

predstavlja neponderisanu aritmetičku sredinu 10 konstatacija kojima su obuhvaćene faze procesa odlučivanja prema EKB modelu ponašanja potrošača (Engel et al., 1968).

3. METODOLOGIJA ISTRAŽIVANJA I UZORAK

Za prikupljanje primarnih podataka neophodnih za sprovođenje statističkih analiza u radu je primenjen metod ankete, distribuiranjem upitnika ličnim putem ispitanicima na teritoriji Srbije. Anketirano je 389 ispitanika različitih demografskih karakteristika koji čine prigodan uzorak često primenjivan u kulturalnim studijama (Leng & Botelho, 2010; Spiers et al., 2014; Asamoah & Chovancova, 2016). Upitnikom su obuhvaćene 32 konstatacije skalirane na petostepenoj Likertovoj skali sa kojima su ispitanici iskazivali svoj stepen slaganja (1-apsolutno se ne slažem; 5-apsolutno se slažem) i 4 demografska pitanja. Pomoću prve četiri konstatacije merena je dimenzija kulture kolektizvam (preuzeto iz: Hofstede et al., 2010; Yoo et al., 2011), slede 4 konstatacija koje su obuhvaćene dimenzijom izbegavanje neizvesnosti (preuzeto iz: Hofstede et al., 2010; Yoo et al., 2011), 3 konstatacije čine varijablu distanca moći (preuzeto iz: Hofstede et al., 2010; Yoo et al., 2011), dok se dimenzija ženske vrednosti meri pomoću 5 konstatacija (preuzeto iz: Hofstede et al., 2010; Guseva, 2013). U vezi navedenog bitno je napomenuti da se dimenzije nacionalne kulture u radu mere na individualnom nivou u skladu sa metodologijom rada relevantnih autora (Matsumoto et al., 1997; Yoo et al., 2011; Bathaee, 2014). Varijabla stil života se u upitniku posmatra kroz šest konstatacija od kojih se po dve odnose na aktivnosti, interesovanja i mišljenja kao AIO komponente stila života potrošača (preuzeto iz: Roberts & Wortzel, 1979; Tai & Tam, 1997; Kwan et al., 2008), dok preostalih 10 konstatacija čini varijablu proces odlučivanja o kupovini, pri čemu se sa po dve konstatacije meri svaka od faza procesa odlučivanja obuhvaćenih EKB modelom ponašanja potrošača (preuzeto iz: Bruner, 1987; Nagaraja & Girish, 2016). Što se tiče strukture uzorka, u istom dominiraju ispitanici ženskog pola kojih je 235 odnosno 60,4%, dok ispitanici muškog pola obuhvataju 39,6% uzorka i ima ih 154. Prema kriterijumu starost, najveći procenat uzorka čine ispitanici starosti od 26 do 35 godina (27,5% odnosno 107), neznatno manje ima ispitanika koji imaju između od 18 i 25 godina (26,5% odnosno 103), sledi 88 ispitanika starosti od 36 do 45 godina koji čine 22,6% uzorka, 63 ispitanika ima između 46 i 55 godina (16,2%), dok najmanji procenat uzorka, 7,2%, čine ispitanici koji su stariji od 55 godina kojih ima 28. Kada se posmatra stepen obrazovanja anketiranih ispitanika, 55,5% uzorka obuhvataju visokoobrazovani ispitanici (216), slede ispitanici sa master diplomom (86 odnosno 22,1%), 77 ispitanika ima srednje obrazovanje (19,8%) dok svega 10 ispitanika nosi titulu doktora nauka (1,3%). Konačno, prema kriterijumu mesta stanovanja, većina ispitanika se izjasnila da živi u gradu (71% odnosno 276), 70 ispitanika potiče iz prigradskih naselja (18%), dok je najmanje ispitanika koji žive u selu (43 odnosno 11,1%). Obrada primarnih podataka izvršena je u statističkim paketima SPSS 20 i AMOS 20 primenom statističkog metoda. U okviru programa SPSS sprovedena je deskriptivna statistika za određivanje strukture uzorka i analiza pouzdanosti varijabli istraživanja, dok je u programu AMOS testirana skladnost istraživačkog modela primenom konfirmativne faktorske analize (CFA - *Confirmatory Factor Analysis*), a zatim su sprovedeni model strukturalnih jednačina za testiranje efekata nezavisnih na zavisnu varijablu i moderacijska regresija u cilju testiranja moderatorskih efekata stila života kada se posmatra relacija između dimenzija nacionalne kulture i procesa odlučivanja potrošača o kupovini.

4. REZULTATI ISTRAŽIVANJA

U cilju postavljanja adekvatnog i pouzdanog istraživačkog modela, pre konfirmativne faktorske analize sprovedena je analiza pouzdanosti varijabli istraživanja. S tim u vezi, testirana je interna konzistentnost konstatacija koje čine posmatrane varijable na osnovu vrednosti Cronbach's alpha koeficijenta, pri čemu se vrednost 0.6 posmatra kao prihvatljiv prag pouzdanosti (Hair et al., 2014). Rezultati sprovedene analize prikazani su u tabeli 1.

Tabela 1. Pouzdanost varijabli

Varijabla	Broj konstatacija	Cronbach's alpha
Kolektivizam	4	0,762
Izbegavanje neizvesnosti	4	0,702
Distanca moći	3	0,692
Ženske vrednosti	5	0,614
Stil života	6	0,632
Proces odlučivanja o kupovini	10	0,749

Rezultati analize pouzdanosti pokazuju da sve varijable istraživanja imaju zadovoljavajuću internu konzistentnost konstatacija koje ih čine, pri čemu se kao varijabla sa najvišim stepenom pouzdanosti izdvojila dimenzija kulture *kolektivizam*, dok varijabla *ženske vrednosti* ima najniži stepen interne konzistentnosti. Na osnovu dobijenih rezultata utvrđeno je da se istraživački model bazira na pouzdanim varijablama, čime je obezbeđena adekvatna osnova za dalju statističku analizu.

U sledećem koraku sprovedena je konfirmativna faktorska analiza kako bi se testirala skladnost istraživačkog modela. Nakon što je utvrđena pouzdanost varijabli istraživanja, sledeći uslov za sprovođenje konfirmativne faktorske analize odnosi se na veličinu uzorka koja bi prema autorima Myers et al. (2011) trebalo da iznosi minimalno 200 ispitanika. Kako uzorak u radu obuhvata 389 ispitanika, uočava se da je navedeni uslov ispunjen. U pogledu analiziranih parametara, na skladnost istraživačkog modela ukazuje vrednost GFI, CFI, TLI i IFI indeksa veća od 0.9 (Byrne, 1998), RMSEA indeksa manja od 0.1 (Steiger, 1990) i χ^2/df racia manja od 3 (Hair et al., 2014). Kada se govori o rezultatima istraživanja, vrednost χ^2/df racia iznosi 2.01, što je u skladu sa preporukama autora. RMSEA indeks iznosi 0.051, što je takođe u prihvatljivim granicama. Konačno, vrednosti GFI indeksa 0.939, IFI indeksa 0.923, TLI indeksa 0.903 i CFI indeksa 0.922 ukazuju na skladnost istraživačkog modela. Polazeći od dobijenih rezultata, u nastavku rada primenjen je model strukturalnih jednačina čiji su rezultati prikazani u tabeli 2.

Tabela 2. Model strukturalnih jednačina

Relacije	β	p
Kolektivizam→proces odlučivanja o kupovini	0,015	0,809
Izbegavanje neizvesnosti→ proces odlučivanja o kupovini	0,403	0,000**
Distanca moći→ proces odlučivanja o kupovini	0,108	0,048*
Ženske vrednosti→ proces odlučivanja o kupovini	0,215	0,006**

Na osnovu dobijenih rezultata modela strukturalnih jednačina uočava se da jedino dimenzija kulture *kolektivizam* ne ispoljava statistički značajne efekte na ponašanje

potrošača u procesu odlučivanja o kupovini ($p > 0.1$), dok se od preostalih dimenzija *izbegavanje neizvesnosti* izdvaja kao najjača antecedenta (zbog najviše vrednosti β koeficijenta), a kao najslabija dimenzija kulture *distanca moći*. Vrednost koeficijenta determinacije R^2 pokazuje da je 30.9% varijabiliteta zavisne varijable obuhvaćeno posmatranim modelom. Na osnovu dobijenih rezultata može se zaključiti da su hipoteze H2, H3 i H4 dokazane dok se hipoteza H1 odbacuje.

Nakon modela strukturalnih jednačina, testirane su hipoteze u pogledu prisustva moderacijskih efekata stila života u odnosu između dimenzija nacionalne kulture i procesa odlučivanja o kupovini. Moderacija je sprovedena polazeći od stila života prema kom su ispitanici podeljeni u dve grupe. Prva grupa se odnosi na 243 ispitanika koji su konstatacijama kojima se mere AIO komponente stila života potrošača dali niske ocene (od 1 do 3,5), označeni kao potrošači koji ne preduzimaju aktivnosti, ne ispoljavaju interesovanja i ne dele mišljenja u vezi kupovine koja su posmatrana u radu. S druge strane, drugu grupu čini 146 ispitanika koji su ispoljili jači stepen slaganja sa konstatacijama iz upitnika (ocene od 3,5 do 5) pa se shodno tome karakterišu kao potrošači koji svoj stil života ispoljavaju preko posmatranih AIO komponenti stila života. Za navedene grupe sprovedena je analiza invarijanse čiji rezultati pokazuju da generalno postoje razlike između istih ($p = 0,027$). Zatim je poređenjem β koeficijenata kojima su mereni efekti dimenzija kulture na ponašanje potrošača u oba poduzorka ispitano prisustvo moderacijskog efekta stila života (tabela 3). Na osnovu vrednosti z skora može se uočiti da kod tri od četiri relacije stil života ispoljava statistički značajne moderatorske efekte, konkretno kada se radi o relacijama između kolektivizma, izbegavanja neizvesnosti i distance moći, s jedne strane, i procesa odlučivanja o kupovini, s druge strane. Evidentno je da je se kod sva tri slučaja ispoljavaju statistički signifikantni uticaji dimenzija kulture na potrošače koji vode posmatrani stil života, dok se kod prve grupe potrošača statistički značajni efekti javljaju kod dimenzija kolektivizam i izbegavanje neizvesnosti. Pritom, obe dimenzije imaju jači uticaj na kupovno ponašanje druge grupe ispitanika, odnosno na ponašanje potrošača koji vode posmatrani stil života u pogledu kupovine. Navedeno pokazuje da sa porastom tendencije ka izbegavanju neizvesnosti potrošači veću pažnju posvećuju praćenju cena proizvoda koje kupuju, teže da uštede, ispoljavaju jače preferencije ka brendiranim i stranim proizvodima jer dele mišljenje da su strani brendovi boljeg kvaliteta od domaćih, kao i da je visoka cena odraz visokog kvaliteta. Takođe, negativna vrednost z skora ukazuje na prisustvo negativne relacije između dimenzije kolektivizam i ponašanja potrošača koji vode posmatrani stil života u procesu kupovine. Preciznije, negativna relacija ukazuje da što se potrošač više vodi interesima drugih u kupovini i pada pod uticaj okoline prilikom kupovine ili formiranja mišljenja o proizvodima, onda će manje štedeti, neće tako često kupovati brendove iz inostranstva i neće se previše voditi visokom cenom kao pokazateljem kvaliteta. Dobijeni rezultat može se tumačiti kao potpuno logičan ukoliko se, na primer, obavljaju kupovine koje će zadovoljiti interese svih članova porodice. Samim tim, može se pretpostaviti da zbog veće kupovine potrošač više troši, zbog čega prednost prilikom kupovine daje nižoj ceni a ne kvalitetu, ili domaćim i nebrendiranim proizvodima koji su generalno jeftiniji od stranih i brendiranih.

Tabela 3. Rezultati moderacijske regresione analize (moderator: stil života)

Relacije	Grupa 1	Grupa 2	z skor
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	β	p	β	p	
Kolektivizam→ proces odlučivanja o kupovini	0,171	0,036	-0,296	0,011	-3,282**
Izbegavanje neizvesnosti→ proces odlučivanja o kupovini	0,255	0,010	0,667	0,012	1,95*
Distanca moći→ proces odlučivanja o kupovini	0,033	0,642	0,286	0,002	1,91*
Ženske vrednosti→ proces odlučivanja o kupovini	0,281	0,004	0,078	0,511	-0,731

Na osnovu prethodno iznetih rezultata može se zaključiti da sa jačanjem preferencija potrošača ka određenom stilu života prilikom kupovine, efekti dimenzija kulture na njihovo ponašanje u procesu odlučivanja o kupovini postaju značajniji i jači, osim u slučaju dimenzije ženske vrednosti za koju je ustanovljena nesignifikantna relacija sa kupovnim ponašanjem potrošača nezavisno od toga da li isti vode ili ne posmatrani stil života vezano za kupovinu. Uzimajući u obzir postavljene istraživačke hipoteze, može se zaključiti da su hipoteze H1a, H2a i H3a dokazane, dok je obrnuto u slučaju hipoteze H4a.

5. ZAKLJUČAK

Istraživanje je sprovedeno u cilju empirijskog testiranja efekata kulture na ponašanje potrošača, uz uvažavanje prisustva moderatorskih efekata stila života. Rezultati su potvrdili prisustvo statistički signifikantnih relacija između dimenzija srpske nacionalne kulture i ponašanja potrošača u procesu odlučivanja o kupovini, osim u slučaju dimenzije kolektivizam. Kupovno ponašanje potrošača posmatrano kroz izostanak kupovine novog proizvoda dok je stari još na raspolaganju, prikupljanje informacija o ponudi na tržištu u prodajnim objektima ili onlajn, uvažavanje recenzija drugih potrošača, kupovinu u prodavnicama sa dodatnom uslugom uz duže zadržavanje i spremnost preporuke proizvoda i prodavnica najjače je determinisano tendencijom potrošača ka izbegavanju nepoznatih situacija prilikom kupovine, praćenjem uputstava i instrukcija za kupovinu i korišćenje proizvoda i oslanjanjem na znanje prodavca. Preciznije, dobijeni rezultat pokazuje da jača sklonost ka izbegavanju neizvesnosti potrošača doprinosi većem angažovanju istog u procesu kupovine tj. detaljnijem informisanju, praćenju ocena drugih potrošača, dužem zadržavanju u prodajnim objektima i dr. Dobijeni rezultat odgovara rezultatima prethodnih studija o efektima izbegavanja neizvesnosti na ponašanje potrošača prilikom kupovine (Money & Crofts, 2003; Šapić et al., 2018). S druge strane, posmatrani aspekti kupovnog ponašanja potrošača najslabije su pod uticajem visoke distance moći koja se ogleda kroz tendenciju donošenja kupovnih odluka i preuzimanja inicijative prilikom kupovine od strane starijih članova porodice. Posmatranu relaciju između distance moći i kupovnog ponašanja potrošača takođe su dokazali autori poput Yacout & Hefny (2014), Šapić & Golo (2017) i Shavitt & Barnes (2020). Sledeći rezultat modela strukturalnih jednačina pokazuje da će potrošači biti skloniji da ispoljavaju posmatrano kupovno ponašanje ukoliko jačaju njihove preferencije ka skromnosti u kupovini, poverenju u prodavca nezavisno od njegovog pola i kompromisnom rešavanju konflikata koji mogu nastati tokom kupovine. Navedeni rezultat studije u skladu je sa rezultataima

studija koje su sprovedeli Pandey et al. (2015) i Pinna (2019). Konačno, sklonost potrošača ka podređivanju sopstvenih interesa u kupovini interesima porodice, zajedničkoj kupovini, oslanjaju na mišljenje okoline tokom formiranja sopstvenih mišljenja o proizvodima i ponašanja u potrošnji ispoljila je nesignifikantan uticaj na ponašanje potrošača u procesu donošenja kupovnih odluka. U pogledu dobijenog rezultata mogu se uočiti odstupanja u odnosu na ranije studije (Nayeem, 2012; Khare, 2013). Dalje, u radu je kao moderator posmatran stil života potrošača. Ispitanici iz uzorka podeljeni su u dve grupe na osnovu odgovora koje su dali konstatacijama koje se odnose na AIO komponente stila života, a zatim je ispitano da li se sa promenom stila života potrošača odnosno pripadnošću jednoj od ove dve grupe menjaju efekti dimenzija nacionalne kulture na ponašanje potrošača prilikom kupovine. Dobijeni rezultati su pokazali da jedino uticaj dimenzije ženske vrednosti izostaje kod obe grupe potrošača, odnosno da stil života nema ulogu moderatora u relaciji ove dimenzije i kupovnog ponašanja potrošača. Što se tiče ostalih dimenzija, iste su se za grupu potrošača koja prati promene cene proizvoda koji redovno kupuje, šteti prilikom kupovine, preferira strane i brendirane proizvode, smatra da su strani brendovi kvalitetniji od domaćih i da je visoka cena odraz visokog kvaliteta pokazale kao značajne antecedente ponašanja u procesu odlučivanja o kupovini. Dobijeni rezultat vezano za prisustvo moderatorskih efekata stila života kada se posmatraju dimenzije kolektivizam i izbegavanje neizvesnosti odgovara rezultatima prethodnih studija (Pandey & Chawla, 2016; Leonhardt et al., 2020). S druge strane, kada se posmatra grupa potrošača koji su se izjasnili da ne ispoljavaju interesovanja, ne dele mišljenja i ne preduzimaju prethodno navedene aktivnosti, uočen je izostanak signifikantnih efekata distance moći na ponašanje tokom kupovine, dok se tendencija ka podređivanju ličnih interesa u kupovini interesima drugih i izbegavanju neizvesnih kupovnih situacija izdvojila kao značajan prediktor, što je takođe u skladu sa prethodnim studijama (Pandey & Chawla, 2016; Leonhardt et al., 2020). Dakle, generalno se na osnovu dobijenih rezultata može zaključiti da promene u stilu života potrošača u značajnoj meri uslovljavaju promene u odnosu između kulturalnog okvira jedne zemlje i ponašanja potrošača dok prolaze kroz proces odlučivanja o kupovini, čime su potvrđene pretpostavke na kojima se baziraju teorijski modeli od koji se pošlo u radu (Mehrabian & Russell, 1974; Hawkins et al., 2004).

Polazeći od dobijenih rezultata sprovedene empirijske studije, mogu se identifikovati kako teorijske tako i praktične implikacije istih. Naime, osim što rezultati omogućavaju precizniju i sveobuhvatniju analizu odnosa između kulturalnog okvira, stila života i ponašanja potrošača, sprovedena studija nudi integrativni istraživački okvir koji se dalje može prilagođavati i samim tim poslužiti kao adekvatna osnova za buduća istraživanja, kako u oblasti ponašanja potrošača tako i u kros-kulturalnim studijama. Rezultati istraživanja u pogledu moderacijskih efekata stila života mogu se izdvojiti kao posebno značajan doprinos naučnoj literaturi u kojoj je teško naći istraživanja sa sličnom ili istom problematikom, uprkos činjenici da neki od najrelevantnijih teorijskih modela ponašanja potrošača jasno ukazuju da način reakcije potrošača na eksterne stimulanse zavisi od internih karakteristika istih. Osim navedenog, upitnik na osnovu kog su prikupljeni primarni podaci predstavlja jedan od retkih pokušaja u literaturi da se posmatrane dimenzije nacionalne kulture sagledaju u kontekstu kupovnog ponašanja potrošača, na šta se takođe mogu osloniti autori u narednim studijama.

Kada se posmatraju praktične implikacije rada, najpre se može ukazati na značaj dobijenih rezultata za donošenje optimalnih poslovnih odluka od strane marketara. Preciznije,

rezultati se mogu iskoristiti kao osnova za formulisanje i implementaciju marketinških strategija koje uvažavaju ne samo direktne efekte kojima kultura prožima svaki aspekt ponašanja potrošača, već i one koji zavise od stila života koji potrošač vodi. Dakle, napori preduzeća da utiču na ponašanje svojih ciljnih grupa potrošača moraju biti prilagođeni kulturalnom miljeu u kome isti žive, uz uvažavanje stila života koji vode sagledanog kroz aktivnosti koje obavljaju, interesovanja koja ispoljavaju i mišljenja koja podržavaju. Pritom, kada se posmatra tržište Republike Srbije, rezultati pokazuju da se posebno moraju uvažiti izrazita sklonost potrošača ka izbegavanju neizvesnosti, visokoj distanci moći i ženskim vrednostima, s obzirom da su se iste pokazale kao značajna prediktori kupovnog ponašanja, dok je u slučaju dodatnog uključivanja psihografskih karakteristika potrošača u donošenje poslovnih odluka potrebno posvetiti detaljniju pažnju relacijama između kolektivismu, izbegavanja neizvesnosti i distance moći i donošenja odluka o kupovini. To se, između ostalog, može postići ukoliko se prilikom kreiranja promotivne strategije za ciljno tržište, nezavisno od stila života koji potrošači vode, akcenat stavi na detaljno i precizno informisanje potrošača, pozitivnu ulogu iskustva i starosti potrošača u procesu kupovine, kompromisno rešavanje svih problema potrošača, izbegavanje stereotipnih reklama i sl. Ukoliko preduzeće pak teži da promotivnu strategiju prilagodi specifičnim psihografskim segmentima potrošača, onda je potrebno staviti veći akcenat na zajedničke koristi koje se ostvaruju po osnovu kupovine i korišćenja određenog proizvoda ili usluge umesto na stereotype u kupovini, skromnost, rešavanje problema potrošača i dr. Konačno, može se izdvojiti značaj rezultata psihografske analize za preciznije sagledavanje kupovnog stila života koji vode srpski potrošači.

Uprkos prethodno navedenim prednostima, rad ispoljava i određena ograničenja. Pre svega, tu se može izdvojiti mali uzorak na osnovu kog su dobijeni rezultati koji se ne mogu generalizovati za čitavu populaciju. Dalje, istraživačkim modelom nisu obuhvaćene kratkoročna orijentacija i uzdržanost kao preostale dimenzije nacionalne kulture koje je identifikovao Hofstede. U vezi navedenih ograničenja, preporuka za buduće istraživače odnosi se pre svega na proširivanje uzorka. U zavisnosti od problematike budućih studija i interesovanja istraživača, model se dodatno može proširiti dodavanjem preostale dve dimenzije nacionalne kulture. Osim navedenog, istraživački model se može prilagoditi za konkretne proizvode ili usluge kako bi se dobile preciznije informacije koje mogu poslužiti preduzećima iz različitih sektora i grana za donošenje optimalnijih poslovnih odluka. Takođe, sličan ili isti istraživački pristup može omogućiti istraživačima i marketarima da za potrebe poslovanja preduzeća na svim tržištima sprovedu istraživanje kako bi identifikovali relacije između posmatranih varijabli, naročito kada se radi o zemljama bivše Jugoslavije koje imaju slične odlike kulturalnog okvira kao Srbija.

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NATIONAL CULTURE DIMENSIONS AND CONSUMER DECISION MAKING: TESTING THE MODERATING EFFECTS OF LIFESTYLE

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ABSTRACT:

The aim of the paper is to test the effects of Serbian national culture dimensions on consumer behavior in the purchase decision-making process. Additionally, the paper examines the presence of moderating effects of lifestyle when observing the relationship between national culture dimensions and consumer purchasing behavior. Relationships between national culture dimensions and consumer behavior in the purchase decision-making process were tested using the structural equation model. The results of the study show that uncertainty avoidance is the strongest predictor of consumer purchasing behavior, while power distance is the weakest. Collectivism did not exhibit statistically significant effects on the observed dependent variable. Furthermore, moderation analysis indicates that the effects of collectivism, uncertainty avoidance, and power distance on consumer purchasing behavior change with the change in consumers' lifestyles, whereas the moderating effect was not confirmed for femininity. The scientific contribution of the study is based on the originality of the research model. Additionally, significant practical implications of the work, namely its results, for the formulation of optimal business strategies, both generally for the target consumer groups and depending on their psychographic characteristics, can also be distinguished.

Keywords: national culture dimensions, lifestyle, consumer behavior, purchase decision-making process

UTICAJ MEĐUNARODNIH MIGRACIJA NA DOHODOVNU NEJEDNAKOST U EVROPSKIM TRANZICIONIM ZEMLJAMA

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SAŽETAK:

Tokom protekle tri decenije odigrale su se značajne transformacije u bivšim evropskim komunističkim zemljama koje su za rezultat imale njihovu integraciju u globalnu ekonomiju i povećanje životnog standarda. Međutim, prvih nekoliko godina tranzicije ka tržišnoj privredi praćeno je drastičnim padom autputa, porastom nezaposlenosti, visokom inflacijom i porastom nejednakosti. Smanjenje dohodovnih nejednakosti jedno je najvažnijih ekonomskih i političkih pitanja u Evropi, budući da se ona sastoji od heterogenih zemalja koje odlikuju dispariteti u dohotku per capita. Predmet ovog rada je analiza uticaja međunarodnih migracija na nivo dohodovne nejednakosti u tranzicionim zemljama koje su pristupile Evropskoj uniji, CIE-11 i zemljama Zapadnog Balkana. U istraživanju je kao metodološki okvir korišćen panel regresioni model, a vremenski okvir je ograničen na period 2000-2020. godinu. Rezultati pokazuju da međunarodne migracije doprinose smanjenju dohodovnih nejednakosti u analiziranim zemljama.

Ključne reči: međunarodne migracije, dohodovna nejednakost, evropske tranzicione ekonomije, panel regresija

1. UVOD

Među različitim demografskim, ekonomskim, socijalnim, institucionalnim i političkim varijablama koje utiču na ekonomsku nejednakost, migracije sve više dobijaju na značaju. U kojoj meri migracija utiče na nejednakost zavisi od niza faktora. Jedan od njih je struktura migranata: ko ide, kuda i kada (na primer, da li su migranti muškarci ili žene, mladi ili stari, kvalifikovani ili nekvalifikovani, bogati ili siromašni, da li idu u razvijene ili nerazvijene regione, da li dolaze u dobrim ili lošim vremenima, koliko planiraju da ostanu). Migracija može uticati na plate ili zaposlenost u zemljama emigracije i imigracije jer migranti šalju doznake porodici koja je ostala. Migracije mogu takođe uticati i na vladine politike, kao što su politike preraspodele i pristup socijalnoj zaštiti. One mogu dovesti do transfera tehnologije, trgovine i tokova kapitala. Efekti migracije takođe zavise od toga kako se imigranti integrišu u društva koja ih primaju i kako se društva koja šalju stanovništvo i primaju prilagođavaju migraciji.

Od početka 1990-ih godina zemlje Centralne i Istočne Evrope (CIE) su prilikom transformacije iz centralnoplanske u tržišnu privredu doživele i značajnu promenu u migracionom ponašanju. Sve do kasnih 1980-ih godina, ovaj region je bio relativno

izolovan od ostatka sveta, a migracija je bila ograničena u svim zemljama ovog regiona. Nakon početne i prilično kratke epizode egzodusa iz sela u grad 1950-ih godina, prostorna mobilnost ljudi je bila umerena i slaba. Međunarodna migracija radne snage bila je ograničena unutar regiona Centralne i Istočne Evrope i pod strogom kontrolom vlade. Međutim, od ranih 1990-ih godina situacija se drastično menja. Dva istorijska događaja su od presudnog značaja za oblikovanje novih migracionih trendova u Centralnoj i Istočnoj Evropi: raspad Sovjetskog Saveza i članstvo osam zemalja CIE u Evropsku uniju 2004. godine. Sloboda kretanja koja je ponovo uspostavljena u regionu oko 1990. godine dovela je do masovnih migracija stanovništva. Ono što je odlikovalo ove migracije jeste intenziviranje međunarodnih tokova unutar Centralne i Istočne Evrope, priliv ljudi izvan regiona i ilegalna tranzitna migracija. Region je bio svedok ogromnog porasta složenosti migracionih oblika – od mobilnosti radne snage preko tranzitnih migracija do prisilnih migracija. Tokom devedesetih godina migracije u tranzicionim zemljama su bile posledica delovanja tri različite vrste neravnoteža: demografske, ekonomske i političke čiji ishod jeste postojanje latentnog potencijala za emigraciju (Okolski, 2004).

Razumevanje odnosa između migracije i dohodovne nejednakosti nije važno samo sa aspekta kreiranja migracijske, ekonomske i socijalne politike, već i za razumevanje trenutnih političkih i javnih debata o migracijama u Evropi. Imajući u vidu napred navedeno, predmet ovog rada jeste analiza uticaja međunarodnih migracija na dohodovnu nejednakost u evropskim tranzicionim zemljama. Saglasno opredeljenom predmetu, osnovni cilj istraživanja je da se na bazi relevantne teorijsko-metodološke i empirijske analize, ispita da li međunarodne migracije imaju uticaj na dohodovnu nejednakost.

U skladu sa postavljenim predmetom i ciljem istraživanja, u radu će biti testirana sledeća hipoteza:

H1: Međunarodne migracije smanjuju dohodovnu nejednakost u evropskim tranzicionim zemljama.

Od istraživačkih metoda u radu su korišćeni: deskriptivni metod, komparativni metod, metod analize i sinteze i statistički metod (panel regresioni model).

Ostatak rada je strukturiran na sledeći način. U drugom delu dat je pregled literature o odnosu između međunarodne migracije i dohodovnih nejednakosti. U trećem delu dat je pregled modela koji se koristi za empirijsku analizu i prikazuju se izvori podataka korišćenih u istraživanju. Četvrti deo sadrži empirijsku analizu i validaciju hipoteze o uticaju međunarodnih migracija na dohodovnu nejednakost. U Zaključku, kao petom delu rada, sumirani su glavni rezultati rada.

2. PREGLED LITERATURE

Ekonomska nejednakost je u svojim različitim oblicima i kontekstima predstavljala ključno pitanje javne politike i centralnu temu u ekonomskoj literaturi. Literatura ukazuje na složen odnos između ekonomke nejednakosti i migracije. Prema neoklasičnoj ekonomskoj teoriji, pretpostavlja se da razlike u dohotku pokreću migracije i da, dugoročno gledano, međunarodne migracije doprinose smanjenju nejednakosti u dohotku. Naime, teorija pretpostavlja da neravnoteže u ponudi i tražnji za radnom snagom koje rezultiraju razlikama u zaradama, pokreću migracione tokove iz zemalja sa niskim zaradama i dohotkom u zemlje sa visokim zaradama i dohotkom (Harris & Todaro, 1970). Migracija radne snage ima potencijal da alokaciju proizvodnih faktora učini efikasnijom i

na taj način obezbedi koristi i za zemlju emigracije i zemlju imigracije (Kahanec & Guzi, 2017). Zemlje imigracije dobijaju dodatnu radnu snagu koja je na raspolaganju domaćim poslodavcima, a zemlje emigracije imaju koristi od doznaka i veština koje su stekli migranti koji su se vratili u svoju zemlju. Kako migracija umanjuje početne neravnoteže i zarade konvergiraju, osnovni neoklasični model predviđa niže nivoe nejednakosti u dohotku između zemalja na dugi rok.

U emirijskoj literaturi ne postoji saglasnost po pitanju uticaju međunarodnih migracija na dohodovnu nejednakost. Howell (2017) je analizirao uticaj migracije na disparitet dohotka u ruralnim manjinskim oblastima Kine. Zaključio je da će kontinuirano kretanje migranata iz ruralnih u urbane oblasti voditi nejednakostima među etničkim grupama u ruralnim manjinskim područjima. Do istih zaključaka je došao i Zhan et al. (2021) koji navodi da će migracija voditi povećanju nejednakosti u dohotku u ruralnim područjima, iako može smanjiti nejednakost u urbanim sredinama. S druge strane, Nobahar and Ghorbani (2021) su otkrili da migracija povećava nejednakost dohotka u gradovima emigracije, a smanjuje u gradovima imigracije. Blau and Kahn (2015) tvrde da migracija može dovesti do nejednakosti dohotka jer prebrzo povećava ponudu radne snage, utiče na konkurenciju među grupama na tržištu rada i na kraju smanjuje zarade. S druge strane, Kalleberg (2011) tvrdi da efekat migracije zavisi od toga da li su imigranti zamena ili dopuna lokalnim radnicima. Ako su imigranti supstituti lokalnim radnicima, oni mogu smanjiti zarade i dovesti do nejednakosti u dohotku, dok ukoliko su komplementarni, mogu stvoriti radna mesta za lokalne radnike. Umprety (2020) koristeći panel podatke za 110 zemalja u razvoju od 1980. do 2010. godine zaključuje da migracija visokokvalifikovane radne snage povećava nejednakost dohotka, dok migracija niskokvalifikovane radne snage nema efekta na nejednakost dohotka.

U literaturi postoje dokazi o pozitivnim efektima migracije na dohodak per capita zemlje emigracije. Ovo se ostvaruje zahvaljujući većem rastu zarada, većem zapošljavanju onih koji ostaju ili pozitivnom uticaju doznaka na ekonomski razvoj. Proširenje EU 2004. i 2007. godine dovelo je do veće mobilnosti radne snage unutar EU i doprinelo povećanju zarada i smanjenju nezaposlenosti u novim državama članicama (Zaiceva, 2014). Tehnološki transfer takođe može uticati na stvaranje pozitivnog efekta emigracije na zemlju porekla (Fassio et al., 2019). Istraživanja su pokazala da doznake posebno doprinose ekonomskom rastu (Catrinescu et al., 2009) čime se potencijalno smanjuje nejednakost dohotka među zemljama. Catrinescu i saradnici (2009) navode da stepen u kome će doznake uticati na ekonomski razvoj zavisi od kvaliteta ekonomskih politika i ekonomskih i političkih institucija. Fayissa and Nsiah (2010) pokazuju da doznake predstavljaju alternativan način finansiranja investicijama i pomažu u prevazilaženju ograničenja likvidnosti čime doprinose ekonomskom rastu. Negativna veza između doznaka i ekonomskog rasta potvrđena je u radu Chami, Fullenkamp & Jahjahe (2005) koji navode da prihod od doznaka smanjuje podsticaje za zapošljavanje čime se smanjuje ukupna produktivnost. Pored toga, zemlja emigracije su pogođene gubitkom stanovništva i ljudskog kapitala, odnosno odlivom mozgova. Docquier (2006) razmatra veliki deo literature fokusirajući se na dobitke i gubitke od odliva mozgova i zaključuje da je optimalna stopa emigracije kvalifikovanih radnika između 5 i 10%, dok je emigracija veća od 15% štetna za razvoj zemlje.

Perrons (2009) navodi da će efekat migracije na zemlju emigracije zavisiti od niza faktora kao što su priroda migracija (privremena, stalna, cirkularna, transnacionalna), ukupni tok

doznaka, veza između dijaspore i matične zemlje kroz transfer kapitala ili veština. Kapur and McHale (2009) koriste uzorak od 134 zemlje i zaključuju da međunarodna migracija povećava globalni dohodak per capita za 1 %, a smanjuje nejednakost između zemalja za 2%. Negativna korelacija između međunarodne migracije i nejednakosti potvrđena je u radovima: Stark, Taylor & Yitzhaki (1986), McKenzie & Rapoport (2007), Kahanec & Zimmerman (2009), Felbermayr et al. (2010), Sanderson (2013), Maestri et al. (2017); Kóczán & Loyola (2018); Guzi et al. (2021).

3. METODOLOGIJA ISTRAŽIVANJA

Uzorak se sastoji od 12 evropskih zemalja (Albanije kao jedine zemlje Zapadnog Balkana i 11 zemalja “novih” članica EU: Bugarska, Rumunija, Mađarska, Poljska, Slovačka, Slovenija, Hrvatska, Češka, Estonija, Letonija i Litvanija). Analiza obuhvata period od 2000. do 2020. godine pri čemu su podaci u petogodišnjim intervalima, u skladu sa podacima dostupnim za međunarodnu migraciju. Podaci su prikupljeni iz baza Svetske banke i Ujedinjenih nacija.

U istraživanju su korišćeni panel podaci koji imaju karakter balansiranih makro podataka. Za testiranje uticaja međunarodne migracije na dohodovnu nejednakost korišćena je sledeća jednačina:

$$GINI_{it} = \beta_0 + \beta_1 MIG_{it} + \beta_k X_{itk} + \varepsilon_i + v_t + u_{it}$$

gde je:

$GINI_{it}$ - zavisna varijabla i predstavlja Gini indeks u zemlji i u vremenu t,

MIG_{it} - nezavisna varijabla i merena je kao udeo emigranata u ukupnoj populaciji u zemlji i u vremenu t .

X_{kit} - kontrolna varijabla,

ε_i – individualni efekti,

v_t – vremenski efekti (t = 2000... 2020)

u_{it} – slučajna greška sa nultom srednjom vrednošću i konstantnom varijansom

Kontrolna varijabla X_{kit} uključuje BDP po stanovniku u zemlji i u vremenu t, stopu inflaciju u zemlji i u vremenu t, finalnu javnu potrošnju u zemlji i u vremenu t i upis u srednju školu u zemlji i u vremenu t.

Model fiksnih i slučajnih efekata je korišćen za ispitivanje uticaja nezavisnih promenljivih na zavisnu promenljivu. U cilju odabira adekvatnog i reprezentativnog modela, Hausman test je korišćen za izbor između modela fiksnih efekata i modela slučajnih efekata.

Nakon izbora odgovarajućeg modela, testirano je postojanje problema autokorelacije i heteroskedastičnosti primenom sledećih testova: Wooldridge test za identifikovanje problema autokorelacije, i Wald test za identifikovanje problema heteroskedastičnosti. U cilju dobijanja validnog statističkog zaključka kada su neke od pretpostavki osnovnog regresionog modela narušene, oslanjanje na robusne standardne greške je uobičajeno (Hoechle, 2007).

4. REZULTATI ISTRAŽIVANJA

Ekonomska interpretacija rezultata i njihova diskusija dati su u nastavku. Rezultati deskriptivne statistike uz obrazloženje vrednosti aritmetičke sredine, standardne

devijacije, minimalnih i maksimalnih vrednosti, asimetrije i spljoštenosti prikazani su u Tabeli 1.

Tabela 1. Deskriptivna statistika

	Gini indeks	Udeo emigranata u ukupnoj populaciji	DP per capita	Finalna javna potrošnja	Stopa inflacije	Upis u srednju školu
Broj opservacija	60	60	60	60	60	60
Aritmetička sredina	20,281	11,423	20.796,78	18,223	3,463	97,131
Standardna devijacija	2,652	9,072	9.830,985	2,749	6,355	9,275
Minimum	15,704	3,174	3.862,48	9,692	-4,298	71,078
Maksimum	24,905	44,065	43.005,55	22,433	45,667	115,605
Asimetrija	0,188	1,992	0,318	-1,458	5,040	-0,329
Spljoštenost	1,877	6,681	2,224	5,003	33,737	3,040

Izvor: Autori

Prosečno učešće emigranata u ukupnoj populaciji u posmatranom periodu iznosilo je 11,4%, prosečan BDP per capita 20,796, prosečna javna potrošnja 18,22% BDP-a, prosečna stopa inflacije 3,46%, i prosečan upis u srednju školu 97,1%. Prosečno odstupanje od srednjih vrednosti učešća emigranata u ukupnoj populaciji iznosilo je 9,07, prosečno odstupanje od srednjih vrednosti BDP per capita iznosilo je 9.830, prosečno odstupanje od srednjih vrednosti javne potrošnje 2,74, prosečno odstupanje od srednjih vrednosti stope inflacije 6,35%, a prosečno odstupanje od srednjih vrednosti upisa u srednju školu 9.275. Minimalno učešće emigranata u ukupnoj populaciji iznosilo je 3,17 u Hrvatskoj u 2000. godini, maksimalno učešće emigranata u ukupnoj populaciji od 44% imala je Albanija u 2020. godini. Minimalan BDP per capita iznosio je 3.862 dolara u Albaniji 2000. godine, a najveći BDP per capita iznosio je 43.005 dolara u Češkoj 2020. Godine. U posmatranom periodu minimalna javna potrošnja iznosila je je 9,69% BDP-a u Albaniji 2000. godine, a maksimalna 22,4% BDP-a u Litvaniji u 2000. godini. Minimalna stopa inflacije iznosila je -4,29% u Albaniji u 2010. godini, a maksimalna 45,6 u Rumuniji u 2000. godini. Minimalni upis u srednju školu iznosio je 71% u Albaniji 2000. godine, a maksimalni 115,6% u Estoniji u 2020. godini. Vrednosti koeficijenta asimetrije i spljoštenosti u svim slučajevima različite su od nule i ukazuju na odsupanje vrednosti ovih promenljivih od normalne raspodele.

U cilju provere korelisanosti i prirode veze između nezavisnih varijabli korišćen je Pirsonov koeficijent linearne korelacije (Pearson's Coefficient Correlation). U Tabeli 2 prikazani su rezultati korelacione analize.

Tabela 2. Korelaciona matrica

	Udeo emigranata u ukupnoj populaciji	BDP per capita	Finalna javna potrošnja	Stopa inflacije	Upis u srednju školu
Udeo emigranata u ukupnoj populaciji	1				
BDP per capita	-0,1943	1			
Finalna javna potrošnja	-0,8261	0,2724	1		
Stopa inflacije	-0,1943	-0,3440	0,0483	1	
Upis u srednju školu	-0,1622	0,5772	0,2849	-0,3259	1

Izvor: Autori

Rezultati korelacione analize pokazuje da između nezavisnih promenljivih postoji slaba ili neznatna korelacija, osim između promenljivih Finalna javna potrošnja i Udeo emigranata u ukupnoj populaciji gde postoji snažna korelacija ($r=0,82$). Međutim, kako je koeficijent korelacije u ovom slučaju neznatno iznad 0,8 može se zaključiti da u istraživanju problem multikolinearnosti ne postoji.

Metod slučajnih efekata je korišćen za ocenu uticaja nezavisnih promenljivih na zavisnu promenljivu u periodu od 2000. do 2020. godine (Hausman test: $\chi^2(4) = 6,58$ i $\text{prob} > \chi^2 = 0,1599$)

Pre tumačenja dobijenih ocena u Tabeli 3 prikazani su rezultati testiranja autokorelacije i heteroskedastičnosti. Rezultati testiranja postojanja heteroskedastičnosti pokazuju da se nulta hipoteza o nepostojanju heteroskedastičnosti ne prihvata jer $\text{chibar}2(01)=58,27$, a $p > \text{chibar}2 = 0,000$. Dakle, heteroskedastičnost postoji i varijansa rezidualnih odstupanja nije jednaka. Rezultati testiranja postojanja autokorelacije pokazuju da se prihvata nulta hipoteza o nepostojanju autokorelacije jer $F(1,11)=4,440$, a $p > F=0.0589$ i zaključuje se da ne postoji autokorelacija, odnosno slučajne greške nisu međusobno korelisane.

Tabela 3. Rezultati dijagnostičke provere

	Breusch and Pagan Langrangian multiplier test for random effects	Wooldridge test for autocorrelation
CIE-11+WB	$\text{chibar}2(01)=58,27$	$F(1,11)=4,440$
	$p > \text{chibar}2 = 0,000$	$p > F=0.0589$

Izvor: Autori

Nakon rešavanja problema heteroskedastičnosti i autokorelacije pokazatelji dobijeni u okviru analize panel regresije i regresioni koeficijenti su prikazani u Tabeli 4.

Tabela 4. Ocenjene specifikacije modela

	RE
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	CIE11+WB
Gini indeks	
Udeo emigranata u ukupnoj populaciji	-13.661** (4.8223)
BDP per capita	0,000076** (0.000018)
Finalna javna potrošnja	0.1635** (0.6288)
Stopa inflacije	0,0469** (0.0135)
Upis u srednju školu	-0.0218 (0.0211)
Konstanta	19.2373** (2.6273)
Broj opservacija	60
R ²	0,4028
Wald chi2(5)	51.10

Napomena: standardne greške su u zagradama, * p<0.1; ** p<0.05; *** p<0.01.

Izvor: Autori

Nakon sprovedene panel regresije u periodu od 2000. do 2020. godine u evropskim tranzicionim ekonomijama dobijeni su sledeći rezultati. U okviru posmatranog vremenskog intervala od 2000. do 2020. godine postoji pozitivan i statistički značajan uticaj emigracije na nejednakost dohotka. Porast emigracije za 1% uticaće na smanjenje nejednakosti za 13,6%. Na nejednakost dohotka neznatan pozitivan i statistički značajan uticaj ima BDP per capita. Porast BDP per capita za 1% usloviće neznatan porast nejednakosti približan nuli. Pozitivan i statistički značajan uticaj na nejednakost imaju i finalna javna potrošnja i stopa inflacije. Porast finalne javne potrošnje za 1% usloviće porast nejednakosti za 0,16%, a porast stope inflacije za 1% dovešće do porasta nejednakosti dohotka za 0,05%. Upis u srednju školu nema statistički značajan uticaj na nejednakost dohotka. Vrednost koeficijenta detreminacije od 0,403, pokazuje da je modelom objašnjeno 40,3% varijabiliteta zavisne promenljive Gini indeks.

5. ZAKLJUČAK

Među različitim faktorima koji utiču na ekonomsku nejednakost, međunarodnim migracijama se u poslednje vreme poklanja značajna pažnja, kako u Evropi, tako i u SAD i drugim delovima sveta. Jedan od razloga je to što migracije menjaju strukturu stanovništva u zemlji emigracije i imigracije u smislu distribucije društvenih i demografskih karakteristika, kao što su veštine, pol i starost, što može uticati na konkurenciju i blagostanje, sa posledicama po ekonomsku nejednakost. Migracija i nejednakost dohotka su u interakciji kroz različite kanale, od kojih neki deluju kroz strukturu stanovništva zemlje emigracije i zemlje imigracije. Drugi kanali se manifestuju kroz efekte na prirodu konkurencije na tržištu rada zemlje emigracije i zemlje imigracije. Postoje i kanali koji deluju na nejednakost kroz efekte migracije na poslovne, trgovinske,

investicione i inovativne obrasce. Takođe, institucije i politike mogu posredovati u odnosu između migracija i nejednakosti.

Predmet ovog istraživanja bila je analiza uticaja međunarodnih migracija na dohodovnu nejednakost u evropskim tranzicionim zemljama. Rezultati pokazuju da postoji negativan odnos između međunarodnih migracija i nejednakosti dohotka, odnosno porast emigracije iz evropskih tranzicionih ekonomija doprinosi smanjenju nejednakosti u dohotku u ovim zemljama. Ovakav rezultat ne iznenađuje imajući u vidu da doznake obezbeđuju značajan devizni priliv u ove zemlje i čine veliki udeo u BDP-u ovih zemalja. U 2019. godini prosečan udeo doznaka u BDP-u analiziranih zemalja iznosio je oko 4,5%, s tim da je ovo učešće veće u zemljama Zapadnog Balkana nego u zemljama CIE-11. Iako rezultati ovog istraživanja potvrđuju da emigracija može smanjiti nejednakost dohotka, odnos između migracije i ekonomske nejednakosti zahteva dalja istraživanja kako bi se mapirala njena složena interakcija sa različitim institucionalnim i političkim kontekstima, njena zavisnost od različitih vrsta migracija i njenog porekla i odredišta. Dobijeni rezultati su u skladu sa neoklasičnom ekonomskom teorijom koja predviđa da razlike u dohotku pokreću migracije i da, dugoročno gledano, međunarodne migracije doprinose smanjenju nejednakosti u dohotku.

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IMPACT OF INTERNATIONAL MIGRATION ON INCOME INEQUALITY IN EUROPEAN TRANSITION COUNTRIES

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ABSTRACT:

During the past three decades, significant transformations took place in the former European communist countries, which resulted in their integration into the global economy and an increase in living standards. However, the first few years of the transition to a market economy were accompanied by a drastic drop in output, an increase in unemployment, high inflation and an increase in inequality. Reducing income inequality is one of the most important economic and political issues in Europe, since it consists of heterogeneous countries characterized by disparities in per capita income. The subject of this paper is the analysis of the impact of international migration on the level of income inequality in transition countries that have joined the European Union, CEE-11 and the countries of the Western Balkans. The research used a panel regression model as a methodological framework, and the time frame was limited to the period 2000-2020. The results show that international migration contributes to the reduction of income inequality in the analyzed countries.

Keywords: *international migration, income inequality, European transition economies, panel regression*

FINANSIJSKO UPRAVLJANJE I KONTROLA NA PRIMJERU OBRAZOVNIH USTANOVA U BIH I SRBIJI

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SAŽETAK:

U radu smo se bazirali na jedan segment finansijskog upravljanja i kontrole u javnim institucijama, a to su obrazovne ustanove osnovnog, srednjeg i visokog obrazovanja u Bosni i Hercegovini i Srbiji. Autori rada su zaposleni u javnim ustanovama i na direktan, ili indirektan način, su uključeni u sistem uspostave i provođenja finansijskog upravljanja i kontrole: generisanje poslovnih procesa, aktivnosti, zapisa koji nastaju iz pomenutih aktivnosti, utvrđivanje rizika, otklanjanje rizika. U skladu sa tim ćemo prezentovati primjere problema i rješenja sa kojima smo se susreli u postupku uspostave i provođenja kao i primjere „dobre prakse“. Pored navedenog, u radu smo pokušali odgovoriti i na pitanje povezivanja sistema finansijskog upravljanja i kontrole sa ISO standardom te pripreme javnih ustanova, konkretno obrazovnih ustanova, za ISO certificiranje.

Ključne riječi: *finansije, kontrola, obrazovne ustanove, metoda analize i sinteze, metoda deskripcije*

1. UVOD

Zakonom o finansijskom upravljanju i kontroli u javnom sektoru propisano je da su sve javne institucije koje se finansiraju iz javnog budžeta ili javnih sredstava, kao i institucije i ustanove koje se finansiraju iz fondova i programa Europske unije, dužne primjenjivati odredbe Zakona i Pravila o finansijskom upravljanju i kontroli. Pomenuti zakon se odnosi i na javne obrazovne ustanove, jer se njihov rad velikim dijelom finansira iz javnih prihoda u skladu sa drugim zakonima i pravilnicima koji regulišu oblast obrazovanja.

Finansijsko upravljanje i kontrola obuhvata sve finansijske i nefinansijske procese i aktivnosti unutar obrazovne ustanove, sprovodi se na svim nivoima i obuhvata sva sredstva ustanove uključujući i sredstva dobijena iz drugih izvora. Sredstva iz drugih izvora mogu biti upisnine učenika i studenata, razni vidovi donacija, reatiranje prostorija unutar ustanove ili prostorija i površina koje se nalaze pod upravljanjem obrazovne ustanove.

Svrha uspostavljanja sistema finansijskog upravljanja i kontrole, općenito, jeste praćenje usklađenosti poslovanja institucije sa propisima, politikama poslovanja, procedurama,

obavljanje aktivnosti na ekonomičan i efikasan način, zaštita imovine, pravovremeno finansijsko izvještavanje i praćenje rezultata poslovanja, kao i utvrđivanje rizika te svođenje rizika na minimum ili potpuno otklanjanje uz pomoć zakonskih i podzakonskih rješenja kao i internih akata ustanove.

Ovim rješenjem se omogućuje uključivanje većeg broja zaposlenika u samo poslovanje ustanove na različite načine kao koordinatora za provođenje, voditelja procesa, internih revizora (unutar same ustanove), komisija za utvrđivanje rizika i upravljanje rizicima i otklanjanje nedostataka.

U okviru jedne obrazovne ustanove moguće je da postoji više desetina definisanih procesa koji su povezani sa finansijskim upravljanjem i kontrolom i svaki od tih procesa mora imati rukovodioca odnosno voditelja procesa.

Provođenjem sistema finansijskog upravljanja i kontrole, u teoriji, trebao bi biti olakšan rad zvaničnom rukovodstvu obrazovne ustanove jer bi većina zaposlenika u obrazovnoj ustanovi ako ne i svi bili uključeni na određeni način. Da li je to baš u praksi tako?

2. PROBLEMI PRI IMPLEMENTIRANJU FINANSIJSKOG UPRAVLJANJA I KONTROLE

U praksi se pokazalo da postoji veliki broj problema pri samom provođenju sistema. Ovdje ćemo navesti neke od problema sa kojima smo se lično susretali pri provođenju kao i probleme iz iskustva kolega koji su bili zaduženi za provođenje sistema.

Osnovni problem jeste sam menadžment obrazovnih ustanova koji nije shvatao ili razumio ozbiljnost provođenja sistema finansijskog upravljanja i kontrole gdje su kasnili sa delegiranjem koordinatora za implementiranje sistema ili to još uvijek nisu učinili. Zbog obima posla, pri uspostavi samog sistema, jako je teško unutar kolektiva pronaći osobu koja je dovoljno odgovorna, sposobna i puna entuzijazma da se prihvati poslova koordinatora. Usljed svega navedenog na nivou Federacije Bosne i Hercegovine je u 2023. godini samo 45% ustanova dostavilo potrebnu dokumentaciju kroz PIFC aplikaciju¹. U Republici Srpskoj su sa implementacijom sistema počeli još nešto ranije tokom 2019. godine. Zbog uticaja pandemije bilo je zastoja u uspostavljanju sistema te se ponovo aktivno počelo raditi 2022. godine. Republika Srbija je započela svoje aktivnosti mnogo ozbiljnije gdje se putem javnih nabavki tražilo pravno lice za implementaciju sistema u obrazovnim ustanovama. Na taj način su probali prevazići problem informisanosti menadžmenta i koordinatora.

Drugi problem je nedovoljno obuke, seminara i konferencija, za koordinate unutar obrazovnih ustanova kao i za direktore obrazovnih ustanova. Koordinatori bi trebali biti osobe iz reda zaposlenika obrazovnih ustanova koji nisu direktno zaposleni na poslovima vezanim za finansije ili računovodstvo zbog same transparentnosti procesa i aktivnosti. Unutar obrazovne ustanove postoji direktor ustanove koji je zakonski odgovorna osoba za procese i aktivnosti koji se provode u ustanovi. Osim direktora, u okviru ustanove može i trebala bi biti imenovana odgovorna osoba za provođenje sistema koja dalje formira radnu grupu i zajedno sa radnom grupom kreira procedure za poslovanje. Procedure poslovanja moraju biti usaglašene sa Ustavom, Zakonom, izmjenama i dopunama Zakona koji se

¹ interni podaci koordinatora

odnose na obrazovanje, obrazovne ustanove i finansije, pravilnicima, izmjenama i dopunama pravilnika za navedene oblasti, standardima, kao i odlukama ministara vezanim za oblasti obrazovanja i finansija u obrazovnim ustanovama. Na osnovu utvrđenih procedura, formiraju se procesi, iz procesa proizilaze aktivnosti i na osnovu aktivnosti nastaju zapisi kao dokumenti koji se arhiviraju na mjesto predviđeno za dokumentaciju finansijskog upravljanja i kontrole i dostupni su u svakom trenutku internoj kontroli obrazovne ustanove a po potrebi i eksternoj kontroli. Usljed nedovoljne obučeniosti direktora i nerazumijevanja, sistem se uglavnom nije implementirao navedenim redoslijedom jer se osporavalo propisivanje procedura unutar ustanove time da obrazovne ustanove nisu u mogućnosti pisati ili usvajati bilo kakve akte bez Ministarstva obrazovanja jer su obrazovne ustanove u njihovoj nadležnosti, iako je procedurama trebalo biti jasno definisano funkcionisanje jedinki unutar sistema finansijskog upravljanja i kontrole.

Treći problem je generalni „strah od nepoznatog“ gdje su zaposlenici, nastavno i nenastavno osoblje u obrazovnim ustanovama odbijali da se aktivno uključe u implementaciju sistema uglavnom iz razloga što nisu razumjeli vezu između poslova koje obavljaju i finansija, kao i lošeg interesovanja za savladavanje nekih novih vještina. Smatraju da su finansijski radnici i pravnici unutar ustanove zaduženi da rade taj dio posla u saradnji sa menadžmentom i da je to u njihovom opisu posla. Postoji jako puno zakonskih i podzakonskih akata koje je potrebno pročitati i razumjeti kako bi se moglo po njima postupati. Pri tome, ti zakonski i podzakonski akti mogu a ne moraju imati nikakvih dodirnih tačaka sa samim pedagoškim radom zaposlenika kao što su zakon o slobodi pristupa informacijama, zakon o elektronskom potpisu, zakon o javnom informisanju, itd. Na primjer, pregled zakonskih i podzakonskih akata za jedan proces organizacije nastave u srednjoj školi sadrži 20 akata i tu listu je potrebno dopunjavati ukoliko dođe do izmjena i dopuna, odnosno promjene važećih akata. U uvodu je pomenuto da može biti definisano na desetine procesa unutar jedne ustanove. Kada se upoznaju sa činjeničnim stanjem, postaje izražena slaba zainteresovanost zaposlenika za usavršavanje iz navedene oblasti pa čak i onda kada se obuka održava unutar ustanove u kojoj su zaposleni gdje je posjećenost do 30% od ukupnog broja zaposlenih u ustanovi¹.

Iz prethodnog proizilazi sljedeći problem a to je slaba motiviranost zaposlenika jer dobijaju dodatnu odgovornost i posao koji bi se trebao kvalitetno završiti a najčešće nije plaćen i nije predviđen pedagoškim standardima i 40-časovnom radnom sedmicom radnika u obrazovnoj ustanovi. Osim navedenog, problem predstavljaju i rizici ili adekvatna procjena rizika zbog različitog tumačenja zakonskih odredbi i njihove primjene, kao i subjektivnosti ili objektivnosti i nedovoljnom iskustvu radnika koji rade na procjeni rizika.

Primjetan je nedostatak kadra koji se prethodno susretao sa nekim oblikom standardizacije, bilo kroz javni ili privatni sektor a samim tim i nedostatak iskustva i kompetencija u ovoj oblasti. Detektovani problemi koji su navedeni kao i oni koji nisu predstavljeni u radu su realni problemi sa terena sa kojima su se suretali autori rada.

Navedeni problemi su pretežno organizacione i operativne prirode unutar same obrazovne ustanove, zavise od sistematizacije radnih mjesta i samog menadžmenta obrazovne ustanove.

¹ interni podaci autora

3. PRIMJERI DOBRE PRAKSE I POVEZANOST SA ISO STANDARDOM

Iako je uočen veliki broj problema u relativno kratkom vremenskom periodu od početka implementacije sistema finansijskog upravljanja i kontrole u obrazovnim ustanovama, postoje i svijetli primjeri ili primjeri dobre prakse. Neke od njih smo već naveli prethodno u radu, na primjer ustanove u Srbiji uvođenje sistema i obuke zaposlenika rade kroz eksterne pravne subjekte putem javnih nabavki i na taj način pospješuju sam kvalitet kadra koji će dalje raditi na implementaciji sistema u obrazovnim ustanovama. Stiču se dobre osnove za dalji rad i napredovanje u tom segmentu.

Pored navedenog, iako je manje od polovine ustanova u FBiH dostavilo podatke kroz PIFC aplikaciju u 2023. godini JU Gimnazija „Meša Selimović“ Tuzla je dobila pohvale od federalnog koordinatora za implementaciju finansijskog upravljanja i kontrole kao obrazovna ustanova koja može biti primjer kako se vode procesi i dokumentacija nastala iz tih procesa.

Do decembra 2023. godine definisano 11 procesa unutar ove obrazovne ustanove uključujući pregled važećih zakonskih i podzakonskih akata po organizacionim jedinicama, popis važećih internih akata, mape poslovnih procesa, utvrđivanje rizika, procjenu rizika, mjere za ublažavanje rezidualnog rizika.

Neki od procesa su:

- proces izrade finansijskih izvještaja
- proces obračuna plata i naknada
- proces godišnjeg popisa imovine i obaveza
- proces organizacije informacionog sistema
- proces organizacije nastave
- proces evaluacije nastave
- proces eksterne mature i sl.

U nastavku su tabelarni prikazi utvrđivanja rizika, procjene rizika kao i mjere ublažavanja za proces organizacije informacionog sistema. Zbog raznih ograničenja, u smislu pisanja rada kao i autorskih prava i poslovne tajne nismo u mogućnosti prikazati kompletnu dokumentaciju za jedan proces.

NAZIV ORGANIZACIJE:		JU GIMNAZIJA „MEŠA SELIMOVIC“				
NAZIV ORGANIZACIONE JEDINICE:		IT				
Rbr.	PROCES	CILJ	RIZIK	KATEGORIJA RIZIKA	UZROK RIZIKA	UTJECAJ / POSLJEDICA
	Proces organiziranja informacionog sistema	Učinkovito upravljanje podacima	Sigurnost podataka: neovlašteni pristup, krađa identiteta	Operativni i pravni rizik	Ljudski faktor i informacione tehnologije	Interno i eksterno poslovanje ustanove
	Proces organiziranja informacionog sistema	Automatizacija administrativnih procesa	Tehnički problemi	Finansijski i organizacijski	Ljudski faktor i informacione tehnologije	Interno i eksterno poslovanje ustanove
	Proces organiziranja informacionog sistema	Olaškavanje komunikacije između profesora, učenika, roditelja i administracije	Gubitak podataka i zloupotreba informacija	Finansijski, organizacijski i pravni	Ljudski faktor i informacione tehnologije	Interno i eksterno poslovanje ustanove
	Proces organiziranja informacionog sistema	Podrška nastavnim procesima	Nedostatak backupa i oporavka podataka	Organizacijski i operativni	Ljudski faktor i informacione tehnologije	Interno i eksterno poslovanje ustanove
	Proces organiziranja informacionog sistema	Sigurnost podataka	Cyber sigurnost: zlonamjerno softveri i pokušaji prevare	Finansijski, operativni i pravni	Ljudski faktor i informacione tehnologije	Interno poslovanje ustanove
	Proces organiziranja informacionog sistema	Efikasno upravljanje resursima	Nedostatak fizičke sigurnosti	Operativni i finansijski	Ljudski faktor	Interno i eksterno poslovanje ustanove
	Proces organiziranja informacionog sistema	Povećanje dostupnosti obrazovnih resursa	Nedostatak obuke korisnika	Finansijski i organizacijski	Ljudski faktor i informacione tehnologije	Interno i eksterno poslovanje ustanove

Slika 1. Utvrđivanje rizika za proces organizacije informacionog sistema

NAZIV ORGANIZACIJE:		JU GIMNAZIJA „MEŠA SELIMOVIC“									
NAZIV ORGANIZACIONE JEDINICE:		IT									
Rbr.	RIZIK	OCJENA INHERENTNOG RIZIKA (Rizik ocijenjen u odsutnosti bilo kakvih kontrola)				OCJENA REZIDUALNOG RIZIKA (uzimajući u obzir provedene interne kontrole i mjere za ublažavanje)					
		VJEROVATNOŠĆA (1-5)	UTJECAJ (1-5)	UKUPNO	OCJENA RIZIKA	VJEROVATNOŠĆA (1-5)	UTJECAJ (1-5)	UKUPNO	OCJENA RIZIKA		
	Učinkovito upravljanje podacima	2	2	4	Nizak prioritet	Zakonske mjere	Aдекватne mjere	1	1	1	Nizak prioritet
	Automatizacija administrativnih procesa	3	1	3	Nizak prioritet	Zakonske mjere, primjena pravilnika	Aдекватne mjere	1	1	1	Nizak prioritet
	Olaškavanje komunikacije između profesora, učenika, roditelja i administracije	3	2	6	Srednji prioritet	Zakonske mjere	Aдекватne mjere	1	1	1	Nizak prioritet
	Podrška nastavnim procesima	2	2	4	Nizak prioritet	Zakonske mjere	Aдекватne mjere	1	1	1	Nizak prioritet
	Sigurnost podataka	3	3	9	Srednji prioritet	Zakonske mjere	Aдекватne mjere	1	1	1	Nizak prioritet
	Efikasno upravljanje resursima	2	1	2	Nizak prioritet	Zakonske mjere	Aдекватne mjere	1	1	1	Nizak prioritet

Slika 2. Procjena rizika za proces organizacije informacionog sistema

NAZIV ORGANIZACIJE:		JU GIMNAZIJA „MEŠA SELIMOVIC“							
NAZIV ORGANIZACIONE JEDINICE:		IT							
Rbr.	RIZIK	VISTA ODGOVORA NA RIZIK	DODATNE MJERE ZA UBLAŽAVANJE	REZULTAT MJERE	POTREBNI RESURSI	VLASNIK ZADATKA	ROK	VEZA S DRUGIM ORGANIZACIONIM JEDINICAMA I ORGANIZACIJAMA	PRIORITET
	Učinkovito upravljanje podacima	Smanjenje rizika	Edukacija zaposlenika	Smanjenje vjerovatnosti događaja rizika	Ljudski resursi, IT resursi	Organizaciona jedinica, organizacija	31.12.2023.	Nastava	Nizak prioritet
	Automatizacija administrativnih procesa	Smanjenje rizika	Edukacija zaposlenika	Smanjenje vjerovatnosti događaja rizika	Ljudski resursi, materijalni resursi	Organizaciona jedinica, organizacija	31.12.2023.	Nastava	Nizak prioritet
	Olaškavanje komunikacije između učitelja, učenika, roditelja i administracije	Smanjenje rizika	Kontinuirano praćenje i ocjena rizika	Smanjenje vjerovatnosti događaja rizika	Ljudski resursi, IT resursi	Organizaciona jedinica, organizacija	31.12.2023.	Nastava	Nizak prioritet
	Podrška nastavnim procesima	Smanjenje rizika	Kontinuirano praćenje i ocjena rizika	Smanjenje vjerovatnosti događaja rizika	Ljudski resursi, IT resursi, finansijski	Organizaciona jedinica, organizacija	31.12.2023.	Nastava	Nizak prioritet
	Sigurnost podataka	Smanjenje rizika	Sigurnosna politika i postupci	Smanjenje vjerovatnosti događaja rizika	Ljudski resursi, IT resursi	Organizaciona jedinica, organizacija	31.12.2023.	Nastava	Nizak prioritet

Slika 3. Mjere ublažavanja rezidualnog rizika za proces organizacije informacionog sistema

Uz ove definisane procese postoji baza od preko 50 različitih dokumenata vezanih za zakonske i podzakonske akte kao i različita interna dokumentacija koja je u korelaciji sa COSO modelom.

Implementacija ovog sistema je živ proces i konstantno se može unaprijeđivati i proširivati. Kroz rizike se uočavaju nedostaci i pronalaze rješenja za otklanjanje tih nedostataka.

Finansijsko upravljanje i kontrola u javnim institucijama bi se moglo posmatrati kao jedan segment standardizacije za sve javne ustanove unutar jedne države. Provođenjem sistema finansijskog upravljanja i kontrole postiže se transparentnost u radu, lakše je ispratiti novčane tokove javne ustanove jer su zapisi nastali iz aktivnosti deponovani na više različitih mjesta kao fizičke kopije ili u elektronskom obliku i pri tome svaki zapis mora biti potpisan od strane odgovorne osobe. Svi zapisi su dostupni koordinatoru, voditeljima procesa, internoj i eksternoj kontroli kao i odgovornim osobama unutar same ustanove.

Sa druge strane, privatne ustanove koje žele da dokažu svoju transparentnost i ozbiljnost u poslovanju kao i da olakšaju svoje poslovanje, provode standardizaciju najčešće sistemom ISO 9001 odnosno sistem upravljanja kvalitetom što je po svojoj strukturi najbliži sistemu finansijskog upravljanja i kontrole i imaju mnogo zajedničkih tačaka iako se ovdje ne bi trebalo ograničiti samo na sistem upravljanja kvalitetom. Standardizacija u bilo kojoj oblasti poslovanja je pozitivno rješenje i primjer dobre prakse.

4. ZAKLJUČAK

Implementacija sistema finansijskog upravljanja i kontrole u obrazovnim ustanovama ima mnogobrojne prednosti: transparentnost utroška i naplate sredstava, pregled imovine, procesi koji se odvijaju unutar ustanove ne ovise o pojedincima i nisu skriveni, u zavisnosti od interesa pojedinaca lako su dostupni, funkcionalnost osoblja ustanove se podiže na viši nivo jer je veći broj ljudi upućen u pojedine segmente poslovanja i može dati adekvatnu primjedbu, pospješuje se donošenje novih internih akata kao rješenje određenih problema a time se unapređuje rad obrazovne ustanove, na osnovu rizika moguće je pisati prijedloge ministarstvima za izmjenu i dopunu postojeće zakonske regulative.

Primjetan je nedostatak kvalifikovane radne snage u obrazovnim institucijama za obavljanje poslova implementacije sistema što se može prevazići povećanim brojem stručnih seminara na tu temu, prikazom konkretnih primjera kao što je urađeno u radu, stimulacijom radnika koji bi bili uključeni u implementaciju samog sistema finansijskog upravljanja i kontrole jer je to jedan od načina kako da se unaprijedi poslovanje obrazovne ustanove i uspješno implementira sistem.

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FINANCIAL MANAGEMENT AND CONTROL ON THE EXAMPLE OF EDUCATIONAL INSTITUTIONS IN BOSNIA AND HERZEGOVINA AND SERBIA

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ABSTRACT:

Our work was based on one segment of financial management and control in public institutions, namely educational institutions of primary, secondary and higher education in Bosnia and Herzegovina and Serbia. The authors of the paper are employed in public institutions and are directly or indirectly involved in the system of establishing and implementing financial management and control: generation of business processes, activities, records resulting from the mentioned activities, identification of risks, elimination of risks. Accordingly, we will present examples of problems and solutions that we encountered in the process of establishment and implementation, as well as examples of "good practice". In addition to the above, in the paper we tried to answer the question of connecting the financial management and control system with the ISO standard and the preparation of public institutions, specifically educational institutions, for ISO certification.

Keywords: *finance, control, educational institutions, method of analysis and synthesis, method of description*

ASSOCIATION BETWEEN MENTORSHIP AND CAREER DEVELOPMENT OF INSURANCE COMPANY EMPLOYEES

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ABSTRACT:

Career development is a multifaceted process, encompassing the evolution of occupational interests and competencies and the integration of work-life experiences over an individual's lifespan. The symbiosis between career development and mentorship is evidenced by the pivotal role that mentorship programs play in facilitating personal growth, professional skill enhancement, and the strategic navigation of career trajectories. The purpose of this study was to analyse the association between mentorship and the career development of renowned Serbian insurance company employees. The sample of this study consisted of seventy (n=104) participants. A two-component survey, digitally-delivered to participants, was used to collect data. The survey was filled out by participants and returned through the mail. Analysis of the data was conducted by (descriptive statistics, the Kolmogorov-Smirnov test, and the and the Pearson correlation coefficient) SPSS 21.0 (IBM SPSS 21.0, SPSS Inc., Chicago, USA). The main findings indicate a positive correlation between mentorship and career development (p=0.05), positively impacting employees' professional growth. Furthermore, a significant link between mentorship and improved job performance suggests that supported employees contribute more effectively to organisational objectives. These findings underscore mentorship's crucial role in fostering employees' career development.

Keywords: Professional growth, mentorship, association, development

1. INTRODUCTION

The insurance industry, characterised by its critical economic role and dynamic nature, demands continual professional development and adaptation as its sales acumen is oriented towards direct employee-client relationships (Mohy ul Din, Regupathi, & Abu-Bakar, 2017). Mentorship, a foundational element within this sector, significantly bolsters employees' skill sets and knowledge base, contributing to their professional growth in alignment with both individual career aspirations and overarching corporate goals (Kay, Hagan, & Parker, 2009). Bunjes and Canter (1988) provided foundational research that demonstrates how the business environment makes mentorship programmes indispensable for fostering employee growth, enhancing sales strategies, and driving organisational success. Career development is an essential element of organisational strategy, focusing on the systematic enhancement and progression of an individual's professional capabilities (Collings, 2014; Asplund, 2020). It encompasses planned learning activities, skill acquisition, and advancement opportunities, all designed to align employee goals with the

strategic objectives of the organisation (Dachner, Ellingson, Noe, & Saxton, 2021). A substantial body of literature highlights the benefits of mentorship, once again demonstrating its critical role in the development of individuals' careers (Linehan & Walsh, 1999; Higgins & Kram, 2001; Scandura & Williams, 2004). Within the rapidly evolving and competitive landscape of the insurance industry, mentorship constitutes a critical component of professional development strategies (Young, 2015). It involves experienced professionals providing guidance and support to less experienced colleagues, thereby facilitating the enhancement of their skills, knowledge, and workplace adaptability (Ragins & Kram, 2007). Although research in the field has advanced, existing studies on formal mentoring reveal several deficiencies: there has been insufficient focus on the roles of mentors, the reciprocal benefits for mentors and mentees, and the competencies that promote personal growth, especially in the insurance industry (Chun, Sosik, & Yun, 2012). Young (2015) also states that the challenge in business overall is the deficiency of efficacious mentoring schemes essential for cultivating future leaders, particularly as certain leaders in the financial insurance sector are uninformed about the strategic requisites of formal mentoring programmes aimed at leadership preparation. In the complex environment of insurance, where detailed product knowledge and intense client interactions are prevalent, the role of mentors is critical (Young, 2015). As heretofore stated, the aim of this study was to examine the association between mentorship and the career development of insurance company employees.

2. METHODS

Sample

Hundred and four male and female employees ($n = 104$) of a renowned insurance company in Serbia participated in three surveys. The selection of participants was based on the findings by Dreher and Ash (1990), which indicated that mentoring impacts career outcomes similarly for both genders. Therefore, the sample was randomly chosen without regard to gender, ensuring a balanced representation in the study.

Procedures and Measurements

Data was gathered through digital surveys distributed to participants. These surveys were completed by participants and returned via mail. For this research, three questionnaires were administered. The first survey, concerning "mentors' characteristics," included six statements, the second, addressing "mentors' engagement," comprised eight statements, and the third focused on "career development," also included eight statements. All surveys utilized a Likert scale, where a score of 1 represents "completely disagree" and 5 signifies "strongly agree." This method follows the framework suggested by Rad & Yarmohammadian (2006), which highlights the importance of creating and validating questionnaires for data collection and linking variables in empirical research that explores the relationships between management, leadership styles, and their effects on employee satisfaction. The thorough process of designing, developing, and validating these instruments emphasizes their importance in elucidating real-world phenomena via

empirical research methods. Similarly, the study by Podsakoff, MacKenzie, Moorman, and Fetter (1990), showcases the deployment of surveys to develop and validate a multidimensional scale of transformational leader behaviors and their impact on followers' trust in leader, satisfaction, and organizational citizenship behaviors, confirming the reliability and validity of the questionnaire. Their findings further support the utilization of survey questionnaires in capturing complex constructs between leadership and employees, which is essential for understanding mentorship and its influence on individual career development.

The first survey, focusing on "Mentors' characteristics," included six statements: 1) I see my mentor as an enthusiastic person (A1); 2) I see my mentor as a critically minded person (A2); 3) I see my mentor as a reliable person (A3); 4) I see my mentor as an anxious person (A4); 5) I see my mentor as a person who is open to new experiences and collaboration (A5); 6) I see my mentor as an empathetic person (A6).

The second survey, addressing "Mentors' engagement," comprised eight statements: 1) To what extent did the mentor assign challenging tasks that offered opportunities to learn new skills? (B1); 2) To what extent did the mentor help in developing skills for independent problem-solving and decision-making? (B2); 3) To what extent did the mentor demonstrate exemplary work methods and professional behavior? (B3); 4) To what extent was the mentor open to sharing personal experience that could help me in my career development? (B4); 5) To what extent did the mentor provide support in developing my individual talents and competencies? (B5); 6) To what extent did the mentor encourage independence in work and decision-making? (B6); 7) To what extent did the mentor demonstrate ways to stand out and advance within the company? (B7); 8) To what extent did the mentor show understanding and empathy towards personal and/or professional challenges? (B8).

The third survey focused on "Career development," also consisted of eight statements: 1) I possess extensive knowledge in my current field of work (C1); 2) I have a diverse set of skills that is applicable in various positions (C2); 3) My organization offers opportunities for advancement (C3); 4) My current job presents challenges and helps in improving skills (C4); 5) My job is a key part of my identity and I am strongly attached to it (C5); 6) I am confident in my ability to effectively manage and develop my career (C6); 7) I have clear personal career goals but understand what is needed to achieve them (C7); 8) I regularly receive feedback about my work that helps me identify areas for career improvement (C8).

Statistical analysis

The data was analysed with IBM SPSS 21.0. Descriptive statistics (mean values and standard deviation) were computed for each variable. The Kolmogorov-Smirnov test was used to check the normality of the data distribution, and Pearson's correlation analysis was used to determine the relationship between customer empowerment and sales performance.

3. RESULTS

Baseline characteristics of the sample, in total are presented below, in Table 1.

Table 1 - Descriptive statistics of the sample	
Number of participants	of N=104
Mean Age	41.4 ± 10.4 y
Length of employment (years)	7.08 ± 3.6 y

Legend: N: Number of participants; y: years.

The results of Pearson's correlation are presented below (Table 2.). Namely, the results were presented as follows: Significant correlations were flagged red with an added r (correlation coefficient value) value, while for non-significant correlations we presented only a p value.

Table 2. Results of Pearson's correlation analysis

	A1	A2	A3	A4	A5	A6
B1	.000** r = .579	.444	.000** r = .435	.069	.000** r = .562	.000** r = .574
B2	.000** r = .558	.020* r = .246	.000** r = .488	.04* r = .216	.000** r = .562	.642
B3	.000** r = .593	.130	.000** r = .488	.942	.000** r = .530	.000** r = .558
B4	.000** r = .542	.020* r = .245	.000** r = .501	.101	.000** r = .622	.08
B5	.000** r = .613	.493	.000** r = .498	.134	.000** r = .557	.001** r = .364
B6	.000** r = .623	.224	.000** r = .566	.068	.000** r = .577	.05* r = .111
B7	.000** r = .576	.668	.000** r = .456	.001** r = .455	.000** r = .538	.004** r = .375
B8	.000** r = .573	.173	.000** r = .423	.001** r = .402	.000** r = .531	.000** r = .370
C1	.249	.811	.746	.05* r = .101	.911	.988
C2	.068	.224	.599	.04* r = .098	.535	.166
C3	.000** r = .368	.001** r = .623	.001** r = .133	.04* r = .098	.000** r = .429	.168
C4	.000** r = .369	.000** r = .623	.001** r = .341	.01** r = .199	.000** r = .481	.04* r = .236

C5	.000** r = .439	.000** r = .623	.000** r = .361	.478	.000** r = .380	.148
C6	.034* r = .439	.789	.001** r = .382	.919	.171	.737
C7	.025* r = .237	.996	.06	.04* r = .237	.04* r = .118	.001** r = .432
C8	.000** r = .536	.955	.001** r = .347	.101	.01** r = .298	.000** r = .570

Legend: r – Pearson's correlation coefficient; * - p value significance of ≤ 0.05 ; ** - significance ≤ 0.01 ; A1 - I see my mentor as an enthusiastic person; A2 - I see my mentor as a critically minded person; A3 - I see my mentor as a reliable person; A4 - I see my mentor as an anxious person; A5 - I see my mentor as a person who is open to new experiences and collaboration; A6 - I see my mentor as an empathetic person; B1 - To what extent did the mentor assign challenging tasks that offered opportunities to learn new skills?; B2 - To what extent did the mentor help in developing skills for independent problem-solving and decision-making?; B3 - To what extent did the mentor demonstrate exemplary work methods and professional behavior?; B4 - To what extent was the mentor open to sharing personal experience that could help me in my career development?; B5 - To what extent did the mentor provide support in developing my individual talents and competencies?; B6 - To what extent did the mentor encourage independence in work and decision-making?; B7 - To what extent did the mentor demonstrate ways to stand out and advance within the company?; B8 - To what extent did the mentor show understanding and empathy towards personal and/or professional challenges?; C1 - I possess extensive knowledge in my current field of work; C2 - I have a diverse set of skills that is applicable in various positions; C3 - My organization offers opportunities for advancement; C4 - My current job presents challenges and helps in improving skills; C5 - My job is a key part of my identity and I am strongly attached to it; C6 - I am confident in my ability to effectively manage and develop my career; C7 - I have clear personal career goals but understand what is needed to achieve them; C8 - I regularly receive feedback about my work that helps me identify areas for career improvement.

Table 2 shows the values of Pearson's correlation on the association between mentorship and the career development of insurance company employees. The main findings of this study indicated that there was a statistically significant correlation between many variables ($p < 0.01$) (Table 2). Firstly, a significant correlations were found between variables A1 with B1-B8 ($p = .000$) and A1 with C3-C8 ($p = 0.001$). Furthermore, a significant link was found between variable A2 and B2, B4, C3-C5 ($p = .001$). In addition, A3 showed a significant link with B1-B8, C3-C6 and C8 ($p < .001$). Moreover, a statistically significant association was found between A4 and B2, B7-C4 and C7 ($p < .04$). Besides, A5 showed a significant link with B1-B8, C3-C5, C7 and C8 ($p < 0.01$). To boot, A6 was significantly correlated with B1, B3, B5-B8, C4, C6 and C7 ($p < 0.03$). The study's main findings show that mentoring has a significant impact on the career development of insurance company employees. Specifically, better mentoring, or a better perception of the mentor, as well as a greater commitment of the mentor, is associated with better career development, i.e., better competence of employees in an insurance company. It is important to note that all correlations were of a positive type, which means that when one variable moves in a positive/larger direction, the other variable also moves positively. Namely, if the employee has a better perception of the mentor, the results of personal competence also increase.

4. DISCUSSION

The purpose of this study was to analyze the association between mentorship and the career development of insurance company employees. The main findings indicate a significant link between effective mentoring and enhanced career progression among employees in the insurance sector. Namely, better mentoring, or a better perception of the mentor, as well as a greater commitment from the mentor, is associated with better career development, i.e., better competence of workers in an insurance company. It is worth noting that all correlations were positive, which means that when one variable moves in a positive or larger direction, the other variable follows suit.

Fundamental research was conducted demonstrating how the business environment necessitates mentorship programmes for promoting employee growth, improving sales techniques, and driving organisational success (Bunjcs & Canter, 1988). Career development entails evaluating one's current situation and taking actions to advance to a better position in the future. It necessitates forward-thinking, careful evaluation, and purposeful movement towards certain goals. It demands a connection between thinking and acting. During this process, the mentor becomes a supporter. A mentor always addresses the mentee's questions about how to achieve his goals (Jyoti & Sharma, 2015). In support of this idea, our findings strengthen the body of literature that demonstrates a positive and significant association between mentorship and the career development of insurance company employees. As stated, there is scientific evidence that is in line with our results (Collings, 2014; Asplund, 2020; Chun, Sosik, & Yun, 2012; Young, 2015; Hackman & Oldham, 1976; Jyoti & Sharma, 2015). It is worth mentioning that although the previously mentioned studies were conducted in different countries, there were no differences in the results that would lead us to question whether mentoring has a different impact in different subcultures. From this, we can suggest that it is „well perceived mentor“ by the employee, and purposeful mentoring has positive effects on the career development of employees in insurance companies, regardless of gender, ethnicity, and other social factors. Mentors provide a secure environment for employees to experiment with new ideas without fear of punishment, encouraging them to attempt innovative approaches to workplace management and customer service, particularly in insurance companies. During this process, the mentee might develop competencies that will help him or her advance in his or her profession. The coaching method serves to establish links between mentor and mentee by providing guidance and comments with the goal of strengthening the mentee's decision-making abilities and increasing competence level, which aids in career growth (Jyoti & Sharma, 2015). Taking into account the previous information, we can highlight the importance of the perception of the mentor by the employee in order to create the most pleasant working environment that aims at improvement and career development. Mentorship has a positive impact on career development because, during the mentoring relationship, the mentee is able to develop internal and external networks that help him or her enhance their knowledge of career opportunities and develop their careers appropriately (Ragins & Scandura, 1999). This study is especially essential for global managers and workers because most organisations deploy their bright personnel to crucial international tasks. As a newbie, it might be

challenging to adapt to the host country's culture and surroundings. In such a case, assigning mentors to advise expats through their jobs and social norms would assist expatriate employees and mentees in better adjusting to their new surroundings. Mentoring makes it easier for employees and managers to acquire and share information in a global context (Jyoti & Sharma, 2015). In this regard, this type of study can help to show the importance of mentoring not only for a start-up but also for later career development.

Given that the results of this study are based on the perception of the mentor by the employee as well as the perception of self-competence, we can say that the two mentioned variables are significantly related (Table 2). Namely, by conducting this type of study, it gives us an insight into the relationship between mentoring and career development and can help, in a practical sense, to create a model of a „good mentor“ in the branch of insurance companies. This study had some limitations that should be highlighted. First, we used a cross-sectional study design, which cannot establish causal associations between variables. In future investigations, we recommend using a longitudinal design to validate our and other cross-sectional findings. Second, the variable was measured using the self-reporting method in an electronic setting, which could lead to a method effect. Therefore, we recommend a third-party evaluation of career development as well as mentoring. Additionally, just one well-known insurance company was sampled. This could have an impact on the reproducibility of our results, and extending these findings to other parts of the region requires evaluation. Therefore, future studies should include different insurance firms. Finally, insurance firms are prone to change. Management structures, policies, and strategies may change throughout time, affecting the validity and application of study findings for implementation in future organisations.

3. CONCLUSION

Career development is a comprehensive process that includes the progression of occupational interests and competencies. The symbiosis between career development and mentorship is evidenced by the pivotal role that mentorship programmes play in facilitating personal growth, professional skills, etc. Therefore, the purpose of this study was to examine associations between mentorship and the career development of insurance company employees. The major findings of this study suggest that mentorship has a substantial impact on the career development of insurance company personnel. Specifically, stronger mentorship, or a better view of the mentor, as well as a greater dedication of the mentor, is connected with better career development, i.e., improved competence of insurance business employees.

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IMPACT OF INTERNATIONAL MIGRATION ON INCOME INEQUALITY IN EUROPEAN TRANSITION COUNTRIES

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ABSTRACT:

During the past three decades, significant transformations took place in the former European communist countries, which resulted in their integration into the global economy and an increase in living standards. However, the first few years of the transition to a market economy were accompanied by a drastic drop in output, an increase in unemployment, high inflation and an increase in inequality. Reducing income inequality is one of the most important economic and political issues in Europe, since it consists of heterogeneous countries characterized by disparities in per capita income. The subject of this paper is the analysis of the impact of international migration on the level of income inequality in transition countries that have joined the European Union, CEE-11 and the countries of the Western Balkans. The research used a panel regression model as a methodological framework, and the time frame was limited to the period 2000-2020. The results show that international migration contributes to the reduction of income inequality in the analyzed countries.

Keywords: *international migration, income inequality, European transition economies, panel regression*

AN APPROACH TO MARKETING MANAGER SELECTION BASED ON THE USE OF THE PIPRECA-S METHOD

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ABSTRACT:

The selection of suitable managers for important positions in the organization can have a significant impact on the efficiency and functioning of the organization. Therefore, this article presents a multi-criteria decision procedure for personnel assessment in the hospitality industry based on the use of the Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) method. The applicability and usability of the proposed approach was examined using the example of the selection of a marketing manager in hospitality industry, but can easily be adapted for similar cases of candidate selection.

Keywords: *marketing manager, personnel selection, hospitality industry, MCDM, PIPRECIA-S*

1. INTRODUCTION

According to definition provided by American Marketing Association marketing (management) is the process of planning and executing the conception, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational goals [1]. Kotler [2] considers marketing management as the art and science of applying core marketing concepts to choose target markets and get, keep, and grow customers through creating, delivering, and communicating superior customer value.

In the field of human resources management, the process of personnel selection is recognized as a fundamental concern. The efficacy of this process directly influences the quality and productivity of the workforce.

Personnel selection and evaluation can be described as one of the current research trends in the field of multiple criteria decision making (MCDM). The following researches can be mentioned as some of the significant researches in the mentioned field: Taylor et al. [3]

use the AHP method to evaluate candidates, while Kusumawardani and Agintiara [4] combine AHP and TOPSIS methods for evaluation. Baležentis et al. [5, 6] and Deliktas and Ustun [7] applied MULTIMOORA method, while Stanujkic [8] combine MULTIMOORA, WASPAS and WISP methods for candidate selection. Urosevic et al. [9] and Karabašević et al. [10] combine SWARA and WASPAS methods for personnel selection.

Unfortunately, the problem of selecting marketing managers was not sufficiently addressed using MCDM methods, and such researches are rare. As one of such research can be mentioned Chen et al. [11] which uses 2-tuple linguistic variable and fuzzy PROMETHEE method to select the best overseas marketing manager.

The Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) method [12], is actually simplified variant of Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA) method, proposed by Stanujkic et al. [13]. Although PIPRECIA-S was recently proposed, it has been used in several studies so far, mainly for determining criteria weights. However, PIPRECIA-S, in addition to determining the criteria weights, can also be used for the complete solution of MCDM problems [14-18], similar to the AHP, SWARA, or PIPRECIA methods.

This article presents the application of the PIPRECIA-S method for the evaluation of marketing manager. Therefore, the rest of article is organized as follows: In Section 2 the PIPRECIA-S is presented in details, and in section 3 an empirical illustration of marketing manager evaluation in an hospitality industry is considered, with the aim to explain in detail the proposed approach. Finally, the conclusions are given at the end of the article.

2. MATERIAL AND METHODS

This part of the article presents the calculation procedure of the PIPRECIA-S method, as well as one of its applications in the group decision-making environment, based on the theory of dominance.

2.1. The Simplified Pivot Pairwise Relative Criteria Importance Assessment method

As earlier mentioned the PIPRECIA-S method [13] was proposed with the aim to enable easier determining criteria weights, compared with PIPRECIA or SWARA methods. The computational procedure of PIPRECIA-S method used for evaluating m criteria or alternatives can be presented as follows:

Step 2. Set the relative significance s_j of each criterion or alternative, except the first, as follows:

$$s_i = \begin{cases} > 1 & \text{if } E_i > E_1 \\ 1 & \text{if } E_i = E_1, \\ < 1 & \text{if } E_i < E_1 \end{cases} \quad (1)$$

where E_i denotes the significance or performance of i -th criterion or alternative. Similar to the PIPRECIA method, the value of s_1 is set to 1, while values of s_i belong to the interval (1, 1.9] when $E_i > E_1$, that is to the interval [0.1, 1) when $E_i < E_1$.

Step 3. Calculate the coefficient k_i of each criterion or alternative, except the first, as follows:

$$k_i = 2 - s_i. \quad (2)$$

In the PIPRECIA-S method the k_1 is set to 1.

Step 4. Calculate the recalculated weight q_j of each criterion or alternative, except the first, as follows:

$$q_i = \frac{1}{k_i}. \quad (3)$$

In the PIPRECIA-S method the q_1 is set to 1.

Step 5. Determine the relative weights of the evaluation criteria w_i or importance of alternative in relation to the criteria I_{ij} in relation of the criteria as follows:

$$w_i = \frac{q_i}{\sum_{k=1}^n q_k}, \text{ or} \quad (4)$$

$$I_{ij} = \frac{q_i}{\sum_{k=1}^m q_i}. \quad (5)$$

Step 6. Determine the overall importance of each alternative as follows:

$$S_i = \sum_{j=1}^n I_{ij} w_j. \quad (6)$$

2.2. Application of the PIPRECIA-S method in group decision-making, based on the theory of dominance

As is evident, the PIPRECIA-S method, as well as the PIPRECIA and SWARA methods, can be used in various ways in group decision-making. However, one of the simplest approaches is the approach based on dominance theory, which is similar to the approach proposed in the MULTIMOORA method. In this approach, the alternative with the highest number of appearances in the first position is considered the most acceptable.

3. A NUMERICAL ILLUSTRATION OF THE PIPRECIA-S ON THE EXAMPLE OF SELECTING A MARKETING MANAGER IN HOSPITALITY INDUSTRY

In order to present the usability of the PIPRECIA-S method, a numerical illustration of selecting a marketing manager is considered in this section. Five candidates for position of marketing manager were evaluated based on the following criteria: Education (C_1), Relevant work experience (C_2), Relevant certificates (C_3), Communication and presentation skills (C_4), People management skills (C_5), Organizational and planning skills (C_6), and Foreign language skills (C_7).

The criteria weights calculated using PIPRECIA-S method, as well as calculation details, are presented in Table 1.

Table 1. Criteria weights

Criteria	s_j	k_j	q_j	w_j
C_1		1	1	0.12
C_2	1.20	0.80	1.25	0.15
C_3	1.20	0.80	1.25	0.15
C_4	1.10	0.90	1.11	0.13
C_5	1.30	0.70	1.43	0.17
C_6	1.25	0.75	1.33	0.16
C_7	1.10	0.90	1.11	0.13

The values for k_j , q_j and w_j , in the previous table, were calculated using Eqs. (2) – (4).

The evaluation of five candidates, two of whom had completed their respective studies, two of whom had not yet graduated and one of whom had completed a Master's degree, is shown in the following tables. This simulation was carried out on the basis of information from a real job interview previously conducted in a company. The procedure for calculating the candidate's competence on the basis of the first and the second criterion are detailed in Table 2 and Table 3, while the competences of the evaluated candidates in relation to the selected criteria are summarized in Table 4.

Table 2. Competence of evaluated candidates in relation to the first criterion

Candidate	s_i	k_j	q_j	I_j
A_1		1	1	0.18
A_2	1.00	1.00	1.00	0.18
A_3	0.80	1.20	0.83	0.15
A_4	1.10	0.90	1.11	0.20
A_5	1.35	0.65	1.54	0.28

The values for k_j , q_j and w_j , in the previous table, were calculated using Eqs. (2), (3) and (5).

Table 3. Competence of evaluated candidates in relation to the first criterion

Candidate	s_i	k_j	q_j	I_j
A_1		1	1	0.20
A_2	1.1	0.90	1.11	0.22
A_3	1.2	0.80	1.25	0.24
A_4	0.9	1.10	0.91	0.18
A_5	0.8	1.20	0.83	0.16

Table 4. Competencies of evaluated candidates in relation to all criteria

	C₁	C₂	C₃	C₄	C₅	C₆	C₇
w_j	0.12	0.15	0.15	0.13	0.17	0.16	0.13
A_1	0.18	0.20	0.15	0.20	0.23	0.21	0.18
A_2	0.18	0.22	0.19	0.22	0.22	0.21	0.16
A_3	0.15	0.24	0.19	0.20	0.18	0.18	0.15
A_4	0.20	0.18	0.22	0.15	0.17	0.17	0.26
A_5	0.28	0.16	0.24	0.22	0.19	0.23	0.26

Table 4 also shows the weights of the criteria. Based on the data from Table 4, Table 5 shows the summarised competencies of the evaluated candidates.

Table 5. The summary competencies of five candidates

	I₁	I₂	I₃	I₄	I₅	I₆	S_i	Rank
A_1	0.02	0.03	0.02	0.03	0.04	0.03	0.196	3
A_2	0.02	0.03	0.03	0.03	0.04	0.03	0.204	2
A_3	0.02	0.04	0.03	0.03	0.03	0.03	0.186	5
A_4	0.02	0.03	0.03	0.02	0.03	0.03	0.191	4
A_5	0.03	0.02	0.04	0.03	0.03	0.04	0.223	1

The overall importance of each candidate, *in the previous table, were calculated using Eq. (6).*

As can be observed from Table 5, applying the proposed approach, the candidate marked as A_5 was selected as the most suitable marketing manager.

The above-explained candidate evaluation procedure was repeated based on the attitudes of four more decision-makers (*DM*), and the achieved rankings of the candidates are summarized in Table 6.

Table 6. Ranking orders of candidates

	DM₁	DM₂	DM₃	DM₄	DM₅
A_1	3	1	2	1	2
A_2	2	3	3	2	3
A_3	5	5	4	4	5
A_4	4	4	5	5	4
A_5	1	2	1	3	1

As can be observed from the table above, candidate A_5 is ranked first three times and represents the best alternative, while candidate A_1 is ranked first twice and represents an alternative solution. The other candidates do not appear in first position and do not represent the right choice.

4. CONCLUSION

MCDM is recently used to solve a problems in various areas [19-21]. This article presents the procedure for applying the PIPRECIA-S method in the evaluation of candidates, i.e. in the selection of marketing manager. Additionally, this similar procedure can be adapted for assessing candidates across various other professional domains.

PIPRFECIA-S was proposed primarily with the aim of enabling decision-makers to easily determine the importance of criteria, but it can also be used to fully solve the problem of multi-criteria decision-making, as shown in this example. In addition, PIPRECIA-S can be easily applied for evaluation in cases of group decision-making, in a very simple way based on the dominance theory.

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MANAGEMENT OF DEVELOPMENT OF A SUSTAINABLE GASTRONOMIC TOURISM OFFER OF THE MORAVICA ADMINISTRATIVE DISTRICT (SERBIA)

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ABSTRACT:

Gastronomic tourism (gastro-tourism) is a form of tourism that is characterized by a high level of attractiveness on a global level. Following world trends, various forms of tourism offer based on food and drink have become one of the indispensable elements of the tourism offer of the Republic of Serbia, as a destination that has a variety of high-quality gastronomic products. Gastro-characteristics within Serbia differ among its individual geographical-administrative areas. The Moravica administrative district, as part of Serbia, also has gastro-tourism in its tourism offer, which is the subject of this paper. The aim is to establish the existing and potential elements of the gastro-tourism offer that could contribute to the sustainable development of the mentioned area. The focus is on the analysis of the state of agriculture, tourism events and gastronomic products by which the Moravica administrative district is recognizable or could be in the future. Also, an important element of development is the existence of educational institutions that enable formal education in the field of gastronomy, as well as the existence of scientific and research institutions in the field of agriculture. Based on the analysis of the current situation, guidelines were given for the management of the improvement of the gastro-tourism offer of the Moravica administrative district while simultaneously respecting the principle of sustainable tourism.

Keywords: *gastronomy, gastronomic tourism, sustainable tourism, tourism destination management, event tourism*

1. INTRODUCTION

Culinary tourism, or gastro-tourism, is a type of tourism that involves attracting tourists through food and drink offerings. Food and drink can be tourists' primary or secondary motivation to visit a particular destination. Gastro-tourism can be seen as a distinct form of tourism and an element of other forms of tourism. The key to understanding the concept of gastro-tourism lies in the attractiveness of food and drink for tourists.

Interest in gastronomy in tourism and hospitality is growing, as evidenced by the annual number of published papers ([1], [2]). Wine tourism is one of the most significant elements of gastro-tourism. This is confirmed by the number of papers on this topic [3], especially when compared with beer tourism, which, like wine, is also part of beverage tourism [4]. Sustainable tourism is becoming an increasingly relevant field of research ([5], [6]). Modern gastro-tourism is anything but simple food and drink consumption. That is just one component. Another component is the attractiveness of gastronomy [7].

The Moravica administrative district, a part of the Republic of Serbia, is a unique destination for gastro-tourism. Comprising of three municipalities – Gornji Milanovac, Lučani, and Ivanjica – and the city of Čačak, this district offers a distinct gastro-tourism experience, which is the paper’s subject. The aim of this paper is to identify the existing and potential elements of the gastro-tourism offered in this area, which can significantly contribute to its sustainable development.

2. AGRICULTURE

In each of the four administrative units of the Moravica administrative district, orchards cover over 2,000 hectares (Table 1). According to the criteria mentioned, they belong to the most significant municipalities and cities in the Republic of Serbia [8]. Within the total area of orchards, there are also plantation-type orchards. The largest areas of plantation orchards are in Čačak and Ivanjica (over 1,500 hectares), so according to the mentioned criteria, they also belong to the most significant municipalities/cities in the Republic of Serbia. Then follow Gornji Milanovac (1,000.1-1,500 hectares) and Lučani (500.1-1,000 hectares) [8].

Table 1. Fruit varieties in the Moravica administrative district (Authors; based on [8])

Fruit type		GM	ČA	LU	IC
Pome fruit	Apple	100.1-200	>1,000	200.1-500	200.1-500
	Pear	>100	>100	30.1-50	10.1-30
	Quince	>25	>25	≤5	≤5
Stone fruit	Plum	>1,500	>1500	1,000.1-1,500	1,000.1-1,500
	Sour cherry	≤30	30.1-100	≤30	≤30
	Cherry	≤10	100.1-200	≤10	≤10
	Apricot	10.1-50	>200	≤10	≤10
	Peach	≤10	10.1-50	≤10	≤10
	Nectarine	≤1	10.1-50	≤1	≤1
Nuts	Walnut	20.1-40	>60	5.1-20	5.1-20
	Hazelnut	≤15	15.1-30	≤15	≤15

Fruit type		GM	ČA	LU	IC
Aggregate fruit	Raspberry	>100	>100	>100	>1,000
	Blackberry	>50	>50	>50	>50

Notes: GM – Gornji Milanovac, ČA – Čačak, LU – Lučani, IC – Ivanjica.

Among the administrative units of the Moravica administrative district, Čačak is the most significant in terms of fruit cultivation. Čačak belongs to the group of most significant municipalities/cities in the Republic of Serbia in terms of apple, pear, quince, plum, apricot, walnut, raspberry, and blackberry orchard areas. After Čačak, Gornji Milanovac plays a vital role, belonging to the most significant municipalities/cities in the Republic of Serbia in pear, quince, plum, raspberry, and blackberry orchard areas. Lučani and Ivanjica belong to the most significant municipalities/cities in the Republic of Serbia regarding raspberry and blackberry cultivation areas. The conclusion is that raspberries and blackberries are fruit species whose cultivation is characteristic of the four administrative units of the Moravica administrative district.

In each of the administrative units of the Moravica administrative district, there are over 5,000 agricultural households. According to the criteria mentioned, they belong to the group of most significant municipalities/cities in the Republic of Serbia [9]. The total number of agricultural households in the entire district is 28,078. Over a third of agricultural households are in Čačak (10,602; 37.76%). After Čačak, Ivanjica follows (6,697; 23.85%), then Lučani (5,509; 19.62%), and Gornji Milanovac (5,270; 18.77%) [10].

Data on animal and plant cultivation in the Moravica Administrative District are shown in the following figure (Fig. 1). Poultry is the most represented, followed by a significant number of sheep. Pigs come next, while the smallest number is of cattle. Regarding plant cultivation, the most significant areas are occupied by fields and gardens, with a significant area of meadows and pastures. Vineyards are the least represented.

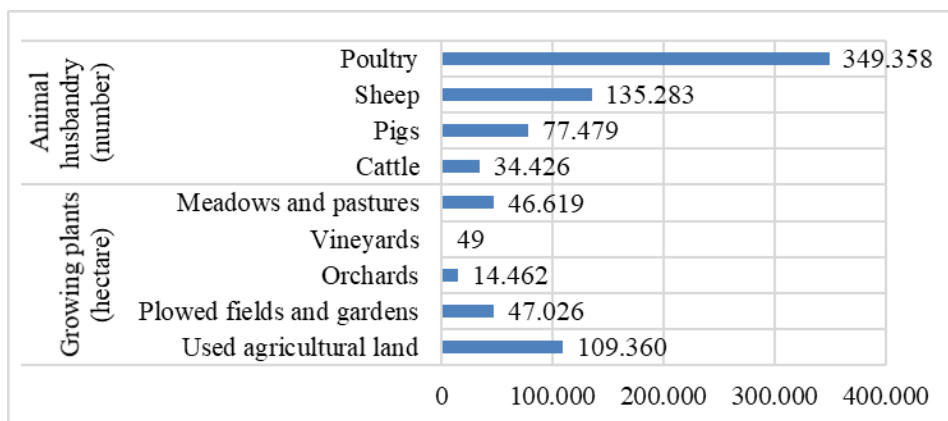


Fig. 1. Animal husbandry (number) and growing plants (hectares) (Authors; based on [10])

Čačak and Ivanjica belong to the category of municipalities/cities with 30,000.1-50,000 hectares of utilized agricultural land. Gornji Milanovac and Lučani belong to the category of municipalities/cities with 10,000.1-30,000 hectares of utilized agricultural land [9]. The most significant areas of utilized agricultural land (29.17%), fields and gardens (40.75%), orchards (31.19%), and vineyards (93.88%) are in Čačak (Fig. 2) [10]. Ivanjica has the largest areas of meadows and pastures (43.50%). Areas under vineyards in each municipality/city are ≤ 50 hectares [9]. More precisely, vineyards are only registered in Čačak and Lučani, with Lučani having a negligible presence [10].

The average utilized agricultural land per household by municipalities is highest in Gornji Milanovac (5.1-7), followed by Čačak, Lučani, and Ivanjica (3.1-5) [9]. According to the criterion of meadow and pasture areas, Gornji Milanovac and Ivanjica belong to the most significant municipalities/cities in Serbia ($>10,000$ hectares), which is not the case for Čačak and Lučani (5,001-10,000 hectares) [9]. Utilized agricultural land according to the irrigated area is >8 hectares [9], which positions the Moravica administrative district among the best-positioned municipalities/cities in Serbia according to the mentioned criterion. Unused agricultural land is most abundant in Ivanjica ($>10,000$ hectares), followed by Lučani (1,000.1-2,000 hectares), Gornji Milanovac, and Čačak ($\leq 1,000$ hectares) [9].

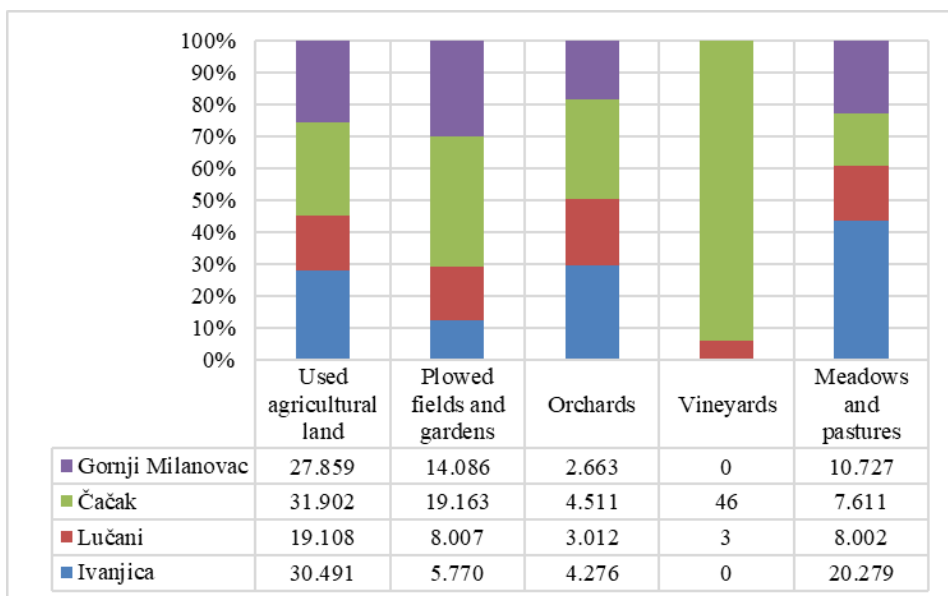


Fig. 2. Land use in agriculture (hectares) (Authors; based on [10])

Analyzing the available data (Fig. 3) [10], it is concluded that Čačak has the highest number of cattle (34.43%), pigs (57.39%), and poultry (52.98%). Gornji Milanovac has the highest number of sheep (31.07%).

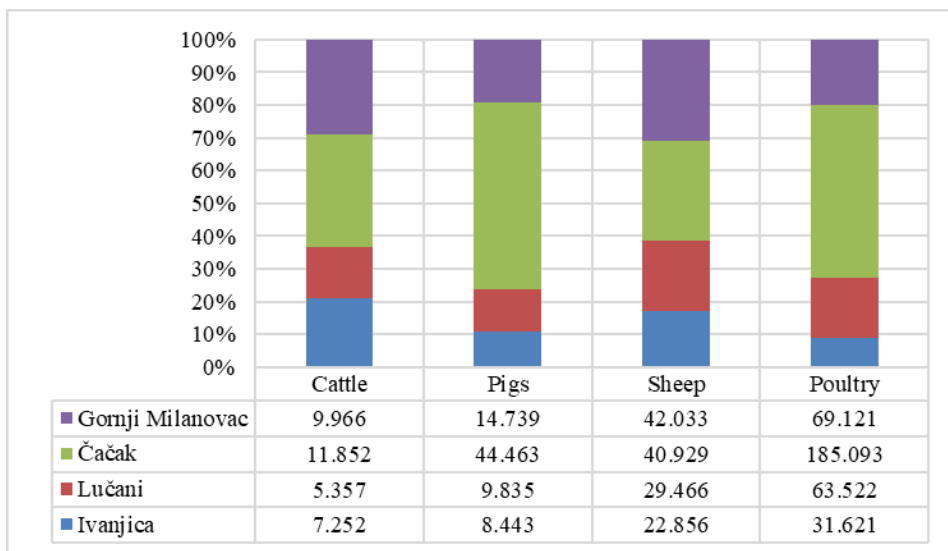


Fig. 3. Animal husbandry (Authors; based on [10])

3. GASTRONOMIC TOURISM EVENTS

Many tourist events are held in the Moravica administrative district, including gastronomic events. The following table (Table 2) provides basic information about what the authors of this paper consider to be the most significant gastronomic tourist events in the Moravica administrative district.

Table 2. Gastronomic tourism events

No	Name	Place	M/C	Initiation	Month
1	“Kupusijada”	Mrčajevci	ČA	2003	September
	Cabbage festival – cabbage cooking competition in clay pots.				
2	“Rakijada”	Pranjani	GM	2003	September / October
	Festival dedicated to brandy (“rakija”). Competitions: Best Fruit Brandy, Brandy Drinking, and Gibanica Making.				
3	“Plodovi zapadnog Pomoravlja”	Zablaće	ČA	2007	September
	Fruits of Western Pomoravlje – Economic-touristic event. Food exchange. Home brewing festival.				

No	Name	Place	M/C	Initiation	Month
4	“Dani srpske kajsije”	Miokovci	ČA	2009	July
	Serbian apricot days – Apricot festival – fruit and processed products.				
5	“Gulašijada”	Prijedor	ČA	2014	May
	Goulash festival – goulash cooking competition.				
6	“Dragačevski Hajduk fest”	Guča	LU	2018	June
	Competition in preparing Hajduk-style cevapi.				
7	“West Wine Fest”	Gradska plaža	ČA	2019	July
	Presentations of wine producers, as well as brandies and delicacies.				
8	“Cug Fest”	Park mladosti	ČA	2021	August
	Craft beer festival. Presentation of local brewers with a music and entertainment program.				
9	“Mlečni put”	Gornja Gorevnica	ČA	2022	September
	<i>Milky way – dairy and dairy products fair.</i>				

Notes: M/C – municipality/city; GM – Gornji Milanovac; ČA – Čačak; LU – Lučani.

The “Kupusijada” (Cabbage Festival) is singled out as one of the well-known food and beverage events in the Republic of Serbia [11]. Promoting certain gastronomic events in the Moravica administrative district is done through the Internet, but this method of promotion needs improvement, both in terms of website usage and social media [12]. Gastronomic tourist events are particularly characteristic of Čačak, while they are least represented in Ivanjica. Of course, other events with a gastronomic character are held throughout the year besides the ones mentioned.

4. GASTRONOMIC PRODUCTS

The Moravica administrative district has the potential for the development of gastronomic tourism by incorporating into the tourist offer good quality domestic food and beverages, as well as traditional food and beverages. There are hospitality establishments that provide services in the food and beverage sector. For example, the Tourist Organization of Čačak highlights restaurants, cafes and clubs, roast shops, pastry shops, and pizzerias among hospitality establishments [13]. Roasting is one of the most famous products for which Čačak is known.

Gastronomic products are characteristic of the Moravica administrative district and have a certain level of protection. Elements of the intangible cultural heritage of gastronomic type include [14]: 1) Šljivovica – western and central Serbia; Čačak; 2) Knowledge and skills of making kajmak – rural households in hilly and mountainous areas of central and western Serbia; Western Morava.

Among the products with a protected geographical indication at the national level is the Ivanjica potato [15]. At the international level, there is protection of geographical origin for certain alcoholic beverages [16]. In addition to the mentioned “protected” products,

cabbage, apricot, brandy, and other products are also essential as the basis for the aforementioned tourist events.

5. EMPLOYMENT, EDUCATION, AND SCIENTIFIC RESEARCH IN THE FIELD OF GASTRONOMY

In order to analyze employment in the gastronomy sector from a broader perspective, data on employment from several industries related to gastronomy have been considered. Regarding employees in legal entities, there were 660 (1.0%) in agriculture, forestry, and fishing, 22,352 (35.5%) in the manufacturing industry, and 2,421 (3.8%) in accommodation and food services. There were 1,430 (2.3%) registered individual farmers [10]. Data on employment according to the administrative units of the Moravica administrative district are shown in the following table (Table 3).

Table 3. Employment in the field of gastronomy [10]

	Employees in legal entities, entrepreneurs, persons who independently perform activities and their employees						Registered Individual Farmers	
	Agriculture, Forestry, and Fishing		Processing Industry		Accommodation and Catering Services			
	No	%	No	%	No	%	No	%
Gornji Milanovac	101	0.8	5,043	40.0	403	3.2	389	3.1
Čačak	167	0.5	11,489	31.2	1,506	4.1	495	1.3
Lučani	31	0.6	2,541	51.9	154	3.1	239	4.9
Ivanjica	361	4.2	3,278	38.0	358	4.1	307	3.6

The largest number of employees in all mentioned industries is in Čačak. By analyzing the percentage share in the total number of employed, it can be concluded that agriculture, forestry, and fishing are most significant in Ivanjica, manufacturing industry and registered individual agricultural workers in Lučani, and accommodation and food services in Čačak and Ivanjica.

The basis for preparing future and improving existing employees in the gastronomy sphere is the formal education system, including: 1) Secondary education, and 2) Higher education.

In the Moravica administrative district, three institutions of secondary education enrolled students in educational profiles in the broader field of gastronomy and gastronomic tourism in the 2023/2024 school year [17]: 1) Prehrambeno-ugostiteljska škola (Food and Hospitality School), Čačak, 2) Ekonomsko-trgovačka škola “Knjaz Miloš” (Economic and Commercial School “Knjaz Miloš”), Gornji Milanovac, and 3) Tehnička škola (Technical School), Ivanjica. Educational profiles in the broader field of gastronomy and gastronomic

tourism are implemented in two areas of work (Table 4): 1) Agriculture, food production, and processing, and 2) Trade, hospitality, and tourism.

Table 4. Educational Profiles in the Field of Gastronomy in Vocational High Schools (Authors; based on [17])

Field of Work	Educational Profile	Quota	Institution
Agriculture, Food Production, and Processing	Baker (3 years)	15	Food and Hospitality School, Čačak
	Food Industry Operator (3 years)	15	Food and Hospitality School, Čačak
	Food Technician (4 years)	30	Food and Hospitality School, Čačak
Trade, Hospitality, and Tourism	Waiter (3 years)	15	Food and Hospitality School, Čačak
		15	Technical School, Ivanjica
	Chef (3 years)	15	Food and Hospitality School, Čačak
		15	Economic and Commercial School “Knjaz Miloš”, Gornji Milanovac
		15	Technical School, Ivanjica
	Tourism Technician (4 years)	30	Food and Hospitality School, Čačak

By analyzing study programs [18], it is observed that no institution in the Moravica administrative district offers study programs in gastronomy. However, there are study programs indirectly related to the development of gastronomy. These study programs are conducted at the Faculty of Agronomy of the University of Kragujevac. This institution belongs to the technical-technological scientific field and offers the following study programs: 1) Undergraduate academic studies: zootechnics, fruit and grape growing, food technology, general agronomy; 2) Master’s academic studies: agronomy, food technology, zootechnics; 3) Doctoral academic studies: agronomy. Scientific research organizations in the Moravica administrative district that can be linked to gastronomy, from a broader perspective, are: 1) Fruit Research Institute in Čačak: scientific field – biotechnical sciences; type of institute: research and development institute [19]; 2) University of Kragujevac, Faculty of Agronomy in Čačak: scientific fields – biotechnical and technical-technological sciences [20].

6. CONCLUSION

The Moravica administrative district has possibilities for developing gastronomic tourism, but the degree of potential utilization has yet to reach an optimal level. The focus should

be on several points. First, efforts should be made to preserve existing and create new fruit-growing areas. Second, efforts should be made to preserve existing and increase the number of livestock. Livestock represents the basis for the production of quality meat and meat products, from which numerous food products are made. Third, it is necessary to develop existing gastronomic events, especially in terms of content, and promote them better. Fourth, promoting existing significant gastronomic products. Fifth, improving the state of agriculture, processing agricultural products, and providing accommodation and catering services. Sixth, the state of education in gastronomy should be improved, especially in the field of higher education. In addition to existing scientific research organizations, due to its importance and recognisability in this region, especially in the geographical areas of Dragačevo and Ivanjica, efforts should be made to strengthen scientific research related to potatoes. The described management guidelines could potentially achieve better management of the sustainability of gastro-tourism, viewed from two aspects of sustainability. The first aspect is creating a gastro-tourism offer on strategic grounds, i.e., long-term-oriented gastro-tourism. The second aspect is the contribution that gastro-tourism would have to improve: 1) the economic development – developing of agriculture, processing industry, tourism, and hotel industry, and increasing employment; 2) the ecological state – striving for organic and traditional production; 3) the social state – improving the demographic situation by retaining people in rural areas, as well as preserving tradition and culture.

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GLOBAL ECONOMIC CYCLES AND THE RESPONSE OF ECONOMIC POLICY

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Abstract: *Past decades of economic development worldwide have been characterized by increasingly frequent economic fluctuations, prompting questions in economic science about the causes of economic cycles and necessary economic policy responses to cyclic fluctuations. The forms of economic cycles are determined by national specificities of each economy as well as international events, increasingly transmitting from one country to another or to several others. In recent decades, financial crises in developed world economies, starting from USA and EU, are most often resolved through monetary policy measures. These crises are characterized by simultaneous occurrences of economic stagnation alongside inflation growth, over-indebtedness of most countries, fluctuations in interest rates, disruptions in supply due to global geopolitical events, energy crises, and more. The necessity of state involvement in addressing these complex issues and restoring macroeconomic stability to the global economy is becoming increasingly apparent.*

Keywords: *economic cycles, economic crisis, economic policy, macroeconomics*

Introduction

Until the 20th century, the economies of developed countries were not subject to shocks of large scales because the influence of the state on economic movements was small, and the financial-banking sector was much less developed compared to the modern era. Between the two World Wars, the economic crisis of 1929 occurred, affecting most countries worldwide. The period after World War II began with significant economic growth: the time from the late 1940s to the early 1970s is considered a period of long and substantial economic growth, characterized by high rates of investment, productivity, income, and wages, along with low unemployment rates. This lasted until 1973 when there was a significant surge in oil prices, which further impacted the already reduced profitability of the economy, leading to a long period of economic slowdown and decline, which, with short interruptions, lasted until the mid-1990s.

In recent decades, global economic development has been characterized by increasingly frequent economic fluctuations, prompting questions in economic science about the causes of economic cycles and necessary economic policy responses to cyclical fluctuations. Particularly, financial crisis of 2008 deepened these questions as the process of globalization led to the crisis spilling over from one country to another, regardless of geographical location or level of development. On the other hand, crises are becoming more complex, resulting in declining investments, productivity, economic recessions, all accompanied by high inflation, significant increases in food prices, and an energy crisis.

Normal trade relations and supply chains are disrupted, necessitating an appropriate response to restore macroeconomic stability in the global economy.

Macroeconomic instability and economic cycles

State of an economy is determined based on time series of three key variables: inflation, unemployment, and real growth. If a country has low and stable inflation, low unemployment rates, and high continuous economic growth, it will provide the foundations for the prosperity of most of its citizens. A stable macroeconomic environment is necessary for the smooth functioning of the economy, increasing the quantity and quality of long-term investments in the economy, infrastructure, and new technologies to maintain a stable rate of economic growth (Mankiw, 2001).

Development of macroeconomic analysis has provided a consensus on the key facts of cyclical economic movements, which concern the behavior of the most significant macroeconomic variables during cycles, but the following questions are still relevant (Prašević, 2008): a) what causes cyclical fluctuations, i.e., what is the nature of shocks? and b) what economic policy is needed in response to cyclical fluctuations? Shocks affecting the economy can be: real – shocks that disrupt the real side of the economy, and nominal – shocks to the money supply and other shocks affecting aggregate demand.

Macroeconomic instability has a negative impact on economic development as it lowers the level of investment. Macroeconomic instability also adversely affects every economic entity by reducing the level of profits earned by businesses and consequently, lowering the standard of living of the population. Long-term investments are one of the most significant sources of economic growth because it is necessary for investors to have confidence in the economic conditions that will exist in the long run.

Business cycle represents recurrent expansion and contraction of the national economy and is characteristic only for the capitalist economic system (Burns, Mitchell, 1946). Another group of definitions (Lucas, 1995) defines the business cycle as short-term deviations of economic variables from the long-term trend movement. The view of the business cycle as short-term fluctuations is based on the premise that two different processes affect the economy; the long-term process, which determines the GDP growth rate, and the short-term process that causes short-term fluctuations over several quarters or years. According to Nelson and Plosser (1982), business cycle cannot be viewed solely as a temporary event without noticeable long-term consequences.

Joseph Schumpeter's theory of cycles, as presented in his work "Business Cycles" (1939), is an example of the real theory of extensive investments. The phase of economic expansion is caused by real factors that act on the aggregate supply side. The most important factor is innovation, which is taken up and driven by the boldest entrepreneurs in the economy. According to his theory, a combination of five factors that represent the expression of innovation stimulates economic expansion. These factors include new products, new production technologies, opening new markets, introducing new resources and raw materials, as well as new organization of economic activities.

In his work "The General Theory of Employment, Interest and Money" (1936), J. M. Keynes points out that cyclical economic movements cause fluctuations in the marginal efficiency of investments, triggered by changes in expectations and fluctuations in consumer expenditures as a result of changes in the wealth available to consumers. Keynes viewed economic fluctuations, especially fluctuations in employment, as consequences of

the nature of the market economic system because the economic system is unable to ensure full employment or fair distribution of wealth and income.

The forms of business cycles are determined by the national specificities of each economy, as well as international events. Cycles vary in terms of cause, duration, intensity, significance, and the speed with which they spread from one economy to another. The most developed countries, starting from the USA, Britain, Germany and France, had almost coinciding cycles. Developing countries dominated by agricultural production, such as China, Russia or Brazil, had completely different development trajectories and, of course, different cyclical fluctuations.

Historically, until the 20th century, economy was not subject to shocks of large scales because the influence of the state on economic movements was not significant, and the financial-banking sector was much less developed. In the interwar period, the economic crisis of 1929 occurred, affecting most countries worldwide. The period after World War II began with significant economic growth: the time from the late 1940s to the early 1970s is considered a period of long and substantial economic growth, characterized by high rates of investment, productivity, income, and wages, along with low unemployment rates. This lasted until 1973 when there was a significant surge in oil prices, which further impacted the already reduced profitability of the economy, leading to a prolonged period of economic slowdown and decline, which, with short interruptions, lasted until the mid-1990s. During this period, there was a significant decrease in investments and productivity, along with rising unemployment and high inflation rates. Characteristic of the cyclical economic fluctuations during the 1970s, 1980s and 1990s is that due to the integration and globalization of the international economy, contractions in economic activity occurred simultaneously in European countries, Japan and USA.

As a result of the failure of Keynesian policies in the 1970s to cope with simultaneously rising inflation and unemployment, monetarism emerged, advocating a policy of "managing money" instead of "demand management." The most prominent representatives of monetarism include Milton Friedman ("A Program for Monetary Stability" and "Monetary History of the United States"), H. Simons ("Economic Policy for a Free Society"), K. Brunner, A. Meltzer and others. Monetarism is also referred to, in economic theory, as the Chicago School, considering that the most prominent monetarists worked or are working at the University of Chicago.

Monetarists placed much greater emphasis on direct mechanism of money's impact on economic activity than other economic theories before them. In their theoretical explanations of the impact of money on the functioning of economic processes in the real sphere of economy, monetarists emphasize the importance of money as a specific form of total assets of economic agents. They attribute special importance to money, considering the demand for money and the relationship between the existing quantity of money and the demand for money as a significant element of the process of aligning the real volume and structure of total assets of individuals with desired values.

Monetary policy in addressing economic crises

Monetarists emphasize the crucial role of monetary policy both in establishing stability and in disrupting it. When monetary equilibrium is disrupted, the central bank plays a key role, while in restoring it, the real sector of the economy plays a crucial role. Monetary imbalance affects the entire economic system, leading to the activation of automatic market processes that aim to bring the economy back to a new equilibrium. The exclusive

way to establish a new equilibrium is through changes in the nominal price level. In such circumstances, government intervention not only lacks positive effects but also acts destabilizing and inflationary (Dimitrijević et al., 2016).

It is widely accepted that money can influence other economic phenomena, so the influence of money should be understood not only in terms of its impact on prices but also on other economic movements such as investment, production, employment, consumption and others. If the necessary amount of money is created, then monetary sector does not provide any impulses that can affect the process of social reproduction. Monetary factors influence real flows of social reproduction when monetary equilibrium is disrupted, which implies that the existing quantity of money is equal to the demand for money (Živković et al., 2019).

Based on empirical data, Milton Friedman found that the majority of instability in economies during the 1950s and 1960s stemmed from changes in the money supply, which he deemed exogenous, while changes in the demand for money were minimal, or stable. This theory is known as monetarism and is based on the following principles:

- The money supply is an exogenous variable determined by the decisions of monetary authorities, meaning that the money supply is not passive but actively influences economic movements. Thus, money supply affects the general price level, i.e., inflation and income, rather than the other way around.
- In the short run, money supply is neutral, meaning it affects the level of real economic activity, as the transmission mechanism's effect in the short run splits into price increases and income growth.
- In the long run, money supply determines solely the general price level, i.e., the inflation rate.
- There is a certain time lag between changes in money supply and the effects of such changes on both real and nominal variables.
- Money supply represents the primary target variable of monetary policy, to which the interest rate would merely adjust.

Monetarists have identified the following key objectives of economic policy:

- Maximum stability of the general price level, which will ensure that a balance between relative prices and real quantities is achieved in a relatively short period.
- Stability of income in response to shocks, meaning avoiding the situation where decisions of monetary policy regarding the money supply worsen the impact on income caused by the initial shock, as Friedman argued was the case during the Great Depression of the 1930s.

To achieve these two objectives, monetarists advocate for a monetary policy based on the rule of target money supply, where a stable rate of monetary growth would correspond to stable demand for money. This would ensure long-term price stability, with income levels tending to be determined near equilibrium (Minford, 1997). In this case, money supply would also act as an automatic stabilizer of income, responding to shocks and eliminating cyclical movements. For instance, during an economic depression, with income declining, interest rates would fall, increasing demand for money and equating it with supply.

Conversely, during an economic expansion, interest rates would rise, inducing deflationary pressures.

Although it is widely accepted that the long-term effect of money is solely on prices, while money has a significant short-term impact on real variables (such as employment or income), questions arise about the direction of causality. If money supply is used as a measure of monetary policy, could it be that income influences money rather than the other way around (Walsh, 2003)? Applied to business cycles: can economic expansion trigger a credit expansion by commercial banks, increasing money supply, even if the central bank hasn't changed its monetary policy?

With the expansion of government influence in the economic sphere, it was only a matter of time before the real motives of economic policy makers were focused on, as an important factor in the functioning of the economic system and as a possible source of fluctuations. This was first done through the concept of "electoral economic cycles," and then through the concept of "political macroeconomic cycles." It became clear that the influence of policy on macroeconomic policy depends on the predominant level of politicians (Alesina, 1989).

Today, differences in defining the concept of the state, its activities and the goals it should achieve are still present. These differences stem from both scientific and ideological factors. However, there is almost a general consensus that state intervention relates to two spheres:

- Ensuring the legal framework for societal functioning (respecting laws and maintaining order) and protecting state territory.
- Influencing the economic system, which involves direct management of production, influencing income redistribution and providing public goods.

Global economic crisis marked the end of the dominance of rigid rules in economic policy-making, which characterized the development of macroeconomics since the 1970s. The sudden occurrence of such a severe, prolonged and global contraction in economic activity served as a reminder of the need to view macroeconomics, especially economic policy within it, more as a "skill," rather than previously dominant outcome of complex macroeconomic models involving a large number of interdependent macroeconomic variables.

The onset of the economic crisis in late 2007 led to changes in the goals and measures of economic policy in most countries. Naturally, developed countries, led by the United States where the crisis originated, spearheaded these changes. However, developing economies, as well as those with emerging markets or countries in transition, followed these trends. International Monetary Fund (IMF) played a significant role in shaping these changes through its new guidelines regarding necessary economic policy measures (Jakšić, 2009).

As the lender of last resort, coordinator of financial assistance packages to countries, and an institution overseeing macroeconomic indicators and conditions worldwide across various countries, IMF had a crucial, if not decisive, role in all post-war financial and economic crises. These crises, whether international or domestic in nature, highlighted all the functions carried out by IMF. However, many shortcomings also became apparent, indicating the need for changes that would occur as part of the creation of a new

international financial architecture, in which IMF would still hold a central position (Nanto, 2009).

Conclusion

In recent decades, policymakers have been faced with solving complex issues in the functioning of global economy and maintaining macroeconomic stability. The beginning of the twenty-first century and global economic crisis of 2007-2009 have called into question previous basic economic principles and imposed a new role on fiscal and monetary policy, the functioning of financial system, the role of central banks and the state itself, in economic events at both national and global levels. Slow recovery and economic problems largely generated by the measures taken in economic policy have led to a demand for the development of new models of economic development and new rules for economic policymaking. It has become entirely clear that relying solely on market forces leads to significant cyclical fluctuations in global economy and that involving the state in addressing the accumulated problems of the world economy is necessary.

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EFIKASNOST I PROFITABILNOST U BANKARSKOM SEKTORU: KOMPARATIVNA ANALIZA REPUBLIKE SRBIJE I DRUGIH ZEMALJA ZAPADNOG BALKANA

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SAŽETAK:

Tokom druge decenije XXI veka, bankarski sektor, posmatrano na međunarodnom nivou, suočio se sa brojnim izazovima. To su, između ostalog, globalno niske kamatne stope, digitalna transformacija koja je povećala konkurenciju u oblasti bankarskih usluga, i na kraju, kriza COVID-19 koja je stvorila dodatni pritisak na bankarski sektor. Smatra se da su u takvom okruženju efikasnije banke otpornije na nepovoljna tržišna kretanja i u boljoj su poziciji da se nose sa povećanom konkurencijom. Takođe, banke koje ostvaruju stabilne i konkurentne stope profitabilnosti obično imaju veće šanse za rast i širenje svojih poslovnih aktivnosti. Kada je reč o Republici Srbiji i drugim zemljama Zapadnog Balkana, ove karakteristike su posebno važne zbog njihove tranzicije ka tržišnoj ekonomiji i integraciji u međunarodne finansijske tokove. S tim u vezi, cilj ovog rada je da pruži dublje razumevanje efikasnosti i profitabilnosti u bankarskom sektoru, kroz komparativnu analizu između Republike Srbije i drugih zemalja Zapadnog Balkana, te da identifikuje ključne sličnosti i razlike među navedenim zemljama. U radu se primenjuje kvalitativna metodologija, utemeljena na dominantnoj primeni metoda dinamičke makroekonomske analize i metoda komparativne analize.

Ključne riječi: *efikasnost, profitabilnost, bankarski sektor, Republika Srbija, Zapadni Balkan*

1. UVOD

Poslovne banke predstavljaju vodeće finansijske posrednike u Republici Srbiji (u daljem tekstu Srbija) i ostalim zemljama Zapadnog Balkana (Albaniji, Bosni i Hercegovini, Crnoj Gori i Severnoj Makedoniji). Drugim rečima, u finansijskim sistemima zemalja Zapadnog Balkana, banke drže 83–98% aktive finansijskog sektora koja je uglavnom u stranom vlasništvu [1]. To govori u prilog činjenici da bankarski sektor ima važnu ulogu u podršci ekonomskim aktivnostima tj. predstavlja važan izvor finansiranja investicionih poduhvata i tehnoloških inovacija.

Osnovne usluge poslovnih banaka vekovima unazad podrazumevaju primanje depozita od klijenata i odobravanje kredita stanovništvu i privredi. Pored osnovnih poslova, većina

banaka obavlja usluge platnog prometa, izdavanja garancija, menjačke poslove, poslove u vezi sa obavljanjem spoljnotrgovinskih transakcija i brojne druge. Inovacije i ekspanzija bankarskih usluga predstavljaju kontinuiran proces u savremenim uslovima, pri čemu se efikasnost, profitabilnost i stabilnost nameću kao imperativi poslovanja bankarskog sektora.

Predmet ovog rada je analiza efikasnosti i profitabilnosti bankarskog sektora u zemljama Zapadnog Balkana korišćenjem sekundarnih podataka koji su preuzeti iz baze podataka Svetske banke za period 2010–2021. Shodno navedenom predmetu, cilj istraživanja je da pruži dublje razumevanje efikasnosti i profitabilnosti u bankarskom sektoru, kroz komparativnu analizu između Srbije i drugih zemalja Zapadnog Balkana, te da identifikuje ključne sličnosti i razlike među navedenim zemljama.

Rad je strukturiran na sledeći način. Nakon, uvoda, u drugom delu se ukratko sagledavaju karakteristike bankarskih sektora u zemljama Zapadnog Balkana. Treći deo se bavi analizom ključnih pokazatelja efikasnosti bankarskog sektora. U četvrtom delu pažnja se posvećuje analizi profitabilnosti bankarskog sektora. Konačno, peti deo rada sadrži zaključna razmatranja.

2. OPŠTE KARAKTERISTIKE BANKARSKIH SEKTORA U ZEMLJAMA ZAPADNOG BALKANA

U zemljama Zapadnog Balkana, kao i u drugim tranzicionim privredama, bankarski sektori su doživeli značajne promene tokom protekle tri decenije. Privatizacija imovine u državnoj i društvenoj svojini je bila jedan od najvažnijih procesa u tranzicionim zemljama, tj. neizbežan korak za promenu centralno planskih ekonomija u tržišne ekonomije [2]. U bivšem društveno-ekonomskom uređenju, banke su bile osmišljene da podrže centralno-planski privredni sistem gde država preuzima kompetencije u regulisanju privrednog života. Pored privatizacije državnih banaka, značajan segment reformi činila je liberalizacija domaćeg finansijskog tržišta. S tim u vezi, jedan je od glavnih pozitivnih aspekata privatizacije banaka je dolazak stranih investitora koji su uneli dodatni kapital, veštine, iskustvo i menadžerske sposobnosti. Takođe, važna korist je i viši nivo konkurencije u bankarskom sektoru i eliminacija političkih pritisaka na banke [3].

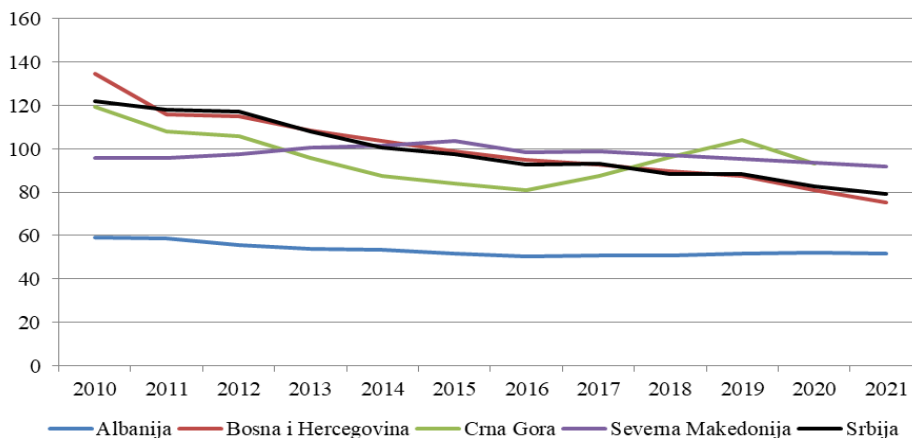
Kada je reč o ulasku stranih banaka, prisutna je šira saglasnost da internacionalizacija bankarstva u zemljama Zapadnog Balkana predstavlja jedno od najizrazitijih obeležja procesa restrukturiranja. Prema raspoloživim podacima u bazi podataka Svetske banke [4], krajem 2016. godine u posedu stranih banaka u Srbiji nalazilo se 76,74% sektorske imovine. Zemlje koje imaju manje internacionalizovan bankarski sektor su Severna Makedonija (69,9%) i Crna Gora (75,5%). Znatno viši procenat bankarske aktive u stranom vlasništvu krajem 2016. godine imala je Albanija (85,2%) i Bosna i Hercegovina (90,8%).

U pogledu tržišne strukture, može se reći da bankarski sektor u Srbiji karakteriše umeren nivo koncentracije. Naime, vrednost racia koncentracije C3, koji se odnosi na udeo aktive tri vodeće banke koje posluju na bankarskom tržištu u jednoj zemlji, u 2021. godini iznosila je 47.68%. Niži nivo koncentracije zabeležen je u Bosni i Hercegovini (41,65%), dok je aktiva bankarskog sektora znatno koncentrisanija u Albaniji (74,01%), Crnoj Gori (83,18%) i Severnoj Makedoniji (97,38%).

Kao jedan u nizu rezultata restrukturiranja bankarskog sektora zemalja u tranziciji jeste i finansijsko produblјivanje, oliceno kroz rast domaće kreditne aktivnosti u odnosu na brito domaći proizvod (BDP). Tokom perioda koji je prethodio pojavi globalne krize 2008. godine, bankarski krediti privatnom sektoru u zemljama u tranziciji beležili su intenzivan rast. Rastući trend na kreditnom tržištu počev od 2010. godine zamenila je stagnacija. Između ostalog, zaoštavanje kreditnih standarda u matičnim bankama i rastuća averzija prema riziku doveli su do smanjenja kreditne aktivnosti banaka. Sa udelom domaćih bankarskih kredita u BDP-u od 43,4% Srbija je 2021. godine bila na začelju liste zemalja Zapadnog Balkana, ispred Albanije (36,6%). Inače, proporcija domaćih kredita odobrenih privatnom sektoru prema BDP-u je relativno niska u posmatranim zemljama. Na to jasno ukazuje podatak o prosečnoj vrednosti udela domaćih kredita u BDP koji na globalnom nivou iznosi 146,9% [4].

3. EFIKASNOST BANKARSKIH SEKTORA U ZEMLJAMA ZAPADNOG BALKANA

Koncept efikasnosti kao opšti indikator performansi za sve oblike poslovanja interpretira se kao maksimalni potencijalni odnos između autputa i inputa [5]. Efikasnost u bankarskom sektoru podrazumeva sposobnost banaka da optimalno koriste svoje resurse, uključujući kapital, radnu snagu i tehnološke inovacije, kako bi pružile usluge klijentima uz minimalne troškove.



Slika 1. Odnos odobrenih kredita i primljenih depozita (%)

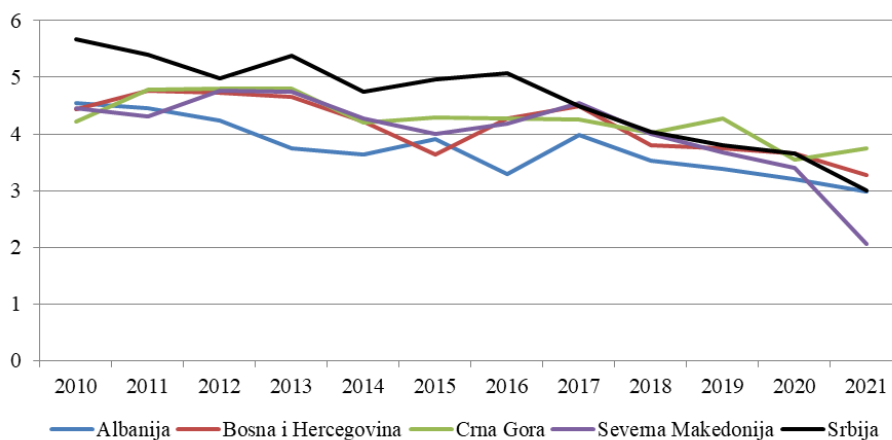
Izvor: Autor, na osnovu: World Bank (2024), World Development Indicators Database, <https://databank.worldbank.org/source/global-financial-development>

Za merenje efikasnosti banaka u literaturi je definisan određen broj indikatora. Jedan od njih predstavlja odnos potraživanja od privatnog sektora i depozita poslovnih banaka [6], [7]. Reč je zapravo o odnosu iznosa odobrenih kredita i primljenih depozita. Ovaj racio

pokazuje procenat štednje koji je transferisan u kredite privatnog sektora. Depoziti, po pravilu, nisu jedini izvor sredstava banaka i krediti nisu jedina aktiva u koju banke investiraju. Visoka vrednost indikatora koji stavlja u odnos bankarske kredite i bankarske depozite ukazuje na visoku efikasnost posredovanja banaka. Ipak, ovaj indikator treba tumačiti sa izvesnom dozom opreza, jer vrednost veća od jedan, odnosno 100%, upućuje na zaključak da banke kreditiraju privatni sektor iz sredstava koja potiču iz nedepozitnih izvora, što može biti jedan od uzročnika nestabilnosti u finansiranju [8].

Na slici 1 prikazana je dinamika odnosa odobrenih kredita i primljenih depozita i zemljama Zapadnog Balkana u periodu 2010–2021. Generalno gledano prisutan je opadajući trend ovog pokazatelja tokom posmatranog perioda. Najniže vrednosti, ispod 60%, izmerene su u Albaniji. Najoštriji pad imale su Srbija (sa 121,9% 2010. godine na 79,3% 2021. godine) i Bosna i Hercegovina (sa 134,5% 2010. godine na 75,1% 2021. godine). Nešto blaži pad beleži Crna Gora, dok je Severna Makedonija imala prilično stabilan trend.

Drugi indikator efikasnosti je neto kamatna marža koja predstavlja odnos knjigovodstvene vrednosti neto bankarskih prihoda od kamata i ukupne aktive banaka. Na početku posmatranog perioda najveća vrednost neto kamatne marže zabeležena je u Srbiji (5,67%), dok je najmanja vrednost zabeležena u Crnoj Gori (4,22%) (slika 2). Ukoliko se uproseče vrednosti neto kamatne marže tokom posmatranog perioda, evidentno je da se radi o opadajućem trendu koji je svakako poželjan u ovom slučaju. Tokom posmatranog perioda najveći rast efikanosti, koji se ogleda u smanjenju neto kamatne marže, desio se je u Srbiji. Na slici 2 se takođe može videti da je najefikasniji bankarski sektor u Severnoj Makedoniji.

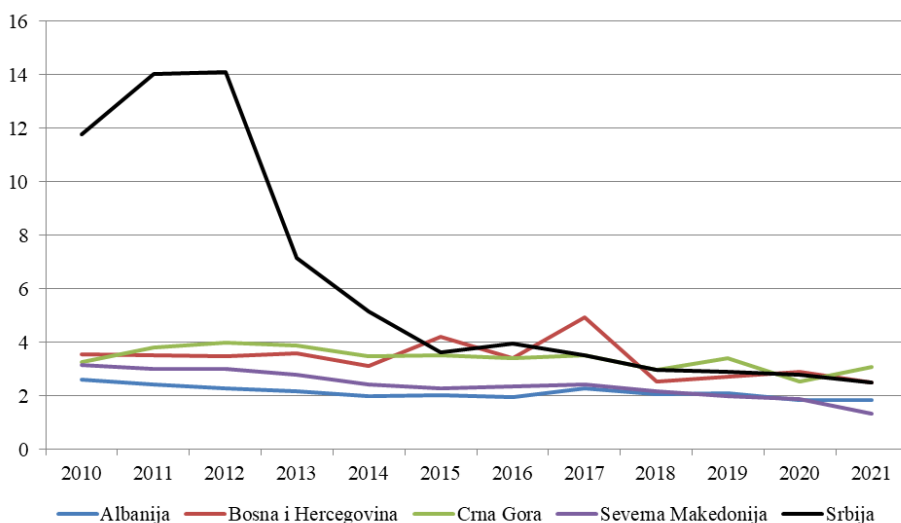


Slika 2. Tendencija kretanja neto kamatne marže (%)

Izvor: Autor, na osnovu: World Bank (2024), World Development Indicators Database, <https://databank.worldbank.org/source/global-financial-development>

Sledeći indikator predstavljaju operativni troškovi ili troškovi poslovanja banke koji se odnose na udeo knjigovodstvene vrednosti bankarskih operativnih troškova u ukupnoj

aktivni. Ovaj racio nije pod uticajem promena u kamatnim stopama i pruža objektivniju sliku efikasnosti banke u smislu kako upravlja svojim troškovima u poređenju sa svojom imovinom. Stoga, ovaj racio pomaže u merenju efikasnosti banke ili finansijske institucije u trenucima kada dođe do značajnih promena kamatnih stopa ili kamatnih razlika [9]. Niže vrednosti operativnih troškova, kao i u slučaju neto kamatne marže, ukazuju na viši nivo bankarske efikasnosti. Osim toga, niži racio znači i da je imovinska baza banke dovoljna da pokrije njenje operativne troškove. Viši nivo imovine je poželjan, ali ne i viši nivo operativnih troškova. Stoga, banka koja redovno ostvaruje niži racio operativnih troškova prema imovini je bolja u smislu operativne efikasnosti.



Slika 3. Udeo operativnih troškova u ukupnoj aktivi bankarskog sektora (%)

Izvor: Autor, na osnovu: World Bank (2024), World Development Indicators Database, <https://databank.worldbank.org/source/global-financial-development>

Na slici 3 prikazan je racio operativnih troškova i ukupne aktive bankarskih sektora u zemljama Zapadnog Balkana. Tokom posmatranog perioda Albanija, Severna Makedonija i Crna Gora beleže blago opadajući trend, odnosno poboljšanje efikasnosti, dok se u slučaju Bosne Hercegovine sredinom perioda uočava izvesna cikličnost posmatranog racia. Međutim, kada je u pitanju Srbija, u prvoj polovini posmatranog perioda dolazi do značajnog poboljšanja operativne efikasnosti bankarskog sektora i ona tokom druge polovine datog perioda bitno ne odstupa u odnosu na druge posmatrane zemlje.

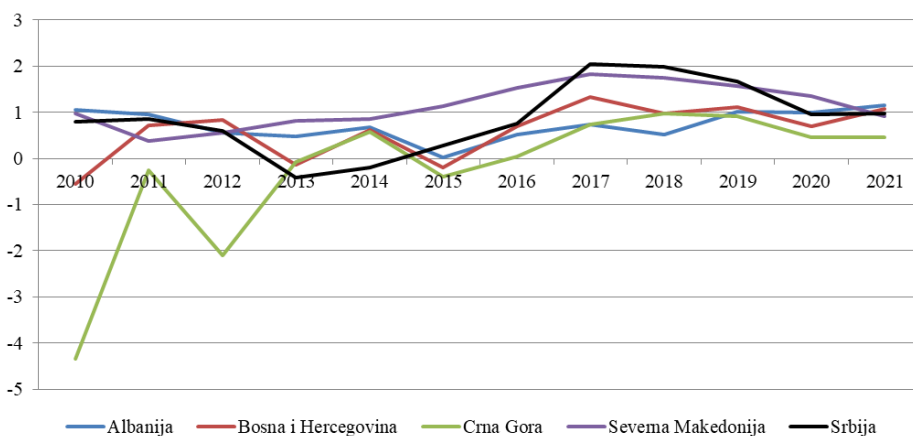
4. PROFITABILNOST BANKARSKIH SEKTORA U ZEMLJAMA ZAPADNOG BALKANA

Pored efikasnosti, glavni cilj svake poslovne aktivnosti je profitabilnost, te je stoga profit imperativ i u bankarskom poslovanju. Profit je konačni i nedvosmisleni rezultat uspešnosti koji pokazuje neto učinak politike banke i aktivnosti tokom finansijske godine.

Pokazatelji profitabilnosti su usko povezani sa pokazateljima efikasnosti. Iako efikasne finansijske institucije takođe imaju tendenciju da budu profitabilne, veza nije baš bliska. Na primer, neefikasan finansijski sistem može da ostvari relativno visoku profitabilnost kada posluje u periodu ekonomskog uspona, dok inače efikasan sistem pogođen negativnim šokom može da generiše gubitke [10].

Osnovni pokazatelji profitabilnosti banaka su prinos na ukupnu aktivu banaka (ROA) i prinos na ukupni kapital banaka (*return on equity* – ROE). Pojedini autori daju prednost ROA u odnosu na ROE [11]. Međutim, oni takođe navode da pokazatelj prinosa na ukupni kapital banke ostaje standardna mera profitabilnosti banaka zbog uvažavanja efekta leveridža.

Na slici 4 prikazana je dinamika prinosa na ukupnu aktivu bankarskog sektora (ROA). U prvoj povini posmatranog perioda jedino je bankaarski sektor u Crnoj Gori beležio negativne vrednosti ROA, dok je u Bosni i Hercegovini i Srbiji to takođe bio slučaj ali samo tokom dve godine i to u znatno manjem obimu. S druge strane, banke u Albaniji i Severnoj Makedoniji su tokom posmatranog perioda poslovale pozitivno.

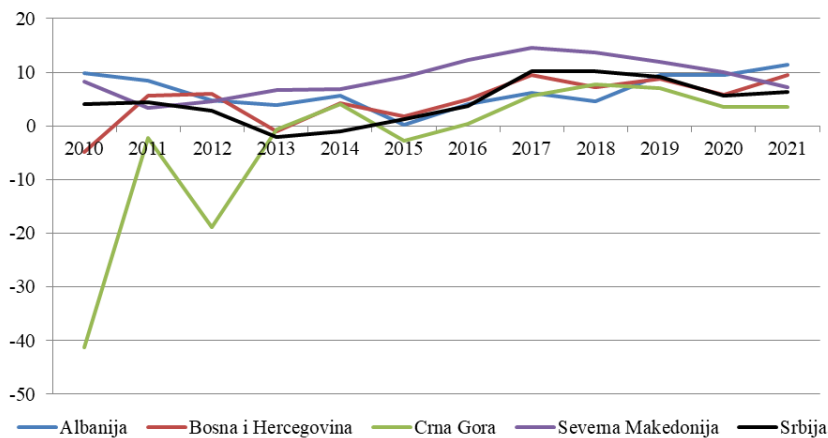


Slika 4. Dinamika prinosa na ukupnu aktivu bankarskog sektora – ROA (%)

Izvor: Autor, na osnovu: World Bank (2024), World Development Indicators Database, <https://databank.worldbank.org/source/global-financial-development>

Na slici 5 ilustovana je dinamika ROE pokazatelja. ROE meri stopu prinosa koja pripada akciobnarima [12]. U ovom slučaju tendencija ROE je gotovo identična kretanju ROA pokazatelja. Jedan od uzroka opadajućeg trenda profitabilnosti, posebno u prvoj polovini posmatranaog perioda, može se naći u padu kreditne aktivnosti banaka, o čemu je bilo reči u drugom delu ovog rada. Takođe, jedan od razloga pada profitabilnosti može biti i smanjenje neto kamatne marže, naravno uz uvažavanje činjenice da postoji ogroman broj sistemskih i nesistemskih rizika koji utiču na performanse banaka.

Kada se, na primer, uporede vrednosti ROE u 2021. godini u Albaniji (11,3%), Bosni i Hercegovini (9,4), Crnoj Gori (3,4%), Severnoj Makedoniji (7,1%) i Srbiji (6,3%) i vrednosti ROE u naprednim zemljama u tranziciji kao što su Slovenija (10,9%), Mađarska (10,2%) i Poljska (4,7), evidentno je da banke u zemljama Zapadnog Balkana u proseku ne zaostaju bitno u pogledu u profitabilnosti za zemljama koje su ranije restrukturirale svoje bankarske sisteme i uspostavile tržišne principe poslovanja.



Slika 5. Dinamika prinosa na ukupni kapital bankarskog sektora – ROE (%)

Izvor: Autor, na osnovu: World Bank (2024), World Development Indicators Database, <https://databank.worldbank.org/source/global-financial-development>

Banke obično upravljaju profitabilnošću na način da nastoje ostvariti rezultate koji su viši od tržišnog proseka i održati ih stabilnim i predvidljivim, jer to zauzvat privlači ulagače. Pokazatelji su stoga vrlo korisni, ali, kao i kod drugih analitičkih metoda, oni se moraju koristiti sa oprezom i uz pravilno tumačenje s obzirom na to da oni sami za sebe ne pružaju potpune odgovore o uspešnosti poslovanja banaka [13].

5. ZAKLJUČAK

Zemlje Zapadnog Balkana imaju izvesne zajedničke karakteristike: istoriju društveno-ekonomskog razvoja, transformaciju političkog i ekonomskog sistema, preduzete reforme, liberalizaciju i svojstven put ka razvoju. Njihovi finansijski sistemi su bankocentrični, tako da su performanse bankarskog sektora važne za stabilnost i napredak privreda ovih zemalja.

Jedna od najčešće korišćenih metoda za ocenu performansi banka je racio analiza. U radu je praćena dinamika određenih racio pokazatelja efikasnosti i profitabilnosti bankarskog sektora tokom druge decenije XXI veka, a to je zapravo period nakon globalne krize 2008. godine. Na osnovu sprovedene analize može se izvesti jedan opšti zaključak. Naime, prvu polovinu posmatranog perioda obeležila je stagnacija i pritom volatilitnost pokazatelja efikasnosti i profitabilnosti. S druge strane, počev od 2015. godine pa do kraja

posmatranog perioda, dolazi do poboljšanja kako efikasnosti tako i profitabilnosti bankarskog sektora u Srbiji i drugim zemljama Zapadnog Balkana.

Što se tiče budućih istraživanja, svakao će bito zanimljivo pratiti dalje trendove efikasnosti i profitabilnosti u bankarskim sektorima zemalja Zapadnog Balkana. Jedan od razloga je i činjenica da u nastavku posmatranog perioda sledi kriza izazvana pandemijom COVID-19 i s tim u vezi potreba za sagledavanjem njenih posledica na ekonomsku aktivnost.

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THE EFFICIENCY AND PROFITABILITY IN THE BANKING SECTOR: A COMPARATIVE ANALYSIS OF THE REPUBLIC OF SERBIA AND OTHER WESTERN BALKAN COUNTRIES

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ABSTRACT:

During the second decade of the 21st century, the banking sector, observed on an international level, faced numerous challenges. These included, among other things, globally low interest rates, digital transformation that increased competition in the field of banking services, and finally, the COVID-19 crisis, which created additional pressure on the banking sector. It is believed that in such an environment, more efficient banks are more resilient to unfavorable market movements and are better positioned to deal with increased competition. Additionally, banks that achieve stable and competitive profitability rates typically have a greater chance of growth and expanding their business activities. When it comes to the Republic of Serbia and other Western Balkan countries, these characteristics are particularly important due to their transition to market economies and integration into international financial flows. In this regard, the aim of this study is to provide a deeper understanding of efficiency and profitability in the banking sector through a comparative analysis between the Republic of Serbia and other Western Balkan countries, and to identify key similarities and differences among the mentioned countries. The study employs a qualitative methodology, grounded in the predominant application of dynamic macroeconomic analysis method and comparative analysis method.

Keywords: *efficiency, profitability, banking sector, Republic of Serbia, Western Balkans*

FROM THEORY TO PRACTICE: QUALITY MANAGEMENT TOOLS IN DIVERSE INDUSTRIES

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ABSTRACT:

To maintain or enhance its market position, a contemporary business must adhere to the principles of quality control in its operations. During daily operations, manufacturing companies encounter a multitude of defects in their products. It is crucial to promptly identify the root cause of a defect when it arises and implement preventive measures thereafter. To achieve this, leveraging quality management tools becomes imperative. This article analyzes quality management systems in different industries in Serbia, using seven basic quality management tools, and certain technologies (internal auditing, poka-yoke, statistical process control, 5S methodology, Six Sigma, and customer satisfaction surveys) that help determine the root causes of product defects. Research was carried out in 27 companies in Serbia that perform various activities: automotive industry, metal processing industry, food production, beverage production, and clothing production. Based on the presented cases it can be concluded that quality tools are used in companies, structured into organizational units, but their choice varies according to the type of work processes, so the possibilities of applying individual quality tools vary by work system.

Keywords: *quality management tools, statistic process control, control chart, Ishikawa diagram, Pareto analysis*

1. INTRODUCTION

Tools for quality management encompass a range of concepts, techniques, methods, studies, and means – all aimed at enhancing the quality of processes and products, and thus the competitiveness of companies. These tools, including Pareto diagrams, regression analysis, control chart techniques, sampling and acceptance methods, and studies on precision, accuracy, and process stability, among others, are integral to quality management systems. Quality management is achieved through these systems, by defined quality policies, objectives, and responsibilities.

Different research was done to identify and classify a large number of quality tools, to identify the most effective quality tools for application in different areas of industry, or to recommend adequate quality tools concerning business processes.

Some authors performed an analysis of the factors contributing to the return of damaged or faulty goods in the automotive industry using quality management tools like the Ishikawa diagram and Pareto analysis [1]. One study examines the influence of quality management tools on organizational performance among those implementing the ISO 9001:2000 standard versus the EFQM model for quality management systems. A survey was conducted involving 107 experienced and independent quality management assessors. The results indicate that organizations adhering to the ISO 9001:2000 standard predominantly utilize general-purpose qualitative tools, which positively impact their overall performance [2]. Other authors have introduced a fresh approach, presenting a novel roadmap for integrating seven fundamental and innovative quality tools and techniques within a cohesive framework. To achieve this, a panel of experts was tasked with completing a matrix questionnaire. Subsequently, two methodologies were employed to analyze the outcomes of these questionnaires [3]. Research was done to investigate the impact of company sector and size on the utilization of Basic and Advanced Quality Tools. Analysis was conducted based on responses from 202 managers, and statistical tests were performed. Regarding company size, larger companies exhibit a greater tendency to utilize Advanced Quality Tools compared to smaller ones [4]. Some authors investigated the influence of quality tools and the adoption of quality management systems (QMSs) on organizational management. They concluded that companies integrate multiple quality management systems (QMSs) and employ more than nine quality tools. Also, the utilization of various tools, and techniques, and the integration of multiple QMSs (management systems) can significantly contribute to various aspects of organizational performance and functioning [5]. One research was conducted to demonstrate the effective application of quality management techniques. A case study was undertaken in a company that faced an issue on the production floor: a significant number of products did not meet customer specifications. To address this challenge, the new seven quality tools were used to identify and understand the factors contributing to the defects in products. Subsequently, a quality improvement plan was developed to reduce the number of product defects [6]. A global survey was conducted to assess the accuracy of Dr. Ishikawa's assertion that "95% of problems in processes can be resolved using the 7 Quality Control (QC) tools" within organizational contexts. An online survey instrument was created and distributed, garnering responses from 456 senior quality professionals across five continents. The primary finding of this research indicates that less than a quarter of participants believe that the seven QC tools can address over 95% of quality issues. Additionally, 40% of quality professionals admitted to incorrectly applying the tools during problem-solving processes on their initial attempt [7].

This article analyzes quality management systems in different industries in Serbia, using seven basic quality management tools, and certain technologies (internal auditing, poka-yoke, statistical process control, 5S methodology, Six Sigma, and customer satisfaction surveys) that help determine the root causes of product defects.

2. QUALITY MANAGEMENT TOOLS

The application of methodology and principles of quality improvement management implies the use of quality tools. The role and importance of quality tools in quality improvement activities are highlighted in the ISO 9004:2018 standard [8], noting that the application of any quality tool will provide some quality improvement. The advantages of applying quality tools are reflected in the following:

- Raising the level (value) of quality in all work processes of the company,
- Reduction of all types of costs,
- Lowering the price of the product,
- Creating trust with customers,
- Raising the level of knowledge of employees,
- Increase in employee motivation,
- Organizational simplification of companies, etc.

The seven basic quality tools consist of check sheets, Pareto charts, histograms, scatter diagrams, run charts, control charts, and cause-and-effect diagrams. Check sheets are straightforward forms designed for structured data collection and recording. Pareto charts are bar graphs illustrating the frequency or impact of different causes or categories of problems, arranged in descending order. Histograms offer graphical representations of numerical data distributions, showcasing the shape, central tendency, and variation of the data. Scatter diagrams plot two variables to depict their relationship or correlation. Run charts are line graphs tracking changes in a process variable over time, revealing trends, cycles, and shifts. Control charts, a specialized type of run chart, display process variable variation within upper and lower control limits, indicating process stability and control status. Lastly, cause-and-effect diagrams, also known as fishbone or Ishikawa diagrams, are visual tools used to identify and organize potential causes of a problem.

Table 1. Commonly used tools and techniques [9]

The seven basic quality control tools	Techniques
Cause-and-effect diagram	Benchmarking
Check sheet	Departmental purpose analysis
Control chart	Design of experiments
Graphs (Trend Analysis)	Failure mode and effects analysis
Histogram	Fault tree analysis
Pareto diagram	Poka-yoke
Scatter diagram	Problem-solving methodology
	Quality costing
	Quality function deployment
	Quality improvement teams
	Statistical process control

Figure 1 illustrates the interrelationships among these seven tools and their applications in identifying and analyzing quality improvement.

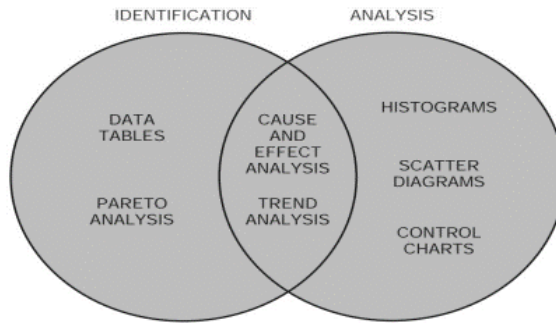


Fig. 1. The seven quality control tools [10]

Companies usually first introduce seven basic quality control tools, so they are also known as the "magnificent seven" because they lead to extremely pronounced improvements. However, since the basic quality tools are introduced into permanent practice, there is a need to introduce quality tools that will support the decision-making process in the business system - management tools. Management tools are used for collecting (brainstorming method) and processing non-numerical data (other management tools).

3. USE OF QUALITY MANAGEMENT TOOLS IN DIFFERENT INDUSTRIES

To analyze quality management systems in different industries in Serbia, an examination of the use of basic seven quality control tools and certain technologies (internal auditing, poka-yoke, statistical process control, 5S methodology, Six Sigma, and customer satisfaction surveys) was carried out in 27 companies in Serbia that perform various activities: automotive industry, metal processing industry, food production, beverage production, and clothing production. Figure 2 shows the degree of use of quality tools and quality management technologies in the surveyed companies.

From the obtained results it can be concluded that tools requiring a higher level of expertise or experience, particularly quantitative techniques like Statistical Process Control (SPC) or Six Sigma, were utilized less frequently compared to other tools. Conversely, qualitative techniques such as opinion-gathering through surveys and improvement groups were notably employed more frequently.

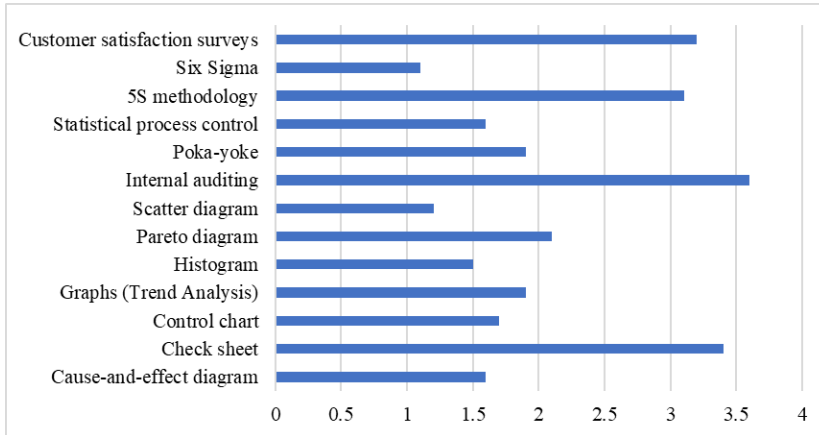


Fig. 2. Degree of use of quality tools and quality management technologies

Table 2 presents The distribution of tools and technologies usage across various industries. The highest utilization of the seven quality tools and certain technologies was observed within the automotive industry and metal processing industry, surpassing usage in other industries.

Table 2. The distribution of tools and technologies usage across various industries

	Automotive industry	Metal processing industry	Food production	Beverage production	Clothing production
Cause-and-effect diagram	31%	28%	16%	11%	14%
Check sheet	42%	33%	5%	5%	15%
Control chart	26%	24%	17%	16%	17%
Graphs (Trend Analysis)	19%	21%	20%	18%	22%
Histogram	21%	20%	19%	21%	19%
Pareto diagram	20%	19%	18%	22%	21%
Scatter diagram	17%	19%	22%	23%	19%
Internal auditing	28%	20%	14%	15%	23%
Poka-yoke	35%	32%	13%	10%	10%
Statistical process control	20%	44%	12%	9%	15%
5S methodology	20%	20%	20%	20%	20%
Six Sigma	26%	26%	21%	9%	18%

Customer satisfaction surveys	20%	20%	20%	20%	20%
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To gauge organizational performance, the study referred to literature to identify commonly utilized indicators assessing the influence of quality management on company performance [2]. Five commonly used indicators were chosen for use in the present study: improvement in the quality of its products, cost-effectiveness of the company, sales growth, productivity, and price/cost ratio of the product. Companies were requested to rate the significance of these items on a scale of 1 to 5, where 1 denoted “very little impact”, and 5 signified “very significant impact”.

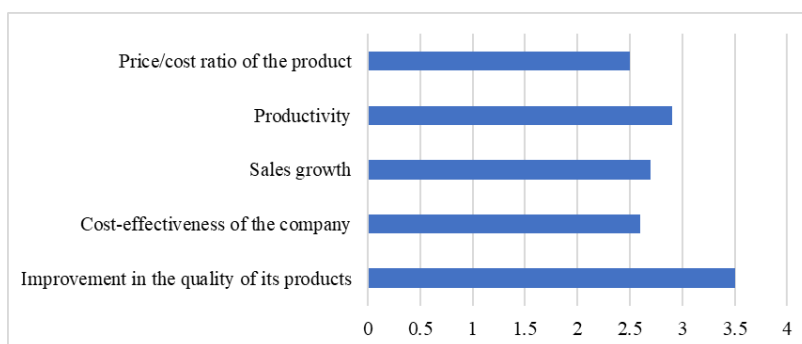


Fig. 3. The improved performance indicators

It is concluded that the use of basic quality tools and some quality management technologies greatly affects the company's performance. According to the companies, it mostly affects the improvement in the quality of its products and productivity.

4. CONCLUSION

Quality improvement tools encompass various concepts, techniques, methods, studies, and means, all directed toward enhancing the quality of processes and products. By doing so, these tools contribute to enhancing the competitiveness of companies.

To scrutinize quality management systems across different industries in Serbia, an investigation into the utilization of the basic seven quality control tools and specific technologies was conducted. This examination involved 27 companies in Serbia engaged in diverse industries: the automotive industry, metal processing industry, food production, beverage production, and clothing production.

Based on the presented results it can be concluded that quality tools are used in companies, structured into organizational units, but their choice varies according to the type of work processes, so the possibilities of applying individual quality tools vary by industry. Tools requiring a higher level of expertise or experience, particularly quantitative techniques like Statistical Process Control (SPC) or Six Sigma, were utilized less frequently compared to other tools. Conversely, qualitative techniques such as opinion-gathering through surveys and improvement groups were notably employed more frequently.

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PREISPITIVANJE TEORIJE HOMO ECONOMICUS UPOTREBOM INSTRUMENTA I METODA NEURONAUKA

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SAŽETAK:

Počev od druge polovine 19. veka, model „Homo Economicus“, koji postavlja „John Stuart Mill“, opstaje u ekonomskoj teoriji do današnjih dana. Koncept „calculating man“ je predmet različitih interpretacija kroz vreme, dok su najveći doprinos njegovom razvoju pružili zagovornici klasične i neoklasične ekonomske misli. Koreni ovog pojma potiču iz teorije racionalnog izbora, prema kojoj ljudi biraju najoptimalnije rešenje, u cilju maksimizacije sopstvenih koristi. U skladu sa ovom tezom, donet je zaključak da ljudi reaguju racionalno na stimulanse, koji su postavljeni u njihovom neposrednom okruženju. Pri tom stavu, zanemaruje se uticaj emotivnog stanja, intuitivnog reagovanja i nedovoljne informisanosti ljudi u procesu odlučivanja. Kritiku teorije savršene racionalnosti, pružaju osnivači bihejvioralne škole, koji razvijaju teoriju „ograničene racionalnosti“. Usled razvoja ICT tehnologija, dolazi do inovacije medicinskih uređaja, koji se koriste za merenja impulsa moždane aktivnosti i stanja organizama ispitanika. Kako bi razumeli uzroke za pojavu iracionalnog donošenja odluka, koristimo dostupne neuronaučne tehnike. U radu se definišu tehnike poput: ftonske emisije tomografije, topografije stabilnog stanja, elektromiografije lica, pozitronske emisije tomografije, funkcionalne magnetne rezonance, merenja pokreta očnih zenica, vlažnosti dlanova, magnetnoencefalografije i elektroencefalografije. Metodološki deo rada obuhvata deskriptivnu statistiku, definisanje „EEG“ indeksa i kvalitativnu analizu ograničenja neuronaučnih studija. Ključni doprinos ovog rada podrazumeva definisanje neuronaučnih alata, za potrebe analize procesa donošenja odluka i osporavanja teorije savršene racionalnosti.

Ključne riječi: Homo Economicus, Iracionalno ponašanje, Medicinski uređaji, Neuronaučne tehnike, Ograničena racionalnost.

1. UVOD

U drugoj polovini 19. veka, predstavnici klasične ekonomske misli, uvode latinski termin „Homo Economicus“ (Mill J.S., 1861), koji označava proračunato i bezgrešno ljudsko biće sa neograničenim stepenom racionalnosti i odsustvom intuitivnih reakcija, tokom procesa odlučivanja (Logachev M., 2016). Proračunom i komparacijom ponuđenih alternativa, subjekat vrši odabir ekonomski najoptimalne opcije, koja mu obezbeđuje

maksimizaciju sopstvenih koristi. Prema ovoj teoriji, proces donošenja odluka nije vođen osećanjima, mislima, željama, skrivenim nagonima i sistemom vrednosti. (Efeoğlu & Çalışkan, 2019).

Sa razvojem „bihevioralne“ ekonomske škole, započinje proces ispitivanja racionalnosti u ljudskom ponašanju (Ramsøy, 2014). U nizu eksperimentalnih istraživanja, dokazuje se značajna iracionalnost u ljudskom ophođenju, kao i pregršt kognitivnih pristrasnosti tokom procesa odlučivanja. Počev od H. A. Simona-a (1978), gde se ljudsko ponašanje značajno razlikuje od ponašanja „homo economicus-a“, sve do eksperimentalnih studija D. Kanemana i V. Smit-a (2002), naglašava se uticaj emocija, skrivenih preferencija, kao i odsustva potpune informisanosti pri donošenju odluka od strane ispitanika (Alion G., 2020 & Kristić M., 2022).

Tradicionalni model „Homo Economicus“ je izgrađen na 4 pretpostavke, koje ujedno predstavljaju i glavno polje osporavanja ove teorije, od strane pripadnika bihevioralne škole. Teorija podrazumeva posedovanje neograničene količine informacija, što omogućava komparativno vrednovanje ponuđenih opcija. Druga teza se odnosi na nemogućnost učenja, na osnovu prethodno pogrešno donetih odluka (Thaler R. H., 2000). Treća stavka podrazumeva zanemarivanje uticaja emocionalnog stanja i intuitivnog reagovanja ljudi, u momentu donošenja odluka (Damasio A., 2015). Na kraju, četvrta teza upućuje na postojanje potpune racionalnosti subjekata, u cilju maksimizacije sopstvenih interesa. (Brzezicka & Wisniewski, 2014).

Pomeranjem fokusa sa teorijske na empirijsku analizu, uspostavlja se koncept ograničene racionalnosti („bounded rationality“), koja zauzima mesto teorije savršene racionalnosti (Gigerenzer, 2020 & Wheeler, 2018). Oscilacija emocionalnog statusa ispitanika, zadobija značajniju ulogu u objašnjenju iracionalnog ljudskog ponašanja (Damasio et al, 2015). S toga, razvija se model „kvazi-racionalnog“ ekonomskog bića, koje poseduje značajni set ograničenja prilikom pravljenja konačnog izbora (Hudak, 2015 & Brzezicka, et al. 2014).

Napretkom informaciono komunikacionih tehnologija, dolazi do proširenja upotrebne funkcije medicinskih uređaja, u svrhu sprovođenja empirijskih studija o ljudskom ponašanju (Solomon P. R., 2018). Sofisticirani neuronaučni instrumenti, postaju kvalitetan alat za detektovanje promene stanja organizma ispitanika, koje nastaju pod uticajem stimulansa iz neposrednog okruženja (Nazarova & Lazizovich, 2019).

Na osnovu toga, razvija se niz neuronaučnih instrumenata i metoda za razotkrivanje ključnih faktora, koji pokreću intuitivno ljudsko ponašanje i impulsivno donošenje odluka, što direktno prkosi konceptu savršeno racionalnog bića, poznatijeg pod terminom „Homo Economicus“ (Sebastian et al, 2014, Hansen & Nielsen, 2023).

2. Pregled literature

U okviru rada Brzezicka J. i Wisniewski R. (2014), sprovodi se osporavanje savršeno racionalnog bića („Homo Economicus“), kroz isticanje niza faktora koji mogu doprineti iracionalnom ljudskom ponašanju. Pomoću neuronaučnih tehnika zabeleženo je intuitivno donošenje kupovnih odluka, što ukazuje da ljudi nisu potpuno racionalni u dugom vremenskom periodu.

Prema navodima Jahedi S. (2015), osnovni principi i neuronaučni uređaji, služe za detektovanje okidača za donošenje nesvesnih odluka, kao i osporavanje teze da ljudi

donose isključivo racionalne odluke. U radu se dokazuje da promena emocionalnog stanja ispitanika, predstavlja važan faktor u procesu odlučivanja.

Prema Sebastian V. (2014), neuronski instrumenti i metode razvijaju se kao interdisciplinarna naučna oblast, koja spaja psihologiju, ekonomiju i marketing. U radu se navodi da grupa medicinskih uređaja za praćenje stanja organizma, služi za razumevanje procesa donošenja odluka. U ovom eksperimentalnom istraživanju, pokazalo se da ispitanici ne vrše odabir ekonomski najoptimalnije opcije, već donose odluku na osnovu intuicije.

U okviru svog istraživanja Nermend K. (2017), ističe da neuronaučne tehnike postaju efikasan alat, za ispitivanje stepena ljudske racionalnosti, prilikom donošenja kupovnih odluka. Putem elektroencefalografije, merenja otkucaja srca, vlažnosti dlanova, pokreta očnih zenica, detektovani su faktori za izbor neke od ponuđenih opcija. Empirijski je potvrđeno da ljudi, koji su izloženi različitim stimulansima, postaju podložniji impulsivnom odlučivanju.

Prema navodima Efeoglu E. i Çalışkan Y. (2018), osporava se teorija savršeno racionalnog bića („Homo Economicus”), koje donosi kupovne odluke u smeru maksimizacije sopstvene koristi, uz potiskivanje sopstvenih emotivnih nagona i nepromišljenog kupovnog delovanja. Referišući se na druga empirijska istraživanja, autori dolaze do zaključka da izloženost čoveka različitim stimulansima okruženja, kod njega razvija sklonost ka iracionalnom ophođenju.

U svom radu Shukla S. (2019), razvrstava tehnike neuronauke, koje služe za analizu ljudskog ponašanja i impulsivnog odlučivanja. Utvrđeno je da tradicionalne istraživačke tehnike poput fokus grupa, anketnih upitnika, conjoint analiza, ustupaju mesto neuronskim metodama („fMRI“, „EEG“, „PET“, „MEG“, „GSR). S toga, potvrđuje se značajna razlika između iskazanog i učinjenog, što doprinosi stavu da ljudsko ponašanje odstupa od racionalnog.

Chouzouris M. , Xenos P. i Tinios P. (2022), sprovode empirijsko istraživanje koncepta „racionalnog ekonomskog ponašanja” ispitanika. U radu je primenjen „CRT” test i niz neuronskih instrumenata, kako bi se bolje razumeo proces donošenja kupovnih odluka. Zaključak ovog rada se odnosi na potvrdu hipoteze da su ljudi skloni finansijski iracionalnim izborima, u procesu donošenja kupovnih odluka.

U okviru studije Dennison J. B., Sazhin D., Smith D.V. (2022), ističe se rast upotrebe neuronskih instrumenata i tehnika, u funkciji boljeg razumevanja ljudskog ponašanja i procesa donošenja odluka. Usled korišćenja digitalnih uređaja, za praćenje nesvesnih reakcija, otkriva se važnost emocija, u trenutku pravljenja izbora. S toga, odbacuje se tvrdnja o savršenoj racionalnosti, u korist teorije ograničene racionalnosti.

3. Predstavljanje neuronskih metoda za kritiku teorije savršene racionalnosti

Razvoj informaciono komunikacionih tehnologija, uzrokovao je širenje primene medicinskih uređaja, za sprovođenje empirijskih istraživanja, ka ostalim naučnim disciplinama. Neuronski uređaji se koriste za merenje unutrašnjeg stanja organizma ispitanika i reagovanja na postavljene stimulanse, kako u realnom okruženju, tako i na elektronskim prodajnim platformama. U zavisnosti od toga da li se beleže impulsi unutar

moždane aktivnosti ili fiziološke promene stanja organizama ljudi, pravimo podelu na dve grupe ovih metoda. U nastavku rada predstavljamo neuronaučne tehnike, pogodne za preispitivanje teorije savršeno racionalnog bića („Homo Economicus“).

Tabela 1. Metode i tehnike neuronaučnih istraživanja

Tehnike neuronaučnih istraživanja		
Naziv tehnike	Opis	Prednost
(AFC) „Automatsko očitavanje facijalne ekspresije“	„AFC“ se upotrebljava za očitavanje mišićnih pokreta na licima ispitanika. Omogućava razlikovanje emocija poput ljutnje, besa, straha, gađenja, tuge, sreće, spokoja. Izvršava automatsko kodiranje izraza lica za potrebe naučnih istraživanja. Metod meri i klasifikuje izraze lica, koji su vidljivi golim okom.	„AFC“ podrazumeva manje zahtevnu i jeftiniju tehniku za potrebe sprovođenja neuronaučnih istraživanja. „AFC“ služi za detektovanje promene izraza lica. Koristi se za praćenje uticaja audio-vizuelnih stimulansa, putem kojih se vrš procena vizuelnog doživljaja proizvoda.
(ET) „Merenje pokreta očnih zenica“	Uređaji za merenje pokreta očnih zenica potrošača, koji precizno određuju tačku najdužeg zadržavanja pogleda. Uređaji su prikaceni ispred očiju potrošača, što omogućava očitavanje proizvoda koji su izazvali rast pažnje (širenje zenica).	Glavne prednosti uređaja su lakoća upotrebe, uz jednostavno postavljanje „Eye tracking“ naočara ispred očiju ispitanika. „ET“ uređaji su prenosivi, što omogućava praćenje pokreta očiju tokom kretanja ispitanika.
(FEMG) „Facijalna elektromiografija“	Psihofiziološki neuronaučni alat, koji se upotrebljava za merenje aktivnosti mišića lica. Očitava mikro pokrete mišića lica. Senzori su integrisani u softveru za facijalno kodiranje emocionalnih stanja: radost, iznenađenje, gađenje, strah, tuga, bes i prezir.	Tehnika omogućava dobijanje robusnih podataka, uz beleženje pokreta mišića lica koji nisu vidljivi golim okom. Unapređena varijanta tehnike „AFC“ jer omogućava očitavanje mikro pokreta mišića lica.
(GSR) „Merenje vlažnosti dlanova“	Automatski se očitava stepen potrošačkog uzbuđenja koji je povezan sa radom znojnih žlezda. Povećanje vlažnost dlanova ispitanika, sugeriše na rast nivoa uzbuđenja u toku procesa kupovine.	Galvanska reakcija kože meri suptilne promene na koži (temperatura & znoj). Uređaj se postavlja na vrh prsta, što ih čini prenosivim i cenovno povoljnim. „GSR“ dodatno meri rast pažnje ispitanika.
(FMRI) „Funkcionalna magnetna rezonanca“	„FMRI“ koristi magnet i radio talase za očitavanje slike mozga, uz praćenje protoka krvi u njegovim režnjevima, Uređaji se nazivaju „MRI“ skeneri. „FMRI“ beleži pojačanu aktivnost određenog moždanog	„FMRI“ uređaji precizno očitavaju sve čulne nadržaje ispitanika. Dodatna prednost jeste što beleže skrivene preferencije, tokom procesa kupovine. Metoda „FMRI“ je

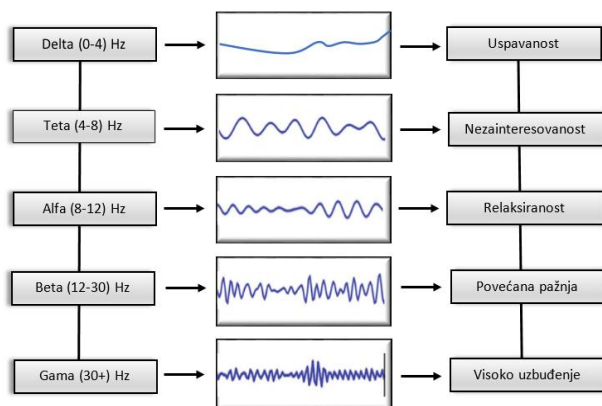
	režnja, što služi za pravljenje obrazaca ponašanja ispitanika.	izuzetno zastupljena u velikom broju naučnih istraživanja.
(EEG) „Elektro - encefalografija“	„EEG“ je neurofiziološka tehnika koja koristi kape sa elektrodama, za potrebe merenja električne aktivnosti mozga ispitanika. „EEG“ uređaji beleže amplitude alfa, beta, gama, delta i teta moždanih frekvencija. „EEG“ beleži stanja spavanja, dremanja ili budnosti ispitanika.	Izuzetno dobar metod merenja impulsa mozga potrošača sa visokom rezolucijom. Oprema može biti prenosiva ili statična. „EEG“ je kvalitetan alat za proveru nivoa pažnje i emocijanog stanja ispitanika. Pogodan za kombinovanje sa drugim neuronaučnim alatima.
(PET) „Pozitronska emisiona tomografija“	Oblast nuklearne medicine koja detektuje stanje metabolizama unutar telesnih tkiva. Vršiti se merenje parametara kao što su protok krvnih zrnaca, nivo glukoze u organizmu, mogućnost sinteze proteina. Može se otkriti promena u hemijskom sastavu i protoku tečnosti, unutar posmatranih moždanih regija.	Obezbeđuje brzu akviziciju podataka i njihovu preciznost. Metoda je značajna za povezivanje kognitivnih reakcija potrošača sa donošenjem odluka u procesu kupovine. „PET“ je supstitutivna tehnika sa „FMRI“ metodom, ali pruža preciznija merenja.
(SST) „Topografija stabilnog stanja“	„SST“ metoda se odnosi na praćenje aktivnosti mozga, dok se ispitanicima prikazuju različite vrste audio-vizuelnih materijala, za promociju proizvoda. Ova tehnika prati fiziološke promene pojedinca prilikom izlaganja različitim vrstama prodajnih stimulansa.	„SST“ prati brze promene moždane aktivnosti koje mogu biti manje od 1 sekunde. Tehnika otporna na buku i zvuke koje dolaze iz okruženja. Dovoljno je izvršiti jedno merenje po pojedincu. „SST“ je unapređena verzija „EEG“ metoda.
(MEG) „Magnetno-encefalografija“	„MEG“ je tehnika zasnovana na merenju magnetnog polja na površini glave ispitanika, koja nastaje usled promene aktivnosti neurona. Istaknuta tehnika snima samo površinske impulse mozga sa skupom i statičnom opremom.	Tehnika „MEG“ u odnosu na „EEG“ poseduje veći kvalitet rezolucije Tehnika „MEG“ služi za identifikovanje koji deo moždane regije je zaslužan za određeni tip ponašanja ispitanika.

Izvor: „Shukla, S. (2019). neuromarketing: a change in marketing tools and techniques. International Journal of Business Forecasting and Marketing Intelligence, 5(3), 267-284.“

4. Upotreba elektroencefalografije za ispitivanje teze Homo Economicus

Upotreba „elektroencefalografskih“ uređaja za merenje moždane aktivnosti, sprovodi se kroz postavljanje elektroda na glave ispitanika, prema internacionalnom sistemu pozicioniranja „10/20“ i „10/10“ (Aldayel et al., 2020). Instaliranjem softvera i kapa sa elektrodama, vrši se merenje moždanih amplituda, što podrazumeva očitavanje alfa (α),

beta (β), gama (γ), teta (θ) i delta (δ) frekvencija (Dadebayev, Goh & Tan, 2022). S toga, pravimo razliku između iskazanog i učinjenog odnosno racionalnog i iracionalnog ljudskog ponašanja. U periodu od 2012 do 2023. godine, upotreba elektroencefalografije je iznosila 60,5%, od ukupnog broja sprovedenih neuronaučnih studija (Alvino, Pavone, Abhishta, & Robben, 2020). Putem formula za obračun indeksa motivacije, indeksa napora, indeksa izbora i indeksa vrednosti, obezbeđuje se ispitivanje okidača za donošenje odluka. Merenjem moždanih impulsa, putem „EEG“ uređaja, utvrđuje se psiho-fiziološko stanje ispitanika.



Slika 1. Pregled amplituda moždanih frekvencija, pomoću elektroencefalografskih uređaja, preuzeto: Dadebayev, D., Goh, W. W., & Tan, E. X. (2022)

4.1. Indeks motivacije („AW indeks“)

„AW indeks“ prati kretanje frontalnih alfa (α) moždanih impulsa. Funkcija ovog indeksa je da kvantitativno izmeri nivo želje, motivacije ili odsustva kupovne namere. „Teorija frontalne asimetrije“ zasniva se na tezi da frontalni delovi leve i desne hemisfere mozga, služe za formiranje pozitivnih ili negativnih osećanja. Pomoću elektroda „EEG“ uređaja, očitavaju se pozitivne vrednosti ovog indeksa u frontalnom delu leve hemisfere (Golnar-Nik, Farashi & Safari, 2019). Negativne vrednosti indeksa detektuju se u okviru levog dela čeonog režnja. Formula za obračun „AW indeksa“ glasi:

$$AW \text{ indeks} = \frac{\alpha(F4) - \alpha(F3)}{\alpha(F4) + \alpha(F3)} \quad (1)$$

Za izračunavanja ovog indeksa, upotrebljavaju se alfa (α) frekvencije, koje se mere putem elektroda F2 i F4. Elektrode su pozicionirane u okviru čeonog režnja. Frontalni moždani režanj ima funkciju u pokretanju kupovne namere, a smer promene se oslikava kroz pozitivnu ili negativnu vrednost „AW indeksa“ (Soufneyestani et al., 2020).

4.2. Indeks napora („EF indeks“)

Indeks napora se obračunava uz pomoć teta (Θ) moždanih amplituda, koje se prate u okviru čeonog režnja („Frontal lobe“). Vrednost „EF indeksa“ predstavlja nivo mentalnih napora ispitanika, koji su povezani sa formiranjem dugoročne memorije (Ramsøy et al., 2014). S toga, razvoj većeg stepena lojalnosti ispitanika je pozitivno korelisan sa rastom

vrednosti indeksa napora (Bazzani, Ravaioli, Trieste, Faraguna & Turchetti, 2022). Formula za obračun „EF indeksa“ glasi:

$$EF \text{ indeks} = \frac{\Theta (F4) - \Theta (F3)}{\Theta (F4) + \Theta (F3)} \quad (1)$$

Indeks napora se dobija očitavanjem moždanih impulsa dobijenih putem elektroda, koje su instalirane u okviru frontalnog režnja. Za izračunavanje indeksa napora, uzimaju se vrednosti sa elektroda Fp1/Fp2, AF7/AF8, F7/F8, kao i F1/F2. (Touchette B. & Lee S.E., 2017). Obračun indeksa napora („EF indeks“), sprovodi se putem teta (Θ) moždanih frekvencija, koje se beleže pomoću elektroda F2 i F4. Navedene elektrode su pozicionirane u okviru čeonog režnja. Frontalni moždani režanj ima ulogu u stvaranju dugoročne memorije, što dovodi do izgradnje većeg stepena lojalnosti ispitanika. (Soufineyestani, Dowling & Khan, 2020).

4.3. Indeks izbora („CH indeks“)

Indeks izbora zavisi od kretanja Beta (β) i Gama (γ) moždanih talasnih frekvencija. Vrednost indeksa izbora se dobija kroz merenje moždane aktivnosti u okviru prednjeg dela čeonog režnja. Indeks izbora ukazuje na efikasnost u donošenju odluka i stepen spremnosti na kupovinu određenih proizvoda. Procena skrivenih preferencija ispitanika se utvrđuje analizom Gama (γ) talasnih frekvencija. Dok se spremnost na kupovinu proizvoda meri putem Beta (β) frekvencija. Formula za obračun „CH indeksa“ glasi:

$$CH \text{ indeks} = \frac{\text{Log (AF3)} - \text{Log (AF4)}}{\text{Log (AF3)} + \text{IOG (AF4)}} \quad (1)$$

Povećan intezitet „gama“ (γ) i „beta“ (β) talasnih frekvencija frontalnog moždanog režnja, dijagnostikuje se posmatranjem vrednosti koje pružaju elektrode AF3 i AF4 (Ramsøy et al., 2014). Veća vrednost talasnih amplituda se očitava u okviru desnog dela frontalne moždane regije, dok se niži intezitet prepoznaje na levoj strani čeonog moždanog režnja (Aldayel M. et al., 2020).

4.4. Indeks vrednosti („VA indeks“)

Indeks vrednosti se obračunava putem alfa (α) i beta (β) moždanih amplituda, koje se aktiviraju u frontalnom delu leve moždane hemisfere. Indeks vrednosti predstavlja meru emocionalnog uzbuđenja ispitanika. Formula za obračun „VA indeksa“ glasi:

$$VA \text{ indeks} = \frac{\beta (AF3, F3)}{\alpha (AF3, F3)} - \frac{\beta (AF4, F4)}{\alpha (AF4, F4)} \quad (1)$$

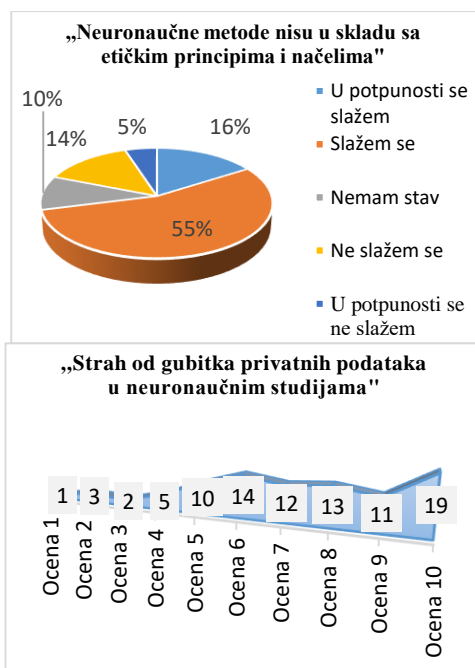
Usled rasta „indeksa vrednosti“ dolazi do promene emocionalnog stanja ispitanika. Navedeni „VA indeks“ se izračunava praćenjem moždanih impulsa, putem elektroda F3, F4, Fz, AF3, AF4, koje se postavljaju u okviru frontalnog moždanog režnja ispitanika (Al-Nafjan, Hosny, Al-Wabil & Al-Ohali, 2017).

5. Ključna ograničenja neuronaučnih studija

Usled rane faze upotrebe metoda neuronauke, za potrebe analize ljudskog ponašanja i procesa donošenja odluka, dolazi do pojave niza kritika i ograničenja, u pogledu etičke opravdanosti i relevantnosti datih studija. Ključna ograničenja su nepoverenje javnosti, neusklađenost sa etičkim principima i visoki troškovi realizacije (Flores, Baruca & Saldivar, 2014). Korišćenje sofisticiranih medicinskih uređaja nije dozvoljeno u pravcu otkrivanja kupovnih okidača za postizanje komercijalnog rasta i ugrožavanja slobode izbora ispitanika (Slijepčević, Popović-Šević & Radojević, 2019). Koristan lek za prevazilaženje datih ograničenja je veća edukovanost ispitanika, kako bi se anulirao strah od zloupotrebe ličnih podataka u komercijalne svrhe.

Kvalitativna analiza stavova ispitanika o stepenu etičnosti neuronaučnih studija, sprovedena je kroz formiranje strukturalnog upitnika. Prvi deo je sačinjavala grupa demografskih pitanja o polu, mestu i regionu boravka, obrazovnoj i starosnoj strukturi anketiranih. Drugi deo je podrazumevao proveru stepena poznavanja neuronaučnih tehnika. Treći deo se odnosio na davanje ocena, u pogledu opravdanosti korišćenja datih alata za ispitivanje ljudskog ponašanja. Na kraju, postavljena su pitanja koja proveravaju stavove ispitanika, u pogledu etičnosti upotrebe medicinskih uređaja u naučne svrhe.

Učešće u anketnom istraživanju je prihvatilo 92 ispitanika, od toga 53% muškaraca i 47% žena. Starosna struktura: od 18-25 godina (27%), od 26-35 godina (32%), od 36-45 godina (24%), od 46 do 55 godina (10%), preko 55 godina (7%). Struktura obrazovanja: osnovna škola (6%), srednja škola (55%), viša škola (10%), fakultetsko obrazovanje (29%). Vreme prikupljanja podataka putem anketnog upitnika, sprovedeno je u periodu od 19.01.2024 do 29.01.2024 godine. Prethodno učešće u neuronaučnim eksperimentima, ostvarilo je 2.17%, što je 2 ispitanika od ukupnog broja učesnika ankete.



Grafik 1. Kalkulacija autora rada, na osnovu rezultata anketnog upitnika

Razumevanje osnovnih postulata neuronauke, poseduje 34% od ukupnog broja anketiranih. Strah od ugrožavanja ličnih podataka je iskazalo 82% ispitanika. Rezultati ukazuju da 71% ispitanika, smatra neuronaučne metode neinvazivnim, što uzrokuje otklon od uzimanja učešća u istim. Na pitanje o učešću u budućim studijama, pozitivan odgovor je pružilo 27%, uz uslov novčane nadoknade. Dok je 7% prihvatilo učešće, ako je studija u naučne svrhe. Negativan odgovor na pitanje o učešću u budućim studijama je iskazalo 47% anketiranih. Zaključujemo da nepoštovanje etičkih standarda može predstavljati značajno ograničenje, u pogledu realizacije budućih neuronaučnih studija.

6. ZAKLJUČAK

Teorijski koncept „savršene racionalnosti“, postaje predmet kritike u nizu istraživačkih studija, u kojima se analizira ljudsko ponašanje i proces donošenja odluka. U radu je ukazano da ponašanje ljudi prati promenu njihovog emocionalnog stanja. Pored toga, utvrđeno je da različite grupe faktora iz neposrednog okruženja, ostvaruju značajan doprinos u složenom procesu donošenja odluka.

Pojava tehnoloških dostignuća u polju razvoja medicinskih instrumenata, koji se koriste za merenje stanja organizama i impulsa moždane aktivnosti, dovodi do proširenja njihove upotrebe u naučne svrhe. Na taj način, dolazi do boljeg razumevanja ponašanja ljudi i procesa pravljenja izbora. Elektroencefalografskim uređajima je zabeleženo da su ljudska bića sklona impulsivnim odlukama i odsustvu racionalnosti u dužem vremenskom periodu, što se kvantitativno izražava putem „EEG“ indeksa.

Razlog smanjenoj upotrebi neuronaučnih metoda, nastaje usled visokih troškova njihove realizacije, strogih etičkih standarda, kao i straha ispitanika od gubitka privatnosti. Obezbeđivanjem zakonski propisanih dokumenata, kao i pravilnim informisanjem ispitanika o tehnikama nauronaučnih istraživanja, uspešno se prevazilaze ograničenja u pogledu etičkih dilema njenih učesnika.

Vođeni intuicijom u trenutku izbora, ljudska bića ne vrše isključivo maksimizaciju finansijskih koristi, već sprovode celokupno zadovoljenje svojih preferencija. U radu se osporava teorijski koncept „Homo Economicus“, kroz isticanje iracionalnog ophođenja ljudi, u trenutku donošenja odluka. U tom pogledu, dolazimo do zaključka da ne postoje potpuno racionalna bića u dužem vremenskom periodu, što uzrokuje pomeranje od teorije savršene racionalnosti ka teoriji ograničene racionalnosti.

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RE-EXAMINING THE THEORY OF HOMO ECONOMICUS USING THE INSTRUMENTS AND METHODS OF NEUROSCIENCE

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ABSTRACT:

From the second half of the 19th century, the „Homo Economicus model“, which was established by John Stuart Mill, retained its role in economic theory until today. The concept of „calculating man“ has been subject of various interpretations over time, while the main contribution to the further development of this model was provided by theorists of the classical and neoclassical economic thought. The roots of this term come from the theory of rational choice, which indicates that people choose the most optimal solution, with the intention of maximizing their own interest. In accordance with this thesis, it was concluded that people react rationally to stimuli, which are placed in their immediate environment. With that attitude, the influence of the emotional state, intuitive reaction and insufficient information of people decision-making process was neglected. Criticism of the theory of perfect rationality was provided by representatives of behavioral economic thought, who developed the theory of „bounded rationality“. Through the development of ICT technologies, medical devices have been innovated, which are used to measure the impulses of brain activity and the state of the human organism. With the aim of analyzing the causes of irrational-decision making by respondents', we apply various neuroscientific techniques. This research paper defines methods such as: photon emission tomography, steady state topography, facial coding, positron emission tomography, functional magnetic resonance imaging, eye tracking, galvanic skin response, magnetoencephalography, electroencephalography. The methodological part of this research includes descriptive statistics, defining the „EEG“ index and qualitative analysis to reveal the limitations of neuroscientific studies. The key contribution of this research involves the definition of neuroscientific tool, for the purposes of analyzing the decision-making process and criticizing the theory of perfect rationality.

Keywords: *Homo Economicus, Irrational behavior, Medical devices, Neuroscientific methods, Bounded rationality.*

PERSPEKTIVA RAZVOJA KORPORATIVNIH OBVEZNICA U REPUBLICI SRBIJI

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SAŽETAK:

Kako bi se izborile sa konkurencijom, koja je u uslovima globalizacije i liberalizacije postala veoma jaka, kompanije su često primorane da investiraju u nova postrojenja i opremu. Ove investicije su uglavnom dugoročnog karaktera i prevazilaze iznose akumuliranih sredstava. S tim u vezi, kompanije su često prinuđene da se na različite načine zadužuju ili da putem emisija akcija prodaju deo vlasništva. Ukoliko se opredele za zaduživanje na finansijskom tržištu, što je najčešće slučaj, korporativne obveznice mogu imati veoma važnu ulogu u ovom procesu. Međutim, za razliku od tržišno orjentisanih finansijskih sistema, gde ova vrsta hartija od vrednosti ima veoma značajnu ulogu u procesu finansiranja kompanija, u bankocentričnim finansijskim sistemima korporativne obveznice su slabije zastupljene. S tim u vezi, Svetska banka je 2023. godine definisala program podrške razvoju korporativnih obveznica u Republici Srbiji koji bi trebalo da doprinese intenzivnijem razvoju ovih hartija od vrednosti u narednom periodu.

Ključne reči: direktno finansiranje, korporativne obveznice, hartije od vrednosti, zaduživanje.

1. UVOD

U savremenim uslovima poslovanja kompanije su, kako bi se uspešno izborile sa konkurencijom, primorane da kontinuirano ulažu u unapređenje uslova poslovanja, odnosno u modernizaciju postojećih postrojenja i nabavku nove opreme. Ove investicije su uglavnom dugoročnog karaktera i prevazilaze akumulirana sredstva, pa su, s tim u vezi, kompanije često primorane da na finansijskom tržištu potraže dodatne izvore finansiranja. Pored toga, finansijska tržišta predstavljaju mesta na kojem se vrednuju ostvareni rezultati poslovanja kompanija. Tako da ukoliko kompanija uspešno posluje ima bolji rejting koji joj omogućava da do nedostajućih sredstava dođe po povoljnijim uslovima. Na razvijenim finansijskim tržištima kompanijama je na raspolaganju nekoliko različitih izvora finansiranja koji se mogu svesti na dve alternative: zaduživanje (krediti banaka ili emitovanje dužničkih hartija od vrednosti) ili prodaja dela vlasništva (emitovanje akcija). Finansijska tržišta manje razvijenih zemalja odlikuje manji broj kvalitetnih finansijskih instrumenata pa su privrede ovih zemalja uglavnom oslonjene na bankarske kredite. S

druge strane, na razvijenim tržištima omogućeno je uspostavljanje direktnog odnosa između investitora i kompanija, odnosno mnogi investitori ulazu direktno u kompaniju, investirajući u akcije i korporativne obveznice. Pritom, kompanije se češće odlučuju za emisiju obveznica nego akcija, jer se emisijom obveznica ne menja njihova vlasnička struktura. Takođe, zaduživanje putem korporativnih obveznica može imati i brojne prednosti u odnosu na bankarske kredite. Bankarski kredit predstavlja bilateralni privatni ugovor, što može predstavljati problem kada su potrebe za finansijskim sredstvima veoma velike i kompanije ne mogu obezbediti sredstva samo od jednog investitora. S druge strane, obveznice su hartije od vrednosti sa neograničenom prenosivošću i predstavljaju multilateralni oblik duga, odnosno obično imaju više investitora (Marinković, 2011, 117). Srbija, kao i većina slabije razvijenih zemalja, ima bankocentrični finansijski sistem. Za potrebe finansiranja razvojnih projekata, ali i tekućeg poslovanja, kompanije koriste isključivo bankarske kredite. Iz toga razloga, od velikog je teorijskog i praktičnog značaja sagledati mogućnosti intenzivnijeg razvoja korporativnih obveznica na posmatranom području. Pritom, treba napomenuti da podsticanje finansiranja privrede emitovanjem korporativnih obveznica najverovatnije ne bi negativno uticalo na uspešnost poslovanja banaka već bi, naprotiv, vodilo diversifikaciji njihovog poslovanja. Ako bi razvoj tržišta korporativnih obveznica delimično i izazvao smanjenje obima kreditnih poslova komercijalnih banaka, sasvim sigurno bi podstakao razvoj drugih bankarskih aktivnosti koje se odnose na poslove investicionog bankarstva. S tim u vezi, treba očekivati da će visok stepen konkurencije na kreditnom tržištu u Srbiji uticati na razvoj investicionog bankarstva, jer razvoj tržišta dužničkih hartija od vrednosti predstavlja jednu od novih poslovnih mogućnosti banaka (Marinković, 2011, 117). Pored toga, banke kao uglavnom uspešne kompanije mogu emitovati i svoje obveznice. One će tu mogućnost iskoristiti ukoliko žele da prošire i dodatno diversifikuju izvore sredstava ili u slučaju da žele da obezbede dugoročna i stabilna dinarska sredstva za dinarske plasmane. Upravo volja i potencijal banaka da razviju poslove investicionog bankarstva predstavljaju važan preduslov za razvoj tržišta korporativnih obveznica u Srbiji (Jovanić, 2008).

Imajući u vidu nedovoljnu razvijenost ovog segmenta finansijskog tržišta, u Srbiji je krajem 2021. godine definisana "Nacionalna strategija za razvoj tržišta kapitala za period 2021-2026. godina". Ovom strategijom su utvrđeni prioritetni ciljevi i mere za razvoj tržišta kapitala na posmatranom području. Primena ove strategije je pokazala da u Srbiji postoji veliki potencijal za razvoj tržišta kapitala. S tim u vezi, Svetska banka je 2023. godine odobrila projekat za podsticanje njegovog razvoja u narednom periodu (World Bank, 2023). Značajan deo ovog programa namenjen je razvoju korporativnih obveznica. Takođe, važno je napomenuti da je 2020. godine, u okviru "Mera Vlade Republike Srbije za ublažavanje ekonomskih posledica nastalih usled pandemije virusa SARS-CoV-2", doneta uredba kojom je velikim kompanijama olakšan postupak emitovanja obveznica. Glavni podsticaj za emitovanje korporativnih obveznica jeste uključivanje Narodne banke Srbije u ulogu kupca na sekundarnom tržištu. Imajući u vidu sve navedene aktivnosti, može se reći da je realno očekivati da će u narednom periodu u Srbiji doći do intenzivnijeg razvoja korporativnih obveznica.

2. OSNOVNE KARAKTERISTIKE KORPORATIVNIH OBVEZNICA

Korporativne obveznice se uglavnom definišu kao finansijski instrumenti koje emituju preduzeća, odnosno kompanije, čime se obavezuju da će u definisanim rokovima plaćati ugovorenu kamatu, a u roku dospeća vratiti glavnicu. Korporativna obveznica se može posmatrati i kao ugovor na osnovu kojeg investitori pozajmljuju novac kompaniji koja se obavezuje da će holderima obveznice plaćati kamatu u sukcesivnim vremenskim periodima i isplatiti nominalnu vrednost obveznice o roku dospeća (Cecchetti & Schoenholtz, 2011, 167). Kao i većina drugih hartija od vrednosti, korporativne obveznice su prenosivi vrednosni papiri (nezavisno od toga da li glase na ime ili na donosioca). Mogućnost kupovine i prodaje obveznica na sekundarnom tržištu povećava njihovu atraktivnost, jer omogućava njihovim vlasnicima da dođu do gotovog novca pre roka dospeća ovih hartija od vrednosti. Dakle, korporativne obveznice investitori mogu držati do roka dospeća uz redovnu isplatu kamata i glavnice i na taj način ostvariti prinos, ali mogu ih i prodati drugom zainteresiranom investitoru u bilo koje vreme pre roka dospeća i pritom ostvariti kapitalni dobitak/gubitak (Fabozzi, 2013, 158).

Ključne odrednice korporativnih obveznica su: nominalna vrednost, kamatna stopa i rok dospeća. *Nominalna vrednost* obveznice se isplaćuje pri roku dospeća i predstavlja iznos pozajmljene sume, odnosno glavnica duga. Većina korporativnih obveznica u SAD imaju nominalnu vrednost od 1.000 dolara (Mishkin & Eakins, 2003, 252). Nekada su se obveznice prodavale sa priloženim kuponima vlasnika obveznice. To su obveznice koje glase na donosioca, jer se isplaćuju onome ko ih fizički poseduje. Ove obveznice su vremenom zamenjene obveznicama koje glase na ime i nemaju kupone. Međutim, kamata koja se plaća na obveznice još uvek se naziva kuponska kamata, a kamatna stopa na obveznice kuponska kamatna stopa (Mishkin & Eakins, 2005, 253). Kuponska kamatna stopa je godišnja kamata izražena kao procenat nominalne vrednosti obveznice (Brealey, Myers, & Marcus, 2007, 136). Međutim, korporativne obveznice tradicionalno se nazivaju hartijama od vrednosti sa fiksnim prihodom zato što većina njih plaća fiksni iznos kamate za svaku godinu (Rose & Marquis, 2011, 632). U odnosu na druge tipove obveznica, ove obveznice podrazumevaju veće kamate, jer nose veći rizik. S druge strane, u odnosu na akcije korporativne obveznice su manje rizične hartije od vrednosti, jer ukoliko dođe do eventualnog bankrota kompanije iz likvidacione mase se najpre isplaćuju poverioci, odnosno vlasnici korporativnih obveznica, pa tek onda vlasnici kompanije, tj. akcionari. Pored nominalne vrednosti i kamate, neizostavna karakteristika obveznica je i rok dospeća ili ročnost obveznice. Dospeće dužničkog instrumenta je broj godina (razdoblja) do datuma isteka instrumenta (Mishkin, 2007, 26). Na razvijenim finansijskim tržištima, npr. SAD, dužničke hartije od vrednosti preduzeća koje imaju rok dospeća do 10 godina, a ponekad i duži, nazivaju *note*, dok se korporativnim obveznicama uglavnom nazivaju samo hartije od vrednosti koje imaju rok dospeća 20 do 30 godina (Fabozzi, 2013, 158). Dužničke hartije od vrednosti kompanija koje imaju veoma kratke rokove dospeća poznate su pod nazivom komercijalni papiri (u SAD od 1 do 270 dana). Početkom XX veka na tržištu SAD postojale su korporativne obveznice mnogih železnica sa rokovim dospeća od 100 godina i više. Kasnije, tokom pedesetih i šezdesetih godina rokovi dospeća bili su kraći i dominiraju korporativne obveznice sa rokovima dospeća od 20, 30 i 40 godina. Ovakav trend je nastavljen tokom sedamdesetih i osamdesetih godina i na tržištu su se javljale samo korporativne obveznice sa rokovima dospeća od 5 do 15 godina (Rose & Marquis, 2011, 628). Savladana inflacija i veoma niske kamatne stope početkom devedesetih godina doprineli su da se rokovi dospeća ovih hartija od vrednosti enormno

povećaju. U tom periodu kompanije Walt Disney i Coca Cola uspele su da na tržište plasiraju obveznice sa dospećem od 100 godina (Marinković, 2011, 117).

Korporativne obveznice mogu imati brojne prednosti u odnosu na tradicionalne izvore finansiranja. U odnosu na bankarske kredite, emitovanje ovih hartija od vrednosti može predstavljati povoljniji izvor finansiranja, pri čemu je prisutna manja zavisnost od samo jednog izvora finansiranja. Takođe, prisutnost kompanija na tržištu kapitala doprinosi podizanju rejtinga izdavaoca i ostvaruje pozitivni marketinški efekat koji obezbeđuje lakše plasiranje novih proizvoda i usluga. Pritom, zaduživanje putem korporativnih obveznica predstavlja transparentno zaduživanje koje najčešće podrazumeva zaduživanje bez kolatera. S druge strane, zbog svoje sigurnosti i prinosa koji donose korporativne obveznice su privlačne za investitore, naročito institucionalne.

U praksi postoji nekoliko vrsta korporativnih obveznica, pri čemu je najzastupljenija podela na osigurane i neosigurane (obične). Osigurane korporativne obveznice kao obezbeđenje koriste imovinu ili kolateral, dok neosigurane obveznice kao obezbeđenje koriste kreditnu sposobnost i ugled emitenta (Mishkin & Eakins, 2005, 255). S obzirom da osigurane korporativne obveznice kao sredstvo obezbeđenja koriste opremu, nekretnine i sl, nazivaju se još i hipotekarne obveznice. Osigurane korporativne obveznice, zbog veće sigurnosti, odlikuje niža kamatna stopa u odnosu na neosigurane (Saunders & Cornett, 2012, 196). Pored ove dve osnovne vrste, u praksi postoje i neke posebne vrste korporativnih obveznica, kao što su: garantovane, konvertibilne i opozive. Garantovane korporativne obveznice podrazumevaju da finansijski slabije kompanije u procesu emitovanja obveznica koriste (kupuju) finansijske garancije drugih subjekata kako bi smanjile rizik svoj obveznica. U tom slučaju, kreditni rejting onoga koji daje garanciju služi umesto kreditnog rejtinga emitenta (Mishkin & Eakins, 2005, 257). Kada korporativne obveznice imaju veoma duge rokove dospeća najčešće emitentu daju mogućnost da ih otkupi nakon protoka određenog vremenskog perioda, npr. nakon trideset godina (Jakšić, 2005, 231). U tom slučaju korporativne obveznice se emituju kao opozive obveznice ili obveznice sa kol opcijom. Navedena opcija dopušta emitentu da otkupi obveznicu po utvrđenoj ceni pre roka dospeća (Ritter, Silber & Udell, 2004, 133). Konvertibilne korporativne obveznice kupcu daju mogućnost da ih zameni za drugu vrstu hartija od vrednosti. S tim u vezi, može ih po unapred utvrđenoj konverzionalnoj ceni zameniti za akcije kompanije, a da li će to iskoristiti zavisi od kretanja tržišne cene tih akcija (Ćirović, 2007, 35).

Korporativne obveznice imaju veoma važnu ulogu u tržišno orjentisanim finansijskim sistemima, ali i u nekim bankocentričnim sistemima (npr. Kina). Pritom, ne treba gubiti iz vida da banke aktivno učestvuju u njihovim emisijama, kao pokrovitelji i kupci, ali emituju i svoje korporativne obveznice. Najveće i najrazvijenije tržište korporativnih obveznica na svetu imaju SAD, gde predstavljaju dominantnu hartiju od vrednosti na tržištu dugoročnog duga. Korporativnim obveznicama se na posmatranom području uglavnom trguje preko dilera, odnosno market mejkera na vanberzanskom tržištu (Cecchetti & Schoenholtz, 2011, 167), a samo mali broj ovih obveznica se nalazi na listingu Njujorške berze (NYSE). Kompanijama kao što su Ford, IBM ili recimo General Electric veoma je lako da emituju obveznice i na taj način da dođu do potrebnih finansijskih sredstava (Cecchetti & Schoenholtz, 2011, 167). Međutim, obim sekundarnog trgovanja korporativnim obveznicama je na veoma niskom nivou, pa čak i kada se radi i o najkvalitetnijim kompanijama (Rose & Marquis, 2011, 638). To je iz razloga što se mnogi

institucionalni investitori opredeljuju za strategiju „kupi i drži“. U Velikoj Britaniji, najčešće korišćene korporativne obveznice su obične obveznice. Poznate su i pod nazivom neosigurane obveznice ili zadužnice (debentures) (Mishkin & Eakins, 2005, 255), ali ponekad mogu imati bolji rejting od osiguranih obveznica (PSinvest, 2024). Korporativne obveznice se u Velikoj Britaniji često emituju i kao garantovane obveznice. S tim u vezi, njihova isplata garantovana je od strane nekog drugog ekonomskog subjekta (Jakšić, 2005, 231). U Kini, koju odlikuje bankocentrični finansijski sistem, korporativne obveznice takođe imaju veoma značajnu ulogu, pri čemu se emituju sa veoma dugim rokovima dospeća.

3. ANALIZA RAZVOJA KORPORATIVNIH OBVEZNICA U SRBIJI

Srbiju odlikuje bankocentričan i u celini posmatrano nedovoljno razvijen finansijski sistem, jer se stepen razvijenosti finansijskog tržišta uglavnom sagledava na osnovu raznovrsnosti i kvaliteta finansijskih instrumenata koji se na njemu nalaze. Na srpskom tržištu kapitala se nalazi mali broj kvalitetnih hartija od vrednosti, naročito akcija. S tim u vezi, na Beogradskoj berzi je tokom 2022. godine ostvaren najmanji promet akcijama u poslednjih 20 godina, ukoliko se posmatraju samo standardni metodi trgovanja. S druge strane, od 2015. godine u trgovanje na Beogradskoj berzi uključene su brojne emisije obveznica Republike Srbije, pri čemu ove dužničke hartije od vrednosti čine više od 80% ukupnog prometa. Međutim, pored transakcija zaključenih na Beogradskoj berzi u sistemu Centralnog registra, depo i kliring hartija od vrednosti a.d. Beograd (u daljem tekstu samo Centralni registar) se evidentiraju i transakcije zaključene na OTC tržištu. OTC tržište je sekundarno tržište za trgovanje finansijskim instrumentima koje ne mora da ima organizatora tržišta i čiji sistem trgovanja, podrazumeva pregovaranje između prodavca i kupca finansijskih instrumenata u cilju zaključenja transakcije (Zakon o tržištu kapitala, čl. 2). Na OTC tržištu se može trgovati: dužničkim finansijskim instrumentima; finansijskim instrumentima koje je izdala Republika Srbija i Narodna banka Srbije; akcijama u skladu sa zakonom kojim se uređuje preuzimanje akcionarskih društava i zakonom kojim se uređuju privredna društva, kao i u ostalim slučajevima propisanom članom 48. Zakona o tržištu kapitala. OTC transakcije se zaključuju preko aukcijske platforme ministarstva finansija Republike Srbije, aukcijske platforme Narodne banke Srbije, korisničke WEB aplikacije Centralnog registra i drugih platformi za vanberzansko trgovanje (Centralnog registra, *Pravila poslovanja*, čl. 47b). Transakcije finansijskim instrumentima zaključene na ovom tržištu tokom 2022. godine činile su oko 99% vrednosti ukupno saldiranih transakcija. Ukupna vrednost saldiranih transakcija tokom 2022. godine iznosila je nešto više od 6.891 mlrd. RSD. Najveća vrednost saldiranih transakcija na OTC tržištu odnosila se na repo kupovinu i prodaju finansijskih instrumenata, konkretno blagajničkih zapisa Narodne banke Srbije. Na osnovu prethodno navedenih podataka može se reći da postoji veliki potencijal za razvoj tržišta kapitala na posmatranom području.

U cilju podsticanja daljeg razvoja tržišta kapitala, u Srbiji je krajem 2021. godine usvojena „Nacionalna strategija za razvoj tržišta kapitala za period 2021-2026. godina“. Kao rezultat primene ove strategije utvrđeno je da je za razvoj tržišta kapitala na posmatranom području potencijalno na raspolaganju između 12 i 14 mlrd. EUR, što su viškovi likvidnih sredstava banaka, investicionih i penzionih fondova. Pored toga, tu je i štednja građana

koja je, i pored ne baš povoljnih uslova za štednju, dostigla nivo od 15 mlrd. EUR. Imajući u vidu nizak nivo razvijenosti tržišta kapitala u Srbiji i uočeni potencijal za njegov budući razvoj, Svetska banka je 2023. godine odobrila 27,7 miliona evra za podsticanje njegovog razvoja u narednom periodu (World Bank, 2023). Važno je napomenuti da je značajan deo ovog programa usmeren ka razvoju tržišta korporativnih obveznica. Pored toga, u Srbiji je 2020. godine, u okviru "Mera Vlade Republike Srbije za ublažavanje ekonomskih posledica nastalih usled pandemije virusa SARS-CoV-2", doneta "Uredba o postupku za izdavanje dužničkih hartija od vrednosti" kojom je velikim kompanijama u značajnoj meri olakšan postupak emitovanja ovih hartija od vrednosti.

Zakonom o tržištu kapitala bliže su definisani osnovni pojmovi vezani za emitovanje i trgovinu korporativnim obveznicama u Srbiji. Emitent, odnosno dužnik je lice koje upućuje javnu ponudu u postupku izdavanja hartija od vrednosti i drugih finansijskih instrumenata i koje se obavezuje da će na osnovu ugovora izvršiti sve svoje obaveze po osnovu emisije korporativnih obveznica, a to su isplata kamate u dogovorenim vremenskim intervalima i nominalne vrednosti, odnosno glavnice duga o roku dospeća. Poverilac, odnosno investitor je lice koje kupuje korporativne obveznice, pri čemu ono može biti pravno ili fizičko lice koje ima dovoljno finansijskih sredstava i motiva da uloži finansijska sredstva u preduzeće, odnosno kompaniju. Pomenutim Zakonom je definisano da korporativne obveznice mogu emitovati domaća pravna lica i biti nominirane u dinarima ili u nekoj stranoj valuti. Takođe, predviđeno je da mogu biti diskontne i kamatonosne, s tim što su diskontne pogodnije za sekundarno trgovanje. Primarna prodaja korporativnih obveznica u Srbiji se može vršiti putem javne distribucije ili za profesionalne ulagače (privatno emitovanje) (Jakšić, 2005, 44). Kod privatnog emitovanja kompanija direktno prodaje svoje obveznice, najčešće manjem broju investitora, kao što su institucionalni investitori. Ovaj način prodaje, za razliku od javnog plasmana, ne zahteva registracionu proceduru kod nadležnih organa što im u osnovi može smanjiti troškove emisije.

Iako se na razvijenim finansijskim tržištima korporativne obveznice emituju sa veoma dugim rokovima dospeća, od 20, 30, 50 pa čak i 100 godina, u Srbiji se još uvek izdaju sa dosta kraćim rokovima dospeća. Ipak, ubrajaju se u dugoročne hartije od vrednosti što podrazumeva da imaju rok dospeća duži od godinu dana. Ukoliko se izuzmu emisije kratkoročnih dužničkih hartija od vrednosti kompanija sa veoma kratkim rokovima dospeća, može se reći da je razvoj korporativnih obveznica u Srbiji počeo sredinom 2010. godine. Kompanija Telefonija a.d. Beograd je emitovala prve dugoročne korporativne obveznice na srpskom tržištu kapitala sa rokom dospeća od četiri godine u vrednosti 50 miliona dinara. Tom prilikom izdato je ukupno 5.000 obveznica nominalne vrednosti 10.000 dinara i roka dospeća od četiri godine. Emisija je bila za unapred poznatog kupca, osiguravajuću kuću „*Wiener Städtische*“. Međutim, ova kompanija je u narednom periodu veoma loše poslovala i pri roku dospeća ovih obveznica suočila sa ogromnim problemima. Najpre je Beogradska berza, iz opravdanih razloga 2. oktobra 2014. godine, privremeno obustavila trgovanje akcijama "Telefonije a.d. Beograd". Dve nedelje kasnije rešenjem Privrednog suda u Beogradu nad ovom kompanijom otvoren je stečajni postupak i imenovan stečajni upravnik. Bez obzira što korporativne obveznice sadrže pravo prioritete naplate u odnosu na vlasnike običnih i preferencijalnih akcija, sve ovo je imalo veoma negativan uticaj na dalji razvoj korporativnih obveznica u Srbiji. Pre 2014. godine, osim obveznica ove kompanije bilo je još nekoliko emisija korporativnih obveznica

(Dugalić & Stojković, 2015). U julu 2010. godine “NLB banka a.d. Beograd” realizovala je emisiju dugoročnih kuponskih obveznica u vrednosti od 461 mil. RSD. Hartije su emitovane putem zatvorene emisije unapred poznatim kupcima – profesionalnim investitorima, među kojima su osiguravajuća društva i penzioni fondovi. Rok dospeća ovih obveznica bio je 5 godina i imale su fiksnu kamatnu stopu od 5%. Ove hartije od vrednosti su emitovane sa evro valutnom klauzulom. Iste godine, u avgustu i oktobru, kompanija “Tigar a.d. Pirot” emitovala je dve serije dugoročnih korporativnih obveznica u obimu od 250 mil. RSD i sa rokom dospeća od 5 godina. Ove obveznice su imale stopu prinosa od 7,75 % i bila je definisana kvartalna isplata kupona. Emisija je bila namenjena profesionalnim investitorima. Sredinom 2011. godine ova kompanija je realizovala i treću emisiju korporativnih obveznica za unapred poznate kupce u obimu od 90 mil. RSD. One su nosile devizni prinos od 9% godišnje, a rok dospeća bio im je četiri godine. U istom periodu, dakle sredinom 2011. godine, kompanija “Galeb GTE a.d. Beograd” emitovala je korporativne obveznice sa rokom dospeća od 5 godina. Ukupna nominalna vrednost ovih obveznica bila je 50 mil. RSD, a kuponska stopa iznosila je 7,85% na godišnjem nivou. Izdavanje obveznica bilo je zatvorenog tipa, a investitor koji je otkupio celokupnu emisiju je austrijsko osiguravajuće društvo koje posluje u Srbiji “*Wiener Staedtsche*”. U 2012. godini u ulozi izdavaoca korporativnih obveznica našle su se dve banke: *Societe Generale banka*, koja je izdala prvu dugoročnu korporativnu dinarsku dužničku hartiju od vrednosti bez zaštitne valutne klauzule, i *Erste banka a.d. Novi Sad*, koja je realizovala prvu primarnu javnu prodaju dinarskih dužničkih hartija od vrednosti na organizovanom tržištu. Emisija korporativnih obveznica *Societe Generale* banke bila je za unapred određene kvalifikovane investitore. Vrednost emisije bila je 1,7 mlrd. RSD, a rok dospeća 3 godine. Isplata glavnice je po dospeću obveznice, a struktura kamatne stope sastojala se iz fiksnog (5,25 na godišnjem nivou) i varijabilnog dela (referentna kamatna stopa NBS). Emitovane su sa *put* klauzulom što je pogodnost za investiture, jer se oslobađaju neizvesnosti i rizika nelikvidnosti. Na regulisano tržište Beogradske berze, segment *Open Market*, uključene su 14. septembra 2012. godine (Miladinovski, 2012). Investitori su bili iz sektora osiguranja i dobrovoljnih penzijskih fondova (ukupno 8 ili 15%) i bankarskog sektora (ukupno 3 ili 85%). Obveznice Erste banka a.d. Novi Sad imale su rok dospeća novembar 2014. godine. Ukupna vrednost emisije iznosila je 2,1 milijardi dinara, a kamata se obračunavala kvartalno po fiksnoj godišnjoj stopi 15%. Na primarnoj prodaji 6. novembra 2012. godine ukupno je prodato 146.500 obveznica (70% ponuđene količine). Sekundarno trgovanje dugoročnim dinarskim korporativnim obveznicama Erste banke počelo je 30. novembra 2012. godine na Open market segmentu Beogradske berze. Sve dotadašnje emisije korporativnih obveznica, osim emisija koje su realizovale Societe Generale banka i Erste banka, odlikovala je zaštitna valutna klauzula.

Nakon 2014. godine i stečaja kompanije Telefonija, usledio je pad poverenja u korporativne obveznice i veliki zastoj u daljem razvoju tržišta ovih hartija od vrednosti. Početkom 2019. godine Erste banka je emitovala drugu emisiju korporativnih obveznica u vrednosti od 3,5 mlrd RSD, sa rokom dospeća od dve godine. Nakon toga, emitovano je nekoliko emisija korporativnih obveznica od strane drugih kompanija, ali u veoma skromnom obimu. U okviru mera za suzbijanje negativnih efekata Covida 19, u Srbiji su definisane određene podsticajne mere usmerene ka unapređenju tržišta korporativnih obveznica. Kao najznačajnija mera može se izdvojiti Uredba o postupku za izdavanje dužničkih hartija od vrednosti doneta 10. aprila 2020. godine kojom se, između ostalog,

pojednostavljuje postupak izdavanja obveznica tokom trajanja vanrednog stanja i šest meseci nakon njegovog ukidanja (KPMG, 2020). Glavni podsticaj za emitovanje korporativnih obveznica jeste uključivanje centralne banke u ulogu kupca na sekundarnom tržištu. S tim u vezi, tokom 2020. godine realizovano je pet emisija korporativnih obveznica ukupne nominalne vrednosti od 50,3 mlrd. RSD. U skladu sa prethodno pomenutom uredbom i definisanim propisima, Narodna banka Srbije je na sekundarnom tržištu od poslovnih banaka otkupila deo ovih obveznica, uglavnom državnih preduzeća, u vrednosti od 27,5 mlrd. RSD (NBS, 2021). Kao rezultat ovog poteza i rasta poverenja u korporativne obveznice, u narednom periodu je registrovano još nekoliko novih emisija ovih hartija od vrednosti. Tokom 2022. godine izvršen je upis 10 novih emisija korporativnih obveznica (Centralni registar, *Izveštaj o poslovanju za 2022. godinu*). Prema podacima Centralnog registra, dostupnim u aprilu 2024. godine, na srpskom tržištu kapitala trenutno postoji 10 aktivnih emitenata korporativnih obveznica. Karakteristike njihovih korporativnih obveznica prikazane su u Tabeli 1.

Tabela 1. Aktivne emisije korporativnih obveznica u Republici Srbiji

Emitent	Datum upisa	Datum dospeća	Ukupna vrednost (RSD)	Kamatna stopa	Garancija
AD Mlekara Šabac	23.06.2022	21.06.2024	60 mil.	promenljiva	Neobezbeđeno
	07.09.2022	02.09.2024	50 mil.	promenljiva	Neobezbeđeno
	16.12.2022	16.12.2024	80 mil.	promenljiva	Neobezbeđeno
	31.03.2023	28.03.2025	50 mil.	promenljiva	Neobezbeđeno
Borbeni složeni sistemi doo	09.09.2020	09.09.2027	5.405 mil.	Promenljiva	Ima garanciju
	04.10.2022	04.10.2032	5.083 mil.	Promenljiva	Neobezbeđeno
Energoprojekt Holding a.d.	30.12.2020	30.12.2025	3.300 mil.	Promenljiva	Neobezbeđeno
JP Jugimport SDPR	10.09.2020	10.09.2025	15.275 mil.	Promenljiva	Neobezbeđeno
	03.10.2022	03.10.2032	6.650 mil.	Promenljiva	Neobezbeđeno
	28.02.2023	28.02.2033	47.000 mil.	Promenljiva	Neobezbeđeno
M.I. Finance D.O.O. Šabac	18.08.2023	08.02.2027	35 mil.	Promenljiva	Neobezbeđeno
	23.10.2023	21.04.2025	35 mil.	Promenljiva	Neobezbeđeno
	21.12.2023	21.03.2025	30 mil.	Promenljiva	Neobezbeđeno
	29.02.2024	27.02.2027	25 mil.	Promenljiva	Neobezbeđeno
Mediolanum Invest a.d.	20.09.2021	20.09.2026	235,2 mil.	Promenljiva	Neobezbeđeno
	16.12.2021	16.12.2026	110 mil.	Promenljiva	Neobezbeđeno
	24.02.2022	17.02.2027	235,2 mil.	Promenljiva	Neobezbeđeno
PMC Inženjering doo Beograd	09.09.2020	09.09.2025	2.820 mil.	Fiksna	Ima garanciju
Spring UP Alijansa doo	14.03.2024	10.03.2025	14 mil.	Fiksna	Neobezbeđeno
Telekom Srbija a.d.	25.09.2020	25.09.2025	23.500 mil.	Promenljiva	Neobezbeđeno

W.D. Concord West doo	15.03.2024	31.01.2025	468,75 mil.	Nulta stopa	Neobezbeđeno
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Izvor: Centralni registar depa i kliring hartija od vrednosti ad Beograd, Izveštaj o poslovanju za 2022. godinu

Na osnovu prikazanih podataka može se zaključiti da se u Srbiji još uvek mali broj kompanija odlučuje na ovaj vid finansiranja, pri čemu su uglavnom zastupljeni veoma kratki rokovi dospeća. Trenutne emisije korporativnih obveznica su negarantovane, pa su strani institucionalni investitori na srpskom tržištu kapitala još uvek nedovoljno spremni da ulažu u ove hartije od vrednosti. Trenutni kupci korporativnih obveznica u Srbiji su uglavnom domaći institucionalni investitori, pri ču sekundarno trgovanje gotovo da ne postoji. S tim u vezi, na Beogradskoj berzi, na segmentu Open Market, nalaze se samo obveznice Energoprojekta (Belex, *Finansijski instrumenti*, 2024). Svakako da je jedan od uticajnijih faktora nedovoljne razvijenosti tržišta korporativnih obveznica u Srbiji loša slika iz prošlosti, odnosno problemi u servisiranju obaveza kod nekih izdavaoca u prethodnom periodu.

Ukoliko uporedimo nivoe razvijenosti tržišta korporativnih obveznica Srbije i razvijenijih zemalja jasno se uočava zaostatak srpskog tržišta kapitala. Kao adekvatan primer za poređenje može poslužiti Hrvatska, i to iz bar tri razloga: prvo, Zagrebačka berza je reosnovana 2 godine kasnije od berze u Beogradu; drugo, radi se o državi koja je članica Evropske Unije; i treće, radi se o tržištu kapitala koje ima u velikoj meri sličan regulatorni okvir na tržištu kapitala. Zakon o tržištu kapitala koji je stupio na snagu u Srbiji krajem 2011. godine i zamenio do tada važeći Zakon o tržištu hartija od vrednosti i drugih finansijskih instrumenata najviši je zakon i na hrvatskom tržištu kapitala od 2009. godine. Takođe, treba napomenuti da je početkom 2022. godine stupio je na snagu novi Zakon o tržištu kapitala u Srbiji. Prve korporativne obveznice u Hrvatskoj emitovane su 2002. godine, dok je njihovo značajnije emitovanje počelo od 2004. godine. Trenutno se na Zagrebačkoj berzi nalazi 13 emisija korporativnih obveznica: 11 emisija na *Službenom tržištu* i 2 emisije na *Redovitom tržištu* (Zagrebačka berza, *obveznice*, 2024).

4. ZAKLJUČAK

Korporativne obveznice emituju pre svega kapitalno jake i profitabilne kompanije. Emitovanjem ovih hartija od vrednosti kompanije se obavezuju da će investitorima periodično plaćati kamatu i isplatiti glavnicu o roku dospeća. U Srbiji se korporativne obveznice emituju uz rokove dospeća od 1 do 10 godina, dok se ove hartije od vrednosti na visoko razvijenim tržištima emituju sa veoma dugim rokovima dospeća u rasponu od 5 pa čak i do 100 godina (uglavnom 20 ili 30). Korporativne obveznice se ubrajaju u utržive hartije od vrednosti, što znači da ih investitori ne moraju držati do roka dospeća već ih mogu prodati na sekundarnom tržištu. Međutim, sekundarni promet ovim hartijama od vrednosti je veoma slab, pa čak i kada se radi o razvijenim tržištima kapitala i velikim i uspešnim kompanijama. U odnosu na druge vrste obveznica, korporativne obveznice uglavnom nose veći prinos, pa mogu biti privlačnije za investitore. U odnosu na akcije, korporativne obveznice predstavljaju dosta sigurnije hartije od vrednosti, jer podrazumevaju pravo prečeg potraživanja prema prihodu kompanije u odnosu na

akcionare, kao i prioritarno pravo potraživanja na aktivu u slučaju stečaja kompanije. Pored toga, finansiranje putem korporativnih obveznicama može biti veoma pogodno za kompanije, jer ne dovode do promena u vlasničkoj strukturi. Takođe, zaduživanje kompanija putem korporativnih obveznica može imati brojne prednosti i u odnosu na bankarske kredite. Emisijom korporativnih obveznica kapital se pribavlja iz više izvora, dok je kod zaduživanja bankarskim kreditima broj izvora veoma ograničen. S tim u vezi, manji broj izvora finansiranja može predstavljati problem kod velikih investicija. Međuti, pored brojnih prednosti, korporativne obveznice imaju i neke nedostatke. Ove dužničke hartije od vrednosti su dugoročne i izložene su riziku kamatne stope. S tim u vezi, cene obveznica će naglo padati ukoliko kamatne stope budu rasle. Pored ovog rizika, korporativne obveznice su u značajnoj meri izložene i riziku inflacije.

Razvoj korporativnih obveznica u Srbiji je počeo 2010. godine, ukoliko se zanemare dužničke hartije od vrednosti preduzeća sa veoma kratkim rokovima dospeća. Međutim, prve emisije ovih hartija od vrednosti realizovane su u malom obimu i bile su namenjene unapred poznatim investitorima. Pored toga, sve do 2012. godine nije bilo emisija koje su realizovane putem javne prodaje na organizovanom tržištu i bez valutne klauzule. Prve takve korporativne obveznice na Beogradskoj berzi emitovale su dve poslovne banke: Societe general i Erste banka. Međutim, problemi u otplati duga po osnovu korporativnih obveznica kod nekih izdavaoca u ovom periodu (npr. stečaj Telefonije) negativno su uticali na dalji razvoj ovih hartija od vrednosti na posmatranom području. S tim u vezi, Erste banka je tek 2019. emitovala drugu emisiju korporativnih obveznica. Početkom 2020 godine, u okviru “Mera Vlade Republike Srbije za ublažavanje ekonomskih posledica nastalih usled pandemije virusa SARS-CoV-2” u Srbiji je doneta Uredba kojom je velikim kompanijama olakšan postupak emitovanja korporativnih obveznica. Glavni podsticaj jeste uključivanje Narodne banke Srbije u ulozu kupca ovih hartija od vrednosti, odnosno uključivanje dinarskih korporativnih obveznica u monetarne operacije. Pored toga, krajem 2021. godine usvojena je “Nacionalna strategija za razvoj tržišta kapitala za period 2021-2026 godina”. Primena ove strategije trebalo bi da ostvari brojne pozitivne efekte na tržište kapitala i unapredi ponudu finansijskih instrumenata. Iste godine, usvojen je novi Zakon o tržištu kapitala koji je stupio na snagu početkom 2022. godine. U skladu sa navedenim podsticajima, tokom 2022. godine uspešno je realizovano deset emisija korporativnih obveznica. Dakle, poslednjih godina definisano je i usvojeno nekoliko važnih dokumenata i propisa koji bi trebalo da doprinesu intenzivnijem razvoju tržišta kapitala u Srbiji u budućnosti. Pored toga, na osnovu uočenog potencijala za njegov razvoj, Svetska banka je 2023. godine odobrila 27,7 miliona evra za podsticanje njegovog razvoja u narednom periodu. Značajan deo ovih sredstava opredeljen je upravo za razvoj tržišta korporativnih obveznica.

Kao najuticajniji faktori niske razvijenosti tržišta korporativnih obveznica u Srbiji mogu se izdvojiti: nizak rejting potencijalnih emitenata, bankocentričan finansijski sistem, neadekvatan regulatorni okvir u prethodnom periodu i slabo razvijeno tržište kapitala u celini. Nizak rejting kompanija odbija potencijalne investitore koji su možda spremni da ulože novčana sredstva u poslovanje preduzeća. Dosadašnje emisije korporativnih obveznica bile su uglavnom negarantovane pri čemu su njihovi kupci bili samo domaći investitori. Velike i uspešne kompanije usled nedostata finansijskih sredstava uglavnom koriste bankarske kredite i nisu dovoljno motivisane da koriste alternativne izvore finansiranja. Beogradsku berzu, kao važan segment tržišta kapitala u Srbiji, odlikuje

poprilično skromna ponuda kvalitetnih hartija od vrednosti, pa se na njenim tržištima ostvaruju veoma slabi promet. S tim u vezi, važno je napomenuti da transakcije zaključene na Beogradskoj berzi čine samo oko 1% vrednosti svih transakcija saldiranih kod Centralnog registra. Promet finansijskim instrumentima koji se ostvaruje na vanberzanskom tržištu (OTC) čini 99% vrednosti svih transakcija saldiranih kod Centralnog registra. Dakle, može se reći da se jasno uočava veliki potencijal za razvoj tržišta hartija od vrednosti, naročito korporativnih obveznica. Međutim, prethodno navedeni razlozi, uz nizak nivo korporativne kulture u Srbiji, mogu predstavljati značajnu prepreku razvoju korporativnih obveznica i u narednom periodu. S tim u vezi, na samom kraju, treba naglasiti da je za prosperitetni razvoj tržišta kapitala na posmatranom području neophodna, pre svega, istinska volja i podrška vladajućih političkih struktura.

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DEVELOPMENT PERSPECTIVE OF CORPORATE BONDS IN THE REPUBLIC OF SERBIA

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ABSTRAKT:

To cope with the competition, which has become very strong in the conditions of globalization and liberalization, companies are often forced to invest in new facilities and equipment. These investments are mostly long-term in nature and exceed the amounts of accumulated funds. Consequently, companies are often compelled to borrow in various ways or to sell part of their ownership through stock issuances. If they opt for borrowing in the financial market, which is most often the case, corporate bonds can play a very important role in this process. However, unlike market-oriented financial systems, where this type of securities plays a very significant role in the company financing process, corporate bonds are less represented in bank-centric financial systems. Considering that, the World Bank defined a corporate bond development support program in the Republic of Serbia in 2023, which should contribute to the development of these securities in the future period.

Keywords: *direct financing, corporate bonds, securities, borrowing.*

LEAN CONSTRUCTION: PREPOZNAVANJE I UKLANJANJE RASIPANJA U LANCU SNABDEVANJA

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SAŽETAK:

Koncept rasipanja u građevinarstvu predstavlja aktuelnu temu istraživanja, nedovoljno obrađenu sa potrebom da se jasnije ukaže na ovaj problem. Lean koncept rasipanja je zasnovan na ideji da je neophodno ukloniti aktivnosti koje ne dodaju vrednost, sa glavnim ciljem da se rasipanje smanji ili eliminiše radi poboljšanja performansi. U ovom radu je pomoću pregleda literature i ekspertskih intervjua obrađena tema prepoznavanja i konceptualizacije rasipanja u građevinskom lancu snabdevanja, sa fokusom na procese projektovanja i izvođenja građevinskih radova. Rezultati ovog rada daju smernice za razvijanje strategije za efikasnije upravljanje lancem snabdevanja i ukazuju na značaj i uticaj rasipanja tokom stvaranje vrednosti.

Ključne riječi: lean, eliminacija rasipanja, stvaranje vrednosti, lanac snabdevanja

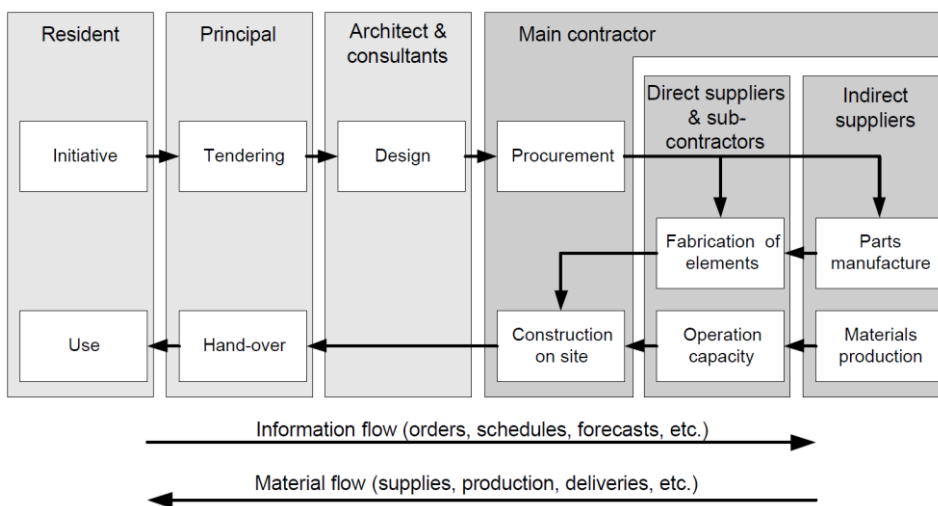
1. UVOD

Menadžment lanca snabdevanja (MLS) je koncept koji je nastao i razvio se u proizvodnoj industriji. Prvi znaci MLS-a bili su uočljivi u „JIT“ sistemu isporuke u okviru Tojotinog proizvodnog sistema. Ovaj sistem je imao za cilj da reguliše snabdevanje Tojotine fabrike motora u optimalnoj količini i vremenu. Glavni zadatak je bilo drastično smanjenje zaliha i efikasnije usklađivanje aktivnosti dobavljača sa proizvodnom linijom. Nakon njegovog pojavljivanja u japanskoj automobilskoj industriji kao dela proizvodnog sistema, konceptualna evolucija MLS-a je rezultirala autonomnim statusom koncepta u teoriji industrijskog menadžmenta i posebnim predmetom naučnog istraživanja [1].

Sa druge strane, Lanac snabdevanja u građevinarstvu se značajno razlikuje od lanca snabdevanja u proizvodnoj industriji. Struktura lanca snabdevanja u građevinarstvu je visoko fragmentisana sa niskim barijerama za ulazak i okrenuta ka lokalnom tržištu. Iako se količina materijala može približno isplanirati, spor i decentralizovan protok informacija, uticaj ljudskog faktora i međusobna nezavisnost učesnika onemogućuje optimizaciju lanca snabdevanja [2]. Pored toga, zbog jednokratnog karaktera projekta i specifičnih zahteva koje nosi svaka nova lokacija, organizacija gradilišta i sam lanac snabdevanja se mora uvek iznova planirati i implementirati u skladu sa kvantitativnim, kvalitativnim i vremenskim stanovištima [3].

Inicijativa i potreba krajnjeg korisnika koji zahteva izgrađeni objekat je početak lanca snabdevanja u građevinarstvu (Slika 1). Neretko korisnika predstavlja investitor koji

angažuje projektanta, konsultante i glavnog izvođača i vodi računa da zahtevi krajnjeg korisnika budu ispunjeni. Projektant izrađuje projektnu dokumentaciju prema zahtevu korisnika, dok konsultanti učestvuju u izboru glavnog izvođača i ugovaranju. U većini slučajeva glavni izvođač samostalno bira podizvođače i dobavljače materijala, organizuje ih i kontroliše. Nakon završetka projekta, sledi primopredaja i korišćenje izgrađenog objekta od strane korisnika. Tok informacija se kreće od korisnika ka poslednjem podizvođaču i dobavljaču u lancu snabdevanja, dok se tok materijala kreće u suprotnom smeru, od poslednjeg dobavljača ka korisniku.



Slika 1. Generička konfiguracija tradicionalnog lanca snabdevanja u izgradnji stambene zgrade [1]

2. LEAN KONCEPT

Lean production i sam termin Lean potiču iz Tojotnog proizvodnog sistema razvijenog 1990-ih godina. Najraniji Lean principi datiraju još od ranih 1900-ih godina, kada je Henri Ford uveo princip montažne trake koja je napravila revoluciju u proizvodnji automobila. Značajan napredak u proizvodnoj filozofiji dogodio se u Japanu 1949. godine kada je Tojota zbog pada prodaje bila primorana da revidira postojeći koncept proizvodnje [4]. Inženjeri Ejdži Tojoda i Taiči Ono su razvili principe upravljanja Lean proizvodnjom i predstavili načine kako da se rasipanja pretvore u vrednost i da ceo proizvodni sistem sa zanatske proizvodnje prebaci fokus na produktivnost radnika i masovnu mašinsku proizvodnju [5]. To je dovelo do uvođenja Tojotnog proizvodnog sistema, što je rezultiralo uspostavljanjem Lean proizvodnje 1990-ih godina.

Kako se navodi u knjizi „Mašina koja je promenila svet“ [4], izraz Lean je smislio Džon Krafčik, istraživač sa IMVP međunarodnog programa za motorna vozila Masačusetskog tehnološkog instituta, jer koristi duplo manje radne snage u fabrici, proizvodnog prostora,

radnog vremena inženjera i potrebnog prostora u skladištu, rezultirajući mnogo manjim brojem kvarova i povećanom proizvodnjom proizvoda.

Radi bolje afirmacije teorijske strane i promocije Lean koncepta, Vomak i Džouns su 1996. godine objavili knjigu pod nazivom „Lean Thinking“ [6] i u njoj definisali pet Lean principa:

1. Precizno odrediti vrednost po specifičnom proizvodu - vrednost se posmatra iz perspektive krajnjeg kupca, koji jedini može da je definiše;
2. Identifikovati tok vrednosti za svaki proizvod - tok vrednosti obuhvata sve radnje koje su potrebne da bi se proizvod dostavio kupcu;
3. Omogućiti tok vrednosti bez prekida - napraviti tok koji stvara vrednost;
4. Neka kupac vuče vrednost od proizvođača - neka kupac vuče proizvod od proizvodnog sistema, a ne da ga proizvodni sistem gura ka kupcu;
5. Težiti savršenstvu - nema kraja smanjenju vremena procesa, prostora, troškova i grešaka.

Pored toga, Vomak definiše Lean i kao koncept koji „radi više uz manje“ tako što se koristi najmanje truda, energije, opreme, vremena, prostora, materijala i kapitala – dok se kupcima dajete upravo ono što žele [6].

3. LEAN RASIPANJA

Rasipanje treba shvatiti kao svaku neefikasnost koja rezultira upotrebom opreme, materijala, radne snage ili kapitala u većem obimu od neophodnog, kao i pojavu materijalnih gubitaka i izvođenje nepotrebnog rada koji stvara dodatne troškove i ne dodaje vrednost proizvodu [7].

Koncept rasipanja i otpada u građevinarstvu nije jasno definisan i još uvek se razvija. Viana, Formoso i Kalsas su ukazali na potrebu da se koristi šira konceptualizacija rasipanja i otpada, zasnovana na ideji da je neophodno ukloniti aktivnosti koje ne dodaju vrednost iz perspektive klijenta [8]. Rasipanje i otpad se obično shvata u dve dimenzije (instrumentalno i suštinski) sa glavnim ciljem da se smanji ili eliminiše radi poboljšanja performansi [9]. Međutim, neki naučnici pod pojmom otpada smatraju isključivo fizički otpad - otpadni građevinski materijala koji dolazi od renoviranja, izgradnje, modifikacije i rušenja puteva, zgrada i drugih građevinskih objekata [10]. Sa stanovišta stvaranja vrednosti, vrednost je različita za svakog krajnjeg korisnika i vrednost je ta koja definiše rasipanje, a samo stvaranje vrednosti predstavlja najbolji način da se smanje rasipanja u projektovanju i izgradnji [11].

Tvorac Tojotinog proizvodnog sistema Taiči Ono [12] osmislio je sedam rasipanja kao deo ovog sistema:

- **Prekomerna proizvodnja** - dovodi do većih količina proizvoda od potreba tržišta ili kupca. To je proizvodnja artikala za koje nema porudžbina i dovodi do rasipanja kao što su višak angažovane radne snage, veći troškovi skladištenja i transporta zbog viška zaliha. Prekomerna proizvodnja je evidentna u push sistemu čija strategija poslovanja nameće proizvode kupcu. U skladu sa

navedenim, možemo napraviti analogiju sa građevinarstvom. Push sistem vođenja radova može dovesti do angažovanja radne snage, mehanizacije i materijala za izvršenje radova u većem obimu nego što je planirano. Pored toga, neretko se izvode čak i oni radovi koji nisu po planu prema važećoj dinamici. Osim povećanja troškova usled angažovanja resursa, ti radovi mogu praviti određene opstrukcije za radove koji slede.

- **Čekanje** - vreme čekanja između faza u proizvodnji rezultiralo je neefikasnom radnom snagom. Ova pojava je veoma učestala i u građevinarstvu. Projektant često čeka investitora da odobri izmene u projektu, izvođač čeka stručni nadzor da odobri materijal ili tehnologiju radova, a loša koordinacija radova na gradilištu uvek rezultuje rasipanjem u vidu čekanja.
- **Transport** - transport proizvoda sa jedne lokacije na drugu povećava troškove energije. Loša organizacija može dovesti do prekomernog transporta materijala ili opreme. Skladištenje materijala na velikoj udaljenosti od mesta ugradnje, kao i neadekvatno dopremanje materijala do mesta ugradnje mogu dovesti do višestrukog transporta istog materijala.
- **Prekomerna prerada** - obrada korišćenjem neefikasnih metoda zahteva više vremena i materijala nego što je potrebno. Ovo rasipanje se može definisati i kao dodavanje veće vrednosti nego što bi kupac bio spreman da plati. Nekada projektanti naprave dosta složeniji i detaljniji projekat nego što je zahtevano i samim tim izvođenje radova učine komplikovanijim. Sa druge strane, izvođenje radova neodgovarajućom tehnologijom će takođe dovesti do neefikasnog korišćenja vremena i materijala.
- **Višak zaliha** - nepotrebne zalihe dovode do prevelikih troškova vođenja zaliha. Cena materijala je značajna i velika količina nabavljenog materijala može negativno uticati na novčani tok. Čuvanje prekomernih zaliha uključuje troškove skladištenja. Materijal koji dugo stoji na gradilištu izložen je vremenskim prilikama, oštećenju, slučajnom gubljenju i krađi.
- **Višak kretanja** – dodatno kretanje predstavlja neproduktivni rad. Loša organizacija posla i neiskustvo radne snage može dovesti do toga da se stvore nepotrebni dodatni koraci za obavljanje posla.
- **Nedostaci** - Neispravna proizvodnja zahteva popravke pre dostave kupcu. Zbog kratkih rokova i visokih zahteva kvaliteta, u građevinarstvu je pojava nedostataka jako velika. Greške u građevinarstvu zahtevaju popravku i sprečavaju nizvodne aktivnosti zbog vremenskih kašnjenja do kojih obično dolazi. Naplata pozicija koje imaju nedostatke je problematična, jer uglavnom stručni nadzor zadržava značajna sredstva dok se ne otklone svi nedostaci.

Osmi tip rasipanja predstavlja **neiskorišćen prenos znanja zaposlenih**.

4. ZAKLJUČAK

Pomoću pregleda literature i ekspertskih intervjuja, zaključeno je da se najznačajniji faktori koji doprinose povećanju rasipanja odnose na projektovanje i projektnu dokumentaciju, pre svega na izmene projekta, komplikovana rešenja i greške u projektu. Projektant igra ključnu ulogu u smanjenju rasipanja od početka projektovanja do završetka izgradnje. Jasni i interdisciplinarno usklađeni crteži smanjuju neusaglašenosti u projektnoj dokumentaciji, što rezultira manjim brojem izmena i prerade tokom izvođenja radova. Pored toga, stavovi, ponašanje i neiskustvo inženjera takođe doprinose stvaranju građevinskog rasipanja.

Osim toga, kao najznačajniji kritični faktor rasipanja koji utiče na performanse građevinskih projekata definisana su kašnjenja u početku aktivnosti. Prerade, neiskorišćena kreativnost zaposlenih, dug proces odobravanja i čekanje zbog posla koji nisu završili drugi predstavljaju naredne kritične faktore. Pored toga, neefikasno upravljanje gradilištem, nepravilno planiranje, loša komunikacija, dodatne prepravke, loš kvalitet i faktori povezani sa ljudima. Operacije kao što su rukovanje, transport i skladištenje materijala i opreme moraju biti optimizovane, a vreme utrošeno tokom nadzora, kontrole pozicija i premeštanja radne snage treba smanjiti kako bi se poboljšao učinak projekta. Još jedan od zaključaka je da većina rasipanja i problema nastaje u nekoj drugoj – ranijoj fazi lanca snabdevanja, gde glavni uzroci rasipanja i problema uglavnom leže u prethodnoj aktivnosti koju je izvršio prethodni akter.

Prepoznavanje i uklanjanje rasipanja u lancu snabdevanja predstavljaju ključne aktivnosti u optimizaciji lanca snabdevanja. Rasipanja se pojavljuju u svim fazama projekta i njihova pravovremena identifikacija uz donošenje korektivnih mera je neophodna radi stvaranja vrednosti za sve učesnike lanca snabdevanja.

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LEAN CONSTRUCTION: WASTE IDENTIFICATION AND ELIMINATION IN SUPPLY CHAIN

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ABSTRACT:

The concept of waste in construction is a current research topic that needs to be addressed, and this problem needs to be pointed out more clearly. The lean concept of waste is based on the idea that it is necessary to eliminate activities that do not add value, with the primary goal of reducing or eliminating waste to improve performance. In this paper, through a literature review and expert interviews, the topic of identification and conceptualizing waste in the construction supply chain is addressed, with a focus on the processes of design and execution of construction works. The results of this paper provide guidelines for developing a strategy for more efficient supply chain management and indicate the importance and impact of waste during value creation

Keywords: lean construction, waste elimination, value creation, supply chain

KRIZNI MENADŽMENT - KLJUČNI FAKTOR OPSTANKA I POSLOVNOG USPJEHA

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APSTRAKT:

Krize su danas postale konstanta u životu i poslovanju. Organizacijske krize se javljaju u različitim oblicima kao što su prirodne katastrofe, ratovi, teroristički napadi, ljudske greške, kvarovi sistema i sl. U takvim okolnostima organizacija lako gubi strateški sklad sa unutrašnjim i vanjskim okruženjem i upada u probleme. Neizvjesnost i nesigurnost koje donosi kriza ugrožavaju održivi razvoj i sam opstanak organizacije. Krize nijesu ograničene na veličinu ili vrstu organizacije, zato je svakoj modernoj organizaciji potreban krizni menadžment. Od trenutka izbijanja krize menadžment ima ograničeno vrijeme da racionalno reaguje na promjene koje kriza izaziva, zato je glavni zadatak kriznog menadžmenta da pripremi plan za suočavanje sa situacijama koje su nezamislive i potencijalno visoko destabilizirajuće. To znači da je krizni menadžment proaktivan proces koji uključuje suočavanje s krizom prije nego što se dogodi, tokom krize i nakon nje. Glavna aktivnost takvog menadžmenta usmjerena je na analizu unutrašnjeg i spoljašnjeg okruženja, definisanje strategija za prevenciju krize i njihova implementacija. Na taj način mogu se minimizirati i ublažiti negativne posljedice neželjenih događaja u životu organizacije.

Ključne riječi: kriza, krizni menadžment, opstanak i poslovni uspjeh

1. UVOD

Poslovni uspjeh svake organizacije, u dinamičnom i sve kompleksnijem okruženju, zavisi prije svega od kvaliteta upravljanja. Menadžment je zadužen za postavljanje ciljeva, definisanje strategija i njihovu implementaciju. Ostvarivanje postavljenih ciljeva ugrožavaju krize koje dolaze „nezvane i nenajavljene“ i prijete organizaciji da je izbace iz ravnoteže. U savremenom svijetu krize su sve češće i razornije, pa krizni menadžment postaje ključno pitanje opstanka i poslovnog uspjeha.

Nekada se na krize gledalo kao na posljedice “više sile” ili Božije volje. Naravno, i danas su česte prirodne nepogode i katastrofe na koje čovjek ne može uticati, međutim mnoge su krize posljedice ljudske greške, nemara ili loše namjere. Menadžment je onoliko dobar koliko se organizacija uspješno nosi problemima i događajima koji ometaju normalno

poslovanje. Sama riječ kriza najčešće asocira na neželjene i neočekivane probleme i događaje i izaziva stres i negativne emocije kod ljudi. Nevolje i neplanirani događaji, u zavisnosti od rizika koje sa sobom nose, ne moraju uvijek predstavljati krizu, no ako se pravovremeno ne riješe prijete da prerastu u istu. Ovdje je važno istaći da je kriza rezultat, a ne uzrok problema u kojima se organizacija nalazi. Uzroke problema treba tražiti u svakodnevnim promjenama koje se dešavaju u spoljašnjem i unutrašnjem okruženju i koje prijete da naruše strategijski sklad organizacije sa tim okruženjima. Zato je zadatak kriznog menadžmenta da te promjene anticipira i budno prati, a probleme blagovremeno rješava kako bi se kriza predupredila ili izbjegla, a ukoliko to nije moguće da se njeni negativni uticaji svedu na najmanju moguću mjeru. Što je vremenski horizont između nastanka problema i pronalaženja rješenja kraći to je manja mogućnost da se razvije krizna situacija. Navedeno implicira da se odluke moraju donositi pod pritiskom vremena, dok budući uspjeh organizacije zavisi od držanja koraka sa promjenama. Na taj način organizacije postaju stabilnije i fleksibilnije, jačaju svoj imunitet na krize, pa za razliku od konkurencije u krizama prepoznaju nove razvojne šanse. U radu će biti riječi o vrstama i osbinama kriza, te o tradicionalnom i savremenom pristupu kriznom menadžmentu.

2. KRIZA JE KONSTANTA U SAVREMENOM POSLOVANJU

Uprkos tome što riječ kriza veoma često izgovaramo i još češće čujemo u svakodnevnoj komunikaciji, još uvijek ne postoji jasno i jednoznačno određenje tog pojma. Međutim, postoje brojne međusobno slične, ali i različite interpretacije ovog pojma koji se uglavnom vezuje za neželjene životne i poslovne situacije. Kriza je proces, stanje i/ili događaj koji pogađa pojedince, privredne subjekte, institucije, države, pa i cijeli svijet i koji može nanijeti veću

štetu. Dakle, riječ kriza asocira na nešto loše, negativno, nešto što predstavlja neku vrstu opasnosti i nevolje. Pod krizom se mogu podvesti svi interni ili eksterni događaji koji predstavljaju prijetnju za ljude, okolinu, imovinu ili reputaciju. To mogu biti teroristički napadi (napadi u SAD 11.septembar 2001, Španiji 2004, Londonu 2005, Parizu 2015...), ratovi (Ukrajina, Sirija, Kongo, Gaza, ...), prirodne katastrofe (zemljotres u Crnoj Gori 1979, cunami u Indoneziji 2004, zemljotres u Turskoj 2023...), štrajkovi (Francuska 2023), kolapsi finansijskih institucija (Velika ekonomska kriza 2008.), kriminalne radnje, skok cijena energenata i repromaterijala (Naftni šok 1973,...), epidemije (Svinjski grip 2009, epidemija ebole u Africi 2014, COVID 19, 2020...), tehničko-tehnološke katastrofe (curenje nafte, eksplozije, požari, havarije), korporativne krize (Kodak, Volkswagen u SAD, Toyota...) i mnogih drugih neželjenih događaja i situacija.

Ne postoji pojedinac kao ni organizacija koja se prije ili kasnije neće suočiti sa krizom. Poslovne krize uvijek nastaju usled promjena, bilo u spoljnom ili unutrašnjem okruženju, a te promjene uzrokuju probleme koji često ugrožavaju poslovanje, pa i opstanak organizacije. Gubitak tržišnog učešća, pad prodaje, gomilanje gubitaka, nelikvidnost,

stečaj i druge nedaće uobičajene su pojave sa kojima se susreću gotovo sve organizacije u krizi. Međutim, kriza ne utiče jednako na sve organizacije niti je one percipiraju na isti način. Jake i otporne organizacije uhvatiće se u koštac sa problemima, prevazići ih i na taj način ojačati svoj “imunitet“ za nove nadolazeće nevolje. Slabe i nespremne organizacije kriza će pokositi poput bolesti, što zapravo i jeste.

Kako kaže Adižez (2009) krize će učiniti da slabi umru, a jaki postanu još jači. Oni koji znaju šta da rade tokom krize izaći će kao pobjednici, a oni koji ne znaju šta da rade biće izgubljeni u pustinji.

2.1. Kako se kriza definiše i šta je karakteriše

Za krizu možemo reći da je neželjena i neplanirana, ali u savremenom poslovanju svakako ne može biti neočekivana. Naprotiv, kriza je danas uobičajena, gotovo neizbježna pojava, može biti izazvana različitim uzrocima i pogoditi bilo koju organizaciju u bilo koje vrijeme. U literaturi postoje brojne definicije krize od različitih autora koje su nastale u prethodnih nekoliko decenija.

Jednu od najranijih definicija krize dao je Hermann (1963), koji je krizu identifikovao kao događaj koji uključuje iznenađenje, prijetnju i kratko vrijeme za odgovor. Fink (1986), krizu tumači kao promjenjivo vrijeme, stanje stvari kada je ključna promjena neizbježna i sadrži dvije mogućnosti: jedna je povezana s neželjenim, negativnim rezultatom i drugi sa odgovarajućim ekstremno pozitivnim ishodom. Šanse su obično jednake, ali ih možemo promijeniti. To je prekretnica ka boljem ili lošijem.

Mitroff (2005) otkriva da je kriza ekstreman događaj, koji doslovno prijeti samom postojanju organizacije, dok Ulmer sa saradnicima (2007) definiše krizu kao specifičan, neočekivan i nerutinski događaj ili niz događaja koji stvaraju visoke nivoe neizvjesnosti i prijete prioritetnim ciljevima organizacije.

Organizacijske krize su stalna prijetnja uspjehu i održivosti organizacije (Hutchins i Wang, 2008). Clark (1988) je identifikovao tri elementa krize s aspekta njenih karakteristika i uticaja: prijetnja ciljevima, smanjena sposobnost kontrole okruženja i percipirani vremenski pritisak. Winkleman (1999) gleda na krizu kao neočekivani događaj koji ugrožava funkciju i postojanje organizacije. Keeffe i Darling (2008) opisuju krizu kao nestabilno vrijeme ili stanje poslova u kojima se sprema presudna promjena, dok Coombs (2012) definiše krizu kao percepciju nepredvidivog događaja koji prijeti važnim očekivanjima stejkoldera i može ozbiljno uticati na učinak organizacije i generisati negativne ishode.

Osim ekonomskih, kriza ima svoje psihološke i socijalne aspekte. Prema MacNeil i Topping (2007) kriza je događaj koji uzrokuje tešku emocionalnu i socijalnu nevolju, koja se može dogoditi u bilo koje vrijeme i bez upozorenja. Shodno tome, šok, strah, tuga i ljutnja su emocionalne faze kroz koje ljudi prolaze tokom krize.

Analizirajući navedene definicije zaključujemo da je kriza, jednostavno rečeno, sve ono što ima potencijal da negativno utiče na poslovanje, reputaciju ili kredibilitet organizacije. Sve one vide krizu kao neželjenu situaciju koja ugrožava organizaciju i njene vrijednosti i zahtijeva hitnu akciju za ublažavanje i saniranje negativnih posljedica.

Takođe, važno je istaći da kriza predstavlja prekretnicu u životu organizacije koju karakteriše ambivalentsnost ishoda, što znači da može završiti povoljno ili nepovoljno za organizaciju. U prilog navedenog ide i, u literaturi često navođena, činjenica da u kineskom pismu znak za krizu uključuje istovremeno „opasnost“ i „priliku“. Poslovna praksa je pokazala da se iz situacije koja prijete organizaciji može stvoriti prilika sa pozitivnim ishodom. Navedeno zavisi od sposobnosti i spremnosti organizacije da se prilagodi novim okolnostima i na njih adekvatno odgovori, a ključnu ulogu u svemu tome igra krizni menadžment.

2.2. Klasifikacija kriza

Za razumijevanje i uspješno upravljanje krizama neophodna je njihova klasifikacija. U literaturi postoji nekoliko osnovnih klasifikacija, međutim one nijesu potpune i konačne s obzirom na kompleksnost kriza koje se događaju danas, a vjerovatno će se događati i u budućnosti. Mnogi autori prave razliku između kriza uzrokovanih prirodnim silama i onih koje uzrokuje čovjek. Lerbinger (1997) je podijelio krize u osam kategorija: prirodne katastrofe, tehnološke krize, sukobljavanje, zlonamjernost, organizaciona nedjela, nasilje na radnom mjestu, glasine i teroristički napadi i katastrofe koje je proizveo čovjek.

Mitroff i Alpaslan (2003) krize izazvane ljudskim djelovanjem klasifikuju u dvije kategorije:

- normalne krize i
- nenormalne kriza

Normalne krize su uzrokovane preopterećenjem sistema i kvarovima (industrijske nesreće i havarije) dok su nenormalne krize namjerne radnje kojima se sabotiraju procesi, izaziva strah kod pojedinaca ili opšta panika (teroristički napadi, hakerski napadi, razne prevare i sl.).

Krize se najčešće klasifikuju prema njihovoj prirodi i vremenskim aspektima.

Gundel (2005), krizni menadžment vidi kao kritični dio strategijskog upravljanja, dok sa aspekta predvidivosti i mogućnosti uticaja na krize razlikuje četiri kategorije kriza:

- konvencionalne krize,
- neočekivane krize,
- nerješive krize i
- fundamentalne krize.

Konvencionalne krize su predvidive, sa značajnom mogućnošću uticaja. Vjerovatnoća nastanka je poznata kao i moguće štetne posledice pa priprema odgovora na ovaj tip kriza ne bi trebalo da predstavlja veliki problem za krizni menadžment. Kod neočekivanih kriza mogućnost predviđanja je mnogo manja, pa i pored toga što se na njih može uticati organizacije ih obično nespremno dočekuju. Nerješive krize su mnogo opasnije od neočekivanih, njih je moguće predvidjeti međutim odvijanje neželjenih događaja obično je van dometa menadžmenta, pa mogućnost uticaja na ovu vrstu krize gotovo da ne postoji. Najopasnije, a istina najređe, su fundamentalne krize zbog toga što su nepredvidive i što je na njih nemoguće uticati. Javljaju se iznenada, najčešće su akterima nerazumljive, pa je priprema za njih praktično nemoguća.

Sa aspekta ugroženosti realizacije postavljenih i konkretnih osnovnih ekonomskih ciljeva organizacije, posebno imajući u vidu vrijeme otkrivanja, prihvatljiva je klasifikacija kriza koju daje Muller (1986), a ona obuhvata:

- Krizu likvidnosti
- Krizu uspjeha i
- Strategijsku krizu.

Kriza likvidnosti predstavlja situaciju u kojoj organizacija nije u mogućnosti da svoje dospjele novčane obaveze izmiruje u utvrđenim rokovima dospjeća, ili uopšte nije u mogućnosti da ih izmiruje. Javlja se kao neplanirano nepoželjno stanje, a rezultat je neadekvatnog planiranja i nefikasne kontrole novčanih tokova, tj. izostanka sinhronizovanog priliva i odliva gotovine.

Kriza uspjeha se odnosi na nerentabilnost i pojavljuje u uslovima kada organizacija ne može da realizuje cilj očuvanja uloženog kapitala i cilj dobiti, odnosno predstavlja situaciju u kojoj je sposobnost organizacije da zarađuje ozbiljno dovedena u pitanje.

Strategijska kriza nastaje zbog propuštenih ili neadekvatno odabranih i realizovanih strategija za ostvarivanje organizacijske misije i ciljeva. U takvoj situaciji trajno su ugroženi strategijski potencijali uspjeha, a prije svega očuvanje uloženog kapitala i rentabilitet. Važno je istaći da krize najčešće nastaju na strategijskom nivou dok se otkrivaju na nivou likvidnosti.

Slika 1. Faze procesa krize prema Mulleru



Izvor: Muller, 1986.

2.2. Procesni pristup krizi

Svaka je kriza priča za sebe. Međutim, zajedničko za sve njih je da prolaze kroz različite faze, bez obzira čime su izazvane, prirodnom pojavom ili ljudskim djelovanjem tj. nedjelovanjem, i kojoj vrsti pripadaju. Fink je (1986) izložio model krize u četiri faze koji se sastoji od prodromalne, akutne, hronične i faze razrješenja. Prodromalna faza obuhvata period između prvih simptoma i izbijanja krize. U tom periodu kako navodi Fink krizni menadžeri bi trebali proaktivno pratiti, i pokušati prepoznati simptome krize koja se sprema i pokušati je spriječiti ili ograničiti njen uticaj. Ukoliko je reakcija menadžmenta u prodromalnoj fazi izostala ili nije bila uspješna, nastupa akutna faza. Ova faza podrazumijeva aktiviranje kriznih menadžera i njihovih planova za suprostavljanje krizi. Neuspješno suprostavljanje krizi dovodi do hronične faze koja obuhvata trajne posledice krize. Faza rješavanja predstavlja kraj krize i vrijeme za analizu temeljnih uzroka i sprovođenje promjena kako se kriza ne bi ponovila.

Slika 2. Finkov model krize



Izvor: Autor prema: Fink, 1986

Coombs (2012) posmatra krizu kao proces od tri faze (faza prije krize, kriza, postkrizna faza). Faza prije krize sastoji se od tri podfaze: otkrivanje signala, prevencija i priprema za krizu. U ovoj fazi, ako je kriza otkrivena, potrebno je spriječiti da se ta kriza dogodi i pripremiti se za upravljanje krizom. Cilj je smanjiti rizike koji mogu stvoriti krizu te biti strateški i taktički pripremljen. U tom smislu, što se tiče djelovanja, od organizacije se u ovoj fazi očekuje je da ima plan upravljanja krizom koji se redovno ažurira. Organizacija formira krizni tim, odabere portparola i priprema nacrt kriznih poruka. Druga faza je sama faza krize, a ovu fazu čine dvije podfaze, a to su prepoznavanje krize i obuzdavanje krize. U ovoj fazi važan je odgovor organizacije na kriznu situaciju, komunikacija sa stejkholderima i način na koji se organizacija nosi s krizom. Ova faza pokriva odgovor organizacije na ono što se stvarno dogodilo. Plan upravljanja krizom se sprovodi pri čemu treba biti brz, tačan i dosljedan. U ovoj fazi veoma je važna podrška odnosa s javnošću budući da se razvijaju poruke koje se šalju svim učesnicima, vodeći računa da je javna bezbjednost najvažniji aspekt. Radi se na popravljanju štete koja je nanescena organizaciji. Treća ili postkrizna faza dolazi nakon razrješenja krize. U ovoj fazi organizacija procjenjuje kako se borila sa krizom. Fokus je da se izvuku iskustva kako bi se bolje pripremili za potencijalne krize.

3. KRIZNI MENADŽMENT KAO ODGOVOR NA KRIZU

Da bi se organizacije nosile sa krizama potreban im je krizni menadžment. Krizni menadžment obuhvata predviđanje, identifikaciju, proučavanje i djelovanje po kriznim pitanjima, te uspostavljanje procedura koje bi omogućile organizaciji da spriječi ili izađe na kraj s krizama (Nurmi i Darling, 1997). Kako se vremenom mijenjaju vrste kriza i obim njihovih uticaja na organizacije tako se mijenjaju i pristupi kriznom menadžmentu. Savremenim organizacijama su potrebni novi pristupi i novi standardi ponašanja i upravljanja kako bi ostvarile svoju misiju i ciljeve. Revolucionarne promjene u tehnološkoj i kulturnoj sferi u budućnosti će nesumnjivo donijeti nove i sveobuhvatne krize. Povećana nesigurnost i rizici po opstanak organizacija postati će njihova svakodnevnica. U takvoj situaciji sa razlogom gledamo na krizni menadžment kao na nasušnu potrebu i neizostavan dio upravljanja svim modernim organizacijama. Krizni menadžment kao proces upravljanja obuhvata faze planiranja, realizacije i kontrole.

S obzirom da kriza remeti poslovanje, prijeti da naškodi ljudima, šteti reputaciji i negativno utiče na finansije (Fearn-Banks, 2016), krizni menadžment se može posmatrati kao značajan, često kritičan, dio stratejskog upravljanja unutar kojeg treba identifikovati potencijalne prijetnje (Gundel, 2005; Khodarahmi, 2009). To je niz koraka koje organizacija preduzima kako bi se suočila sa kriznim događajem. Potrebno je imati jasno definisane krizne ciljeve, koji se naknadno modifikuju iz strateških ciljeva, efikasno se nose s gubicima i štetama i vraćaju poslovne rezultate (Khodarahmi 2009).

Zajednički naponi menadžmenta i ostalih učesnika dovode do stvaranja kriznih scenarija i planova koji se mogu smatrati i postupkom upravljanja krizom i ključnim dijelom procesa strateškog planiranja (Schoemaker, 1993). Crandall, Parnell i Spillan (2013) ističu da postupci i mehanizmi upravljanja kriznim situacijama trebaju biti integralni dio ukupne strategije organizacije, koju treba revidirati nakon svake krizne situacije.

U zavisnosti od ekonomskih, pravnih, kulturoloških, socioloških i psiholoških aspekata krizni menadžment se razlikuje od zemlje do zemlje i od organizacije do organizacije, međutim postoje i neke generalne karakteristike koje važe za sve. Heiderich (2011), smatra da proces upravljanja krizom zahtijeva mnoge vještine i stručnost jer ovdje govorimo o procesu mijenjanja stvarnosti i uvjeravanja javnosti u stavove organizacije koja brani njenu Viziju i interese. Štaviše, krizni menadžment zahtijeva društvena, pravna i ključna komunikacijska znanja u potrazi za mogućim rješenjima.

Za ljude uključene u krizni menadžment veoma su važni psihološki elementi. Samokontrola, samopouzdanje i hladnokrvnost su vrlo potrebni jer proces upravljanja krizom zahtijeva strpljenje, mudrost i zdravo razmišljanje pri planiranju, upravljanju krizom i pružanju odgovarajućih rješenja. Dešava se da menadžeri koji su jednom griješili postaju neodlučni, gube samopouzdanje i ne usuđuju se pokušati nove stvari. Međutim, menadžeri iz grešaka mogu naučiti više nego iz uspjeha. Proces upravljanja krizama prema Jin (2009) zahtijeva neka osnovna znanja iz psihologije, zato što upravljanje nekim krizama u velikoj mjeri zahtijeva kontrolu emocija i osjećaja, samokontrolu, strpljenje, smirenost, dok poznavanje okruženja organizacije može uključivati znanje vezano uz

kulturni, društveni i politički sistem društva. Heath, Lee i Ni, (2009) ističu da je to neophodno zbog složenosti procesa upravljanja krizom koji zahtijeva odlučnost i brze odluke kod planiranja i upravljanja u hitnim situacijama

3.1. Vrste kriznog menadžmenta

U naučnoj i stručnoj literaturi krizni menadžment se najčešće dijeli na dvije osnovne vrste:

- aktivni, i
- reaktivni krizni menadžment;

Na slici 3 su prikazane osnovne vrste kriznog menadžmentu i faze procesa krize krize protiv kojih su usmjerene aktivnosti kriznog menadžmenta.

Dakle, organizacija ima dva izbora, da reaguje prije nego što se kriza stvarno dogodi, ili da se pripremi za brzo i efikasno reagovanje na njenu iznenadnu pojavu. Aktivni pristup kriznom menadžmentu vodi ranom otkrivanju krize i preduzimanju adekvatnih koraka da bi se ista izbjegla, a ako to nije moguće da bi se posledice svele na prihvatljivi nivo. Moor (2006) ističe da je ključni zadatak organizacije i vlade biti oprezan kako bi se smanjile šanse da se problemi pretvore u krizu. Kreativnost i strateško razmišljanje su od presudnog značaja da bi se ispunio navedeni zadatak. Dakle, za aktivni krizni menadžment možemo reći da ima ofanzivni karakter i podrazumijeva aktivnosti koje su usmjerene na izbjegavanje krize. Tačnije rečeno, njegova uloga se ogleda u sprečavanju da se ista uopšte dogodi i primjenjuje se u fazi potencijalne i latentne krize preduzeća.

Aktivno upravljanje kriznim situacijama uključuju stvaranje preventivnih programa ili mehanizama koji sprječavaju potencijalnu krizu. U svemu tome značajnu ulogu igraju analiza potencijalnih kriza i razmjena prethodnih iskustava u cilju organizacijskog učenja (King, 2002, Wagner, 2005).

Aktivni krizni menadžment možemo dalje podjeliti na dva segmenta, i to:

- anticipativni krizni menadžment, i
- preventivni krizni menadžment;

Anticipativni krizni menadžment ima za cilj preduzimanje protivmjera potencijalnoj krizi čije dejstvo može pogoditi organizaciju u budućnosti. Glavne protivmjere su alternativno ili kontigentno planiranje, da bi se dobilo na vremenu u slučaju iznenadnog nastupa krize. Neki autori krizni menadžment uopšteno posmatraju kao proces usmjeren na aktivnosti organizacije sa ciljem prepoznavanja i praćenja simptoma potencijalne krize (Mitroff i Alpaslan, 2003, Paraskevas, 2006).

Slika 3. Vrste kriznog menadžmenta



Izvor: Autor

Takvi koncepti preferiraju proaktivni pristup kriznom menadžmentu, sa fokusom na simptome upozorenja u cilju preduzimanja mjera za sprječavanje nadolazeće krize i zaštitu organizacije od iste. U pitanju je preventivni krizni menadžment koji ima za cilj preduzimanje mjera za pravovremenu identifikaciju latentne, već postojeće krize preduzeća. Pravovremena identifikacija ostvaruje se pomoću sistema za rano upozoravanje, a zatim se na osnovu takvih informacija vrši planiranje sprovođenja i kontrola mjera za izbjegavanje ili sprječavanje latentne krize preduzeća. Naravno, ni najproaktivniji menadžment ne može uvijek spriječiti krizu, ali organizacije sa takvim pristupom mogu upravljati krizom mnogo efikasnije uz minimalne gubitke (Mitroff, Pauchant i Shrivastava, 1988).

U situacijama kada je izaostao aktivni krizni menadžment, ili ne daje odgovarajuće rezultate, na scenu stupa reaktivni krizni menadžment sa zadatkom da suzbije nastalu krizu ili ublaži njene destruktivne posledice. Dakle, reaktivni krizni menadžment ima defanzivni karakter.

Ovdje se radi o akutnoj fazi krize kada su štetne posledice vidljive, a u zavisnosti od same faze procesa krize javljaju se dva odgovora na krizu:

- repulzivni krizni menadžment i
- likvidativni krizni menadžment;

Repulzivni krizni menadžment je najpoznatija i najrasprostranjenija forma kriznog menadžmenta sa zadatkom preduzimanja mjera za odbijanje i savladavanje već nastale akutne krize kako bi se obezbijedio opstanak organizacije.

Ukoliko ni to nije moguće, poslednja opcija je likvidativni krizni menadžment koji preduzima mjere za plansku likvidaciju organizacije zahvaćene akutnom nesavladivom

krizom. Iako je likvidacija nepoželjna i nepopularna mjera istom se zaštićuju vlasnici, zaposleni, ulagači kapitala i dobavljači od još većeg gubitka. Mjere koje preduzima likvidativni krizni menadžment su planiranje, realizacija i kontrola mjera likvidacije.

3.2. Krizno planiranje - osnov za postupanje u krizi

Kriznim planovima se uspostavljaju procedure, mjere i aktivnosti za prevenciju krize i upravljanje istom, bez obzira da li su krize iz političke, ekonomske, socijalne ili ekološke sfere. Kada kriza zahvati organizaciju ili sistem kasno je za planiranje. Za upravljanje kriznim situacijama treba razviti planove za rješavanje problema koji kombinuju interese i aktivnosti svih stejkholdera. Organizacije koje imaju „kriznu kulturu“ bave se planiranjem prije krize, pripremom za krizu, te komunikacijom i evaluacijom nakon krize. U sklopu tih aktivnosti jedna od ključnih je jasno definisanje ciljeva i zadataka, naročito u početnoj fazi suočavanja s krizom. U vrijeme stabilnog poslovanja menadžment mora stalno sebi postavljati pitanja vezana za potencijalne izazove iz unutrašnjeg i spoljašnjeg okruženja, za slabosti u organizaciji koje treba eliminisati, te za snage koje treba dodatno ojačati za budućnost. Odgovore na ovako postavljena pitanja treba prevesti u krizne planove kak bi se organizacija mogla suočiti sa krizom ili je eventualno izbjeći. Krizni planovi se prave za one vrste kriza koje će najvjerovatnije pogoditi organizaciju i najviše uticati na njeno poslovanje. Tako se faktor iznenađenja svodi na prihvatljivu mjeru i otvara mogućnost efikasnog preduzimanja hitnih mjera po unaprijed pripremljenom planu. Organizacija će se lakše uhvatiti u koštac sa krizom i minimizirati njene negativne posledice. Krizni plan ne bi trebao biti suviše obiman, ali bi trebao sadržati sve potrebne elemente. Neki autori se zalažu da pored kriznog plana organizacija treba da ima i hitni krizni plan na najviše par strana sa kojim bi trebalo da su upoznati svi zaposleni.

Većina istraživanja kriza odnose se uglavnom na veće i složenije organizacije, dok ih je za mala i srednja preduzeća znatno manje (Herbane, 2013). Johansen i sar. (2011) govore o snažnoj vezi između veličine organizacije i krize, što je organizacija veća, veća je vjerovatnoća da će pripremiti krizni plan. U literaturi o kriznom menadžmentu posebna poznja je posvećena planovima za potencijalne krize (Herbane, 2011, Doern, 2016; Tyler i sar., 2020). To su one krize koje će se možda dogoditi u budućnosti, a možda i neće. Međutim, dosta autora smatra da se priprema za krize isplati (Pearson i Clair, 1998, Mitroff i Alpaslan, 2003), te da je planiranje ključ uspjeha kako za pojedince tako i za organizacije. Neki od njih tvrede da se efikasnim planom nevolje mogu pretvoriti u konkurentsku prednost. Uprkos tome, nekoliko je studija otkrilo nepostojanje formalnih kriznih planova u malim i srednjim poduzećima (Herbane, 2010). Prema Doern i sar. (2019) za ublažavanje kriza kod malih i srednjih preduzeća postoje dva ključna koncepta: upravljanje krizom i organizacijska otpornost. Woodman i Hutchings (2010) otkrivaju da samo 29 % malih preduzeća ima plan upravljanja krizom, dok se Herbane (2010) pozva na studiju 1000 vlasnika i menadžera malih i srednjih poduzeća u kojoj je

njih 49 % izjavilo da nemaju krizne planove. Takođe se ističe da se mjere prevencije koje organizacije preduzimaju uveliko razlikuju (Tyler i sar., 2020).

Aktivni krizni menadžment ima za cilj proaktivno predviđanje buduće krize, razvoj i implementaciju mjera prevencije i pripremu akcionog plana za tačne korake u slučaju krize. Prije pristupanja izradi kriznog plana, neophodno je izvršiti identifikaciju i analizu rizika. Rizici mogu biti unutrašnji i spoljašnji. Svakako da su unutrašnji uzroci kriza mnogo češći i lakši za sagledavanje i kontrolu. Spoljašnji uzroci kriza nastaju van sistema, pa organizacija ne može bitno na njih da utiče. Ovdje se prije svega misli na elementarne nepogode, prirodne katastrofe, globalne ekonomske krize i sl. Iz toga razloga postupak procjene rizika, usled budućeg razvoja promjena u okruženju, predstavlja težak zadatak. Većina spoljašnjih uticaja se ne može spriječiti. Međutim, ono što je važno jeste razviti i koristiti određene instrumente menadžmenta koji osim što mogu blagovremeno da upozore na negativna kretanja u okruženju, mogu i da doprinesu efikasnijem upravljanju krizom. Krizni plan i plan kriznog komuniciranja čine najmoćniji recept za zaštitu organizacije od kriznog neuspjeha. Za uspješno sprovođenje kriznog plana treba obezbjeđiti povjerenje dioničara, dobavljača, kupaca, zaposlenih, stejkholdera i dr. zainteresovanih strana.

3.3. Savremeni vs tradicionalni pristup kriznom menadžmentu

Menadžment savremenih organizacija suočava se sa brzim i brojnim promjenama koje uzrokuju potencijalne i aktuelne probleme, pa je neophodno da obezbijedi efikasan tok njihovog rješavanja. Međutim, opravdano se postavlja pitanje: da li će postojeći teorijski pristupi biti efikasni za rješavanje kriza u budućnosti?

Williams i sar. (2018) sugeriraju da se pristup upravljanju krizom odnosi na sposobnost aktera da oslabljenu organizaciju vrata u redovno stanje, dok organizacijska otpornost predstavlja sposobnost organizacije da održi pouzdano funkcionisanje tokom krize. Ovakvi i slični stavovi koji se javljaju u novijoj literaturi predstavljaju nov pristup kriznom menadžmentu u odnosu na tradicionalni. Naravno, on ima neke zajedničke karakteristike sa tradicionalnim pristupom, ali i neke važne specifičnosti. Prije svega, na krizni menadžment gleda kao na jednu od komponenata u ukupnoj strategiji otpornosti organizacije i ne oslanja se toliko na preventivno planiranje kao što je to slučaj kod tradicionalnog pristupa.

Tradicionalni pristup je strukturiran i logičan, karakterišu ga proaktivnost, planirani i procesni pristup, ali i nepovezanost kriznog sa stratejskim menadžmentom. Ključna riječ u tradicionalnom kriznom menadžmentu je „prevencija“ i koncentracija primarnih intelektualnih, moralnih, društvenih i tehnoloških napora u periodu prije krize. To znači razmišljati o nepredvidivom, upoznavati nepoznato i planirati neočekivano, a sve sa ciljem da se spriječe negativne posledice za ljude i organizaciju. Naglašava se važnost predviđanja kriza i priprema u skladu sa tim. Potrebno je otkriti simptome krize, pripremiti

preventivne planove i uvježbavati njihovo sprovođenje. Organizacija će se na taj način pripremiti za vrste kriza za koje rukovodioci procijene da od njih prijete najveća opasnost, međutim, neka područja uvijek ostaju zanemarena. Takav krizni menadžment nije u dovoljnoj mjeri povezan sa stratejskim, a odgovornost je na grupi zaposlenih čija je osnovna funkcija identifikovanje, izbjegavanje i ublažavanje rizika. Nadalje, planovi se obično prave s obzirom na postojeće organizacijske strukture i nadograđuju se na iskustva iz prethodnih kriza ili događaja u sličnim organizacijama u istoj grani. Na taj način značajno je ograničena fleksibilnost organizacije u slučaju nastanka krize. Organizacija treba da prati slabe signale iz različitih segmenata okruženja da ih analizira i prepozna rizike. Svi rizici se ne mogu prepoznati niti ublažiti, doka za odabrane treba razviti kontigentne planove. Međutim, kao što ističe Mitroff (1994) rijetko je da se krize razvijaju tačno onako kako se predviđalo, a samim tim i krajnja svrha planiranja trebala bi biti unaprijed zamisliti nezamislivo. Zato se u praksi često dešava da prevencija ne uspije i da kriza iz potencijalne faze uđe u fazu stvarne krize. U ovoj fazi posebno je važna komunikacija i koordinacija među svim učesnicima kako bi se organizacija vratila u normalno stanje. Ukoliko organizacija savlada krizu i preživi, svakako će naučiti određene lekcije koje može iskoristiti za odgovarajuća poboljšanja i pripreme za buduće krize.

Savremeni krizni menadžment, za razliku od tradicionalnog, karakterišu prije svega fleksibilnost, reaktivnost, robusnost, osjećaj sigurnosti i integrisani krizni menadžment. Fleksibilnost organizacije znači da se njena struktura, putevi odlučivanja ili opšta rješenja lako mijenjaju i prilagođavaju zavisno od situacije i vrste krize. Odluka nikada nijesu konačne, u mnogim slučajevima se mijenjaju kako se mijenja situacija.

Reaktivnost predstavlja sposobnost organizacije da se nosi s krizom kad se dogodi, bez pretjeranog oslanjanja na pripremne ili proaktivne aktivnosti kao u tradicionalnom kriznom menadžmentu. To se postiže brzim odgovorima i primjenom pragmatičnog kriznog menadžmenta.

Robusnost za rješavanje kriznih situacija podrazumijeva da je organizacija neosjetljiva i neranjiva na neizvjesnost i da može ublažiti negativne utjecaje u nadolazećim nevoljama zahvaljujući razvijenoj otpornosti.

Osjećaj sigurnosti znači stvaranje organizacijskog okruženja u kojem zaposleni osjećaju povjerenje i sigurnost u načine na koji djeluju kako u kriznim situacijama tako i u svakodnevnim aktivnostima.

Ovdje se radi o integrisanom kriznom menadžmentu koji inherentno postoji u organizaciji i nije posebni dodatak i nepovezani element. To znači da je povezan i sa organizacijskom kulturom, ta da svi zaposleni imaju svoju ulogu u predupređenju i savladavanju krize. Dakle, na krizni menadžment se gleda kao na dio svakodnevnog života savremene organizacije.

U svakom slučaju, krizni menadžment treba da odgovori na pitanja kako i na koji način organizacija može djelovati u kriznim situacijama, ali i kako i na koji način može spriječiti

da se kriza dogodi. U dosadašnjoj teoriji i praksi kriznog menadžmenta prisutni su tradicionalni i savremeni pristup koji su se pokazali više ili manje uspješnim. Oba pristupa podrazumijevaju aktivnosti prije, za vrijeme i nakon krize. Tradicionalni pristup je proaktivan, dok je savremeni pretežno reaktivan. Tradicionalni se oslanja na predviđanje, krizno planiranje i procesni upravljački pristup, dok savremena literatura favorizuje fleksibilan i decentralizovani upravljački pristup kriznom menadžmentu kao integralnom dijelu organizacije. Koji od ova dva pristupa je optimalan za organizaciju zavisi od same organizacije i konkretne situacije.

5. ZAKLJUČAK

Kriza je svaki ekstrem, neočekivan ili nepredvidiv događaj, koji stvara izazove za organizaciju i zahtijeva hitan odgovor za prevazilaženje nastale situacije i minimiziranje poslovnih gubitaka. Zbog globalne povezanosti organizacija, potencijal za razvoj i eskalaciju kriza danas je veći nego ikada ranije, tako da nijedna organizacija nije imuna na njih bilo da dolaze iz spoljašnjeg ili unutrašnjeg okruženja. Nastanak krize se u veoma malom broju slučajeva može pripisati „nedostatku sreće“ i sticaju nepredviđenih okolnosti, dok se u mnogo većem broju slučajeva radi o „nedostatku pameti“ da se preduzmu pravovremene i adekvatne protivkrizne mjere. Krize se teško mogu izbjeći i ne smiju se negirati već je potrebno pripremiti se za njih, zato je krizni menadžment ključni faktor opstanka i poslovnog uspjeha savremenih organizacija. Adekvatan krizni menadžment pomaže organizacijama da opstanu, napreduju i ostvare konkurentsku prednost.

U trenutku izbijanja krize postoji ograničeno vrijeme da se racionalno reaguje na promjene koje je izazivaju. Zbog toga organizacije moraju razvijati kriznu kulturu, a krizni menadžment pripremiti odgovarajuće planove za različite situacije, koji se u datim okolnostima mogu dalje prilagođavati, jer svaka je kriza priča za sebe i nijedna se ne odvija baš onako kako je planirano. Na taj način budući događaji postaju manje neočekivani, nepoznati i nepredvidivi, što organizacijama pruža priliku da se efikasnije suprotstave izmijenjenoj stvarnosti. U poslovnoj praksi se primjenjuju tradicionalni i savremeni krizni menadžment. Koji od ova dva pristupa je optimalan za organizaciju zavisi od same situacije, vrste i veličine organizacije, te faze razvoja krize. Oba pristupa podrazumijevaju sprovođenje određenih aktivnosti prije, za vrijeme i nakon krize. Tradicionalni pristup zagovara djelovanje još u predkriznoj fazi kako bi se kriza spriječila, a krizno planiranje počinje mnogo prije nego što se problem pojavi. Za problemima se traga u fazi stabilnog razvoja, u cilju pripreme za nadolazeće nevolje i predupređenje problema u poslovanju. Na taj način krizni menadžment pomaže organizaciji da izgradi i unaprijedi svoje kapacitete na polju predviđanja, izbjegavanja i sukobljavanja sa krizom. Savremena literatura favorizuje jačanje otpornosti organizacije kroz decentralizovani upravljački pristup kriznom menadžmentu, koji predstavlja integralni dio organizacije, a čije su osnovne karakteristike fleksibilnost, reaktivnost, robusnost i osjećaj sigurnosti.

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CRISIS MANAGEMENT - A KEY FACTOR OF SURVIVAL AND BUSINESS SUCCESS

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ABSTRACT:

Today, crises have become a constant in both life and business. Organizational crises occur in various forms such as natural disasters, wars, terrorist attacks, human errors, system failures etc. In such circumstances, the organization easily loses strategic harmony with the internal and external environment and gets into problems. Crises bring uncertainty and problems to the organization, threatening its survival and sustainable development. Crises are not limited to the size or type of organization, therefore every modern organization needs crisis management. From the moment of crisis management has limited time to react rationally to the changes caused by the crisis, therefore the main task of crisis management is to prepare a plan for dealing with situations that are unimaginable and potentially highly destabilizing. Crisis represents a danger for the business of the organization, from the moment of the outbreak of the crisis there is a limited time to react rationally to the changes it causes. That means crisis management is a proactive process that involves dealing with a crisis before it happens, during the crisis and after it. The main task of crisis management is to prepare organization plan to confront with situations that are unimaginable and potentially highly destabilizing. The essential management activity is focused on the analysis of the internal and external environment and the identification of strategies for preventing crises. In this way, the negative consequences of unwanted events during the life cycle of the organization can be minimized and mitigated.

Keywords: *Crisis, Crisis Management, Modern organization, survival and business success*

EMERGING TRENDS IN THE DEVELOPMENT OF THE SERBIAN STARTUP INNOVATION ECOSYSTEM

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ABSTRACT:

The Serbian startup innovation ecosystem is experiencing a period of dynamic growth and evolution, marked by emerging trends that are reshaping the landscape of entrepreneurship and innovation in the region. Recent research indicates that the ecosystem has continued to grow at nearly 30% annually, despite increasingly challenging global and local circumstances, which is reflected in the increase in the number of startups in the idea phase and pre-seed phase. Through a comprehensive review of recent literature and industry reports, this paper examines the latest developments and emerging trends shaping the development of the Serbian startup innovation ecosystem aiming to contribute to a deeper understanding of the dynamics and opportunities within the region's entrepreneurial landscape. It also provides valuable implications for understanding of the factors driving entrepreneurial activity and innovation in the region. These include the growing prominence of deep tech startups leveraging advanced technologies such as artificial intelligence, blockchain, and biotech, and the expanding role of ecosystem startup support organization such as science and technology parks, accelerators, regional innovation startup centers and academic innovation incubators in supporting startup growth and success.

Keywords: *Serbian startup ecosystem, innovation, emerging trends, startup entrepreneurship*

1. INTRODUCTION

Strengthening the competitiveness of the national economy, with particular emphasis on innovation and startup entrepreneurship is consider as one of Serbia's greatest priorities. Innovations drive progress by challenging traditional industries and introducing new products and services, often leading to the emergence of new technologies, industries, and markets which often highlights the significance of innovative entrepreneurship in advancing economic activities. The growth and development of startups not only contribute to economic development and reducing unemployment, but through new ideas,

products, and services, innovations, knowledge, and the creativity of their members, initiate technological and economic changes within the national economy of Serbia [1]. Startups play a pivotal role in driving the economic advancement of a country. They play a vital role in regional development through innovation, driving institutional changes, enhancing productivity, and introducing fresh products and services to the market. In light of the recent economic crisis, the promotion and support of startup entrepreneurship have become increasingly critical [2].

While considerable advancements have been achieved, the Serbian startup ecosystem encounters hurdles hindering its further expansion. These obstacles encompass talent acquisition, market expansion, regulatory intricacies, and societal perceptions towards entrepreneurship. Overcoming these impediments demands sustained cooperation and alignment among diverse stakeholders, governmental agencies, industry stakeholders, academic institutions, and the startup community. In light of these opportunities and challenges, this paper seeks to examine the emerging trends shaping the development of the Serbian innovation startup ecosystem, providing insights into its evolution, current state, and future trajectory. By understanding the dynamics of the ecosystem and identifying key drivers of success, stakeholders can better navigate the landscape and capitalize on the opportunities presented by Serbia's vibrant startup ecosystem.

2. STARTUP INNOVATION ECOSYSTEM IN SERBIA

The **national innovative ecosystem** can be defined as *the system of interacting private and public firms (either large or small), universities and government agencies, aiming at the production of science and technology within national borders. Interaction among those units may be technical, commercial, legal, social and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology* [3].

The startup ecosystem is an environment where startups develop. It comprises individuals, teams, startups at different stages of development, and various types of organizations and institutions. Together, these elements function as a system to create and accelerate the development of new startups. This ecosystem concerns all stakeholders, such as businesses, governmental bodies, academic institutions, investors, freelancers, and support entities. Their collective involvement is indispensable for the sustainability of startup ventures, as without their collaboration, the survival of a startups is nearly unattainable [4].

Republic of Serbia, with its strategic location in Southeast Europe, rich talent pool, and growing reputation as a growing regional technology hub, has emerged as a more attractive destination for startup investment and entrepreneurship. Over the past decade, the country has made significant strides in fostering a conducive environment for startup innovation, characterized by a supportive regulatory framework, access to funding, and a vibrant entrepreneurial community. Although the Serbian startup innovation ecosystem is gaining more and more importance, it must be noted that it is still a startup ecosystem that

is in the development phase, so it has not been the subject of major research globally but there are more and more initiatives in that direction. In light of this, continued efforts towards strengthening the Serbian startup ecosystem are paramount to unlocking its full potential and positioning it as a prominent player on the regional and global startup stage. By definition, the Serbian startup innovation ecosystem involves Serbian startups, academic institutions, science and research organizations, institutes, governmental agencies, innovators, researchers, domestic and international investors, venture capital funds and public and private entities dedicated to fostering entrepreneurship and startup ventures. Collaboratively, they establish a network of startup enterprises to enhance the business landscape, define regulatory frameworks, exchange knowledge, bridge academia-industry gaps, and promote initiatives for regional economic development.

The Serbian innovative ecosystem includes startups as well as startup teams, where there are significant differences and similarities. Republic of Serbia defined **startup** as a newly established business entity or entrepreneur that develops an innovative product or service with the potential for rapid and substantial growth [5], where **startup team** is a group of individuals who develop an innovative product that demonstrates the potential for large and rapid business growth on the global market - the startup team is not registered as a business entity in the appropriate register. Startup teams that register as business entities become startups in the full sense of that term [4]. A **spinoff startup** represents a startup established by an existing legal entity with the aim of developing and commercializing innovations, while a **spinoff startup from a scientific research organization** represents a startup established with the aim of developing and commercializing innovations stemming from scientific research [5].

According to StartupBlink, Serbian startup ecosystem that include Belgrade, Novi Sad and Niš, has several interesting trends to show [6]:

- Serbia maintained its positive momentum and increased 1 spot in 2023, ranking 51st globally;
- On a regional level, the country remains the 14th startup ecosystem in Eastern Europe and 6th in the Balkans;
- Last year was very good year for Serbia, with 3 ranked cities showing positive momentum;
- The capital and highest ranked city in Serbia, Belgrade, showed an increase of 35 spots to rank 165th;
- Among cities in the Balkans, Belgrade is now ranked 4th, a 2-spot increase from 2022;
- Belgrade outperforms in the Marketing & Sales industry, where it ranks among the top 100 cities globally;
- Novi Sad entered the global top 400 cities with an increase of 59 spots;
- After returning to the Index last year, this year Niš jumped another 145 spots to join the global top 700.

The Global Startup Ecosystem Report 2023, shown that from July 1, 2020 until December 31, 2022, Belgrade and Novi Sad created an ecosystem value of USD 1.1 bn which is a growth of 75.41% compared to the previous period. The value of the ecosystem is expressed through economic influence, calculated as exit value and startup valuation. The startup ecosystems of Belgrade and Novi Sad are recognized among the best 20 European ecosystems by available talent – in the category which measures the ability to employ tech talents [7].

According to Startup Scanner 2024, characteristics of the Serbian startup ecosystem are embodied in several trends [8]:

- According to the Startup Genome methodology, the startup ecosystem is in the first phase of ecosystem development - the activation phase, characterized by intensive growth. This is reflected in the increasing number of startups in the ideation and pre-seed stages;
- Just over half of the startups (56.7%) have non-technical founders in their founding team, who come from industries such as marketing, business, finance, and creative industries, while 43.3% of startups consist of teams without non-technical founders;
- Founder Profile: Founders in Serbia are predominantly male, aged between 30 and 39, with a master's degree, currently residing in Serbia, and most of whom have gained their previous experience through work in corporations;
- A significant concentration of startups is in the Belgrade region (57.9%), as the main business and technological center in Serbia. The second-largest region in terms of the number of startups is the Vojvodina region with 22.9%, while 19.2% of startups originate from the Central Serbia region;
- The main challenges facing domestic startups in Serbia are financing, sales, and hiring talent with the appropriate skills

2. EMERGING TRENDS IN SERBIAN INNOVATIVE STARTUP ECOSYSTEM

Serbian innovation startup ecosystem has been characterized by constant rapid growth, which brings with it economic development and an increase in the number of new employees. In recent years, Serbia initiated several processes that led to a more durable approach to ecosystem growth, internal alignment between different stakeholders, and increased international exposure. According to the previous discussion, there are several important trends indicating the growth and potential of the Serbian startup innovation ecosystem.

Growth in the number of startups. Last year, Serbia witnessed a remarkable surge in the number of startups compared to the previous year, reflecting the growing vibrancy of its entrepreneurial and innovative landscape. The most significant Startup Scanner 2024 research has shown that the domestic innovation ecosystem continues to experience impressive growth of 20% to 30% in new startups annually, indicating vitality and resilience even in challenging global conditions. This occurs despite well-known local challenges such as access to funding, sales and customer acquisition, as well as hiring staff with the appropriate skills. It is estimated that in 2023 the ecosystem grew by around 150 new startups, and that 1,350 new team members were employed at the ecosystem level. It's worth noting that the actual number of new jobs created in 2023 fell short of the projected 3,000, and notably, there was a decrease in hiring across the startup ecosystem compared to 2022. Research from the previous year indicated that 1,600 new hires were recorded in 2022. While it's common for annual projections to be overly optimistic, the discrepancy between anticipated and actual results underscores the significant challenges encountered by the ecosystem throughout the year. In any case, currently, approximately 6,000 people are employed within the domestic startup ecosystem, which is 2,500 more than in 2021[8].

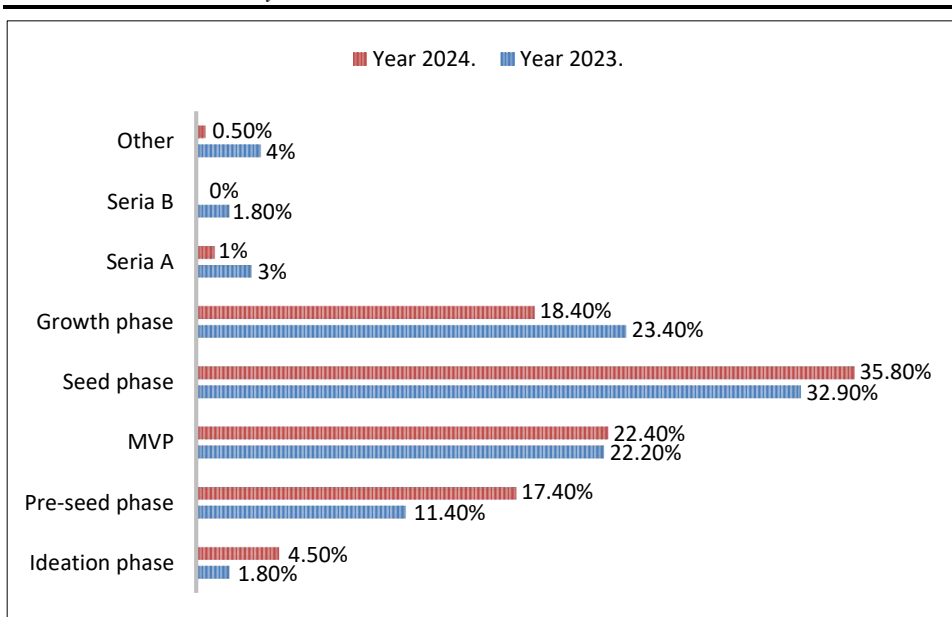


Figure 2 Percentage of startups in different stages of development in 2023/2024 [8,9]

The rise in the number of early-stage (ideation and pre-seed phase) startups suggests a growth in entrepreneurial activity within a given region or industry (Figure 1). The growth of early-stage startups is instrumental in driving economic development by creating new job opportunities, generating revenue streams, and stimulating overall economic growth. Startups inject vitality into the economy, fostering competition, and contributing to productivity gains. These stages are critical for validating startup ideas and often represent a crucial milestone towards further developing and financial support.

Growing interest in advanced technologies. The Serbian IT sector is the country’s most recognizable economic engine of growth - gaming, blockchain, artificial intelligence and web3 as well as the field consisting of medtech, biotech and healthtech, are the most prominent sectors, due to the number of talents, resources, support and activities of Serbian startups. There is a growing number of highly educated and talented young people in Republic of Serbia who are interested in entrepreneurship, with many individuals that are returning from abroad and bringing new ideas and skills with them. This trend is creating a more favorable environment for startups and venture capital funds. Venture capital funds in the Republic of Serbia can play an important role in future with further development of startup innovation ecosystem, in supporting innovative ideas and technological innovations offering financial support to startups engaged in the development of new innovative products and services.

Serbia’s tech industry accounts for at least 6% of the nation’s GDP and is growing rapidly. There are over 45,000 highly-skilled tech professionals in Serbia, which is known globally for its world-class engineers. Computer programming is compulsory for all students over the age of 11, who study Scratch, Python, Pygame, and Jupyter. There are 44 specialized

IT courses taken by 800 pupils annually in high schools. 3,300 software engineers graduate from 26 faculties every year. Main sub-sector strengths that Serbian startup ecosystem is recognizable for gaming industry, blockchain and Life sciences [7].

According to Serbian Gaming Association, estimated number of teams and companies in gaming industry is 150 which had 175m euros in revenue during 2023, with more than 4300 professionals in industry. Comparing data from 2017 to 2023, there is seven-year overview of the growth and development of Serbian gaming ecosystem. Serbian games have been downloaded/ purchased more than 100m times during 2023, the 15 most successful Serbian gaming companies generated over 175m euros which is increase of 17% compared to previous year. Over 70% of the above-mentioned revenue is generated by companies creating and selling a product, while the remaining 30% is attributed to services in the gaming space. The majority of companies depend on a single mature product for a significant portion of their revenue. It is important to note that 25% of the product companies are subsidiaries of international companies, whose work is more similar to providing services, as their work can't be attributed to a specific product of the company. Most known gaming studios are: 3Lateral, Nordeus, Fortuna Esports, Playstudios Europe, Ubisoft Belgrade, Wargaming and others [10].

Serbia has emerged as a hotbed of innovation and entrepreneurship in the field of blockchain, cryptocurrency and web3, and to became the home for many startups related to blockchain. In 2021, Serbia's Law on Digital Assets became effective – that law legalizes cryptocurrency trading and mining, and encourages cryptocurrency service providers to obtain licenses and authorization from Serbian authorities to operate within the country. Two licenses for the provision of digital assets services have been issued to date. Tenderly, with the mission to create a better environment for all web3 developers to build in, raised a \$40 million Series B in March 2022 and Web3 venture-builder Attic42 opened in April 2023. The Serbian government is looking into implementing blockchain technology in healthcare, urban planning, and other areas of interests.

There is a growing interest among domestic startups in artificial intelligence and machine learning as significant drivers of innovation within the startup ecosystem. It's evident that the startup world is entering the era of generative artificial intelligence, with a growing focus on innovative ideas that incorporate AI in various ways. In 2019, the Serbian government adopted the National AI Strategy, which sets out a framework for developing AI in Serbia whit aim to create an environment that fosters innovation, promotes the development of AI talent, and encourages the use of AI in various sectors. During 2022 Serbia become part of the Global Partnership on Artificial Intelligence and seven new master programs in AI was established at six faculties. During 2023 Serbia adopts ethical guidelines for Artificial Intelligence. All previous statements highlight the significance of AI for the Serbian ecosystem.

The construction of BIO4 campus – first Life Sciences campus in the region, a unique multidisciplinary project that will enable Belgrade to become one of the renowned and recognized bioeconomy canters in Europe, began in 2023. The main goal is to BIO4 became most advanced center in biotechnology and genetics, and home for Faculty of

Biology, Faculty of Pharmacy, Faculty of Technology and Metallurgy, eight scientific institutes and national database of genetic resources.

It's important to be noticed The Centre for the Fourth Industrial Revolution in Serbia as platform promoting public-private partnerships in Life Sciences, which coordinates various projects in the field of biotechnology with the aim of enhancing conditions for the development, testing, and advancement of new technologies for the benefit of society. Primary focus is on data from the fields of biomedicine and genetics, infrastructure development for the storage and utilization of big data, as well as the establishment of new protocols to ensure better conditions for the advancement of the health and science sectors.

Increasing availability of venture capital and angel investment. Although that majority of Serbian startups bootstrapping their development (due to number of startups in early stages of growth), one of the key drivers of the Serbian startup ecosystem's growth can be the increasing availability of venture capital and angel investment, both from domestic sources and international investors.

Venture capital funds offer not only financial investment, but also valuable intangible assets based on their experience and networks - this aspect of investment is critical, as startups in early stages often lack both financial and intangible resources, including past experience and knowledge, which are necessary for them to develop their business. However, only a limited number of startup companies have been successful in attracting venture capital funds investment and the timing of receiving investments ranges from the initial stage to the later stage of startup growth [11].

Venture capital funds are recognized in the state legislation of the Republic of Serbia in the past few years. According to the Law on alternative investment funds Venture capital funds are alternative investments funds with a private offer whose assets, in accordance with the alternative investments fund's business rules, are mainly invested in business entities that are newly founded or are in the initial stages of business, and show potential for growth and business expansion [12]. With the right support and investment, the venture capital industry in Republic of Serbia has the potential to drive significant economic growth and job creation in the coming years. Despite the current modest size of the venture capital industry in Republic of Serbia, there have been some notable successes in recent years [13].

According to Startup scanner 2024 there is slight increase in availability of venture capital funds, 13,4% investments in Serbian startups during 2023 came from venture capital funds which is increase comparing to 2022 when 8,4% of domestic startups financed their growth using venture capital funds. It demonstrates a notable uptrend. Comparing the percentage of investments from business angels between 2022 and 2023 (8.4% to 13.4%, respectively) demonstrates a steady trend (Figure 2). This influx of capital has provided startups with the financial resources needed to fuel their growth. Previous data, show that Serbian startup ecosystem is steadily maturing with more startups that are worth investing – venture funds usually invest in startups that are in later stage of growth.

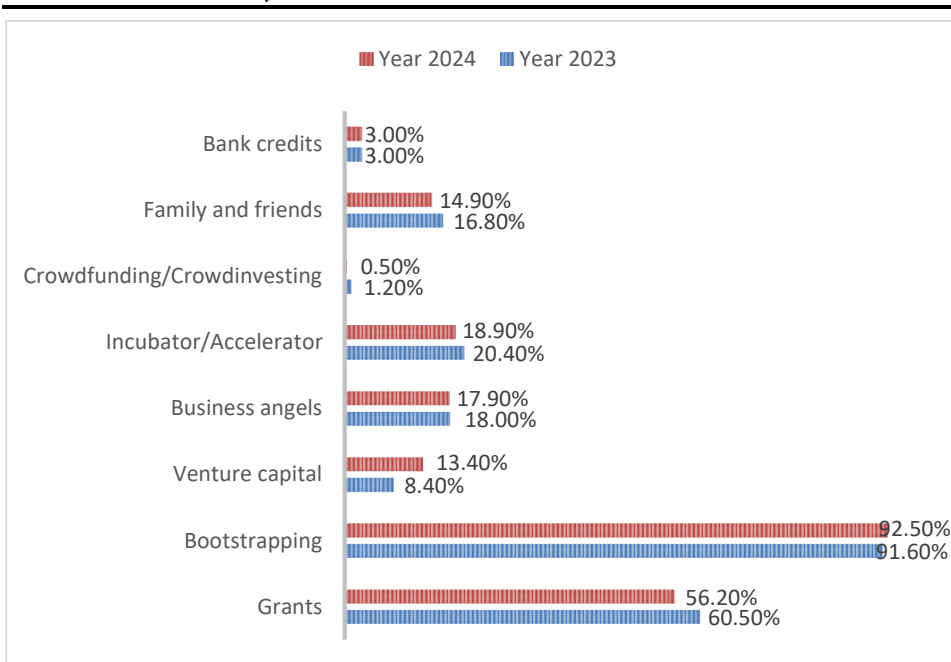


Figure 3 Finance sources of startups growth (*startups can use several different sources of financing) [8,9]

First corporate venture capital fund in this part of Europe was established in 2021 by Serbian state-owned telecommunications operator Telekom Srbija with primary goal to support and invest in technological and business solutions, which due to their innovation in the market can lead to rapid and major transformations. Newly established VC funds. Omorika Ventures and The Fifth Quarter are two new funds that started operations in 2023. In addition to TS Ventures and two new venture capital funds, there is a number of foreign and regional private venture capital funds interesting in local ecosystem, which indicate that domestic startup innovation ecosystem is becoming more attractive and that can be expected more venture funds to enter domestic startup ecosystem in future

Slight increase in academic interest in startups entrepreneurship. Although academic interest remains modest, the recent period has shown a slight but encouraging increase in interest in startup entrepreneurship and the commercialization of innovations stemming from science and research organizations. Significant stakeholders in the startup ecosystem particularly emphasize the great potential of technology transfer from academia to industry.

Particularly noteworthy is the "Expert2Mentors" initiative conducted by the Faculty of Organizational Sciences in Belgrade as part of the Venture an Idea project supported by USAID. This initiative focuses on enhancing mentoring skills among professors and associates from research organizations to work with student startup teams in the critical initial stages of development. Over the past three years, the program has engaged over 80 professors and associates from research organizations at the University of Belgrade and

the University of Kragujevac. They had the opportunity to enhance their knowledge and skills in the field of startup entrepreneurship and innovation development, as well as ways to support students in developing their innovative ideas. As a next step of the program, at the University of Belgrade, the pre-incubation program Route2Launch was implemented, through which 29 student startup teams developed their business ideas [8].

Towards the end of the preceding year, with the goal of aiding entrepreneurial teams (made by students, researchers, and/or faculty members, either individually or in a mixed composition) within scientific research organizations to develop and commercialize their innovations in the market and develop innovative ideas, 14 **innovation incubators** were established at scientific research organizations. This initiative was supported by the Ministry of Science, Technological Development, and Innovation of Republic of Serbia with aim to [14]:

- foster and support the development of entrepreneurial competencies,
- increase the number of startup teams with business ideas,
- boost the number of startups in the earliest stages of development,
- emphasize the provision of training, mentorship, and counseling,
- facilitate their growth and enable smooth entry and success in the market,
- support multidisciplinary and collaboration of scientific research organizations with one or more related scientific research organizations and/or science and technology parks.

Establishing innovation incubators is intended to ignite entrepreneurial spirit among youth and enhance the success rate in the early stage of business development. In the first quarter of the current year, 117 activities were held, including training sessions, workshops, and seminars, with the participation of over 900 students, researchers, and professors.

3. CONCLUSION

Through analysis of the current state and emerging trends, it is evident that the Serbian startup ecosystem is evolving, facing numerous challenges and opportunities. Key emerging trends in ecosystem encompass the growth of number of startups, growing interest in advanced technologies, increasing availability of venture capital and slight increase in academic interest in startups entrepreneurship. The progress of the Serbian startup ecosystem offers numerous opportunities for entrepreneurs, investors, and society as a whole. However, to sustain this positive trend and capitalize on all potential benefits, further enhancement of government support is needed through the creation of a more favorable business environment, increased investment in technological transfer from academia, as well as the growing interest of venture funds. In addition, there are evident movements towards establishing a leadership position in the Western Balkans region, as Serbia emerges as a frontrunner in fostering a vibrant startup ecosystem characterized by innovation, tech talent, and investment.

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JACOBI OPERATORS ON STATISTICAL MANIFOLDS

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ABSTRACT:

In this paper we give definition statistical manifolds and its complex version, holomorphic statistical manifolds. Also, some of the important results that are valid on (holomorphic) statistical manifolds are given. The results are obtained as a generalization of the results on complex manifolds, in particular on Kaehler manifolds (complex space forms). The main interest of this work are Jacobi operators. We define Jacobi operators using a statistical curvature tensor and show some original results on statistical manifolds with commuting Jacobi operators. In particular, we show relation between sectional curvature and manifold flatness on one hand and the condition that Jacobi operators commute on the other hand.

Keywords: statistical manifolds, Jacobi operators

1. INTRODUCTION

In Riemannian geometry, Jacobi operator vector field is defined as $J_X = R(\cdot, X)X$, where R denotes Riemannian curvature tensor, and X is a vector field. Jacobi operators are in relation with Jacobi vector fields which are solutions of Jacobi equation $\nabla_{\gamma'}(\nabla_{\gamma'}Y) + R(Y, \gamma')\gamma' = 0$, along a geodesic γ . Here Y is a vector field and ∇ is the Levi-Civita connection. With Jacobi fields we can describe how fast the geodesics spread apart. Statistical manifolds are important objects that arise from information geometry, defined by Amari ([1]) and Lauritzen ([2]). On them, an affine connection, which we will denote by ∇ , different than the Levi-Civita connection ∇^g exists. This means we observe a triple (M, g, ∇) , where M is a differentiable manifold, g is Riemannian metric and ∇ is a torsion-free connection. A metric g and a connection ∇ are related by the following Codazzi equation

$$(\nabla_X g)(Y, Z) = (\nabla_Y g)(X, Z),$$

where X, Y and Z are vector fields on tangent space of a manifold M , denoted by $T(M)$. A pair (g, ∇) that satisfies Codazzi equation is called statistical structure and a triple (M, g, ∇) is called a statistical manifold.

On a statistical manifold (M, g, ∇) there exist a dual connection ∇^* of a connection ∇ , that is, a relation

$$Xg(Y, Z) = g(\nabla_X Y, Z) + g(Y, \nabla^* X Z),$$

for tangent vector fields X, Y, Z , holds.

For a Levi-Civita connection ∇^g and a statistical connection ∇ , the following relation holds:

$$\nabla_X Y = \nabla_X^g Y + K(X, Y),$$

for tangent vector fields X and Y .

Here $K(X, Y)$ denotes a $(1, 2)$ -tensor that satisfies the following:

- (1) $K(X, Y) = K(Y, X)$,
- (2) $g(K(X, Y), Z) = g(Y, K(X, Z))$,

for tangent vector fields X, Y and Z .

In the case of a statistical dual connection, we have

$$\nabla_X^* Y = \nabla_X^g Y - K(X, Y).$$

Keeping in mind the importance of Jacobi vector fields, we will introduce this object in a statistical manifold environment and give some original results about them.

2. PRELIMINARIES

A classical definition of a Riemannian curvature tensor is

$$R^g(X, Y)Z = \nabla_X^g \nabla_Y^g Z - \nabla_Y^g \nabla_X^g Z - \nabla_{[X, Y]}^g Z,$$

for the Levi-Civita connection ∇^g and tangent vector fields X, Y and Z .

Also,

$$R^g(X, Y, Z, V) = g(R^g(X, Y)Z, V),$$

for tangent vector fields X, Y, Z and V .

A Riemannian curvature tensor satisfies the following:

- (1) $R^g(X, Y)Z = R^g(Y, X)Z$;
- (2) $R^g(X, Y)Z + R^g(Y, Z)X + R^g(Z, X)Y = 0$;
- (3) $R^g(X, Y, Z, V) = R^g(Z, V, X, Y)$.

In this case, a Jacobi operator vector field is defined as

$$J_X = R^g(\cdot, X)X.$$

These operators are of a great importance in differential geometry. For example, if we denote by U the Reeb (structural) vector field of a hypersurface in a complex space form, then the structure Jacobi operator J_U contains much geometric information about the observed hypersurface ([1]).

If (M, g, ∇) is a statistical manifold, then the statistical curvature tensor is defined by

$$R(X, Y)Z = \nabla_X \nabla_Y Z - \nabla_Y \nabla_X Z - \nabla_{[X, Y]} Z.$$

For the dual connection ∇^* , the dual statistical curvature tensor is defined in a similar way as

$$R^*(X, Y)Z = \nabla_X^* \nabla_Y^* Z - \nabla_Y^* \nabla_X^* Z - \nabla_{[X, Y]}^* Z,$$

for tangent vector fields X, Y and Z .

2. STATISTICAL JACOBI VECTOR FIELDS

On a statistical manifolds we can observe two important tensors defined by a difference (1,2)-tensor K :

- (1) A tensor $[K, K]: TM^2 \rightarrow L(TM; TM)$, defined by

$$[K, K](X, Y)Z = [K_X, K_Y](Z);$$
- (2) A tensor $K^b: TM \rightarrow L(TM; TM)$, defined by

$$K^b(X)(Y) = K(X, Y) = K_X Y.$$

This means a two-form dK^b on M , is defined by

$$dK^b = \nabla_X^g K^b(Y) - \nabla_Y^g K^b(X).$$

Since K is totally symmetric, dK^b is self-adjoint endomorphism of TM .

Lemma 1. A tensor $[K, K]$ satisfies the following relation:

$$[K, K](X, Y)Z + [K, K](Y, Z)X + [K, K](Z, X)Y = 0,$$

where X, Y and Z are tangent vector fields on M .

Proof. From the definition of $[K, K]$, we get

$$\begin{aligned} [K, K](X, Y)Z + [K, K](Y, Z)X + [K, K](Z, X)Y &= [K_X, K_Y](Z) + [K_Y, K_Z](X) + \\ &+ [K_Z, K_X](Y) = K_X K_Y Z - K_Y K_X Z + K_Y K_Z X - K_Z K_Y X + K_Z K_X Y - K_X K_Z Y = \\ &= K_X K_Y Z - K_Y K_X Z + K_Y K_Z X - K_Z K_Y X + K_Z K_X Y - K_X K_Z Y = 0, \end{aligned}$$

where we have used $K_X Y = K_Y X$. \square

For the curvature tensors R and R^* associated with statistical connection ∇ and its dual connection ∇^* the following relations hold:

- (1) $R(X, Y) + R^*(X, Y) = 2R^g(X, Y) + 2[K, K](X, Y);$
- (2) $R(X, Y) - R^*(X, Y) = 2dK^b(X, Y);$
- (3) $R(X, Y, Z, W) = -R^*(X, Y, W, Z).$

In particular, we have

$$\begin{aligned} R &= R^g + [K, K] + dK^b, \\ R^* &= R^g + [K, K] - dK^b. \end{aligned}$$

As usual we can define (0,4)-tensors $[K, K]: TM^4 \rightarrow R_M$ and $dK^b: TM^4 \rightarrow R_M$ as

$$\begin{aligned} [K, K](X, Y, Z, W) &= g([K, K](X, Y)W, Z) \\ &= g(K(X, Z), K(Y, W)) - g(K(X, W), K(Y, Z)), \end{aligned}$$

$$dK^b(X, Y, Z, W) = g(dK^b(X, Y)W, Z).$$

Proposition 1. The following conditions are equivalent:

- (a) $R=R^*$;
- (b) $\nabla_X^g K(Y, Z)$ is symmetric on X, Y and Z ;
- (c) $dK^b = 0$;
- (d) $R(X, Y, Z, W) = -R(X, Y, W, Z)$;
- (e) ∇ is conjugate symmetric.

Furthermore,

$$R = -R^* = R^g + [K, K]$$

holds in this case.

Proposition 2. The following conditions are equivalent:

- (a) $R = -R^*$;
- (b) $R^g = -[K, K]$.

In this case, we have

$$R = -R^* = dK^b.$$

For the statistical curvature R , we define a statistical Jacobi vector field J by

$$J(X, Y) = R(Y, X)X = R^g(Y, X)X + \nabla_Y^g K(Y, X) - \nabla_X^g K(Y, X) + J_K(X, Y).$$

Here, K -Jacobi operator operator J_K is defined by

$$J_K(X, Y) = [K, K](Y, X)X.$$

Theorem 1. For the K -Jacobi operator J_K , the following holds: $J_K = 0$ if and only if $[K, K] = 0$.

Proof. From Lemma 1, we have

$$0 = [K, K](X, Y)Z + [K, K](Y, Z)X + [K, K](Z, X)Y = [K, K](X, Y)Z - [K, K](Y, X)Z - [K, K](X, Z)Y = [K, K](X, Y)Z + [K, K](X, Y)Z + [K, K](X, Y)Z.$$

□

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FINANCIAL SUCCESS EVALUATION OF COMPANIES OPERATING IN THE BIST HEALTH SECTOR WITH RATIO ANALYSIS

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ABSTRACT

Company valuation is the process of determining the intrinsic or true value of a company. This process helps investors make an effective, conscious and correct investment decision. Ratio analysis is the comparison of at least two groups or classes in the data in financial statements by proportioning them. This method aims to obtain more meaningful results than examining financial statement items one by one. It examines and analyzes the relative (proportional) relationships of the items in the financial statements of the business. This type of analysis enables evaluation by comparing standard values with the previous year's results of the business, industry averages or the rates of a successful business. Ratio analysis is important for understanding the financial health of the business and making future decisions. Business owners and managers should monitor these ratios regularly.

In this study, the financial performances of healthcare sector companies traded in Borsa Istanbul for the 2021-2022 period were analyzed using financial ratios. The data used in the study was obtained from the Public Disclosure Platform and the data published by relevant businesses for the purpose of informing the public. As a result of the study, information was provided to both the companies examined, investors and researchers in the light of the results obtained from the companies examined. In order to increase the depth of the study, the time series of the data used may cover longer periods.

Keywords: *Financial Performance, Financial Ratios, BIST Health Sector.*

1. INTRODUCTION

Nowadays, businesses in the world are increasingly under the influence of globalization. One of the most important effects of globalization is undoubtedly increasing competition (Kızıl and Aslan, 2019:1778). In today's world where competition is quite tough, businesses should measure their performance accurately and obtain feedback at regular intervals. At the same time, companies should also make sectoral comparisons when comparing their performance with previous periods. Performance, on the other hand, is the quantitative and qualitative expression of what a person, a group, or an enterprise doing a job has achieved and what it has achieved towards the intended goal of that job (Karasoy, 2000; Akal, 2002).

Financial performance analysis is the process of determining the activity and financial structure characteristics of a business by using its accounting and financial statements. The purpose of this analysis is to determine the efficiency and performance of the business management from the financial records and reports of the business (Bhunja et al., 2011: 269). Financial performance is the process of evaluating the financial position of businesses and the safety and risk of their investments. Financial performance measurements are used to evaluate the past, make investment and financing decisions for the future, use resources, and evaluate the performance of managers (Gümüş and Bolel, 2017: 88).

It is possible to measure the financial performance of businesses by various methods. However, ratio analysis is one of the leading methods for measuring financial performance. With the help of ratio analysis reflecting financial performance, companies can evaluate and keep under control their liquidity, financing structure, activity, profitability, growth, and capital market performance ratios. In addition, thanks to the ratio analysis, businesses can achieve their goals and implement their strategies (Örs, Takıl and Altın, 2015).

Ratio analysis was first mentioned by Wiliam M. Rosendale in 1908. Ratio analysis was implemented in a systematic format in 1919. Previously, only the current ratio was used to measure company performance. Over time, the drawbacks of this were expressed and the rates were considered as a whole. Over the years, ratios obtained with different financial data in different countries have begun to be used in company performance measurement (Sarıkaş, 2007). Nowadays, ratio analysis has become a frequently used and utilized method. Ratio analysis is an analysis that points to the relationship between any two items in the financial statements (Berk, 1998).

Ratios used in financial analysis in general can be examined under five different categories according to their purposes and functions. These can be listed as liquidity ratios, profitability ratios, financing structure ratios, activity ratios, and growth and capital market performance ratios (Saraç, 2012). In this study, the financial performances of companies operating in the healthcare sector listed on Istanbul Stock Exchange were evaluated by ratio analysis.

2. RATIO ANALYSIS

Financial analysis aims to examine and evaluate the current situation of a company. Ratio analysis points to the relationship between any two items in the financial statements. Therefore, ratio analysis helps to obtain detailed information about the company by using

the financial items included in the financial statements (Berk, 1998). Ratios used in financial analysis are divided into five separate categories based on their purpose and functions. These; (Saraç, 2012) - Liquidity (Solvency) Ratios, Financial (Capital) Structure Ratios, Activity (Turnover Rate) Ratios, Profitability Ratios, and Market Performance Ratios.

Liquidity (Solvency) ratios; It is used to measure the company's short-term debt payment performance. Liquidity ratios; It can be expressed as Current Ratio, Acid-Test Ratio, Cash Ratio. (Akgüç, 1995):

Financial (Capital Structure) structure ratios include the ratios used to measure the company's resource structure and long-term debt payment performance. Financial structure ratios; Leverage Ratio can be listed as the Ratio of Total Debts to Equity, the Ratio of Short-Term Debts to Total Liabilities, the Ratio of Long-Term Debts to Total Liabilities, and the Ratio of Tangible Assets to Long-Term Debts (Akdoğan and Tenker, 2010).

If we talk about activity ratios, it is worth noting that the ratios in this group are the ratios that determine how effectively the economic assets owned by the company and used in carrying out its activities are used. These rates; can be expressed as Inventory Turnover Rate, Inventory Turnover Period, Receivables Turnover Rate, Receivables Turnover Time, Asset Turnover Rate, and Tangible Asset Turnover Rate (Çabuk and Lazol, 2011). Profitability ratios can be defined as ratios that indicate how effectively the company uses its equity capital, foreign resources, and assets, and how profitable it is in its activities as a whole. Profitability rates; They can be listed as Gross Profit Margin, Return on Equity, and Return on Assets Ratio (Akgüç, 1994).

The variables used in the study were considered the most frequently used ratios as a result of the literature review (Büyükşalvarcı, 2011; Bülbül and Köse, 2011; Akyüz and others, 2017; Güleç and Özkan, 2018; Tayyar and others, 2018).

3. LITERATURE REVIEW

In the study of Sakarya and Erayman (2022), the financial performances of companies traded in Istanbul Stock Exchange (BIST) and the IT sector were analyzed by calculating their ratios based on the cash flow table. As a result of the analysis, the enterprises' performances were ranked according to their negative and positive superiority values. As a result of the study, it was concluded that no single company ranked first in all years covering the analysis period and that the financial performance in the sector was not stable on a business basis.

Kendirli et al. (2019) analyzed the financial performance of participating banks and Commercial Banks operating in Turkey in their study. The analysis was carried out using data from banks before the crisis (2005-2008), during the crisis (2008-2011) and after the crisis (2011-2015). As a result of the study, it was concluded that Turkey was less affected by the financial crisis than other countries. Before or after the crisis, commercial banks came first, in the crisis year (2008) banks performed better, their financial values were higher and they were profitable.

In their study, Paça and Tekel Karabulut (2019) analyzed the financial performances of the companies included in the BIST Tourism (Istanbul Stock Exchange Tourism) Index. For this purpose, the data of the companies in the BIST Tourism Index between 2013 and 2017 were analyzed with the help of financial ratios, and the correlation test and Kruskal

Wallis H test were used in the analysis. As a result of the study, it was seen that there was no significant difference in the ratios of asset turnover rate, working capital turnover rate, net profit to total assets ratio, profit before interest, and tax to total assets and companies of different degrees. their relationships with each other.

In Mendi's (2018) study, the data obtained from the financial statements of ÇAYKUR enterprise, the financial structure of the enterprise, and its situation compared to other companies in the market were analyzed.

Spleen et al. (2018) comparatively examined the use of financial analysis methods in public and non-public airline passenger transportation companies in Turkey. The surveys prepared in this context were distributed to 11 airline passenger transportation companies operating in Turkey, and 4 airline companies, 2 of which are traded on Istanbul Stock Exchange (BIST), responded to the survey. As a result of the research, it was determined that 2 publicly traded airline companies used all financial analysis methods. However, it was understood that 1 of the non-public airline companies used other financial analysis methods other than vertical percentage analysis, and 1 used only ratio analysis. There are differences between companies in terms of the use and importance levels of financial ratios, and companies do not benefit from all ratios.

In the study conducted by Perçin and Aldalou (2018), Turkish Airlines and Pegasus Airlines compared their financial performance. In this context, Fuzzy AHP, Fuzzy TOPSIS, and ratio analysis were used. According to research findings as a result of using the specified methods, Pegasus Airlines has a higher financial performance than Turkish Airlines.

In their study, Güleç and Özkan (2018) analyzed the financial performance of 16 cement companies registered in Istanbul Stock Exchange between 2005 and 2016. The Gray Relational Analysis (GRA) Method was used within the scope of performance evaluation. 17 ratios were selected from the traditional financial ratios of the companies, GIA values were obtained using them and a ranking was made for each year. At the same time, companies' stock returns were calculated using the Buy and Hold Return Method and compared with GRA values.

Tayyar et al. (2018) made a performance evaluation based on financial ratios in their study. Multi-Criteria Decision Making (MCDM) Method was used in this research. In this context, the Reference Ideal Method (RIM) was considered and applied. At the same time, in this study, a performance evaluation based on financial ratios was made using RIM. 17 traditional financial ratios were considered in the research.

Rosini and Gunawan (2018) used ratio analysis to measure the financial performance of the airline industry in their study. TOPSIS and Data Envelopment Analysis methods were also used in the study. Correlation analysis was also conducted in the study to measure the relationship between variables.

Gümüş and Bolel (2017) examined the financial statement values of airline companies operating in BIST for the years 2010-2015 and analyzed the financial performances of the companies with ratio analysis formulas. According to the results obtained from the research, it is emphasized that both companies are financially strong and investable.

Sakız (2017) stated in his study that the national and international airline market has witnessed intense competition in recent years. Therefore, it is emphasized that in such an atmosphere, it is much more important to measure and evaluate the financial performance

and risks of businesses. In the study, the Altman Z Model was considered as a financial risk assessment model and Turkish Airlines an application has been made to it.

In their study, Akyüz et al. (2017) measured the financial performance of 7 companies traded in Istanbul Stock Exchange (BIST) and belonging to the paper and paper products industry sector. They used the Gray Relational Analysis (GRA) Method for financial performance measurement. At the same time, 17 financial ratios identified in the study were used. The 17 financial ratios in question were calculated to cover the years 2011-2016 of the companies.

In their study, Dizkırıcı et al. (2016) revealed the relationships between profitability and traditional financial and airline-specific ratios for the 2011-2013 period for 17 leading airline companies. Therefore, it was tried to determine the effect of companies' traditional ratios on their profitability rates. The research also included descriptive statistics table, correlation, and regression analyses. As a result of the study, relevant comments were presented.

Teker et al. (2016) conducted an empirical study and measured the financial performance of the top 20 airline companies in the world. For this purpose, a harmonic index and ratio analysis were used. As a result of the analysis, the best and worst-performing airline companies are presented in order.

In their study, Meydan et al. (2016) evaluated the financial performances of food companies traded in Istanbul Stock Exchange using the Gray Relational Analysis Method and commented on the companies.

Mushure (2014) conducted a financial analysis of Malaysia Airlines using data between 2007 and 2011. Ratio analysis was carried out using the company's financial statements and annual reports.

In his study, Ekinci (2011) analyzed the place of Turkish Airlines A.Ş. in the industry. The financial statements of the business are subject to analysis and the proportional change of the items in the financial statements are presented.

In their research, Kim and Ayoun (2005) conducted a comparative ratio analysis between the tourism industry and the accommodation, restaurant, airline, and entertainment sectors. The study covered the period 1997-2001. According to the findings of the study, 8 of the 13 ratios included in the analysis showed statistical differences between sectors.

Capobianco and Fernandes (2004) examined the capital structure in the world airline industry in their study. It has been observed that the equity capital in these large airline companies is at least 40%. At the same time, it has been understood that successful airline companies focus on reducing their debts and increasing their return rates. In addition, it was emphasized that the countries of the airline companies do not provide them with an advantage, but rather their management plays a decisive role.

4. ANALYSIS DATA AND METHOD TO BE APPLIED

In the research, the financial performance of Healthcare Sector businesses whose shares are traded in Istanbul Stock Exchange (BIST) between 2022 and 2023 was interpreted through the ratio analysis method. The financial statements of the companies in question were obtained from the Public Disclosure Platform (KAP). Data obtained from KAP was used to calculate the financial ratios. The data in question was determined by taking into account the most commonly used rates in the market. The list of ratios used in the study is given in the table below.

Table 1. List of Ratios Used for Analysis

Ratio Name	Ratio Content
Current Ratio	Current Assets / Short-Term Foreign Resources
Acid-Test Ratio	(Current Assets - Stocks) / Short Term Foreign Resources
Cash Rate	(Cash Values + Securities) / Short-Term Foreign Resources
Leverage Ratio	Total Debt / Total Liabilities
Ratio of Total Debts to Equity	Total Debt / Equity
The ratio of Short-Term Debts to Total Liabilities	Short-Term Debts / Total Liabilities
The ratio of Long-Term Debts to Total Liabilities	Long-Term Debts / Total Liabilities
The ratio of Tangible Assets to Long-Term Liabilities	Tangible Assets / Long-Term Liabilities
Stock Turnover Ratio	Cost of Sales / Average Stock
Receivables Turnover Ratio	Sales / Average Trade Receivables
Asset Turnover Ratio	Net Sales / Average Asset
Tangible Asset Turnover Ratio	Net Sales / Tangible Assets
Gross Profit Margin	Gross Profit / Net Sales
Return on Equity	Net Profit / Equity
Asset Return Ratio	Net Profit / Total Assets

Table 2 includes healthcare sector companies listed and operating in Istanbul Stock Exchange. One of the companies, European Investment Holding (AVHOL), was excluded from the analysis because sufficient data could not be provided. There are a total of 5 companies within the scope of the index. The names and Istanbul Stock Exchange transaction codes of 4 of these companies are given in Table 2 below.

Table 2. Selected List of Firms

Firm Name	BIST (Istanbul Stock Exchange) Code
Lokman Hekim Engurusağ Health Tourism Education Service Corporation	LKMNH
MLP Health Service	MPARK
Nasmed Special Health Service	EGEPO
Tapdi Oxygen Special Health and Education Services	TNZP

The 2022-2023 financial statement analysis data of the companies traded on Istanbul Stock Exchange are given below (It is assumed that the shares do not give bonus shares during the period analyzed.).

Table 3. Istanbul Stock Exchange Firms Ratios (Liquidity Ratios)

LKMNH	MPARK	EGEPO	TNZP
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Liquidity (Solvency) Ratios	2022	2023	2022	2023	2022	2023	2022	2023
Current Rate	0,809	0,915	0,874	0,952	1,722	1,442	2,217	1,338
Acid Test Ratio	0,665	0,759	0,727	0,831	1,599	1,366	2,030	1,217
Cash Ratio	0,112	0,058	0,203	0,316	1,077	0,544	1,429	0,845

Solvency ratios consist of Current Ratio (Standard value is 2), Acid Test Ratio (Standard value is 1) and Cash Ratio (Standard value is 0.05-0.5). Looking at the solvency ratios in Table 3, Nasmed Special Health Service company (EGEPOL) is seen to be in the best position in 2022 and 2023 in terms of current ratio. Looking at the Acid Test ratios, it is seen that the position of the same company is better than others. When cash ratios are examined, it is seen that Tapdi Oxygen Special Health and Education Services (TNZP) is better. In terms of current ratio and acid test ratio, TNZP company is in a better situation in 2022. This situation is also reflected in the year-end closing price changes of the companies.

Table 4. Istanbul Stock Exchange Firms Ratios (Financial Structure Ratios)

Financial Structure Ratios	LKMN		MPARK		EGEPO		TNZP	
	2022	2023	2022	2023	2022	2023	2022	2023
Leverage Ratio	0,494	0,419	0,562	0,546	0,308	0,224	0,198	0,301
Ratio of Total Debts to Equity	0,506	0,581	0,438	0,454	0,692	0,776	0,802	0,699
The ratio of Short-Term Debts to Total Liabilities	1,026	1,384	0,778	0,831	2,252	3,459	4,050	2,319
The ratio of Long-Term Debts to Total Liabilities	0,309	0,283	0,352	0,313	0,087	0,097	0,103	0,123
The ratio of Tangible Assets to Long-Term Liabilities	0,185	0,136	0,210	0,234	0,221	0,127	0,095	0,178
Fixed Assets to Equity Ratio	1,482	1,276	1,581	1,548	1,229	1,108	0,963	1,196

Table 4 shows the financial structure ratios. Financial structure analysis was analyzed with 7 ratios in this study. Among these ratios, Leverage Ratio is the ratio of total debt to total assets. Under Turkish conditions, this structure is expected to be 0.50. When the companies are examined, the company in the best situation in terms of Leverage Ratio is MLP Health Service (MPRK). Equity Ratio is obtained as a result of the ratio of Total Debt to Equity. Under Turkish conditions, this ratio is expected to be around 1. When the companies are examined, it can be seen that the company that is in the best position in terms of this figure is Tapdi Oxygen Special Health and Education Services (TNZP). The ratio of Short-Term Debts to Total Liabilities is represented by the ratio of Short-Term Debts to Total Resources. This ratio is expected to be 0.25 under Turkish conditions. The

company that is in the most positive situation in terms of this ratio is MLP Health Service (MPRK). The ratio of Long-Term Debts to Total Liabilities is represented by the ratio of Long-Term Foreign Resources to Total Resources. This ratio is expected to be 0.25 under Turkish conditions. The company that is in the most positive situation in terms of this ratio is again MLP Health Service (MPRK).

Table 5. Istanbul Stock Exchange Firms Ratios (Activity Ratios)

Activity Ratios	LKMN		MPARK		EGEPO		TNZP	
	2022	2023	2022	2023	2022	2023	2022	2023
Receivables Turnover Ratio	7,008	6,156	6,280	6,138	11,182	6,907	10,295	7,885
Stock Turnover Ratio	15,279	16,169	11,940	14,879	30,588	47,204	19,285	14,472
Active Turnover Ratio	0,774	0,829	0,836	0,790	0,387	0,487	0,482	0,295
Ready Value Turnover Ratio	22,437	50,393	14,979	7,982	5,956	12,272	5,607	2,895
Current Assets Turnover Ratio	3,097	3,197	2,714	2,654	2,593	3,477	2,120	1,796
Fixed Assets Turnover Ratio	1,031	1,119	1,208	1,125	0,455	0,567	0,625	0,353
Equity Turnover Ratio	1,528	1,428	1,910	1,741	0,559	0,628	0,602	0,423

Table 5 shows the Turnover Rate Ratios. Turnover rate ratios were analyzed with 6 ratios. Among these, Receivables Turnover Rate is calculated by dividing sales to trade receivables. It is expected to be as high as possible. It is expected to comply with the forward sales policy. When the companies are examined, it is seen that the companies in the most positive situation in terms of this ratio are Nasmed Special Health Service (EGEPO) (in 2022) and Tapdi Oxygen Special Health and Education Services (TNZP) (in 2023). Stock Turnover Ratio is obtained by dividing the cost of sales to the average stocks. When Table 5 is examined, the company in the most positive situation in terms of Stock Turnover Ratio is Nasmed Special Health Service (EGEPO). Active Turnover Ratio is calculated by dividing sales to total assets. When the table is examined, it can be seen that the company that manages its assets best is Lokman Hekim Engurusag Health Tourism Education Service Corporation (LKMNH).

Table 6. Istanbul Stock Exchange Firms Ratios (Financial Structure Ratios)

Profitability Ratios	LKMN		MPARK		EGEPO		TNZP	
	2022	2023	2022	2023	2022	2023	2022	2023
Gross Sales Profit Ratio	0,123	0,139	0,259	0,286	0,158	0,280	0,232	0,276
Operating Profit Ratio	0,076	0,094	0,157	0,195	-0,051	0,051	0,165	0,129
Term Profit Rate	0,184	0,175	0,259	0,211	-0,293	0,149	0,248	0,627

Net Profit Rate for the Period	0,191	0,170	0,251	0,202	-0,293	0,149	0,248	0,627
Asset Return Rate	0,148	0,141	0,210	0,159	-0,114	0,072	0,119	0,185
Return on Equity Ratio	0,292	0,243	0,479	0,351	-0,164	0,093	0,149	0,265

Table 6 is the ratio that analyzes the profitability of companies. Companies were analyzed with 6 profitability ratios. When the table is examined, it is seen that the most profitable company among the companies is Tapdi Oxygen Special Health and Education Services (TNZP) (in terms of Net Profit Margin) in 2022 and 2023. Among the profitability ratios, this ratio is relatively the most striking for investors. Therefore, only the Net Profit Margin ratio is highlighted.

Table 7. Istanbul Stock Exchange Firms Ratios (Market Data's)

Market Data's	LKMN		MPARK		EGEPO		TNZP	
	2022	2023	2022	2023	2022	2023	2022	2023
Year End Closing Price	36,16	49,660	90,3	141,9	18,12	18,53	11,23	60,4
Changing Ratio of Price	0	0,373341	0	0,571429	0	0,022627	0	4,378451

Table 7 was calculated by taking into account the companies' 2022 and 2023 stock closing prices. The aim here is to highlight the company that brought the highest proportional capital gain at the beginning of the year. When Table 7 is examined, Tapdi Oxygen Special Health and Education Services (TNZP) provided the highest capital gain proportionally according to the year-end closing prices. The company that provides proportionate capital gains to its investors is Tapdi Oxygen Special Health and Education Services (TNZP).

5. RESULT AND CONCLUSION

This study examined the proportional analysis of companies operating in the healthcare sector that were listed on Istanbul Stock Exchange. Data obtained from Turkish Public Disclosure Platform (KAP) and Istanbul Stock Exchange were used in the study. Study data covers the years 2022 and 2023. According to the results obtained from the study, Tapdi Oxygen Special Health and Education Services (TNZP) company showed optimal performance in terms of all ratios. The company that makes a difference in terms of solvency ratios is Nasmed Special Health Service company (EGEPOL). In terms of financial structure ratios, it is a MLP Health Service (MPRK) company. When the turnover rate ratios are examined, it is seen that Nasmed Special Health Service (EGEPO) stands out together with Tapdi Oxygen Special Health and Education Services (TNZP). Tapdi Oxygen Special Health and Education Services (TNZP) stands out in terms of profitability ratios.

We think that this study provides guidance for researchers and investors in terms of Ratio Analysis. Especially if investors direct their investments by taking these analyzes into consideration when investing, they have the possibility of better optimizing their earnings.

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UTICAJ DIGITALIZACIJE I INOVACIJA NA POSLOVANJE ORGANIZACIJA

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“Ne opstaju najjači pripadnici jedne vrste, niti najinteligentniji, nego oni koji se najbolje prilagođavaju promjenama”.

Čarls Darwin

APSTRAKT:

Tehnološki napredak, kao što su digitalizacija, vještačka inteligencija i automatizacija, transformišu tradicionalne načine po kojima poslujemo u savremenim tržišnim uslovima privređivanja. U današnjem svijetu koji se brzo mjenja, inovacije i obrazovanje igraju ključnu ulogu u prilagođavanju globalnim promjenama. Inovacije, posebno u tehnologiji, mijenjaju način kako učimo i prvenstveno kako primjenjujemo to znanje u biznisu. Digitalne platforme, AI, VR i AR tehnologije otvaraju nove pristupe u podršci biznisu, omogućavajući pristup znanju i resursima širom svijeta. Predmet istraživanja u ovom radu je uticaj digitalizacije i različitih vrsta inovacija na poslovanje organizacija.. Cilj rada je da se na istraživačkoj osnovi ispituju pozitivni i negativni efekti kroz prizmu uticaja kojim se stvaraju nove ekonomske mogućnosti, ali istovremeno digitalizacija može dovesti do gubitka radnih mjesta i nejednakosti u društvu posebno radnika s niskim kvalifikacionim vještinama i nivoom obrazovanja.

Ključne riječi : *tehnološki napredak, digitalizacija, vještačka inteligencija, inovacije.*

1. UVOD

Digitalizacija nameće nove izazove u poslovanju kroz digitalnu transformaciju na nivou preduzeća i nacionalne ekonomije u cjelini. Danas se mnoge organizacije bore sa starijim, takozvanim naslijeđenim tehnologijama koje se ne mogu lako zamijeniti. Projekti posvećeni nadogradnji naslijeđenih sistema i njihovoj kompatibilnosti s novim digitalnim tehnologijama zahtijevaju značajne resurse, kako u smislu radne snage, tako i u smislu budžeta.

Na osnovu iskustva država sa većim stepenom digitalne spremnosti da će digitalizacija produbiti nejednakosti u prihodima, kroz širenje nejednakosti, posebno vezano za radnike s niskim prihodima, niskim vještinama i bez obrazovanja. Digitalizacija će nastaviti da izaziva poremećaje u različitim sektorima, i tako će služiti kao pokretačka snaga u prelasku s neformalnom na formalni rad, kao i u prelasku s poljoprivrede na industriju i usluge, sektor s najvećim brojem radnih mjesta. Procjene na globalnom nivou pokazuju da promjene koje sobom nosi digitalna transformacija povećaće prosječni proizvod po radniku za 30% do 2030.g. Međutim, do sredine 2030-ih, 30% radnih mjesta i 44% radnika s niskim vještinama i nivoom obrazovanja biće izloženi riziku da budu zamijenjeni u procesu automatizacije (Izvještaj o razvoju po mjeri čovjeka za Crnu Goru za 2020. godinu).

Rakorak između pogubnih ekonomskih kvazi-teorijskih i kvazi-institucionalnih modela sa praksom je veoma opasan. Dokazano je da je institucionalno neprilagođavanje i/ili kočenje institucionalnih promjena pogubno za društveni i ekonomski razvoj. U svojim brojnim istraživanjima D. North je objasnio kako vektori društvenog i ekonomskog razvoja slijede logiku realnog jačanja i razvoja institucija, što u korelaciji sa progresom znanja dovodi do pojave novih tehnologija i smanjenju rizika, a samim tim i do pojave novih institucija.

U današnjoj ekonomiji znanja i globalnog tržišta, nematerijalna imovina firme (i privrede), tj. intelektualna svojina (kao uži dio intelektualnog kapitala) je ono što je čini uspješnom i konkurentnom (Grgurević, 2021). Nesporno je da budućnost pripada rastu, koji će se ostvarivati isključivo na znanju i inovacijama (a ne na rastu u „inovacionim granama“). Društva koja ignorišu znanje, inovacije, njihovu proizvodnju i proizvodnju dobara uopšte zasnivaju se na antirazvojnim („alternativnim“) strategijama i paradigmatama. Oni su osuđeni da produbljuju i reprodukuju krize. Brojne studije su pokazale pozitivnu korelaciju između institucija, razvoja i znanja. Naravno, pretpostavlja se da znanje ne funkcioniše u društvenom vakuumu, već kao jedan od društvenih sadržaja (odrednica, podsistem), uporedo sa efektivnim (aktuelnim) normama, navikama (uslovno: kulturom) i državnom vlašću (Delibašić, Grgurević, Andriuskevicius, 2024). U razvijenim zemljama postoje uzorni modeli i civilizacijska dostignuća, pa se s pravom očekuje unapređenje

države, njeno stavljanje u službu građana i uspostavljanje pravednijeg građanskog društva (Grgurević, 2022).

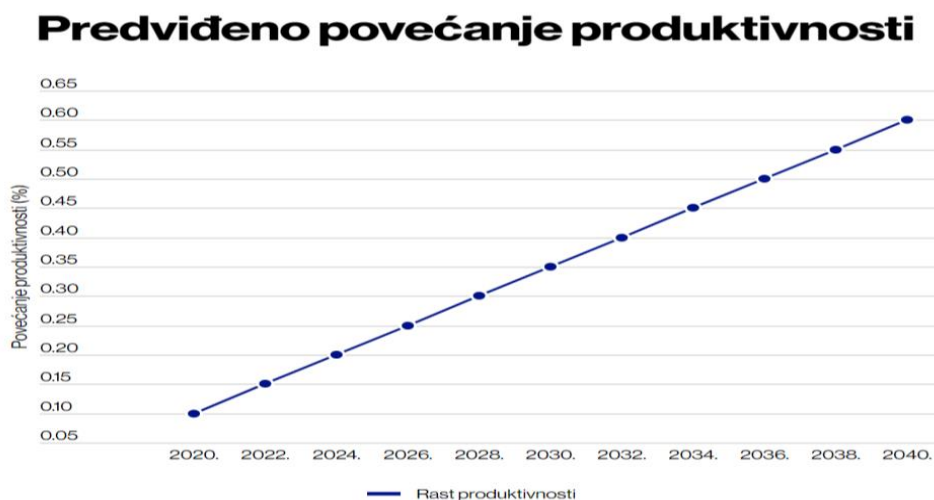
2. UTICAJ DIGITALIZACIJE I INOVACIJA NA POSLOVANJE ORGANIZACIJA

Prema autorima Ilić, Stanković i Ostojić (2024), utvrđeno je da su odnosi između organizacione kulture i inovativnog učinka, kao i organizacionog učenja i učinka inovacija, u potpunosti zavisni i međusobno direktno uslovljeni, dok je odnos između tržišne orijentacije i inovacionog učinka delimično uslovljen i zavisi od inovacione kulture organizacije.

Prema Ilić i Ostojić (2023), digitalni marketing predstavlja savremeno sredstvo komunikacija, odnosno tehnološku inovaciju bez koje se u savremenom poslovanju ne može zamisliti komuniciranje sa klijentima i ispitivanje zadovoljstva korisnika usluga. Sve veća primjena vještačke inteligencije (AI) u biznis analizi ima veliki potencijal za poboljšanje procesa donošenja odluka i uspjeha u modernom poslovnom okruženju. Vještačka inteligencija ima sposobnost da pojednostavi operacije automatizacijom rutinskih zadataka i zadataka koji se ponavljaju. Povjeravajući takve zadatke vještačkoj inteligenciji, analitičari dobijaju luksuz da preusmjere svoje vrijeme ka složenijim aspektima svoga rada. Automatizacija ne samo da ubrzava procese, već poboljšava kapacitete za donošenje odluka. Poslovna praksa pokazuje rastuću upotrebu elektronskih asistenata za bankarstvo i obuku, koji se oslanjaju na vještačku inteligenciju za poslovnu komunikaciju. Vještačka inteligencija nalazi primjenu u korisničkom servisu, radiju, bezbjednosti, digitalnim personalnim asistentima i drugim oblastima. Dugogodišnji rad na vještačkoj inteligenciji sve više dolazi do izražaja u korporativnom kontekstu, pružajući bogat materijal za analizu i istraživanje (Buha, Lečić, Berezljjev, 2024).

Prema nedavnom istraživanju McKinsey Global Instituta, generativna vještačka inteligencija ima potencijal da poveća globalne korporativne profite za 2,6 do 4,4 triliona dolara godišnje. Istraživanje je obuhvatilo 63 različita načina upotrebe ove tehnologije koji bi mogli unaprijediti produktivnost, kao što su podrška klijentima, kreiranje marketinškog sadržaja i pisanje softverskog koda. Predviđa se da će generativna AI povećati vrijednost dobijenu od vještačke inteligencije i analitike za 15 do 40 odsto, a taj bi se iznos mogao udvostručiti sa širenjem tehnologije (<https://rs.bloombergadria.com/>). Takođe, McKinsey procenjuje da bi generativna AI mogla povećati produktivnost rada za 0,1 do 0,6 odsto godišnje do 2040. godine. Kada se kombinuje sa drugim tehnologijama, automatizacija rada mogla bi dodati dodatnih 0,2 do 3,3 procentna boda rasta produktivnosti, što je prikazano na grafiku br.1.

Grafik br.1 Predviđeno povećanje produktivnosti na osnovu generativne vještačke inteligencije



Izvor: Bloomberg Adria prema McKinsey Global Institute

Vještačka inteligencija može igrati ulogu savjetnika i sugerisati kompanijama kako da donesu bolje odluke. Rezultat ovakvih savjeta može biti smanjenje rizika, niže cijene, kraće vrijeme izlaska na tržište i slično. Upotreba tehnologije vještačke inteligencije je u ekspanziji u posljednjih nekoliko godina i predviđa se da će ovo tržište pokazati godišnju stopu rasta od preko 17%, što će rezultirati obimom tržišta od skoro 740 milijardi dolara do 2030. godine. U oblasti finansija i ekonomije, vještačka inteligencija se koristi za rješavanje investicionih problema vezanih za stohastičku prirodu povrata ulaganja. Tehnike vještačke inteligencije primenjuju se za predviđanje ekonomskih pokazatelja kao što su BDP (bruto domaći proizvod), inflacija i stope nezaposlenosti. Algoritmi mašinskog učenja koriste se, na primjer, za prognozu pravca kretanja berze i cijena roba poput nafte i zlata, kao i za predviđanje ponašanja potrošača i optimizaciju marketinških strategija. (Baltezarević, 2023). Promjene u potrošačkim navikama i društvenim vrijednostima takođe oblikuju globalnu ekonomiju. Povećana svijest o održivosti, etičkim pitanjima i digitalnom privatnošću mijenja način na koji kompanije posluju i razvijaju proizvode i usluge. U svijetlu ovih promena, ključno je da države, kompanije i pojedinci budu spremni za prilagođavanje i inovacije. To može uključivati ulaganje u obrazovanje i vještine budućnosti, usvajanje održivih poslovnih praksi i saradnju na globalnom nivou radi rješavanja izazova koji proizilaze iz promjena u globalnoj ekonomiji. Mnogi prepoznaju potencijal razvoja vještačke inteligencije, što potvrđuju i podaci o finansiranju. Prošle godine zabilježen je pad ulaganja u kompanije koje se ne bave vještačkom inteligencijom

za 50% u odnosu na prethodnu godinu, dok su ulaganja u vještačku inteligenciju ostala relativno stabilna (29 milijardi dolara u 2022. godini, u poređenju sa 22 milijarde dolara u 2023. godini). Od 2010. do 2023. godine, najviše je investirano u softver za upravljanje poslovnim operacijama i procesima unutar organizacija, sa ukupnim ulaganjem od 174 milijarde dolara. Slijedi sektor transporta sa investicijama od 117 milijardi dolara, dok je u zdravstvo uloženo 70 milijardi dolara (<https://www.nin.rs/ekonomija/vesti/>).

U današnjem svijetu koji se brzo menja, inovacije i obrazovanje igraju ključnu ulogu u prilagođavanju globalnim promenama. Postavlja se i pitanje o etičkim i pravnim aspektima primjene vještačke inteligencije, važno je da regulatorni okviri uspostave adekvatan balans između zaštite građana i omogućavanja inovacija. Iako razvoj vještačke inteligencije donosi brojne prednosti, on takođe nosi i izazove za pojedince i društvo u cjelini. Neophodno je da tehnološki napredak prati odgovorno i promišljeno rešavanje izazova koji nastaju. Ključni zahtjevi uključuju: ljudsko djelovanje i nadzor, tehničku robusnost i sigurnost, privatnost i upravljanje podacima, transparentnost, raznolikost, nediskriminaciju i pravednost, dobrobit za društvo i životnu sredinu, te odgovornost (Budić,2023).

3. ZAKLJUČAK

Digitalizacija predstavlja neizbežan proces koji postavlja nove izazove kako na nivou preduzeća tako i na nivou nacionalnih ekonomija. Organizacije se danas u svijetu promjena suočavaju sa teškoćama u integraciji naslijeđenih tehnologija sa novim digitalnim rješenjima, što zahtijeva značajne resurse u pogledu radne snage i budžeta. Iskustva zemalja sa većim stepenom digitalne spremnosti pokazuju da digitalizacija može produbiti nejednakosti u prihodima, posebno pogađajući radnike sa nižim prihodima i niskim vještinama. Institucionalna prilagodljivost je ključna za uspješan društveni i ekonomski razvoj. Potrebno je uspostaviti čvrste i fleksibilne institucije koje će podržati razvoj znanja i inovacija. Intelektualna svojina i nematerijalna imovina firme postaju ključni faktori za konkurentnost u globalnoj ekonomiji. Društva koja ne ulažu u znanje i inovacije rizikuju da produbljaju krize. Vještačka inteligencija (AI) stvara mogućnosti za unapređenje poslovnih procesa, donošenje odluka i povećanje produktivnosti. Primena iste u poslovanju može smanjiti troškove, ubrzati procese i povećati efikasnost, dok u finansijskom sektoru pomaže u predviđanju ekonomskih pokazatelja i optimizaciji investicionih strategija. Konačno, svijetu promjena, inovacije i obrazovanje su ključni za prilagođavanje globalnim procesima. Ulaganja u digitalne tehnologije, posebno u softvere za upravljanje poslovnim operacijama, odražavaju rastuće prepoznavanje njihovog potencijala za unapređenje različitih sektora. Budućnost pripada razvoju zasnovanom na znanju i inovacijama, a uspjeh će zavisiti od sposobnosti društava da efikasno integrišu ove promjene u svoje ekonomske i socijalne strukture.

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IMPACT OF DIGITALIZATION AND INNOVATIONS TO BUSINESS OPERATIONS

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ABSTRACT:

Technological progress, such as digitalization, artificial intelligence and automatization, transforms traditional manner in which we do business in modern market conditions. In modern world, which changes rapidly, innovation and education play key roles in adjustment to global changes. Innovations, in particular technological ones, change the way we learn and primarily the manner which we apply knowledge in business. Digitalplatforms, AI, VR and AR technologies open up new approaches to support business, access to knowledge and resources all over the world. Topic of research in this paper is impact of digitalization and different types of innovations to business operations. The aim of this paper is to examine positive and negative effects through the prism of impact by which new economic opportunities are opening, but also negative effects wheredigitalization may lead to loss of jobs and inequality in society, in particular regarding the workers with lower qualifications and levels of education.

Keywords: technological progress, digitalization, artificial intelligence, innovation

***LEGAL AND POLITICAL SCIENCES, SOCIOLOGY,
PSYCHOLOGY,***

POSTUPAK PRISILNOG ZADRŽAVANJA DUŠEVNO BOLESNIH OSOBA, U VANPARNIČNOM POSTUPKU

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SAŽETAK:

Zakon o vanparničnom postupku Federacije Bosne i Hercegovine („Službene novine Federacije Bosne i Hercegovine“, broj: 2/98, 39/04, 73/05, 80/14 – dr. zakon i 11/21; u daljnjem tekstu: ZOV) propisuje postupak zadržavanja duševno bolesne osobe u bolnici, bez njene saglasnosti, dakle prinudno. Ovaj sudski postupak zahtijeva učešće i centra za socijalni rad te liječnika neuropsihijatra, u svojstvu vještaka medicinske struke, kao i predstavnika iz reda advokata kojeg sud imenuje na stranu osobe koja se zadržava. Ovi postupci su hitne prirode jer, prije svega, radi se ograničavanju slobode zadržane osobe, a, zapravo, ne radi se o sankciji u krivičnom postupku koja to određuje pravosnažnom sudskom odlukom. Ovim radom će se dati analiza navedenoga postupka, preciznije, važnost hitnosti postupka i učešća navedenih aktera koji sudjeluju u tome postupku. Osim toga, a u vezi s predmetnim kontekstom, ukazat će se i na prava koja proizlaze iz Evropske konvencije o osnovnim ljudskim pravima i slobodama, a koja su, prema Ustavu Bosne i Hercegovine, imperativ.

Ključne riječi: *zadržavanje, hitnost, neuropsihijatar, ljudska prava, centar za socijalni rad*

PROCEDURE OF FORCED DETENTION OF MENTALLY ILL PERSONS IN NON-LITIGATIVE PROCEDURE

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ABSTRACT:

Law on non-litigation procedure of the Federation of Bosnia and Herzegovina ("Official Gazette of the Federation of Bosnia and Herzegovina", number: 2/98, 39/04, 73/05, 80/14 -other law and 11/21; hereinafter: ZOV) prescribes the procedure of detaining a mentally ill person in a hospital, without his/her consent, i.e. forcibly. This court procedure requires the participation of the Center for social work and a neuropsychiatrist, in the capacity of a medical expert, as well as a representative from the ranks of lawyers appointed by the court on the side of the detained person. These procedures are of an urgent nature because, first of all, it is about restricting the freedom of the detained person, and, in fact, it is not about a sanction in criminal proceedings, which is determined by a final court decision. This paper will provide an analysis of the mentioned procedure, more precisely, the importance of the urgency of the procedure and the participation of the mentioned actors participating in that procedure. In addition, and in relation to the context in question, the rights arising from the European Convention on Fundamental Human Rights and Freedoms, which, according to the Constitution of Bosnia and Herzegovina, are imperative will be pointed out.

Keywords: *detention, urgency, neuropsychiatrist, human rights, center for social work*

1. UVOD

Tema ovoga rada je analiza sudskoga postupka zadržavanje duševno bolesne osobe u zdravstvenoj ustanovi, bez njezine saglasnosti, što se propisuje Zakonom o vanparničnom postupku¹ (u daljnjem tekstu: ZOV), odnosno zadržavanje osobe u zdravstvenoj ustanovi bez njezine saglasnosti, dakle, protiv njezine volje. Na ovaj način se zadržanu osobu, zapravo, lišava slobode. U predmetnom tekstu se analizira i važnost hitnosti postupka, kao i koordinacija svih učesnika u postupku sa sudom. Osim toga, akcentira se i važnost vođenja određenih evidencija koje inicijalno mogu predstavljati određene pripreme nadležnih institucija, u smislu preveniranja postupanja određenih lica te, samim time, i

¹ „Službene novine Federacije Bosne i Hercegovine“, broj: 2/98, 39/04, 73/05, 80/14 – dr. zakon i 11/21.

posljedica koje bi, eventualno, mogle nastupiti. Dakle, lica koja su već bila zadržavana u predmetnom kontekstu. Nadalje, ukazuje se na neophodnost učešća u postupku nadležnog centra za socijalni rad, vještaka liječnika neuropsihijatra, a i angažiranje advokata koji će zastupati interese osobe za koju je predloženo zadržavanje u zdravstvenoj ustanovi.

2. PRISILNO ZADRŽAVANJE DUŠEVNO BOLESNE OSOBE U ZDRAVSTVENOJ USTANOVI

Odredbama člana 45. ZOV-a propisan je postupak ograničenje slobode kretanja i kontaktiranja s vanjskim svijetom uslijed zadržavanja osobe u zdravstvenoj ustanovi ako se utvrdi da postoje razlozi koji opravdavaju zadržavanje takve osobe. Po prirodi brzine postupka, ovaj postupak je hitne prirode i u njemu se odlučuje u roku od sedam dana od dana prijema zahtjeva za sprovođenje.¹ Postupak prisilnog zadržavanja pokreće zdravstvena ustanova u roku od 24 sata od momenta prijema lica koje je zadržano a nije dalo saglasnost.² Odredbom člana 4. Zakona o zaštiti osoba s duševnim smetnjama³ propisano je da se samo zakonom mogu ograničiti slobode i prava osobe s duševnim smetnjama. Ovo iz razloga ako je to nužno radi zaštite zdravlja ili sigurnosti te osobe ili drugih osoba. Dakle, u ovome kontekstu se i ograničenje propisuje za dobrobit ne samo te osobe nego i drugih osoba.

Evropskom konvencijom o ljudskim pravima i osnovnim slobodama propisano je i pravo na slobodu (član 5). Naime, u predmetnoj situaciji zapravo se radi o ograničenju slobode kretanja i kontaktiranja s vanjskim svijetom, a koje se provodi u civilnom dijelu sudskoga postupka. Dakle, odlukom suda ograničavaju se navedena prava zadržanoj osobi. U postupku odlučivanja cijene se okolnosti uslova za zadržavanje, ali pomoću činjenica kojima sud ne raspolaže. Odredbama člana 147. Zakon o parničnom postupku Federacije Bosne i Hercegovine⁴ (u daljnjem tekstu: ZPP) propisano je da, ako sud ne raspolaže stručnim znanjem, u toj situaciji angažira vještaka odgovarajuće struke. U predmetnim situacijama imenuje se vještak medicinske struke neuropsihijatar koji, nakon što provede naloženo vještačenje, izražava mišljenje u nalazu, a u vezi sa zadržavanjem jedne takve osobe, i to sve u skladu s pravilima nauke i struke. Postupak imenovanja vještačenja po vještaku neuropsihijatru, supsidijarno primjenjuje ZPP. Ovo zbog toga što je odredbom člana 2. ZOV-a propisano da se u vanparničnom postupku shodno primjenjuju odredbe parničnoga postupka. U tom smislu, dakle, u pogledu vještačenja kao dokaznoga sredstva, primjenjuju se odredbe ZPP-a.

Odredbom člana 46. ZOV-a propisano je da zdravstvena ustanova može primiti na liječenje duševno bolesnu osobu, uz njenu saglasnost, ako je prema prirodi bolesti u stanju da dâ takvu suglasnost. Saglasnost iz stava 1. člana 46. ZOV-a daje se u pisanom obliku pred ovlaštenim organom zdravstvene ustanove, uz prisustvo dviju punoljetnih osoba koje su poslovno sposobne i pismene, a nisu zaposlene u toj zdravstvenoj ustanovi i nisu krvni srodnici primljene osobe u pravoj liniji, u pobočnoj liniji zaključno s četvrtim stepenom,

¹ Član 45. ZOV-a.

² Detaljnije: Nedeljko Miljević et al., „Modul 8 građanska oblast – vanparnični postupak“, Visoko sudsko i tužilačko vijeće Bosne i Hercegovine, Javna ustanova Centar za edukaciju sudija i tužilaca u Federaciji Bosne i Hercegovine, Sarajevo, januar/siječanj 2006. godine, str. 39–40.

³ „Službene novine Federacije Bosne i Hercegovine“, broj: 37/01, 40/02, 52/11 i 14/13.

⁴ „Službene novine Federacije Bosne i Hercegovine“, broj 53/03, 73/05, 19/06, 98/15.

po tabzini do drugog stepena, niti je neko od njih njezin bračni partner, kao ni osoba koja ju je dovela u zdravstvenu ustanovu.¹ Ako je osobi iz stava 1. člana 46. ZOV-a ograničena sloboda kretanja ili kontaktiranja s vanjskim svijetom, zdravstvena ustanova je dužna u roku od 24 sata o tome obavijestiti sud podnošenjem pisane obavijesti na način propisan članom 47. ZOV-a. Mogućnost pristupa zadržavanju određenih srodnika s osobom koju bi trebalo smjestiti u zdravstvenu ustanovu na liječenje, govori u prilog činjenici koliko je navedeni postupak podložan detaljnom preispitivanju. Naime, moglo bi se zaključiti da se na taj način isključuje bilo kakva eventualna pristranost na osnovu bližega krvnog srodstva, kao i što objektivniji pristup datoj situaciji.

Zdravstvena ustanova koja primi na liječenje duševno bolesnu osobu bez njene saglasnosti ili bez odluke suda, ima obavezu imperativnog karaktera da o tome u roku do 24 sata obavijesti sud na čijem području se nalazi ta ustanova. Obavijest iz stava 1. člana 47. ZOV-a sadrži obavezno podatke o osobi koja je zadržana, kao i o osobi koja ju je dovela u zdravstvenu ustanovu te, ako je to moguće, podatke o prirodi i stepenu bolesti, s raspoloživom medicinskom dokumentacijom.²

Nakon što primi obavijest o zadržavanju duševno bolesne osobe, sud donosi rješenje o pokretanju postupka po službenoj dužnosti i, ako to već nije uradila zadržana osoba, sud zadržanoj sobi, radi zaštite njenih prava, postavlja punomoćnika iz reda advokata.³ Osim toga, u postupak se uključuje i nadležni centar za socijalni rad⁴, kao i vještak neuropsihijatar⁵. Kako je to navedeno, u postupku se obavezno obavještava nadležni centar za socijalni rad, koji ima važnu ulogu u tim postupcima. Naime, ono što je bitno spomenuti jeste praćenje tih situacija kako bi se definirala analiza broja takvih slučajeva, identificirali identiteti tih osoba i poduzele odgovarajuće mjere radi prevencije. Sistemski, kroz praćenje eventualnih ponavljanja takvih situacija, moguće je definirati instrumente za poduzimanje koraka radi sprečavanja negativnog djelovanja takvih incidenata na društvenu zajednicu. Osim toga, na taj način postoji mogućnost da se pronađe i način kako bi se tim osobama pružila daljnja stručna pomoć radi očuvanja njihova zdravstvenog stanja. Zakon propisuje da se zadržana osoba može pustiti i prije isteka vremena koje je određeno za zadržavanje u zdravstvenoj ustanovi ako se utvrdi da je zdravstveno stanje zadržane osobe poboljšano u tolikoj mjeri da su prestali razlozi za daljnje zadržavanje, a postupak je identičan postupku radi zadržavanja osobe.⁶ Dakle, kao što je navedeno, postupak zadržavanja je hitne prirode a može se na određeni način dovesti u vezu s lišenjem slobode, kako je to propisano odredbama Krivičnog zakon Federacije Bosne i

¹ Detaljnije: Nasljedni redovi, Zakon o nasljeđivanju, „Službene novine Federacije Bosne i Hercegovine“, broj: 80/14, 32/19, Odluka US.

² Član 47. ZOV-a.

³ Član 30. Zakona o zaštiti osoba s duševnim smetnjama.

⁴ Prema članu 27. Zakona o zaštiti osoba s duševnim smetnjama, nadležnost centra za socijalni rad određuje se prema posljednjem prebivalištu ili boravištu zadržane osobe, a ako je to nepoznato, onda prema području gdje se nalazi zdravstvena ustanova.

⁵ Član 31. Zakona o zaštiti osoba s duševnim smetnjama. U skladu s odredom člana 32. toga zakona, o zadržavanju ili puštanju zadržane osobe odlučuje se rješenjem u roku od tri dana od završetka postupka. U postupku po eventualno podnesenoj žalbi na to rješenje, drugostepeni sud odlučuje u roku od tri dana od dana prijema žalbe kako je propisano u članu 37. toga zakona. Prema vremenu odlučivanja, također se može utvrditi hitnosti postupka.

⁶ Član 56. ZOV-a.

Hercegovine¹, samo što u ovoj situaciji nije utvrđeno postojanje uslova za pritvor ili utvrđenje krivičnoga djela i odgovornosti koje je sankcionirano krivičnom sankcijom lišenje slobode. Zadržana osoba se na ovaj način, ipak, lišava slobode, s lokacijom u zdravstvenoj ustanovi. Zadržana osoba je pod liječničkim nadzorom, sve radi njena ozdravljenja ili, eventualno, određivanja odgovarajuće terapije. Stoga ovi postupci ne iziskuju samo hitno postupanje nego i uključivanje centra za socijalni rad i vještaka neuropsihijatra, sve kako bi se mogla donijeti adekvatna odluka, a radi dobrobiti zdravstvenog stanja zadržane osobe.

3. ZAKLJUČAK

Shodno sadržaju predmetnoga teksta, ukazalo se na činjenicu postojanja ograničavanja slobode kretanja i kontakta s vanjskim svijetom i u građanskom sudskom postupku. Pravo na slobodu garantirano je i Evropskom konvencijom o ljudskim pravima i osnovnim slobodama, ali odluka suda ograničava to pravo zadržanoj osobi. Naime, radi se, zapravo, o zadržavanju u zdravstvenoj ustanovi osobe kojoj je tome doprinijelo njezino određeno psihičko zdravstveno stanje. Ovo prije svega znači da se radi o prisilnom zadržavanju, nezavisno od dobrovoljnog pristanka.

Ovaj zakonom propisan način ima najmanje dvostruku važnost. Naime, s jedne strane pomaže zadržanoj osobi u postupku liječenja i na taj način sprečava eventualne negativne posljedice za sebe i društvenu zajednicu, a koje bi svojim postupkom, izazvanim tim stanjem, mogla prouzročiti. Nadalje, osim spomenute važnosti, akcentat je i na važnosti vođenje evidencija zadržanih osoba, a s ciljem preveniranja eventualnih daljnjih posljedica, a koje vode nadležne ustanove, kao što su centri za socijalni rad i zdravstvene ustanove gdje se smještaju pacijenti – duševno bolesne osobe. Na taj način se stvaraju uslovi za preveniranje ponavljanja takvih postupaka. U postupku je neophodno učešće spomenutih aktera, a nalaz vještaka neuropsihijatra je vodilja za daljnji postupak. Primjenjujući odredbe ZPP-a, vještačenje u tom kontekstu je neophodno, jer sud ne raspolaže stručnim znanjem iz date oblasti, pa se i na taj način postupa u skladu s odredbama propisanim zakonom. Dakle, na ovaj način, zapravo, civilni dio sudskoga postupka omogućava zadržavanje osobe protiv njene volje u bolnici, ali nakon provedenoga sudskog proceduralnoga postupka, s inputom nalaza vještaka koji utvrđuje neophodnost te aktivnosti.

Prema tome, osim primjenom Krivičnog zakona i civilni dio sudskoga postupka odlučuje o ograničavanju slobode kretanja i kontaktiranja s vanjskim svijetom, dakle, bez pravosnažno utvrđene te vrste krivičnopravne sankcije prema određenoj osobi.

4. LITERATURA

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¹ „Službene novine Federacije Bosne i Hercegovine“, broj: 36/03, 21/04 – ispravka, 69/04, 18/05, 42/10, 42/11, 59/14, 76/14, 46/16, 75/17 i 31/23.

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ANALYSIS OF PROJECTILE EFFECTS ON DIFFERENT TYPES OF MATERIALS

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ABSTRACT: *This paper presents an analysis of the use of optical methods (recording with a high-speed camera and a thermal imaging camera) for analyzing the impact of projectiles on obstacles of different materials and structures. Through a comparative approach, optical methods showed the possibility of application and gave an assessment of their reliability for such tests. The analysis of the data obtained from the video with a high-speed camera and a thermal imaging camera gave results predominantly in the form of modification of the material that the projectile hit. The analysis of the final state of the target after the impact of the projectile has an exceptional military application because the obtained results speak of the effectiveness of protection using different materials. Three types of materials were observed in the research: granular materials, polymer materials (a typical example is Kevlar) and armor steel. The modification of the material is measurable in the final state (permanent change in the material after the impact) but also during the relaxation immediately after the impact of the projectile. Two analyzes are possible: comparison of the state before and finally after the impact of the missile, development of material relaxation dynamics.*

Keywords: *optical methods, high-speed camera, thermal imaging camera, granular materials*

1. INTRODUCTION

The presented research aims to demonstrate how optical methods, specifically through the analysis of images captured by high-speed and thermal cameras, facilitate the examination of the interaction between a rigid body and various types of obstacles [1,2]. The test methodology illustrates how the structural composition of obstacles made of different materials influences the processes of energy transfer and the displacement of matter during the collision of high-speed projectiles with these obstacles, with the objective of optimizing the design of structures and materials for obstacle construction, particularly in the context of ballistic protection [3,4,5]. In the realm of protective clothing production, ceramic materials have surpassed metallic ones, albeit necessitating their use in conjunction with ballistic fiber composites. Currently, a variety of materials are employed for ballistic protection, either independently or in combination [6]. These typically include armored steels, ceramic layers, composite materials, and structures incorporating granular materials. The investigation will focus on the individual interaction of projectiles with each of these material types, as well as the combination of different material layers. Ceramic composite materials utilize a ceramic substrate with favorable temperature resistance characteristics, high strength, and low weight. Given the fragility of ceramic materials, high elasticity and strength fibers are incorporated to mitigate crack propagation and reinforce the ceramic substrate. Ceramic composite materials find extensive usage in aviation and other military sectors [6].

In addition to the aforementioned protective materials, this paper will explore the behavior of granular matter as a protective material. The utilization of granular materials holds promise for reducing the weight of protective vests, enhancing the mobility of individuals wearing such vests, diminishing the pressure exerted on the wearer's body, and increasing the cost-effectiveness of manufacturing vests for soldier protection [6].

2. MATERIALS AND METHODS

Optical methods are modern and practically applicable techniques for determining relevant research outcomes without influencing physical processes, thereby enabling their analysis [7,8,9]. The author's aim is to illustrate the application of these methods and the resultant findings, while also providing a comparative explanation of their utilization in the realm of optics for detecting and determining influential parameters during the interaction of projectiles with obstacles of varying characteristics.

2.1. Granular matters

Granular matter comprises a collection of macroscopic particles ranging from approximately 1 μ m and larger (with practically no upper limit on size). Essentially, granular matter represents a solid body with its own degrees of freedom, composed of macroscopic particles. It is noteworthy that each macroscopic particle possesses its own local degrees of freedom. Collisions between these particles result in the transfer of energy from the solid body (the aggregation of macroscopic particles) to individual particles.

Consequently, there is energy dissipation, which can lead to the cessation of movement of macroscopic particles within the granular material. Granular materials have significant military applications. One such example is the employment of protective glass in military vehicles. These glasses are specialized transparent ceramic materials that behave similarly to granular materials upon impact by a bullet, dispersing pressure in all directions from the point of impact [3,4].



Fig. 1. Granular material

2.1. Optical methods

Traditionally, methods employed to measure the projectile's effect on the target have been complex and necessitate specific conditions, with the analysis process itself being time-consuming [7,8,9]. Commonly utilized techniques include Phase-Evaluation Methods, Holographic Interferometry, Speckle Metrology, and Photoelasticity, all of which have yielded satisfactory results. The author's intention was to streamline engineering procedures and confine the time required solely to the recording of pertinent events.

2.2. Photo processing

The impact of the projectile on the obstacle was captured using a camera, yielding a series of digital photographs in burst mode, taken at equally spaced time intervals [10,11,12,13]. Similarly, video recording can be conducted, resulting in a sequence of temporally equidistant digital photographs [14,15,16]. In both scenarios, the analytics implemented by the developed software function uniformly. For each moment captured in the series of shots, there is a discernible distribution of granules in the space pre-penetration, during penetration, and predominantly post-bullet penetration during the relaxation process of the granulate sample within the container. The input parameters include geometric, ambient, granular material, shot, and projectile parameters. The developed code initially analyzes the number and distribution of granulate grains within the field of view. In each frame before projectile penetration, a consistent distribution of granulate grains with minimal

fluctuation is observed [17,18]. Upon impact of the projectile and penetration through the granular material, significant changes occur in the spatial distribution of the granulate grains, allowing for the analysis of relaxation processes (granulation dynamics records, flight patterns, spatial arrangement of granulate grains, etc.) and surface morphology changes (measurement of surface alteration and bullet penetration depth - depth of pattern change) of the granular material over time. These measurements enable the analysis of bullet penetration depth and impact area caused by projectile impact across different granular material samples under varying bullet firing conditions. The developed application utilizes C++ language with the OpenCV development library. Within the developed code, access to each individual grain is provided, enabling determination of its position over time. Initial results of the code indicate that it processes a series of photos or recordings made by a camera almost in real-time. At this developmental stage, individual grains are identified, facilitating analysis of their movement dynamics in space and time (determining initial and final positions after relaxation). Complications in measurement (analysis of the real spatial X, Y, Z distribution of grain groups over time or time-dependent surface modification of the granular material sample in the container - both cases involve measurements in meters, departing from the realm of projections) would lengthen the time required for result analysis.

2.3. Experimental results

Following the experimental recording captured by a high-speed and thermal imaging camera, the recorded frames of the target were analyzed. The target consisted of two three-layer boards. The first target comprised three layers of granular matter with varying granulations, while the second target contained construction cement serving as a binding matrix. Data regarding the panels made of granular materials are presented in Table 1:

Table 1. Data on plates made of granular materials

Plates	Dimensions [mm]	Dimensions layers [mm]	Layer volume [mm ³]	Volume of binding material [mm ³]
1	267x290x21	267x290x7	542010	2,7x10 ⁵ water
2				2,1x10 ⁵ water, 4,7x10 ⁵ construction cement

The experiment utilized the FLIR SC620 24° Package thermal imaging camera and the Phantom v9.1 ultra-fast camera. The FLIR SC620 24° Package is a high-performance infrared system designed for scientific and research applications within the longwave spectral range. Featuring a 640x480 resolution, it delivers sharp images with precise radiometric readings. Equipped with a standard 24° lens, the camera boasts a sensitivity of 65 mK, streaming real-time radiometric data to the computer via Firewire. It also features a large 5.6-inch high-resolution LCD screen, 1-2x continuous zoom, and a built-in 3.2-megapixel digital camera with a target illuminator. The camera operates within a standard temperature range of -40 °C to 500 °C [20].

The Phantom v9.1, paired with the FLIR SC620 24° Package, utilizes its CMOS sensor to offer 1,000 frames per second at a resolution of 1,632x1,200 active pixels, with 14-bit precision. This camera includes a significantly larger DRAM image memory for multiple movie shooting and continuous data streaming of 8-bit or 12-bit images [21].

During filming, impacts on targets were observed using the automatic rifle "ZASTAVA" M70, firing 7.62x39 mm projectiles at a speed of approximately 720 m/s. In this specific case, the projectile consisted of a grain with a diameter of 10.07 mm and a mass of 7.9 g [19].

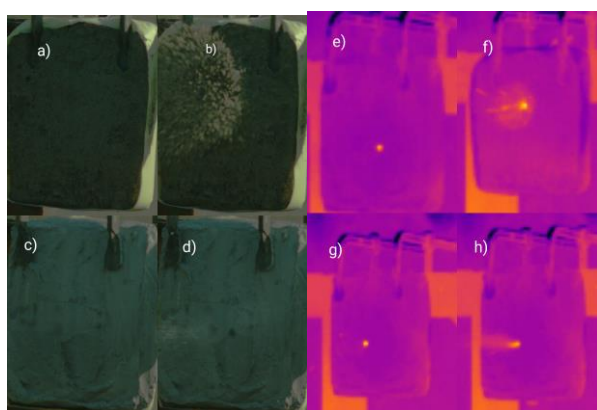


Fig. 2. Target shooting a) immediately before shooting the first target b) after shooting the first target c) immediately before shooting the second target d) after shooting the second target e) temperature profile before shooting the first target f) temperature profile after shooting the first target g) temperature profile before shooting at another target h) temperature profile after shooting at another target

For the execution of the experiment, the targets were positioned at a distance of 30 m, adhering to the standards for testing Kevlar protective plates. Considering the grain's mass of 7.9 g and the speed of the black projectile at 720 m/s, the kinetic energy of 20478J is calculated (as per expression 1), indicating a very high kinetic energy.

On the basis of the acquired recordings, it was observed that the dissipation of kinetic energy (E_k) is higher in targets made of granular materials without binding material compared to targets with a binding material such as construction sand. Additionally, the temperature recorded when the grain impacts the first target is lower than that observed when it impacts the second target.

Figure 2 depicts shots fired at the targets. In Figure 2, (a) displays the target hatch immediately before and after the shot, while (b) provides a comparison. Comparing shooting at target number 2, (c) and (d), with the first target, it is evident that greater

energy dissipation occurs in the case of the first target, suggesting that target 1 (granular matter) may be better suited for use as protective equipment due to its characteristics. Analyzing the temperature profile in Figure 2, (e) and (g) show similar openings when the grain enters the first and second targets, but differing temperature profiles. The second target (granular material and construction cement) exhibits higher temperatures concentrated over a smaller surface area. Based on the above observations, it can be concluded that the first target (granular material without binders) possesses superior characteristics for use as protective equipment.

3. CONCLUSION

The obtained results were compared with those acquired through other methods to evaluate and highlight the advantages of employing optical methods for determining action parameters during dynamic interactions between projectile bodies and various obstacles. The findings underscore the benefits of optical methods in delineating interaction parameters between projectiles and obstacles constructed from different materials. The results contribute new insights from the realm of physics, primarily reliant on optical principles, with significant practical implications for military applications. Utilizing the registered parameters would enhance analytical and numerical calculation methods for understanding material interaction effects in complex dynamic processes.

The rationale for this research is evident in the clear necessity to enable the application of more reliable models for determining dynamic interaction parameters of projectiles with different materials, aligning with the advancement of modern optical and computer technologies. Current methods rely on semi-empirical models and numerical calculations with predefined material dynamic characteristics. In addition to defining modern methodologies for examining characteristic parameters, this research facilitates the detection of crucial parameters in the development, optimization, and construction phases of contemporary ballistic protection systems.

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KRŠENJE MEĐUNARODNIH SPORAZUMA U ORUŽANIM SUKOBIMA

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SAŽETAK:

U radu se analizira primjena međunarodnih sporazuma na oružane sukobe, tačnije da li uopšte dolazi do primjene najvažnijih međunarodnih sporazuma o pravilima ratovanja kada oružani sukob počne.

Analiziraju se najvažnije norme međunarodnih sporazuma i da li su zapravo ikada ispoštovane kada sukobi uzmu maha. Dalje, razmatraju se stavovi vodećih svetskih država o međunarodnim sporazumima i njihovo izbjegavanje potpisivanju i ratifikaciji istih. Postavlja se pitanje koji interesi su vodeći, zaštita života civila ili ekonomski prosperitet svetskih giganata.

U radu se želi prikazati kako je poštovanje međunarodnih sporazuma osnov vladavine prava i poštovanja osnovnih ljudskih prava. Takođe, biće riječi o samim ljudskim pravima koja su direktno ugrožena prilikom ratnih previranja i kako je zapravo civilno stanovništvo ono koje plaća najviši danak ovakvih sukoba. Autor analizira opravdanost derogacije ljudskih prava za vrijeme rata, ako imamo u vidu da je poštovanje ljudskih prava za vrijeme oružanih sukoba zapravo osnov poštovanja osnovnih ljudskih prava i međunarodnog humanitarnog prava.

Ključne riječi: međunarodni sporazumi, oružani sukobi, civili, vodeće države, ljudska prava

1. UVOD

Međunarodni sporazumi koji regulišu pravila ratovanja su osnov Međunarodnog humanitarnog prava kao grane prava koja ne zalazi u sam razlog oružanih sukoba između država, već nastoji da države između kojih se vode oružani sukobu poštuju važeće međunarodne sporazume.

Kršenje međunarodnog humanitarnog prava, odnosno međunarodnih sporazuma o pravilima ratovanja dovodi do direktnog kršenja ljudskih prava. Ovdje jasno vidimo povezanost ljudskih prava sa međunarodnim pravom uopšte a posebno sa humanitarnim pravom, kada su prava civila najugroženija i najosjetljivija. Zaštita ljudskih prava u vrijeme oružanih sukoba je možda i najveći zadatak međunarodnog humanitarnog prava i poštovanja brojnih međunarodnih sporazuma.

Norme međunarodnog prava, međunarodnih običaja i sporazuma ne smiju se tretirati kao puko slovo na papiru, napisano da se ispoštuju međunarodni standardi kojima teže

velesile, već ih trebamo posmatrati kao norme koje u slučaju kršenja istih povlače sankciju, nezavisno o veličine sile koja napada snosiće odgovornost.

Ako posmatramo pravila ratovanja vijekovima unazad, shvatićemo da su i najstarijim vremenima postojala neka tzv. viteška pravila kojih su se zaraćene strane pridržavale. Međutim, i tada a i sada postoji veliki broj slučajeva kršenja tih pravila, što dovodi do najgrubljeg kršenja ljudskih prava.

Najveći pomak na polju zaštite i poštovanja pravila ratovanja i međunarodnog ratnog prava su ženevske konvencije, protokoli i međunarodni običaji, koji predstavljaju kamen temeljac u borbi protiv svake vrste nečasnih oblika ratovanja, kojih sve strane u sukobu moraju da se pridržavaju za vrijeme trajanja oružanog sukoba.

Obaveza države da obezbijede poštovanje međunarodnog humanitarnog prava je njihova glavna obaveza u međunarodnim odnosima, jer ne možemo porediti pronalaženje rješenja za sporna pitanja u vrijeme mira i u vrijeme ratnih previranja, kada je volja i sposobnost država da ispoštuje najvažnije sporazume zapravo osnovni element njene sposobnosti poštovanja ljudskih prava.

2. MEĐUNARODNI SPORAZUMI U ORUŽANIM SUKOBIMA

Međunarodni sporazumi u oružanim sukobima predstavljaju obavezujuća pravila koja naglašavaju važnost očuvanja humanosti čak i u vrijeme neprijateljstva i ratnih sukoba, pozivajući na suzdržavanje od svakog oblika nehumanog, zločinačkog i okrutnog postupanja. Oružani sukob je sukob između dvije strane, konstruiran od strane političkih lidera, u kojem najveće žrtve trpi civilno stanovništvo. "Primjena međunarodnih sporazuma tokom oružanih sukoba je kompleksna tema koja uključuje različite aspekte međunarodnog prava i odnosa. Međunarodni zakoni i sporazumi, poput Ženevskih konvencija, često se primjenjuju u različitim vrstama međunarodnih oružanih sukoba, uključujući državne sukobe, operacije Ujedinjenih nacija, pokrete nacionalnog oslobođenja, pa čak i u situacijama sajber napada, zavisno od praga koji postavlja međunarodno pravo"¹.

Najveći pomak u istoriji međunarodnih sporazuma u oblasti postojanja i poštovanja pravila ratovanja su ženevske konvencije i protokoli uz njih. Ženevsko pravo naziva se vrlo često i humanitarno pravo jer je osnovni cilj ovih konvencija humanizacija rata koliko je to moguće odnosno ublažavanje nečovječnog postupanja i nepotrebnih patnji. Ženevske konvencije posebno štite ranjenike, bolesnike, civilno stanovništvo i decidno navode postupanje sa ovim kategorijama lica.

Ovakva postupanja za vrijeme oružanih sukoba nisu ništa drugo do međunarodna krivična djela, koja su u Haškoj konvenciji nazvana gruba kršenja Ženevskih konvencija. Kada je riječ o postupanju sa ratnim zarobljenicima pored Ženevske konvencije, treba pomenuti i Međunarodni pakt o građanskim i političkim pravima. Naime, u ovom Paktu se ističe da nijedno lice ne smije biti podvrgnuta mučenju, kao i svirepom i nehumanom postupanju. Po završetku II svjetskog rata vladalo je mišljenje da su ovakve konstatacije nepotrebne, s obzirom da se stalo na put drakonskim mjerama prema zarobljenicima. Ipak, to nije bio slučaj u praksi. Danas su uobičajena ratna dešavanja koja su propraćena nečovječnim i

¹ Clapham, A. (2015) "The Concept of International Armed Conflict", in *The 1949 Geneva Conventions: A Commentary*, Vol. 10, No. 2, 1-18.

ničim izazvanim mučenjem civila u oružanim sukobima. Ako samo uzmemo u obzir brojke stradale djece i civilnog stanovništva u oružanim sukobima poslednjih decenija, imaćemo jasnu sliku o nepoštovanju svih međunarodnih sporazuma. Može se, bez potrebe za posebnih dokazivanjem, ukazati da je broj osuđenih lica za ovakve zločine relativno mali ukoliko se uzme u obzir koliki je obim ovih ratnih strahota. Ono što je jasna slika trenutnih ratnih zbivanja je nemogućnost međunarodnih organizacija da na adekvatan način zaštite prava koja su garantovana međunarodnim sporazumima. Prethodno dovodi do stanja zabrinjavajućeg nepovjerenja građana svijeta u mogućnost zaštite elementarnih ljudskih prava.

Kao novi vid borbe protiv kršenja ljudskih prava u oružanim sukobima i nemogućnosti međunarodne zajednice da se izbori za prava koju su garantovana su svakako sankcije, kao od skora najpopularnija mjera. Kada govorimo o sankcijama koje se uvode zemljama koje targetiramo kao zemlje-agresori, trebamo imati u vidu da sankcije koje se uvode pojedinim zemljama utiču na mnogo veći broj aktera od onog kome su namjerene. Svjedoci smo urušavanja ekonomskog sistema mnogih razvijenih zemalja od početka najnovijih ratnih previranja, a uvođenje paketa sankcija je svakako doprinijelo takvom stanju svjetskog ekonomskog sistema.

Međunarodni sporazumi nisu garancije samo za zemlje učesnice već za čitav svijet, te se postavlja pitanje kako napraviti balans sa što manjom štetom po ljudski integritet u svijetu. Jedan od sporazuma čiji je dogovor očigledno prekršen je Budimpeštanski memorandum, u kojem je Ukrajina, uslovno rečeno, izigrana od strane zapadnih razvijenih zemalja. Dobijene su garancije, a rezultat tih garancija možemo uočiti u poslednjim ratnim dešavanjima u Ukrajini. Prethodno navodi na zaključak da Zapadne sile u isuviše velikoj mjeri štite svoje interese na uštrb drugih, što posledično dovodi do toga da manje razvijene zemlje postaju žrtve političkih igranki od onih koji su garantovali dogovor i adekvatnu pomoć, te vidimo da se takve garancije ne ostvaruju.

Postaje jasno da međunarodni sporazumi imaju uticaja na zemlje koje ne predstavljaju opasnost u smislu nuklearnog naoružanja i vojne sile, dok na svjetske velesile njihov uticaj je neznatan. Međunarodni sporazumi u samom korijenu svoje riječi predstavljaju međunarodni dogovor kojeg će se države pridržavati, a svako kršenje istog povlačiće sankciju.

Kada je riječ o krivičnoj sankciji, uviđamo da ne vlada princip jednakosti, već princip povlašćenih i potčinjenih. Ova konstatacija se ogleda u samoj nadležnosti Međunarodnog krivičnog suda kada je riječ o agresiji, s obzirom da je Savjet bezbjednosti taj koji je nadležan da utvrdi postojanje agresije u konkretnom slučaju. Ovdje imamo slučaj direktnog upliva nesudskog organa u nadležnost i nezavisnog Suda.¹ Ovakvo rješenje je političko a ne pravno. Ono izražava namjeru država sa velikim kapacitetom vojne i faktičke moći, da zadrže slobodu djelovanja u odnosu na temeljnu normu pozitivnog međunarodnog prava – normu o zabrani upotrebe sile protiv političke nezavisnosti i teritorijalnog integriteta država.

Osim toga, "postoji opšti princip zasnovan na člancima Komisije UN za međunarodno pravo o posljedicama oružanih sukoba za međunarodne sporazume koji ističe da samo postojanje oružanog sukoba po sebi ne dovodi do prekida ili suspenzije sporazuma između

¹ Kreča, M. (2014), *Međunarodno javno pravo*, Beograd, 667.

država učesnica u sukobu ili između države učesnice u sukobu i države koja nije učesnik. Ovo pravilo ima za cilj promovisanje stabilnosti međunarodnih odnosa¹.

Da bi se moglo govoriti o postojanju međunarodnog krivičnog djela² potrebno je da je radnja izvršenja preduzeta u odnosu na zaštićeno dobro pod sljedećim uslovima:³

1) da postoji oružani sukob – situacija kada se pribjeglo oružanoj sili između država ili kada postoji produženo oružano nasilje između vlasti i organizovanih naoružanih grupa ili pak između takvih grupa unutar jedne države;

2) da postoji veza između krivičnog djela i oružanog sukoba – dovoljno je da su krivična djela bila tijesno povezana sa neprijateljstvima koja su se događala na djelovima teritorija koje su bile pod kontrolom strana u sukobu⁴;

3) oružani sukob mora biti međunarodnog karaktera - Takav sukob postoji u slučaju sukoba dvije ili više država ili kada jedna država interveniše svojim trupama ili na drugi način djeluje za račun jedne od strana u sukobu (kad država ima opštu kontrolu nad trupama u sukobu koje djeluju u drugoj državi) i

4) žrtve zločina moraju pripadati grupi zaštićenih lica u skladu sa odredbama Ženevskih konvencija iz 1949. godine⁵.

Primjena međunarodnih sporazuma u oružanim sukobima zahtijeva kontinuirano praćenje i reviziju kako bi se osiguralo da su pravila ratovanja usklađena s promjenjivim prirodom modernih sukoba. Sukobi danas uključuju različite aktere, od državnih vojski do neformalnih militantnih grupa, što postavlja izazove u interpretaciji i primjeni međunarodnih pravnih standarda. Pored toga, razvoj novih tehnologija, poput autonomnih oružanih sistema i sajber ratovanja, zahtijeva dodatne prilagodbe postojećim zakonima kako bi se adresirale etičke i pravne dileme koje ti sistemi nose. Stoga je esencijalno da međunarodna zajednica radi na stvaranju jasnih smjernica koje će regulisati ove aspekte sukoba, štiteći pritom prava i sigurnost civila u svim situacijama.

3. Stavovi velikih sila prema međunarodnim ratnim pravilima

Velike sile često pokazuju otpor prema ratifikaciji međunarodnih sporazuma, pri čemu se oslanjaju na svoje geopolitičke interese. Primjera radi, u istoriji Sjedinjenih Američkih Država vidljiv je trend otpora prema multilateralim ugovorima, posebno kada su percipirani kao ograničenje nacionalne suverenosti ili kada su u suprotnosti sa nacionalnim interesima. Ovaj trend je naročito bio izražen tokom 1990-ih godina kada je SAD pokazao otpor prema nizu međunarodnih sporazuma uprkos širokoj podršci tih

¹ Tienieshev, V. (2020), "The impact of armed conflict on the effects of international treaties", *Chasprava*, Vol. 1, No. 1, 78.

² J.B. Keenen (1950), *Crimes against international law*, Washington, 89-103.

³ Gagro, S. (2008), "Promjena kvalifikacije oružanog sukoba", u: *Zbornik Pravnog fakulteta u Rijeci*, Rijeka, Vol. 2, 1067–1092.

⁴ Bačić, F. (1992), "Krivičnopravni aspekti rata u Republici Hrvatskoj", *Zakonitost*, Zagreb, Vol. 5, 671–679.

⁵ Gagro, S. (2008), "Zaštita osoba u nemeđunarodnom oružanom sukobu", *Pravni vjesnik*, Vol. 2, 115–135.

ugovora od strane drugih zapadnih saveznika i većine država svijeta, ilustrujući preferenciju za unilateralizam nad multilateralizmom.

Geopolitički interesi takođe igraju značajnu ulogu u pridržavanju međunarodnih ratnih pravila. Primjer Ruske Federacije u kontekstu teritorijalnih konflikata u Gruziji, poput Abhazije i Južne Osetije, demonstrira kako geopolitički interesi velikih sila značajno utiču na poštovanje međunarodnih ratnih pravila. Takvi interesi mogu voditi do različitih tumačenja pravičnosti sporazuma, što dovodi do neslaganja i izazova u postizanju kompromisa u regionima poput Centralne i Istočne Evrope.

Osim toga, velike sile često koriste međunarodna pravila kako bi legitimizovale svoje akcije na međunarodnoj sceni, čime se stvaraju dvostruki standardi i selektivna primjena pravila. Ovakav pristup može dovesti do situacija gdje se međunarodna pravila poštuju samo kada su u skladu sa strateškim ciljevima tih sila, a ignorišaju se kada nisu.

U kontekstu ovih dinamika, važno je razumjeti kako međunarodni pravni okvir i međunarodne institucije mogu biti ojačani kako bi se osiguralo da velike sile ne koriste svoj uticaj na štetu globalne pravde i stabilnosti. Promovisanje transparentnosti, jačanje međunarodnih institucija, i osiguranje odgovornosti za kršenja međunarodnih pravila ključni su koraci ka postizanju ovih ciljeva.

Velike sile često koriste svoj uticaj kako bi oblikovale međunarodna pravila na način koji odgovara njihovim interesima, dok u isto vreme mogu pokazati otpor prema pravilima koja bi mogla ograničiti njihovu slobodu delovanja. Ovaj fenomen je posebno izražen u kontekstu međunarodnih sporazuma o oružju i oružanim sukobima.

Primjer dvostrukih standarda može se videti u pristupu nekih zapadnih zemalja prema ratifikaciji međunarodnih sporazuma koji regulišu upotrebu određenih vrsta oružja. Iako javno promovišu norme o ograničenju oružja, u praksi često nalaze načine da izbjegnu ograničenja koja bi mogla uticati na njihovu vojnu nadmoć ili strategijske interese. Na primjer, Sjedinjene Američke Države i neke evropske zemlje imale su rezervisane stavove prema nekim aspektima Ugovora o konvencionalnim oružanim snagama u Evropi (CFE), ističući potrebu za fleksibilnošću u tumačenju pravila kako bi očuvale svoje strateške interese¹.

Kritičari često navode primjere poput intervencije SAD-a u Iraku 2003. godine, koja je pokrenuta bez jasnog odobrenja Ujedinjenih nacija, kao dokaz selektivne primjene međunarodnih pravila. Ovaj slučaj ilustruje kako velike sile ponekad koriste "pravo na samoodbranu" kao opravdanje za akcije koje bi mogle biti protivne međunarodnom pravu o agresiji.

Stavovi velikih sila prema međunarodnim ratnim pravilima često su oblikovani kombinacijom geopolitičkih interesa, nacionalne sigurnosti i međunarodnih pravnih obaveza. Dvostruki standardi i selektivna primjena pravila pokazuju složenost međunarodnih odnosa i izazove u postizanju globalne pravde i sigurnosti. Ovi trendovi zahtijevaju stalnu pažnju i angažovanje međunarodne zajednice kako bi se osiguralo da međunarodno pravo ostane relevantno i efikasno u regulisanju ponašanja država na globalnoj sceni.

¹ Neff, S. (2018), „Disrupting a Delicate Balance: The Allied Blockade Policy and the Law of Maritime Neutrality during the Great War“, *Evropski časopis međunarodnog prava*, Vol. 29, No. 2, 459-486.

4. Balans između zaštite ljudskih prava i ekonomskih interesa

Velike sile se suočavaju s izazovom kako uskladiti svoje kratkoročne ekonomske i strateške interese s dugoročnim obavezama prema ljudskim pravima. Zahtjevi globalne ekonomije često dovode do situacija u kojima su ljudska prava stavljena u drugi plan, dok su ekonomski ciljevi prioritizovani. Razmatranje ovog pitanja pokazuje koliko je kompleksan odnos između ekonomske moći i moralnih obaveza koje proističu iz međunarodnih sporazuma o ljudskim pravima. Posebno je značajno analizirati kako se ekonomske sankcije, koje velike sile koriste kao političko sredstvo, odražavaju na životni standard običnih ljudi u zemljama koje su njima pogođene. Osim toga, međunarodni trgovinski sporazumi često sadrže odredbe koje bi mogle uticati na ljudska prava, ali se rijetko sprovode s potrebnom rigoroznošću. Trueman ukazuje kako zapadne sile često stave ekonomski interes ispred svojih obaveza prema ljudskim pravima¹.

Salomon² ukazuje na izazove postizanja etičkije forme ekonomske globalizacije, ističući da bogate zemlje trebaju pomoći siromašnijim državama u borbi protiv siromaštva, čime se naglašava potreba za balansom između ekonomskih interesa i ljudskih prava. Evans diskutuje kako velike sile koriste ljudska prava kao sredstvo za legitimaciju praksi koje beneficiraju globalne ekonomske aktere umjesto da zaštite ranjive skupine, naglašavajući složen odnos između ekonomskih odluka i ljudskih prava³. U kontekstu oružanih sukoba, ekonomski interesi velikih sila često igraju ključnu ulogu u oblikovanju međunarodnih odnosa i politika. Ove sile koriste svoje ekonomske moći kao alat za ostvarivanje strateških ciljeva, što može rezultirati negativnim posljedicama po ljudska prava u zonama sukoba. Na primjer, prodaja oružja i vojna pomoć često su uslovljeni političkim i ekonomskim interesima, a ne potrebama zaštite ljudskih prava ili promovisanjem mira.

Osim toga, ekonomske sankcije koje se uvode kao odgovor na kršenje međunarodnih normi mogu nehotično pogoršati humanitarne krize, pogodivši najugroženije grupe u konfliktnim zonama. Ovakve sankcije mogu onemogućiti pristup osnovnim potrebštinama i medicinskoj pomoći, čime se dodatno krše prava civilnog stanovništva koje već trpi zbog sukoba.

Pored toga, ekonomski interesi mogu uticati na odluke o vojnim intervencijama. Vlade mogu biti sklonije intervenciji u regijama koje posjeduju značajne prirodne resurse ili stratešku važnost, često koristeći retoriku zaštite ljudskih prava kao opravdanje za svoje akcije. Takve intervencije mogu imati dvostruki efekt: s jedne strane, mogu pružiti zaštitu od direktnog nasilja, ali s druge strane, mogu proizvesti dugotrajne negativne posljedice za političku stabilnost i ekonomski razvoj regiona.

Da bi se postigao pravi balans između ekonomskih interesa i zaštite ljudskih prava u oružanim sukobima, neophodno je promovisati transparentnost u međunarodnim odnosima i osigurati da se sve akcije vodeći računa o humanitarnim principima. Potrebno je i osnaživanje međunarodnih institucija koje mogu nepristrasno nadgledati i regulisati

¹ Trueman, T. (2013), 'Politics, Profits and Human Rights', *Journal of Human Rights Practice*, Vol. 5, No. 1, 1-24.

² Salomon, M. (2010), „Global Economic Policy and Human Rights: Post-Crisis Perspectives“, *International Review of Applied Economics*, Vol. 24, No. 3, 339-354.

³ Evans, T. (2000), „Citizenship and Human Rights in the Age of Globalization“, *International Sociology*, Vol. 15, No. 2, 215-230.

kako ekonomske tako i vojne aktivnosti na globalnom nivou, osiguravajući da se ljudska prava ne žrtvuju za ekonomske dobiti.

5. Derogacija ljudskih prava u ratnim uslovima

Istraživanje o međunarodnoj pravnoj zaštiti ljudskih prava u situacijama oružanog sukoba pokazuje ozbiljne povrede koje se dešavaju i zaštite koje nude međunarodno pravo ljudskih prava i međunarodno humanitarno pravo. Ove norme su ključne u pokušajima da se očuva dostojanstvo i prava pojedinaca čak i u najtežim vremenima. Konkretni primjeri iz recentnih konflikata ukazuju na to da je poštovanje i garantovanje ljudskih prava tokom oružanih sukoba postalo važan prioritet u međunarodnoj saradnji. Ovo uključuje i sukobe neinternacionalne prirode, gdje međunarodne organizacije i države nastoje da zaštite ljudska prava uprkos izazovima suvereniteta i nacionalne sigurnosti.

Uloga međunarodnih institucija u promociji i zaštiti ljudskih prava tokom oružanih sukoba je ključna, posebno u nadzoru poštovanja normi ljudskih prava od strane država u takvim situacijama. Ove institucije igraju centralnu ulogu u osiguravanju da se kršenja ljudskih prava efikasno adresiraju i sankcionišu, što je od vitalnog značaja za održavanje međunarodnih standarda pravde i humanosti.

Prethodna razmatranja pružaju uvid u kompleksne dileme s kojima se međunarodna zajednica suočava kada je u pitanju balans između nacionalne sigurnosti i zaštite ljudskih prava u vremenima oružanih sukoba. Ona ističu važnost kontinuirane međunarodne saradnje i razvoja pravnih okvira koji štite osnovna ljudska prava čak i pod najtežim okolnostima.

6. REZULTAT KRŠENJA MEĐUNARODNIH SPORAZUMA U ORUŽANIM SUKOBIMA

Kršenjem međunarodnih ugovora u oružanim sukobima krše se osnovna ljudska prava čija zaštita ne bi smjela biti delegirana ratnim dešavanjima. Ženevske konvencije, Evropska konvencija, Povelja UN, Univerzalna deklaracija o ljudskim pravima samo su neke od sporazuma kojim se ljudska prava štite i garantuju u svim prilikama i, pod svim uslovima. Za međunarodno pravo trebalo bi biti nedopustivo svako kršenje ljudskih prava, bez obzira ko ga vrši i zarad kojih ciljeva ga vrši, jer niko i ništa ne može opravdati zločine, žrtve ili nepravde koje su učinjene kršenjem ljudskih prava.

Zaštita ljudskih prava ne bi smjela da bude ostvarivana jedino u vrijeme mira imajući u vidu da su ljudska prava stub svih ostalih iznjedrenih prava, već zaštita treba da postoji uvijek u svim uslovima, bez presedana. Obaveza je svake države i međunarodne zajednice u cjelini da štite ljudska prava¹, obaveza država u ovom pogledu su *erga omnes*, opšte-univerzalnog, nad-ugovornog karaktera, jer je u pitanju zločin, koji podriva temelje civilizovanog društva. Bez obzira će je počinjen, on proizvodi univerzalne posledice,

¹ Vučinić, N. (2001), Osnovi ljudskih prava i sloboda, Podgorica, 262.

nikoga ne može ostaviti ravnodušnim, pa su obaveze država i međunarodnih organizacija u pogledu njegov spriječavanja, univerzalnog karaktera.

Takođe, pogrešno je targetirati jedan cijeli narod ili državu, za zločine koje počine pojedici. Trebamo imati u vidu da krivična odgovornost podrazumijeva vinost, a vinost se ne može prepisati cijelom narodu jedne države.

Rat značajno utiče na civile, posebno u "novim ratovima" devedesetih godina, gdje se pokazuje konzistentan obrazac masovnih civilnih stradanja. Zaštita civila u ratnim vremenima zahtijeva stalne moralne argumente i liderstvo kako bi se održao civilni etos usred političkih, strastvenih i praktičnih protivljenja¹.

Međunarodne mjere za zaštitu civilnih populacija tokom ratnih vremena uključuju dostavu humanitarne pomoći, uspostavljanje sigurnih zona, sprovođenje mirovnih misija, promociju ljudskih prava i sprovođenje međunarodnog humanitarnog prava. Ove mjere su ključne za smanjenje patnje civila i pružanje neophodne zaštite u kontekstu oružanih sukoba.

Napori za zaštitu civila u oružanim sukobima često nailaze na značajne izazove, posebno kad su u pitanju agresivne taktike koje se koriste u vojnim operacijama. Na primjer, agresivne taktike u američkoj kontrainsurgenciji u Iraku snizile su prag za nasilje, prenoseći rizik sa vojnika na civile, posebno u neprijateljskim oblastima, čime se povećava broj civilnih žrtava².

Ove teme ukazuju na složenost izazova s kojima se međunarodna zajednica suočava u pokušajima da zaštiti civilno stanovništvo u ratnim uslovima, ističući važnost kontinuirane posvećenosti i adaptacije međunarodnih normi i praksi kako bi se odgovorilo na dinamične prirode savremenih oružanih sukoba.

7. Međunarodne mjere zaštite civila i prevencija kršenja ljudskih prava u ratnim uslovima

Humanitarna pomoć ima ključnu ulogu u ublažavanju patnji civila u zonama sukoba i doprinosi sprovođenju međunarodnog humanitarnog i ljudskih prava. Humanitarne operacije teže da ublaže patnje pružanjem zaštite i pomoći osobama pogođenim oružanim sukobom, promovisanjem međunarodnog humanitarnog prava prema učesnicima i zauzimanjem prostora kada države ili oružane grupe nisu u mogućnosti da pruže takvu pomoć³.

Međunarodne nevladine organizacije mogu igrati ključnu ulogu u procjeni usklađenosti sa humanitarnim pravom od strane vlada i oružanih opozicionih grupa tokom oružanih sukoba, težištu da zaštite ljudska prava. One se ohrabruju da povećaju svoju efikasnost

¹ Slim, H. (2003), „Why protect civilians? Innocence, immunity and enmity in war“, *International Affairs*, Vol. 79, No. 3, 481-501.

² Smith, T. W. (2008), „Protecting Civilians...or Soldiers? Humanitarian Law and the Economy of Risk in Iraq“, *International Studies Quarterly*, Vol. 52, No. 2, 239-265.

³ Massingham E. & Thynne K. (2020), *Humanitarian Relief Operations*, Oxford University Press, Oxford, 237-255.

učeci iz iskustava organizacija poput Crvenog krsta u zaštiti ljudskih prava u takvim izazovnim kontekstima¹.

Prethodno naglašava važnost humanitarne pomoći i aktivnosti međunarodnih nevladinih organizacija u zaštiti civila tokom oružanih sukoba, ukazujući na složenost izazova s kojima se suočavaju i potrebu za stalnim prilagođavanjem pravnih i operativnih okvira kako bi se efikasno odgovorilo na potrebe ugroženih populacija.

Prevenција kršenja ljudskih prava u ratnim uslovima zahtijeva koordinisanu akciju na međunarodnom nivou, uključujući jasno definisanje pravila i obaveza koje su potpisale sve učesničke strane u sukobu. Fokus je na edukaciji i obuci vojnih snaga o važnosti poštovanja Međunarodnog humanitarnog prava i pravila ratovanja. Ove mjere obuhvataju i stroge procedure za izvještavanje i odgovornost u slučajevima kršenja prava, kako bi se osiguralo da počinioci budu pravovremeno procesuirani.

Međunarodne organizacije igraju ključnu ulogu u monitoringu situacija na terenu i pružanju pravovremenih izvještaja o stanju ljudskih prava u ratnim zonama. One su odgovorne za prikupljanje dokaza i izvještavanje o incidentima, što može poslužiti kao osnova za međunarodne reakcije i potencijalne sankcije protiv onih koji krše međunarodne norme.

Saradnja između država i međunarodnih organizacija je neophodna za efikasnu prevenciju i sankcionisanje kršenja ljudskih prava. To uključuje razmjenu informacija, podršku u obuci i izgradnji kapaciteta, kao i zajedničke inicijative za poboljšanje zaštite civila u ratnim zonama. Kroz ovakve akcije, međunarodna zajednica može bolje da se suprotstavi izazovima koji se pojavljuju u ratnim uslovima i da minimizira štetne posljedice po civilno stanovništvo.

8. Zaključak

Sukobi i ratovi uvijek predstavljaju izazov za očuvanje ljudskih prava i civilnog dostojanstva. Međunarodni sporazumi i zakoni su postavljeni da regulišu ponašanja država i pojedinaca, čime se teži zaštiti ne samo učesnika u sukobima, već i civila koji su često najveće žrtve. Derogacija ljudskih prava, iako ponekad opravdana potrebama zaštite većeg broja ljudi ili nacionalne sigurnosti, zahtijeva pažljivu procjenu i strogo pridržavanje međunarodnih standarda kako bi se izbjeglo nepotrebno kršenje osnovnih prava.

Velike sile imaju posebnu odgovornost i uticaj u međunarodnim ratnim pravilima, a njihovi geopolitički interesi često oblikuju kako se ta pravila primjenjuju ili zanemaruju. Stoga je ključna transparentnost i međunarodni nadzor nad akcijama koje mogu voditi do dvostrukih standarda ili selektivne primjene pravila.

Balans između zaštite ljudskih prava i ekonomskih interesa predstavlja još jedan sloj kompleksnosti, gdje velike sile moraju voditi računa da njihovi ekonomski ciljevi ne zasjenjuju obaveze prema ljudskim pravima. Globalna politika i ekonomski interesi ne smiju kompromitovati temeljna prava i slobode pojedinaca.

¹ David S. Weissbrodt (1987), „Humanitarian Law in Armed Conflict: The Role of International Nongovernmental Organizations“, *Journal of Peace Research*, Vol. 24, No. 3, 267-281.

Zaštita civilnog stanovništva u ratnim uslovima iziskuje konstantnu evaluaciju i prilagođavanje međunarodnih normi i strategija zaštite. Izazovi koje donosi savremeni oblik ratovanja zahtijevaju nove pristupe i tehnologije koje će omogućiti efikasniju zaštitu i smanjenje civilnih žrtava.

Na kraju, prevencija kršenja ljudskih prava u ratnim uslovima je imperativ koji zahtijeva koordinirane međunarodne napore, stalnu edukaciju i obuku, kao i jačanje međunarodnih i lokalnih institucija koje nadgledaju primjenu prava i reaguju na njihova kršenja. Samo kroz zajednički rad i neprekidnu posvećenost možemo se nadati izgradnji pravednijeg i sigurnijeg svijeta za sve, čak i u najtežim vremenima sukoba.

Ovakav pristup zahtijeva izgradnju snažnijih međunarodnih institucija i okvira koji mogu efikasno adresirati i rješavati sukobe. Međunarodna zajednica mora raditi na jačanju kapaciteta Ujedinjenih nacija i drugih relevantnih tijela da ne samo da reaguju na krize, već i proaktivno rade na sprečavanju sukoba i zaštiti ljudskih prava prije nego što dođe do njihovog masovnog kršenja. To uključuje bolje razumijevanje uzroka sukoba, uključujući socijalne, ekonomske i političke faktore koji doprinose nestabilnosti.

Pored toga, potrebno je raditi na jačanju pravnih normi i konvencija koje regulišu ponašanje u ratu, osiguravajući da one budu jasno formulirane i univerzalno prihvaćene. Države moraju biti pod stalnim pritiskom da ratificiraju i pridržavaju se međunarodnih sporazuma poput Ženevskih konvencija i drugih ključnih dokumenata koji štite ljudska prava.

Edukacija i obuka vojnih i policijskih snaga su također ključne u osiguranju poštovanja međunarodnih humanitarnih i ljudskih prava. Vojnici i policajci moraju biti obučeni da prepoznaju i poštuju ljudska prava čak i u najizazovnijim situacijama, što može značajno smanjiti broj incidenata kršenja prava. Ovo obrazovanje mora biti stalno i ugrađeno u redovne trening programe sigurnosnih snaga.

Uloga civilnog društva u nadzoru i izvještavanju o kršenjima ljudskih prava ne može se podcijeniti. Organizacije civilnog društva i mediji igraju ključnu ulogu u otkrivanju i izvještavanju o zloupotrebama, pružajući neophodnu transparentnost i odgovornost. Međunarodna zajednica treba pružiti podršku ovim organizacijama, štiteći ih od represija i omogućavajući im da rade bez straha od odmazde.

Konačno, potrebno je razviti i primijeniti mehanizme za brzu reakciju na kršenja ljudskih prava. Ovi mehanizmi bi omogućili brzo djelovanje u situacijama gdje su civilne populacije izložene riziku, osiguravajući pravovremenu zaštitu i minimizaciju štete. Ovi koraci su ključni za izgradnju globalnog sistema koji može efektivno štititi ljudska prava i smanjiti patnje u vremenima oružanih sukoba, čime se stvara osnova za dugoročiji mir i stabilnost u međunarodnim odnosima.

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VIOLETION OF INTERNATIONAL AGREEMENTS IN MILITARY CONFLICTS

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ABSTRACT:

In this paper the implementation of international agreement has been analysed, wheather there is the implementation of the most important law agreements in military conflicts when the conflicts start.

The most important norms of international agreement are analysed and the fact wheather they have been applied in the situations when the armed conflicts happen. Furthermore, leading states are considering their point of views about international agreements and the avoidance of them regarding their signing and ratification. The question is which interests are the leading ones, protection of civilians or economic prosperity of worldwide giants. In the paper we would like to emphasize the respect of international agreements which is the ground of rights and respect of basic human rights. Also, there will be mentioned the basic human rights that are jeopardized directly during military conflicts and that the civilian are those who pay tribute in these conflicts. The author analyses the justification of human rights derogation during the war, if we have in consideration that the respect of human rights during the military conflicts is actually the base of respect of basic human rights and international humanitarian law.

Key words: *international agreements, military conflict, civilians, leading states, human rights*

ETIČNOST POSLOVANJA U PODUZEĆIMA

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SAŽETAK:

Cilj rada je analiza poslovne etičnosti u poduzećima u sjeverozapadnom djelu Hrvatske, odnosno, istraživanje stavova zaposlenika o etičkim stavovima i dilemama, etičkom kodeksu poduzeća, donošenju odluka i postupanju managera prema zaposlenicima u kontekstu etičkih načela.

Na taj način istražena su obilježja poslovne etičnosti među zaposlenicima u poduzeću, između zaposlenika i nadređenih osoba te obilježja odlučivanja koja proizlaze iz pretpostavljenih etičkih dilema. U radu je korištena kvantitativna metodologija u obliku anketnog istraživanja u kojem je sudjelovalo 129 ispitanika. Više od 80% ispitanika smatra da se njihov nadređeni etički ponaša i donosi etičke odluke, gradi zajedništvo unutar poduzeća, poštuje zaposlenike, pravedan je i iskren prema zaposlenicima te im nastoji pomoći. Također, više od 70% ispitanika smatra da u poduzeću vladaju kolegijalni odnosi koji unaprijeduju međuljudske odnose. No, kada se ispitanici trebaju izjasniti o konkretnim etičkim dilemama vezane za etičku praksu poduzeća, 2/3 ispitanika postupilo bi neetično kada je to nadređeni tražio od njih. Također, ispitanici bi iskoristili svoje privatne veze i poznanstva, ovisno o situaciji i ozbiljnosti problema za potrebe posla.

U radu se zaključuje da je poslovna etika odgovorno poslovno ponašanje jer pomaže unaprijediti međuljudske odnose i graditi etičnu poslovnu klimu.

1. UVOD

Prema Pupovcu, (2006.) poslovna etika može se definirati kao skup moralnih načela i normi kojima se usmjerava ponašanje aktivnih sudionika u gospodarskom sustavu, u skladu s vrijednosnim sudovima koji se temelje na općim ljudskim vrijednostima i usmjerene su na dobrobit čovjeka. Uspješne svjetske i domaće organizacije postale su svjesne činjenice da u konkurentskoj areni poslovna etika omogućuje rast i razvoj, povećava efikasnost i produktivnost (Aleksić, 2007.). Poslovna etika je dakle, način koncipiranja, sklapanja, komuniciranja i izvođenja poslova u istovremenom skladu s duhovnim, sociološkim, biološkim i prirodnim zakonitostima čovjeka i okruženja, ili, jednostavnije, poslovnu etiku možemo objasniti kao prirodno vođenje poslova, odnosno poslovanje u skladu s prirodom (Bebek, Kolumbić, 2005.). U poslovnim odnosima čovjek se uvijek nalazi pred etičkom dilemom - biti pošten ili nepošten, iskren ili neiskren, hrabar ili kukavica, umjeren ili ekstreman, pri čemu svoju moralnu odluku uvijek donosi na temelju moralnih vrijednosti. Uz opća pravila poslovnog bontona koja treba poznavati,

gotovo svaki poslovni sustav donosi još i svoj etički kodeks. Etičkim kodeksom se uređuju standardi i utvrđuju temeljna načela unutar kojih se poslovni subjekt i njegovi zaposlenici ophode prema drugim dionicima (Vujić i sur., 2016.).

U Hrvatskoj je poslovna etika relativno nova znanost i, iako je iznimno bitna za poslovanje svakog poduzeća, tek odnedavno se joj pridaje veća pažnja. Potrebno je naglasiti da poduzetnici imaju sveobuhvatnu i istaknutu ulogu u gradnji „dobrog društva“. (Tudor i sur., 2018.)

2. METODOLOGIJA ISTRAŽIVANJA

Za potrebe ovoga rada provedeno je anketno istraživanje u kojem je sudjelovalo 129 ispitanika, odnosno zaposlenika poduzeća u okviru kojeg je istraživana poslovna etičnost poduzeća iz perspektive zaposlenika.

Anketno istraživanje provedeno je putem Google obrasca na prigodnom uzorku poduzeća u sjeverozapadnom području Hrvatske (Koprivničko-križevačka, Zagrebačka, Krapinsko-zagorska, Varaždinska i Međimurska županija, te grad Zagreb) tijekom travnja i svibnja 2021. godine. Zbog delikatnosti teme istraživanja, zajamčena je anonimnost ispitanicima i poduzećima u kojima su ispitanici radili u trenutku provođenja istraživanja. Dobiveni podatci su obrađeni metodom deskriptivne statistike, analizirani i interpretirani u postotcima ili apsolutnim brojevima.¹

3. REZULTATI I RASPRAVA

3.1. SOCIO-DEMOGRAFSKI PODACI

U istraživanju je sudjelovalo 129 osoba, od kojih je 67 muškaraca i 62 žene odnosno, 52% ispitanika i 48% ispitanica. Najzastupljenije obrazovno postignuće kod ispitanika je srednjoškolsko obrazovanje i završeni diplomski studij. Što se tiče veličine poduzeća (grafikon 1) u kojem su ispitanici zaposleni, 36% (47) ispitanika radi u velikim poduzećima, 36% (46) je zaposleno je u mikro poduzećima, u malim poduzećima radi 15% (19) osoba, a u srednjim poduzećima zaposleno je njih 13% (17).

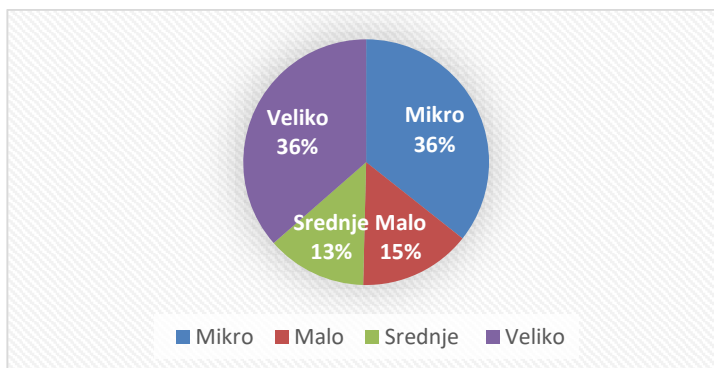
Sukladno zakonu o računovodstvu (NN 78/2015)² mikro subjekti malog gospodarstva su fizičke i pravne osobe (subjekti u poduzetništvu i obrtu) koje prosječno godišnje imaju zaposleno manje od 10 radnika, mali subjekti malog gospodarstva su fizičke i pravne osobe (subjekti u poduzetništvu i obrtu) koje prosječno godišnje imaju zaposleno manje od 50 radnika, srednji subjekti malog gospodarstva su fizičke i pravne osobe čiji je godišnji prosječni broj radnika, ukupni godišnji promet ili zbroj bilance, odnosno dugotrajna imovina, veća od utvrđenih za male subjekte malog gospodarstva. Subjekti koji prelaze mjerila koja određuju malo gospodarstvo su poduzetnici koji zapošljavaju godišnje u prosjeku više od 250 radnika.

Najviše ispitanika radi u privatnim poduzećima i to njih 83, zatim njih 36 radi u javnim poduzećima, a preostalih 10 radi u mješovitim poduzećima

Grafikon 1: Veličina poduzeća

¹ Istraživanja neophodna za ovaj rad realizirana su u okviru diplomskog rada studenta Luke Pompera, back.ing.agr. s Veleučilišta u Križevcima.

² https://narodne-novine.nn.hr/clanci/sluzbeni/2015_07_78_1493.html



Izvor: obrada autora

3.2. ETIČKE PRAKSE U PODUZEĆU

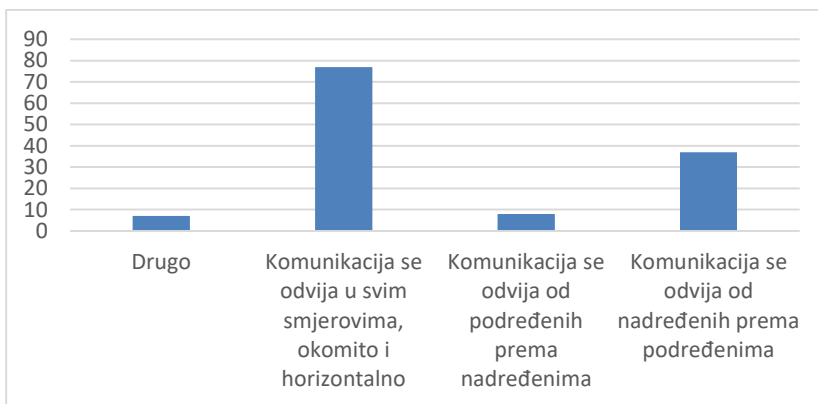
Etičke prakse u poduzeću podrazumijevaju primjenu poslovne etike u poduzeću. Za primjenu poslovne etičnosti u poduzeću važno je da poduzeće ima etički kodeks i prakticira dobru poslovnu komunikaciju. Ključ dobre poslovne komunikacije je unaprjeđenje dobrih međuljudskih i poslovnih odnosa između nadređenih i podređenih osoba u poduzeću, te demokratski princip poslovnog odlučivanja.

Na pitanje: „Ima li Vaše poduzeće etički kodeks?“ 58% ispitanika je odgovorilo potvrdno, 12% ispitanika je odgovorilo negativno, a preostalih 40% ispitanika je odgovorilo „ne znam“.

U skladu s time, prema subjektivnoj procjeni ispitanika, njih 80% smatra da njihovo poduzeće posluje na etičan način. Što se tiče donošenja odluka u poduzeću, ispitanici smatraju da bi se odluke u poduzeću trebale donositi grupnom odlukom (58% ispitanika), zatim slijede oni koji misle da bi odluke isključivo trebao donositi nadređeni (24% ispitanika), a najmanji broj ispitanika se izjašnjava da odluke trebaju donositi pojedinci i to nakon zajedničke rasprave na određenu temu. U praksi poduzeća prevladava istovrsni princip: poslovne odluke donose se grupnim odlučivanjem, zatim slijedi obrazac donošenja odluka nakon rasprave i konačno, nadređeni sam donosi odluke. Može se zaključiti kako u poslovnom odlučivanju sudjeluju različiti subjekti odlučivanja, od uprave preko menadžmenta do izvršnih radnika (Sikavica i sur., 2014.).

Practiciranje grupnog odlučivanja usko je povezano i s oblikom komunikacije u poduzeću. Prema mišljenju ispitanika, najčešći oblik komunikacije u poduzećima odvija se u svim smjerovima (okomito i horizontalno) (58%), a najrjeđi oblik komunikacije odvija se u smjeru od podređenih prema nadređenima. (grafikon 2)

Grafikon 2: Kako se prenose informacije u Vašem poduzeću?

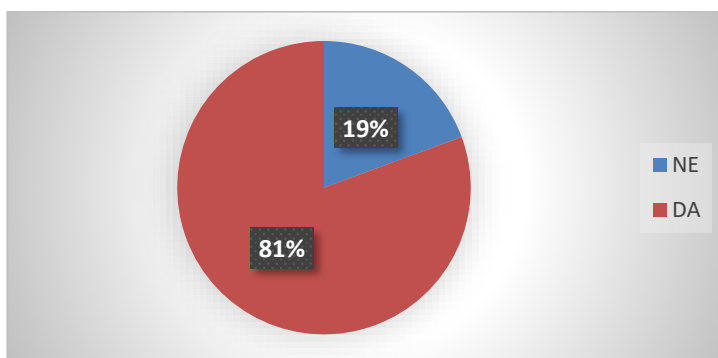


Izvor: obrada autora

3.3. MORALNE I ETIČKE DILEME U PONAŠANJU ZAPOSLENIKA I U ODNOSU NADREĐENI/ZAPOSLENIK

Vodeći se odgovorima ispitanika, njih 106 (82%) smatra da se njihove kolege ponašaju u skladu s načelima koja se odnose na gradnju zajedništva, dok njih 23 (18%) smatra suprotno. Isto vrijedi i za nadređenu osobu u poduzeću, odnosno, 104 (81%) ispitanika smatra da se nadređeni ponaša u skladu prema etičkim načelima koji se odnose na gradnju zajedništva, dok njih 25 (19%) to ne smatra. (grafikon 3)

Grafikon 3: Postupanje nadređenog prema etičkim načelima koja se odnose na izgradnju zajedništva



Izvor: obrada autora

Nadalje, što se tiče kolegijalnih odnosa između ispitanika, mnogi će reći da kolege zaposlenici međusobno postupaju u skladu s načelima koja se odnose na pokazivanje iskrenosti, pokazivanju pravde, poštivanju drugih zaposlenika, te žele pomoći i biti na usluzi svojim kolegama. Isto tako, kada su upitani postupa li njihov nadređeni u skladu s prethodno navedenim načelima, ispitanici odgovaraju potvrdno, a u potpunosti se slažu s tvrdnjom „Nadređeni ima etičku odgovornost da se prema podređenima odnosi

dostojanstveno i s poštovanjem, odnosno da bude osjetljiv na interese, potrebe i pitanja podređenih“.

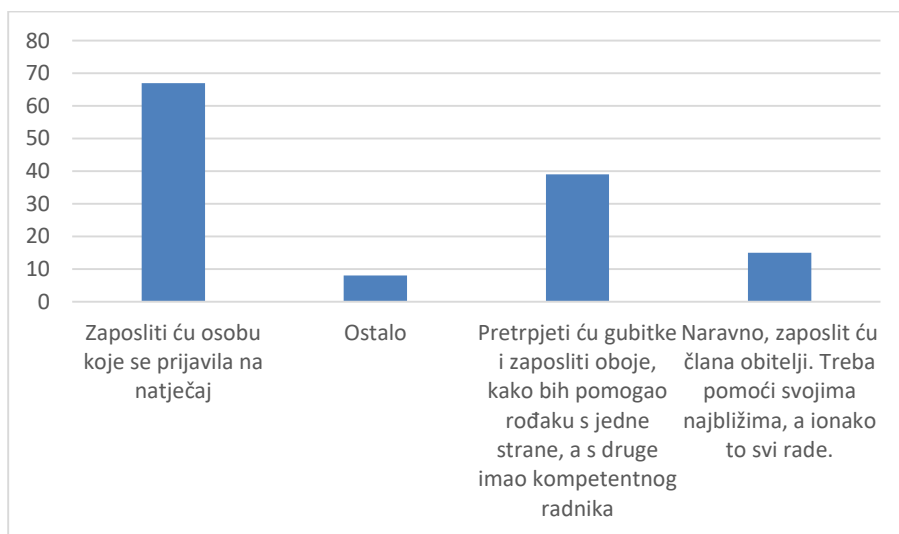
Zanimljiv je odgovor na sljedeće pitanje: „Je li se ikada dogodilo da ste učinili nešto neetično jer je nadređeni tražio to od Vas?“ Oko 76% ispitanika (98) je učinilo neetičnu aktivnost, a 24% ispitanika (31) to nije učinilo ili nije bilo u prilici učiniti.

Nadalje, ispitanicima su predstavljene 3 etičke dileme:

ETIČKA DILEMA1:

U poduzeću se oslobodilo jedno radno mjesto. Za to radno mjesto potrebno je stručna i kompetentna osoba s radnim iskustvom. Raspisali ste natječaj na kojeg se prijavilo mnogo ljudi. U mnoštvu životopisa, za oko Vam je zapeo jedan. Osoba koje se prijavila baš je onakva kakva Vam treba. Međutim, u međuvremenu Vaš blizak član obitelji iznenada je ostao bez posla i hitno mu treba novo zaposlenje. On nije niti upola kompetentan za ovo radno mjesto kao osoba koja se prijavila na natječaj. Zbog trenutnog financijskog stanja u mogućnosti ste zaposliti samo jednu osobu. Što ćete učiniti?

Grafikon 4: Etička dilema- novi zaposlenik i/ili blizak član obitelji



Izvor: obrada autora

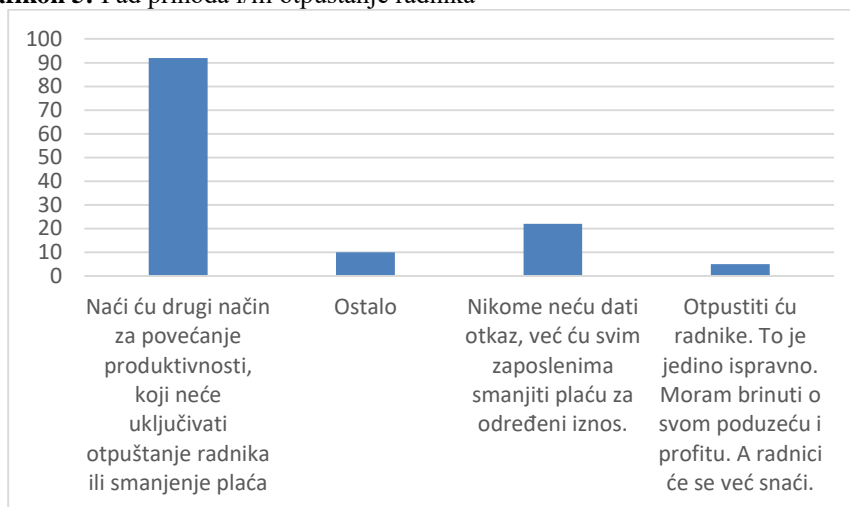
Iz grafikona 4 može se vidjeti sljedeće: 52% ispitanika (67) bi u ovoj situaciji zaposlilo osobu koja bi se prijavila na natječaj, dok bi njih 30% (39) pretrpjelo gubitke i zaposlilo i člana obitelji i novog zaposlenika, a njih 12% (15) bi zaposlilo samo svojeg člana obitelji jer smatraju da treba pomoći svojim najbližima, jer ionako to svi rade.

ETIČKA DILEMA 2:

Prihodi Vaše tvrtke su naglo pali. Sve veći pritisak je nad Vama te ste primorani povećati produktivnost. Najbrži način za to je da otpustite nekoliko radnika i zatražite od ostalih da rade više i duže. Radnici imaju fiksnu plaću i zbog financijske situacije ne postoji mogućnost plaćanja prekovremenih sati. Kad bi otpustili radnike i zatražili od ostalih da

rade deset sati tjedno duže, mogli bi djelotvorno obaviti istu količinu posla s manje radnika. Što ćete učiniti?

Grafikon 5: Pad prihoda i/ili otpuštanje radnika



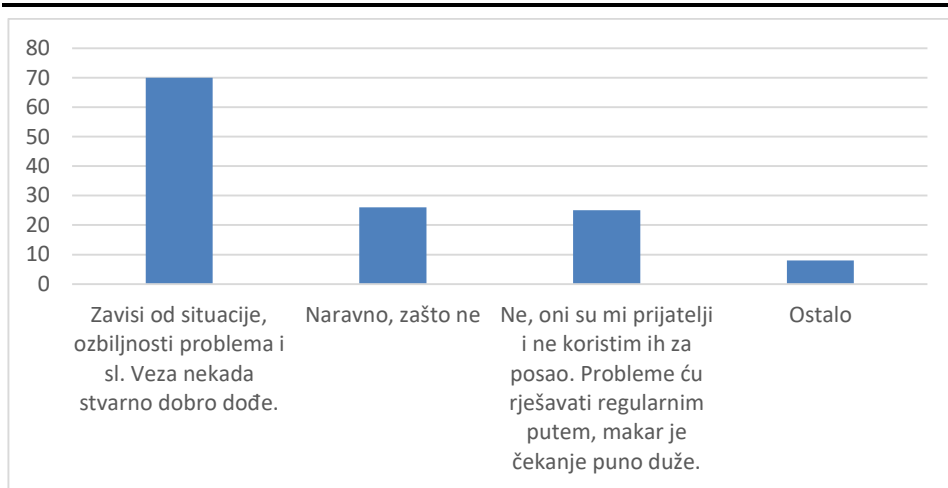
Izvor: obrada autora

Iz podataka (grafikon 5) se može jasno uočiti da 71% (92) ispitanika smatra da će naći drugi način za povećanje produktivnosti koji neće uključivati otpuštanje radnika ili smanjenje plaća a 16% (20) ispitanika ne želi nikome dati otkaz, nego bi radije svim zaposlenicima smanjili plaću za određeni iznos i na taj način sačuvali radna mjesta. Tek neznatan broj ispitanika, njih 5%, namjerava otpustiti radnike jer smatra da je to jedino ispravno u kontekstu brige o poduzeću i profitu.

ETIČKA DILEMA 3:

Imate veliki krug prijatelja i kolega a visokim pozicijama u raznim državnim i privatnim službama. Otvorili ste svoje poduzeće. Hoćete li koristiti navedene privatne „veze“ kako bi lakše i vremenski prije rješavali poslovne probleme.

Grafikon 6: Hoćete li koristiti privatne „veze“?



Izvor: obrada autora

Iz podataka (grafikon 6) razvidno je da bi 54% ispitanika (70) iskoristilo svoje „privatne veze“ u zavisnosti od situacije, jer veza nekada stvarno dobro dođe, 20% ispitanika (26) se izjašnjava: „Naravno, zašto ne?“, dok njih 19% (25) to ne bi učinilo.

4. ZAKLJUČAK

Iako je istraživanje provedeno na relativno malom uzorku, dobiveni rezultati otvaraju neka nova pitanja za raspravu poput primjerice: Kako to da 40% ispitanika ne zna postoji li etički kodeks u njihovom poduzeću? Kako onda poduzeće posluje u kontekstu internih međuljudskih odnosa, komuniciranja, poslovnog odlučivanja i slično? Mogući odgovor na to pitanje leži u obrascima komuniciranja „u svim smjerovima“ između zaposlenika i nadređenih u detektiranju etički izazovnih situacija. Indikativno je i da bi ispitanici učinili nešto neetično kada bi nadređeni tražio od njih da to učine. Istovremeno, ispitanici pokazuju visoku etičnu dosljednost prilikom zapošljavanja novih zaposlenika u kontekstu „prave osobe na pravom mjestu“, neskloni su reduciranju broja zaposlenika u poduzeću u slučaju pada prihoda poduzeća, no kada bi bili u prilici koristiti „privatne veze“ to bi i učinili ovisno o složenosti situacije i ozbiljnosti problema u poduzeću. Stoga se može zaključiti da etički kodeks regulira ovakva i slična problemska pitanja.

Općenito, rezultati istraživanja govore u prilog postojanju pozitivnih obilježja poslovne etičnosti: većina ispitanika smatra da njihovo poduzeće posluje na etičan način što govori u prilog činjenici da je i nadređena osoba ta koja gradi zajedništvo unutar poduzeća, poštuje zaposlenike, pravedna je i iskrena prema zaposlenicima, te utječe na izgradnju kolegijalnih odnosa između zaposlenika. Isto tako, i zaposlenici se u velikoj mjeri rukovode etičkim načelima koja se odnose na izgradnju zajedništva i kolegijalnih odnosa. Sve navedeno, govori u prilog činjenici da poslovna etičnost treba biti jedan od najvažnijih načina odgovornog poslovnog ponašanja jer unaprjeđuje međuljudske odnose čime gradi čvrstu poslovnu zajednicu koja obavlja svoj posao u ugodnom poslovnom okruženju.

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BUSINESS ETHICS IN COMPANIES

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SUMMARY:

The aim of the paper is the analysis of business ethics in companies in the northwestern part of Croatia, that is, the researching of employees' attitudes about ethical attitudes and dilemmas, the company's code of ethics, decision-making and manager's behavior towards employees in the context of ethical principles.

In this way, the characteristics of business ethics among employees in the company, between employees and superiors and the characteristics of decision-making resulting from presumed ethical dilemmas were researched. The paper used a quantitative methodology in the form of a survey in which 129 respondents participated. More than 80% of respondents believe that their supervisor behaves ethically and makes ethical decisions, builds unity within the company, respects employees, is fair and honest with employees, and tries to help them. Also, more than 70% of respondents believe that collegial relations prevail in the company which improve interpersonal relations. However, when the respondents have to express themselves about specific ethical dilemmas related to the company's ethical practice, 2/3 of the respondents would act unethically when their superior asked them to do so. Furthermore, the respondents would use their private connections and acquaintances, depending on the situation and the seriousness of the problem, for work purposes.

The paper concludes that business ethics is responsible business behavior due to the fact that it helps improve interpersonal relationships and build an ethical business climate.

Keywords: *business ethics, northwestern Croatia, survey*

RODITELJSKE KOMPETENCE MAJKI ADOLESCENATA- RAZVEDENIH I ONIH KOJE SU U BRAČNOJ ZAJEDNICI¹

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SAŽETAK : Osnovni cilj ovog istraživanja bio je uporediti roditeljske kompetencije majki adolescenata koje su u braku i onih koje su razvedene. Takođe, cilj je bio i da se ispituju i neki aspekti mentalnog zdravlja: psihološko blagostanje, anksioznost i depresivnost. U istraživanju je učestvovala 201 ispitanika.. Sprovedeni su upitnici: Skala roditeljskog osećaja kompetencije (Gibaud-Wallston & Wandersman, 1978), skraćena verzija Rifine skale psihičkog blagostanja (Ryff, 1989), Bekovog inventara depresivnosti (Beck et al., 1979) i Cungova (Zung) skala za procenu anksioznosti. Rezultati pokazuju da postoje razlike u izraženosti roditeljskih kompetencija psihološkog blagostanja u korist majki u braku, i anksioznosti i depresivnosti u korist razvedenih majki. Regresiona analiza izdvaja, psihičko blagostanje kao pozitivan i depresiju i anksioznost kao negativan prediktor roditeljskih kompetencija. Razlike na sociodemografskim varijablama nisu pronađene u pogledu roditeljskih kompetencija. Dobijeni podaci mogu biti od koristi u praktičnom radu sa roditeljima adolescenata bilo na ličnom ili porodičnom nivou krize.

Ključne reči: roditeljske kompetencije, razvod, adolescenti, psihološko blagostanje.

1. UVOD

U definisanju mentalnog zdravlja nailazimo na različita shvatanja u zavisnosti od naučnika koji pripadaju različitim kulturama. Mentalno zdravlje predstavlja deo opšteg zdravlja sa kojim je uzajamno povezano. Mentalno zdrava osoba poseduje sposobnost „uspostavljanja harmoničnih odnosa sa drugim ljudima i sposobnost realizacije sopstvenih intelektualnih i emocionalnih potencijala u konstruktivnom menjanju socijalne i fizičke sredine, subjektivni osećaj blagostanja, samoeфикаsnosti, nezavisnosti i kompetencije“ (Backović, 2010:833). Ipak moramo naglasiti da mentalno zdravlje ne podrazumeva manifestaciju različitih stanja zadovoljstva, dobrobiti i sreće.

Prema definiciji Svetske zdravstvene organizacije, mentalno zdravlje predstavlja stanje blagostanja u kojem svaki pojedinac ostvaruje vlastiti potencijal, može se nositi s

¹ Rad je nastao kao rezultat istraživanja u okviru naučnoistraživačkog projekta III 47023, Kosovo i Metohija između nacionalnog identiteta i evrointegracija, koji finansira Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije.

normalnim životnim stresom, može raditi produktivno i plodonosno i sposoban je pridonositi svojoj zajednici (Britvić, 2019:3). Mentalno zdravlje označava harmoniju između vrednosti, interesovanja i stavova sa poljem delovanja pojedinaca i sledstveno, realistično planiranje života i svrsishodnu implementaciju životnih koncepata (Stanojević, 2013:8, prema Neumann, 1989:4). Na mentalno zdravlje utiču brojni faktori i njih možemo klasifikovati u dve grupe: spoljašnji i unutrašnji faktori. U spoljašnje faktore bi uvrstili: sredinu (okruženje, uslove života), traumatska iskustva (gubitak, zlostavljanje, zloupotreba supstanci), dok u unutrašnje faktore ubrajamo biološke i genetske predispozicije, kao i takozvane negativne osobine ličnosti, odnosno vulnerabilnost osobe. Svaki od ovih faktora pojedinačno zapravo vodi razvijanju mentalnog poremećaja, ali većina poremećaja predstavlja rezultat akumulacije iskustva koji su konstantno ugrožavali psihološku dobrobit osobe. Može se zaključiti da se potpuna lista svih faktora ne može sastaviti i da glavni razlog zbog kojeg to nije moguće leži u samom pojedincu koji predstavlja svet za sebe.

Roditeljstvo se može definisati kao uloga koja traje celog života a počinje onog trenutka kada osoba sazna da će postati roditelj. Roditelji se danas nalaze pred velikim izazovom u vaspitavanju deteta. Nailazeći na različite izazove i rešavajući probleme sa kojima se suočava, roditelj se često može naći u dilemi da li je na dobrom putu u vaspitavanju svog deteta. Iznalazeći različite izvore saznanja koje mu mogu pomoći u vaspitanju svog deteta, roditelj nailazi na pregršt informacija, koje su dostupne svima, međutim postavlja se pitanje da li možemo naći sve odgovore koji bi nam olakšali rešavanje mnogih nedoumica vezanih za vaspitanje. Ko je kompetentan roditelj i kako ga možemo klasifikovati kao više ili manje kompetentnog? Kompetentan roditelj je roditelj „koji sebe doživljava kao osobu koja ima kontrolu nad svojim roditeljstvom i odnosom sa svojim detetom, i dobro se oseća kao roditelj“ (Milanović i sar., 2000:123). Kompetentan roditelj poseduje određene sposobnosti, veštine i znanja koja usvaja učenjem, a prepoznatljiv je po razvijenom samopoštovanju, pouzdanosti, odgovornosti, doslednosti, toleranciji, pregovaračkim sposobnostima, sposobnostima aktivnog slušanja i mogućnosti efikasnog i prihvatljivog rešavanja sukoba (Šimić i Ljubetić, 2018: 438). Ne postoji univerzalno razumevanje šta kvalitetno roditeljstvo podrazumeva i kako vršiti procenu roditeljskih kompetencija. Pojedine operacionalizacije zasnivaju se na ishodima roditeljstva, što ih čini cirkularnim. Prema Jankoviću „kompetencije roditelja ogleda se i u poznavanju svoje dece, ali i dece uopšte, njihovih faza razvoja, potreba, interesa, kvaliteta njihove percepcije i mogućnosti bar približno objektivne procene ponašanja i niza drugih dimenzija vezanih za vlastitu decu, naročito u kriznim situacijama i teškim razdobljima tokom porodičnog životnog ciklusa“ (Janković, 2008:163).

Kompetentan roditelj poseduje metakompetencije čije su osnovne komponente: funkcionalna (sposobnost uspešnog obavljanja niza zadataka u cilju postizanja određenog cilja)

lični ili bihevioralni (sposobnost da izaberete ponašanje koje odgovara datoj situaciji)

kognitivna (sposobnost vešte primene stečenih znanja u konkretnoj situaciji)

etička/vrednosna kompetencija (posedovanje, sposobnost prosuđivanja i primena osobnih vrednosti u određenoj situaciji) (Ljubetić, 2012: 114).

Za žene, majčinstvo je najznačajniji segment identiteta. Uloga majke menja se od vremena industrijalizacije pa i u savremenom društvu, prolazi kroz značajne promene. Brojne su aktivnosti koje čine suštinu majčinstva, a u takozvanu majčinsku praksu spadaju

„menjanje pelena, kupanje, hranjenje, presvlačenje, uspavljivanje, igra s detetom, bavljenje detetom noću, čitanje detetu, vođenje u vrtić, odlazak kod lekara, vođenje deteta u šetnju“ (Čudina-Obradović i Obradović, 2002:48). Ove aktivnosti su zapravo skup veština i znanja, a stvaranje dubokog emocionalnog odnosa je ključan činilac pravilnog razvoja deteta. Danas, moderna majka može imati više različitih uloga i to od domaćice, majke, supruge, zaposlene žene i slično. Može se reći, da je postalo i društveno poželjno da žena istovremeno ima više navedenih (ili nekih drugih) uloga. Majčinstvo značajno utiče na ženu u svakom smislu i značajnije je od uspeha u karijeri ili braka, utiče na to da se žena oseća ispunjeno, srećno i zadovoljno. Međutim, majčinstvo vrlo često može dovesti i do promena (u negativnom smislu) mentalnog zdravlja žene.

Doživljaj roditeljstva predstavlja samoprocenu o kvalitetu i kompetentnosti ispunjavanja roditeljske uloge. Taj pojam se najčešće opisuje pomoću tri dimenzije: zadovoljstvo roditelja, stres i zahtevi roditeljske uloge, i subjektivni osećaj roditeljske kompetencije (Malčić i sar. 2021, prema Čudina Obradović i Obradović, 2003). Prva dimenzija je zadovoljstvo roditelja i podrazumeva ostvaren uspešan odnos sa partnerom i detetom i lično zadovoljstvo roditeljskom ulogom. Druga dimenzija su zahtevi roditeljske uloge u koje se ubrajaju pritisci i ispunjenje normi i očekivanja koja se pred roditelje postavljaju od društva, a ti zahtevi, odnosno njihovo neispunjavanje direktno proizvode roditeljski stres, kome još može da se doda i depresija roditelja, preterana vezanost za dete i osećaj roditeljske nekompetentnosti. Treća dimenzija je subjektivna roditeljska kompetentnost, koja predstavlja zajednički naziv za različite aspekte ličnog doživljaja uspeha iz perspektive roditeljske uloge (Malčić i sar. 2021, prema Marić i sar., 2020).

Danas se sve više susrećemo sa nepotpunim porodicama u kojima nedostaje jedan ili oba roditelja koji iz različitih razloga ne žive u bračnoj ili vanbračnoj zajednici. Za vaspitanje i formiranje ličnosti deteta važna su oba roditelja, jer se ličnost deteta izgrađuje na osnovi modela ličnosti obaju roditelja i njihovih međusobnih odnosa. Prisustvovanje oba roditelja, njihova emocionalna povezanost i učešće u vaspitanju deteta preko je potrebno zato što osigurava više bitnih elemenata za zdrav razvoj deteta. Programi podrške roditeljima pokazali su se delotvornima u suzbijanju nesigurnosti, anksioznosti i stresa, posebno kod majki, kao i u podizanju samopoštovanja i komunikacije unutar porodice, što je sve uticalo i na zdravstvene ishode dece.

2. METODOLOŠKI OKVIR ISTRAŽIVANJA

2.1. Predmet i značaj istraživanja

Predmet ovog istraživanja je ispitati povezanost doživljaja roditeljske kompetentnosti i mentalnog zdravlja žena majki dece adolescentne dobi i to onih koje su u braku i onih koje su razvedene. Kako su istraživanja pokazala da je mentalno zdravlje roditelja povezano sa njihovim kompetencijama kao roditelji, značajno bi bilo ovu temu dodatno istražiti. U obzir su uzete varijable pozitivnog mentalnog zdravlja, psihološko blagostanje i varijable negativnog mentalnog zdravlja, anksioznost i depresivnost. Predmet istraživanja je ispitati njihovu povezanost sa roditeljskim kompetencijama i da li se ona može predvideti na osnovu varijabli pozitivnog i negativnog mentalnog zdravlja. Teorijski značaj istraživanja se odnosi na bolje razumevanje mentalnog zdravlja i njegovog uticaja na roditeljske kompetencije majki adolescenata. Ovi podaci bi doprineli boljem razumevanju

psihološkog blagostanja, sa jedne strane, i depresivnosti i anksioznosti, sa druge strane, i njihov značaj u ovom procesu. Praktični značaj se ogleda u savetodavnom radu sa majkama adolescenata. Podaci se mogu koristiti u savetovanju ka boljem roditeljskom funkcionisanju majki u braku i nakon razvoda. Kako je razvod sve učestalija pojava u društvu, razumevanje uticaja pozitivnih i negativnih osobina mentalnog zdravlja bi bilo od velikog značaja u praksi psiholozima i psihoterapeutima.

2.2. Instrumenti u istraživanju

- Upitnik socio-demografskih karakteristika;
- Skala roditeljskog osećaja kompetencije Parent Sense of Competency Scale (PSOC) (Gibaud-Wallston & Wandersman, 1978, prema Gilmore&Cuskelly, 2009) meri roditeljsku kompetenciju na dve dimenzije: zadovoljstvo i efikasnost. To je upitnik na Likertovoj skali od 16 stavki (na skali od 6 poena u rasponu od potpuno se slažem [1] do potpuno se ne slažem [6]), sa devet pitanja pod Zadovoljstvo i sedam pod Efikasnost. Odeljak o zadovoljstvu ispituje anksioznost, motivaciju i frustraciju roditelja, dok odeljak Efikasnost razmatra kompetencije roditelja, nivoe sposobnosti i sposobnosti rešavanja problema u njihovoj roditeljskoj ulozi. Skala takođe može biti skala od 17 poena, iako se kao skala od 16 poena, poslednje pitanje ne koristi. Devet (9) stavki (br. 2, 3, 4, 5, 8, 9, 12, 14 i 16) na PSOC-u su obrnuto kodirane.;
- Psihičko blagostanje se meri pomoću skraćene verzije Rifine (Ryff, 1989) Skale psihičkog blagostanja kojom se procenjuje koliko su ispitanici napredovali u svom privatnom, ličnom životu. Ova skala obuhvata šest dimenzija (subskala) od po tri ajtema: 1. samoprihvatanje (npr.: „Sviđa mi se veći deo moje ličnosti“), 2. pozitivni odnosi sa drugima (npr.: „Odražavanje bliskih odnosa mi je bilo teško i frustrirajuće“), 3. doživljaj ličnog rasta (npr.: „Za mene, život je bio stalni proces učenja, menjanja i rasta“), 4. postojanje svrhe u životu (npr.: „Ponekad mi se čini da sam već uradio sve što treba uraditi u životu“), 5. upravljanje okolinom (npr.: „Dobar sam u ispunjavanju obaveza svakodnevnog života“) i 6. autonomija (npr.: „Verujem u ispravnost svog mišljenja čak i kad nije u skladu sa mišljenjem drugih“). Na uzorku odraslih Amerikanaca, subskale imaju relativno malu pouzdanost (oko 0.50, Ryff & Keyes, 1995), a pouzdanost kombinovanih 18 ajtema iznosi 0.81 (Keyes, 2002).
- Depresivnost - Ova varijabla je registrovana pomoću Bekovog inventara depresivnosti (Beck et al., 1979). Ovaj instrument za procenu depresivnosti ispitanika je dobro poznat i široko korišćen u svetu i kod nas, kako u istraživanjima tako i u kliničkoj praksi. Originalni instrument je prvi put objavljen još 1961. godine (Beck et al., 1961), a nakon toga revidiran i objavljen kao BDI IA (Beck et al., 1979) i BDI II (Beck et al., 1996). Iako je poslednja

verzija ovog instrumenta (BDI II) prilagođena dijagnostičkim kriterijuma DSM IV, u ovom istraživanju je korišćena prethodna varijanta instrumenta (BDI IA), koja je prevedena na srpski jezik (Latas, 2010; Timotijević i Paunović, 2003), višestruko validirana na našoj populaciji (prema Ignjatović - Ristić, 2012) i još uvek se često koristi širom sveta. Instrument je zasnovan na Bekovoj kognitivnoj teoriji depresije i sastoji se od 21 pitanja o tome kako se subjekat osećao tokom poslednje nedelje. Svako pitanje ima set od četiri moguća odgovora, rangirana prema intenzitetu (npr. 0 – Nisam tužan, 1 – Tužan sam, 2 - Tužan sam sve vreme i ne mogu da se otrgnem od toga, 3 - Toliko sam tužan i nesrećan da to ne mogu da podnesem). Dobijeni rezultati se sabiraju i svrstavaju u jednu.

- Anksioznost je ispitivana Cungovom (Zung) skalom za procenu anksioznosti (standardizovana srpska verzija skale)[21]. Sadrži 20 tvrdnji koje su »okrenute« pozitivno ili negativno. Pri tome su uključeni simptomi iz područja afektivnih, fizioloških, psihomotornih i psihičkih poremećaja. Ispitanik kod ove skale procenjuje svoje smetnje u zadnjih nedelju dana na skali od četiri stepena: nikada ili vrlo retko, ponekad, često, većinom ili uvek. Teorijski raspon vrednosti je da rezultat 50- 59 predstavlja umerenu anksioznost, 60-69 umerenu do ku anksioznost, a 70 i više bodova jaku anksioznost. Pouzdanost instrumenta u dosadašnjim istraživanjima je na opštoj populaciji .66, na pacijentima .74 (Zung, 1971) i .80 (Ramirez, S., Lukenbill, J. 2008).

2.3. Uzorak ispitanika

U tabeli 1. prikazani podaci govore da je u uzorku učestvovao 201 ispitanik, majke adolescenata, od kojih su 50% u braku i 50% iz rastavljenih brakova. Prosečne godine starosti su 40, a prosečne godine braka 15, dok prosečne godine rastavljenih koji su bili u braku je 9.

Tabela 1. Deskriptivno statistički podaci koji služe opisivanju uzorka

Varijable		Broj ispitanika	Procent
Godine		AS 40,65 god.	Range 29-57
Broj dece	1	80	39,8%
	2	86	42,8%
	3	35	17,4%
Bračni status	1 u braku	101	50,2%
	2 razveden	100	49,8%
Godine u braku		AS 15,07 год	Range 1-33

Razvedena bila u braku		AS 9,09 год	Range 2-35
Obrazovanje	SŠ	59	29,4%
	Viša	62	30,8%
	Visoka	66	32,8%
	Magistratura	11	5,5%
	Doktorat	3	1,5%
Materijalno stanje	Loše	4	2%
	Osrednj	93	46,3%
	Dobro	93	46,3%
	Odlično	11	5,5%
Ukupan broj ispitanika		201	100%

4. REZULTATI ISTRAŽIVANJA

U Tabeli 2. Prikazani rezultati T-testa pokazuju da postoje stistički značajne razlike između majki adolescenata koje su u braku i koje su razvedene. Majke u braku imaju izraženije roditeljske kompetence i zadovoljstvo u roditeljstvu, zatim, izraženije psihičko blagostanje. Dok, razvedene majke su pokazale izraženiju depresivnost i anksioznost kao pokazatelji negativnog mentalnog zdravlja.

Tabele 2. Razlike između majki adolescenata koje su u braku i iz razvedenih brakova

		N	AS	SD	T-test		Левенов тест	
					T	Sig	F	Sig
Roditeljske kompetencije	U braku	100	3,46	0,80	3,589	0,00	0,035	0,85
	Razvedene	101	3,05	0,81				
Depresivnost	U braku	100	0,32	0,25	-5,997	0,00	5,134	0,02
	Razvedene	101	0,60	0,40				
Anksioznost	U braku	100	1,58	0,37	-2,472	0,01	2,206	0,14
	Razvedene	101	1,70	0,35				
Psihičko blagostanje	U braku	100	4,89	0,78	3,393	0,00	2,913	0,09
	Razvedene	101	4,56	0,61				

Rezultati Pirsonovih koeficijenata korelacije (Tabela 3.) pokazuju da su sve prediktorske varijable značajno povezane sa roditeljskim kompetencijama. Negativno mentalno zdravlje, odnosno depresivnost i anksioznost, su negativno povezani. Pozitivno mentalno zdravlje, odnosno psihološko blagostanje je pozitivno povezani sa roditeljskim

kompetencijama. Reč je o korelacijama srednjeg intenziteta izraženosti. Povezanost roditeljskih kompetencija sa pozitivnim i negativnim mentalnim zdravljem.

Tabela 3. Povezanost roditeljskih kompetencija sa pozitivnim i negativnim mentalnim zdravljem

	Depresivnost	Anksioznost	Psihološko blagostanje
Roditeljske kompetencije	-0,605**	-0,629**	0,624**

**statistički značajna povezanost na nivou >0,01

Rezultati hijerarhijsko regresione analize (Tabela.4.) na celom uzorku pokazuju da je bračni status statistički značajan prediktor u prvom koraku i objašnjava 6% i on gubi statističku značajnost uvođenjem prediktora mentalnog zdravlja. Uvođenjem subskala pozitivnog mentalnog zdravlja model pozitivno predviđa 47%, dok uvođenjem subskala negativnog mentalnog zdravlja model negativno predviđa 60% varijanse roditeljske kompetencije (Tabela 4).

Tabela 4. Regresiona analiza roditeljskih kompetencija na celom uzorku

	Korak 1	Korak 2	Korak 3	
	β	β	β	
Bračni status	-0,247*	-0,044	0,024	R²=0,061 F =12,880 p= 0,000 R²=0,475 ΔR²=0,414 F =59,487 p= 0,000 R²=0,607 ΔR²=0,132 F =49,871 p= 0,000
Depresivnost		-0,333*	-0,176*	
Anksioznost		-0,418*	-0,206*	
Psihološko blagostanje			0,272*	

Napomena β – standardizovani regresioni koeficijent beta; r(*) – statistička značajnost; ΔR^2 – koeficijent multiple determinacije; F – Φ količnik; ΔR^2 – razlika u koeficijentima multiple determinacije.

5. DISKUSIJA I ZAKLJUČNA RAZMATRANJA

Sprovedeno istraživanje bavilo se ispitivanjem mentalnog zdravlja majki adolescenata koje su u braku i koje su razvedene. Pre svega značajno je naglasiti da je mentalno zdravlje pojedinca stanje blagostanja u kojem se ostvaruje vlastiti potencijal, može se nositi sa životnim stresom, može raditi produktivno i funkcionisati u svojoj zajednici (Britvić, 2019). Sve zajednice i današnje društvo utiču povratno na pojedinca formirajući ga kao ličnost. Razlike u strukturi i funkcionalnosti savremenih porodica ima veliki uticaj na funkcionisanje pojedinaca. Sve više jednoroditeljskih porodica ili brakova sa različitim porodičnim interakcijama oblikuju globalno funkcionisanje pojedinca (Marić, 2020). Roditelji se nalaze pred velikim izazovom da se prilagode s jedne strane na smanjenu stabilnost institucije braka i vaspitavanjem savremne dece. Prikupljaju se mnoge informacije iz različitih izvora koje imaju zadatak da potpomažu uspešno roditeljstvo (Milanović i sar., 2000:123).

Doživljaj roditeljstva predstavlja ličnu procenu o kvalitetu i kompetentnosti ispunjavanja roditeljske uloge. Ovaj pojam obuhvata doživljavanje zadovoljstva u roditeljstvu i subjektivni osećaj roditeljske kompetencije (Malčić i sar., 2021). Posebnu težinu iznose majke u današnje vreme koje preuzimaju na sebe obaveze domaćice i profesionalnih žena koje su okrenute karijeri. Kao posledica ovih višestrukih faktora razvijaju se mnoge poželjne i nepoželjne osobine ličnosti. Jedan od stresova koji može uticati na mentalno zdravlje žena, jeste stres izazvan razvodom braka. Razvodom braka dolazi i do narušavanja porodice i porodičnih odnosa što značajno utiče na decu kao i na roditelje. Mentalno zdravlje roditelja ima jaku vezu sa psihološkim stanjem njihove dece. Psihički problemi roditelja povezani su sa lošim mentalnim i fizičkim zdravljem dece (Choi et al. 2022).

Naposletku, porodica sa adolescentom jedna je od faza životnog ciklusa porodice koja predstavlja poseban izazov za funkcionisanje porodice u celini a, samim tim, i za roditeljsko funkcionisanje, jer se odnosi između roditelja i dece u tom periodu kvalitativno menjaju i postaju manje-više ravnopravni (Zuković i sar. 2015, prema Smetana et al., 2006). Rezultati dobijeni istraživanjem pokazuju da postoje razlike u izraženosti roditeljskih kompetencija psihološkog blagostanja u korist majki u braku, i anksioznosti i depresivnosti u korist razvedenih majki. Sto znači da majke u braku imaju izraženije psihičko blagostanje. Dok, razvedene majke su pokazale izraženiju depresivnost i anksioznost kao pokazatelje negativnog mentalnog zdravlja. Ranija istraživanja pokazuju da generalnu stabilnost braka predviđa značajno ženino zadovoljstvo bračnim odnosima (Obradovic, Cudina-Obradovic, 2000). Emocionalna i psihološka sigurnost žena u dobrim bračnim odnosima je izraženija u ovom istraživanju. Ženina precepcija kvaliteta bračnih odnosa se pokazala kao prvi i najvažniji faktor koji vodi ka razvodu ili pomaže u percepciji razvoda (Karney, Bradbury 1995). Sam razvod roditelja i rastavljanje ne mora direktno uticati negativno i na decu. Neki autori (Amato, 2000) navode medijatore koji proizvode negativne posledice u ovom procesu. To su, smanjena roditeljska pažnja usmerena deci zbog preokupiranosti samim postupkom razvoda braka ili zbog nepostojanja saradničkog roditeljstva. Roditelji su obuzeti preteranom strepnjom, nespontani, bezvoljni, imaju depresivne tendencije nakon razvoda. Značajna posledica toga je da deca dobijaju manje nežnosti i bliskosti (Wenar, 2003). Regresiona analiza izdvaja, psihičko blagostanje kao pozitivan i depresiju i anksioznost kao negativan prediktor roditeljskih kompetencija.

Razlike na sociodemografskim varijablama nisu pronađene u pogledu roditeljskih kompetencija. Dobijeni podaci mogu biti od koristi u praktičnom radu sa roditeljima adolescenata bilo na ličnom ili porodičnom nivou krize.

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PARENTAL COMPETENCIES OF MOTHERS OF ADOLESCENTS- DIVORCED AND THOSE IN MARITAL UNION

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ABSTRACT: *The research aims to compare parental competencies of mothers of adolescents who are married and of those ones who are divorced. Moreover, the goal is to examine certain mental health aspects: psychological well-being, anxiety and depression. The research included 201 respondents. The following questionnaires were used: Parenting Scale of Competence (Gibaud-Wallston & Wandersman, 1978), shortened version of Ryff's Scale of Psychological Well-Being (Ryff, 1989), Beck's Depression Inventory (Beck et al., 1979), and Zung's Self-Rating Depression Scale. The results show that there are differences in prominence of parental competent and psychological well-being in favour of mothers in marital union, as well as anxiety and depression in favour of divorced mothers. The differences on of sociodemographic variables have not been found in terms of parental competencies. Received data can be used in practical work with parents of adolescents either at the personal or family crisis level.*

Key words: *parental competencies, divorce, adolescents, psychological well-being*

TEŠKO UBISTVO

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SAŽETAK: Život predstavlja najznačajnije dobro, vrednost koja je osnov svih ostalih vrednosti čoveka. On je baza za ostvarivanje drugih tekovina čovečanstva. Kada ne bi postojalo pravo na život čoveka, kao kamen temeljac korpusa ostalih ljudskih prava, onda ni ona ne bi imala nikakvog smisla. Danas ne postoji pravni poredak koji ne štiti pravo na život čoveka. Ta zaštita se ostvaruje kroz različite grane prava (medicinsko pravo, ekološko pravo, itd.), ali je u tom pogledu najznačajnija krivičnopravna zaštita. Zbog toga, krivično delo ubistva predstavlja jedno od najtežih krivičnih dela. Svakim ubistvom čovečanstvo gubi jednog člana društvene zajednice, a čoveku se oduzima život, što je nenadoknadivo dobro. Opšti, društveni interesi u ovoj sferi imaju primat nad individualnim dobrima i vrednostima. Zakonodavac u sferi zaštite života zalazi u subjektivna prava pojedinca da bi ga bolje zaštitio. Pa ipak, pored toga, upravo se ljudsko pravo na život svakodnevno krši, ljudski životi se gase, ne prirodnim putem, već nasiljem, silom, i to najčešće od strane drugih ljudi, istih onih ljudi koji bi upravo pravo na život trebalo da uzimaju kao vrhovni postulat življenja svih nas.

Ključne reči: Život, ljudska prava, pravo na život, pravni poredak, krivičnopravna zaštita, nenadoknadivo dobro, subjektivna prava, nasilje, sila, vrhovni postulat, teško ubistvo.

1. UVOD

Radnja izvršenja običnog ubistva sastoji se u lišenju života drugog lica. To znači da radnja izvršenja može biti svaka ona radnja koja je podobna da prouzrokuje smrt drugog lica.

Krivično delo ubistva može se izvršiti samo prema živom čoveku. U vezi sa tim postavlja se pitanje momenta početka i završetka života, odnosno nastupanja smrti, od čega zavisi postojanje objekta radnje kao bitnog elementa bića krivičnog dela. Radnja

krivičnog dela ubistva se sastoji u svakoj delatnosti koja je podobna da prouzrokuje smrt jednog čoveka. Posledica krivičnog dela jeste smrt drugog lica. Između radnje izvršenja i posledice, za postojanje krivičnog dela mora postojati uzročna veza.

Teško ubistvo predstavlja kvalifikovani oblik krivičnog dela ubistva. Da bi se pravila terminološka razlika između običnog i teškog ubistva, ranije je u srpskom krivičnom zakonodavstvu i Krivičnom zakoniku SFRJ iz 1974. godine, za pojam teškog ubistva upotrebljavana reč umorstvo. Oblici koje srpsko krivično zakonodavstvo inkriminiše kao teško ubistvo su:

- Ubistvo na svirep i podmukao način (na primer, ubistvo iz zasede, na spavanju, ubistvo trovanjem ili kada se žrtva pri izvršenju muči ili joj se pričinjavaju teške patnje);
- Ubistvo pri bezobzirnom nasilničkom ponašanju;
- Ubistvo kojim je sa umišljajem doveden u opasnost život još nekog lica;
- Ubistvo pri izvršenju krivičnog dela razbojništva ili razbojničke krađe;
- Ubistvo iz koristoljublja, radi izvršenja ili prikrivanja drugog krivičnog dela, iz bezobzirne osvete ili iz drugih niskih pobuda;
- Ubistvo službenog ili vojnog lica;
- Ubistvo sudije, javnog tužioca, službenog lica u vezi sa poslovima koje to lice obavlja;
- Ubistvo deteta ili bremenite žene;
- Ubistvo člana svoje porodice kojeg je učinilac prethodno zlostavljao, i
- Ubistvo više lica.

U članu 114. Krivičnog zakonika Republike Srbije propisano je krivično delo teškog ubistva koje ima više oblika. Pored elemenata koji ulaze u osnovni oblik krivičnog dela, kao dopunski element mora biti ostvarena jedna od propisanih kvalifikatornih okolnosti koje se vezuju za način izvršenja, pobude ili svojstvo pasivnog subjekta, ili okolnosti izvršenja dela i obim posledice.

Kvalifikovano ili teško ubistvo postoji kada je umišljajno ubistvo izvršeno na takav način, iz takvih pobuda i pod takvim okolnostima ili prema takvom licu koji mu daju veći stepen težine i opasnosti. Izvršilac dela može da bude svako lice, a u pogledu krivice

potreban je umišljaj. Za ovo delo je propisana kazna zatvora najmanje deset godina ili kazna zatvora od trideset do četrdeset godina.

1.1. Ubistvo

Krivično delo ubistva se sastoji u protivpravnom lišenju života drugog lica sa umišljajem pri čemu ne postoje posebne okolnosti koje ga čine teškim (kvalifikovanim) ili lakim (privilegovanim).

Kod ovog krivičnog dela objekat zaštite je život čoveka ili pravo na život kao jedno od osnovnih, fundamentalnih ljudskih prava¹.

Radnja izvršenja je određena prema posledici, budući da se ovde radi o posledičnoj dispoziciji. Tako se, kao radnja smatra svaka delatnost činjenja ili nečinjenja, psihološka ili fizička delatnost, kojom se neposredno ili posredno prouzrokuje posledica – smrt drugog lica. To mogu biti raznovrsne delatnosti koje su podobne ili dovoljne da prouzrokuju smrt drugog lica. Ubistvo se može izvršiti različitim delatnostima činjenja i nečinjenja.

Nečinjenjem se može prouzrokovati smrt drugog lica u slučajevima kada postoji dužnost na činjenje kojom bi se sprečilo nastupanje smrti. Delatnosti činjenja su raznovrsne i mogu se vršiti na različite načine i raznim sredstvima, posredno ili neposredno. S obzirom na način izvođenja delatnosti ubistvo se može izvršiti direktnim, indirektnim, fizičkim i psihičkim dejstvom. Fizičko prouzrokovanje smrti, koje je i najčešće u praksi, ostvaruje se različitim sredstvima: vatrenim ili hladnim oružjem, oruđem i drugim sredstvima koja su podobna da telo teško povrede ili zdravlje teško naruše. Psihičko prouzrokovanje smrti se vrši izazivanjem uzbuđenja, straha prepasti ili žalosti u takvom stepenu koji ima karakter šoka, podobnog da blokira rad srca ili prekine drugu životnu funkciju.

Posledica dela je povreda u vidu nastupanja smrti lica. Za postojanje ubistva je potrebno da je radnja izvršenja preduzeta protivpravno, tako da ovog dela nema ako je do

¹ Đorđević Đ., Novi oblici teških ubistava u predlogu Krivičnog zakonika, Pravni život, Beograd, 2005. godine, broj 9/2005, str. 135-154.

lišenja života došlo u nužnoj odbrani, krajnjoj nuždi, vršenju dužnosti na poslovima javne i državne bezbednosti ili kada propisi službe to dozvoljavaju ili zahtevaju¹.

Izvršilac dela može da bude svako lice, a u pogledu krivice potreban je umišljaj.

Za ovo je delo propisana kazna zatvora od pet do petnaest godina.

Obično ubistvo predstavlja osnovni oblik krivičnog dela ubistva. Teško ubistvo je kvalifikovano obično ubistvo koje nema samostalnost. Teško ubistvo znači sadrži obeležja različite prirode koja moraju biti zakonom određena i čije prisustvo obično ubistvo čini posebno teškim. Teško ubistvo je samo ono koje je kao takvo označio zakonodavac².

II. TEŠKO UBISTVO

2. Pojam i elementi dela

U krivičnom pravu je uobičajena podela krivičnog dela ubistva na: obično, lako i teško ubistvo, pri čemu se često pravi i terminološka razlika u nazivima između pojedinih oblika ubistava. Teško ubistvo je najteži oblik ubistva i obično se definiše kao protivpravno ubistvo ljudskog bića praćeno specifičnim odnosom učinioaca prema delu³. Sada zakonodavac razdvaja ranije odredbe člana 47. KZS u dva, sada samostalna člana, kao: a) ubistvo (član 113.) i b) teško ubistvo (član 114.).

Postoje i laka, privilegovana ubistva, koja sadrže manji stepen težine i opasnosti, pa neka od njih zakonodavac čak ne naziva „ubistvo“, već „lišenje života“.

To su:

- a) ubistvo na mah (član 115. KZ),
- b) ubistvo deteta pri porođaju (član 116. KZ),
- v) lišenje života iz samilosti – eutanazija (član 117. KZ) i
- g) nehatno lišenje života (član 118. KZ).

Kvalifikovano ili teško ubistvo postoji kada je umišljajno ubistvo izvršeno na takav način, iz takvih pobuda, pod takvim okolnostima ili prema takvom licu koji mu daju veći stepen težine i opasnosti za koje zakon propisuje teže kažnjavanje. Teška ubistva spadaju u red

¹ Jovašević D., Pravo na život i nužna odbrana, Pravni život, Beograd 1998. godine, broj 9/1998, str. 43-61.

² Đorđević Đ., Novi oblici teških ubistava u predlogu Krivičnog zakonika, Pravni život, Beograd, 2005. godine, broj 9/2005, str. 156.

³ Krivični zakonik Republike Srbije („Službeni glasnik Republike Srbije“, broj 85/2005, 88/2005 - ispr., 107/2005 - ispr., 72/2009, 111/2009, 121/2012, 104/2013 i 108/2014).

najtežih krivičnih dela koja su zaprećena najtežom kaznom. Kao dopunski element kod teškog ubistva mora biti ostvarena neka od kvalifikatornih okolnosti. Teška ubistva predstavljaju lišavanje života drugog lica i u tom pogledu sadrže sve elemente kao i obično ubistvo. Međutim, ona se razlikuju od običnog ubistva po tome što u sebi sadrže još neke elemente (tzv. kvalifikatorne okolnosti) koji ih čine težim¹.

Postoji više oblika teškog ubistva, koji se razlikuju prema: a) načinu izvršenja, b) pobudama učinioca, v) okolnostima izvršenja i posledici i g) svojstvu pasivnog subjekta. Kada se u radnjama učinioca stekne više kvalifikatornih okolnosti ubistva, od kojih su neka ostala u pokušaju, sud je dužan da u pravnu kvalifikaciju, pored toga što će uneti kvalifikovane oblike krivičnog dela, unese i da su neka od njih ostala u pokušaju².

Krivično delo teško (kvalifikovano) ubistvo inkriminisano je Krivičnim zakonikom Republike Srbije, u članu 114. Zatvorom najmanje deset godina ili zatvorom od trideset do četrdeset godina kazniće se:

- 1) ko drugog liši života na svirep ili podmukao način;
- 2) ko drugog liši života pri bezobzirnomo nasilničkom ponašanju;
- 3) ko drugog liši života i pri tome sa umišljajem dovede u opasnost život još neko lica;
- 4) ko drugog liši života pri izvršenju krivičnog dela razbojništva ili razbojničke krađe;
- 5) ko drugog liši života iz koristoljublja, radi izvršenja ili prikrivanja drugog krivičnog dela, iz bezobzirne osvete ili iz drugih niskih pobuda;
- 6) ko liši života službeno ili vojno lice pri vršenju službene dužnosti;
- 7) ko liši života sudiju, javnog tužioca, zamenika javnog tužioca ili policijskog službenika u vezi sa vršenjem službene dužnosti;
- 8) ko liši života lice koje obavlja poslove od javnog značaja u vezi sa poslovima koje to lice obavlja;
- 9) ko liši života dete ili bremenitu ženu;
- 10) ko liši života člana svoje porodice kojeg je prethodno zlostavljao i
- 11) ko sa umišljajem liši života više lica, a ne radi se o ubistvu na mah, ubistvu deteta pri porođaju ili lišenju života iz samilosti.

Opšti elementi teškog ubistva su isti kao i kod krivičnog dela ubistva. Ono po čemu se ovo delo razlikuje su neki od elemenata koji ubistvo čine težim, koji su vezani za način izvršenja, motiv, okolnosti izvršenja ili koji su vezani za svojstvo pasivnog subjekta³.

2.1. Oblici teškog ubistva

¹ D. Atanacković, **Krivično pravo - posebni deo, Beograd, 1985. godina, str.135.**

² D. Jovašević, **Krivična dela protiv života i državna reakcija u Republici Srbiji, Zbornik radova, Teški oblici kriminala i državna reakcija, Trebinje, 2013. godine, str. 269-287.**

³ D. Jovašević, **Praktikum za Krivično pravo – Posebni deo, Medinvest, Niš, 2014. godine, str. 13-14.**

Teška ubistva prema načinu izvršenja su: 1) ubistvo na svirep način i 2) ubistvo na podmukao način:

1) Lišenje života na svirep način

Ubistvo na svirep način karakteriše poseban način izvršenja koji dovodi do nepotrebnog nanošenja bola, muka i patnji žrtvi ubistva. Bol ne mora da bude samo fizički, nego i psihički (strah za sopstveni život, posmatranje ubistva druge osobe...). Budući da je svako lišenje života praćeno nanošenjem bola i izazivanjem straha, kod ovog dela bolovi i patnje se nanose s ciljem da se što više namuču žrtva, pa oni po intezitetu i trajanju prevazilaze bolove i patnje koji prate obično ubistvo. Za postojanje ovog dela potrebno je da su preduzete delatnosti objektivno okrutne i stravične, te da je žrtva u svesnom stanju, tako da doživljava i trpi njihovu surovost uz veliki bol, strah i patnju. Pored toga, potrebno je i da je učinilac dela svestan surovih i nečovečnih akata koje voljno preduzima.

Obeležja krivičnog dela ubistva na svirep način su izražena:

- 1) u radnji izvršenja - koja se sastoji u lišavanju života;
- 2) i posledici - koja se ispoljava u nastupanju smrti i
- 3) u subjektivnom elementu - umišljaju učinioca da sa radnjom izvršenja prouzrokuje smrt¹.

Tipični primeri ovog krivičnog dela bili bi mrcvarenje žrtve postupnim sakaćenjem ili nanošenjem više povreda, polivanje žrtve benzinom i njeno paljenje, premlaćivanje do smrti itd.

Što se tiče postojanja direktnog umišljaja kod krivičnog dela teškog ubistva, u presudi Vrhovnog suda Srbije broj Kž. 618/2004, ne može se dovoditi u pitanje postojanje direktnog umišljaja, kada je izvršilac dela udarcima noža naneo oštećenom šest uboda u predelu trbuha i grudi, i pored toga što je nakon kritičnog događaja pokušao da zaustavi krvarenje oštećenog².

„Svirepost izvršenog krivičnog dela mora da ima svoju objektivnu stranu koja se ogleda u nanošenju žrtvi nepotrebnih patnji koje prevazilaze patnje koje obično prate svako lišavanje života i svoju subjektivnu komponentu koja se ogleda u svesti okrivljenog da muči žrtvu i njegovom htenju da to čini i da stoga postupa na navedeni način. Pravilno je prvostepeni sud našao da se objektivna strana svireposti izvršenja ovog krivičnog dela ogleda u nanošenju žrtvi nepotrebnih patnji koje prevazilaze patnje koje obično prate svako ubistvo, pored 20 ubodno-sekotnih rana u prednjoj strani vrata, grudnog koša i trbuha, okrivljeni je prethodno, sada pokojnoj naneo 37 plitkih ubodina dubine do 5 cm na prednjoj strani vrata, u donjem delu grudnog koša sa prednje strane, na prednjoj strani trbuha, pri čemu su joj navedene povrede nanete u više navrata kada je osećala bol i strah za svoj život i braneći se u pokušaju da se spase oštećena je zadobila i tri oguljotine na rukama hvatajući golim rukama nož kojim je napadnuta, pri čemu je sve vreme odbrane osećala maksimalni strah do stepena užasa zbog osećanja ugroženosti za svoj život, pri

¹ Z. Stojanović, O. Perić, Krivično pravo – Posebni deo, Pravna knjiga, op. cit., str. 30.

² D. Kolarić, Krivično delo ubistva, Službeni glasnik, Beograd, 2008. godine, strana 301.

čemu je zadobijanjem svake sledeće povrede, do gubitka svesti, osećala sve veći bol, koji je povećavao osećaj straha i ugroženosti za sopstveni život, pri čemu je bol, patnju i strah za sopstveni život oštećena osećala u dužem vremenskom periodu, za sve vreme događaja, koji je trajao gotovo čitavo pre podne od ranih jutarnjih časova“¹.

Takođe, u presudama apelacionih sudova u Kragujevcu i Beogradu, navodi se sledeće: „Nanošenje usmrćenom većeg broja udaraca drvenom motkom ne mora automatski da znači da se radi o ubistvu na svirep način. Po oceni suda pri razgraničenju običnog ubistva od ubistva na svirep način polazi se od ocene objektivnih okolnosti koje se sastoje u težini prouzrokovanih muka, patnji i bolova žrtve i subjektivnih okolnosti koje se ogledaju u neosetljivosti učinioca ili njegovoj želji da žrtvi nanosi muke, patnje, bolove i osećanjem zadovoljstva takvim načinom lišenja života. Prema oceni suda potrebno je da budu kumulativno ispunjena oba ova elementa. Ocene za težu kvalifikaciju ne leže samo u značaju tehničkog lišenja života, nego i u psihičkom odnosu učinioca koji on ovakvim načinom izvršenja dela pokazuje. Stoji činjenica da je okrivljeni oštećenom naneo više udaraca drvenom motkom i to jednom u predelu ruke, zatim još nekoliko udaraca u predelu glave i da je žrtva trpela bolove velikog inteziteta. Međutim, kako je utvrđeno da je od trećeg udarca motkom u predelu glave usmrćenom naneta jedna od smrtonosnih povreda, u tom momentu je došlo do gubitka svesti kod istog, pa bol od povreda nanetih kasnijim udarcima više nije osećao. Bolove jakog inteziteta žrtva je trpela u kratkom vremenskom periodu, a naneti bolovi oštećenom nisu prevazilazili okvir redovnih bolova s kojima je skopčano svako lišenje života“².

„Svirepost kao obeležje krivičnog dela teškog ubistva ima svoju objektivnu komponentu, koja se ogleda u nanošenju nepotrebnih patnji žrtvi i subjektivnu komponentu, koja se sastoji u nameri okrivljenog da muči žrtvu. Apelacioni sud je uvidom u spise utvrdio da prvostepeni sud uopšte nije dao razloge o odlučnoj činjenici da li je oštećeni kritičnom prilikom trpeo nepotrebne patnje koje prevazilaze patnje koje prate svako lišenje života, a koje okolnosti bi ukazivale na svirepost ubistva oštećenog. Prvostepeni sud u obrazloženju presude, takođe, ne daje razloge o tome da li su okrivljeni kritičnom prilikom bili svesni i nastupali sa namerom da oštećenom nanesu prekomerne bolove i patnje, te da li je takva namera okrivljenih eventualno mogla da se utvrdi iz njihovog ponašanja. Pored navedene objektivne komponente svireposti, koja se ogleda u nanošenju nepotrebnih patnji žrtvi, neophodno je i postojanje subjektivne komponente svireposti, koja se sastoji od namere okrivljenih da muče žrtvu, odnosno da su okrivljeni bili svesni da svojim postupanjem nanose prekomerne bolove i patnje oštećenom i da su to hteli, što je sve od značaja za kvalifikaciju radnji koje se okrivljenom stavljaju na teret“³.

2) Lišenje života na podmukao način

¹ Presuda Apelacionog suda u Beogradu Kž. 351/2012 od 19. aprila 2012. godine, Bilten Višeg suda u Beogradu, Beograd, broj 83/2013. godine, str. 14-15.

² Presuda Apelacionog suda u Kragujevcu Kž. 3141/2010 Bilten sudske prakse Apelacionog suda, Kragujevac, broj 2/2010. godine, str. 40-41.

³ Presuda Vrhovnog suda Srbije Kž. 1077/2004 od 28. septembra 2004. godine, Revija za kriminologiju i krivično pravo, Beograd, broj 1/2006. godine, str. 225.

Ubistvo na podmukao način je ubistvo koje izvršava lukav učinilac na prikriven, potajan način. Podmuklost se sastoji iz toga da žrtva ne očekuje napad, niti može da pretpostavi da joj pretila opasnost od učinioca. Žrtva usled toga nije u mogućnosti da se brani, niti da drugoga pozove u pomoć. Veoma je bitan element poverenja između žrtve i učinioca. Primeri ovog krivičnog dela su ubistvo s leđa, iz zasede, na spavanju i slično. Za izvršenje dela koristi se poverenje žrtve prema učiniocu dela koje se zasniva na srodstvu, prijateljstvu, ljubavi, poštovanju, ugledu.

Podmuklost se manifestuje kroz objektivne (delo se preduzima potajno i prikriveno) i subjektivne (zla namera učinioca) elemente. Podmuklost je subjektivno-objektivna kategorija. Objektivna strana se ogleda u načinu delovanja, a subjektivna u naročito ispoljenoj lukavosti i prepedenosti učinioca. To je negativna ljudska osobina¹.

Na objektivnom planu potrebno je da se radi o posebno prikrivenom, odnosno potajnom načinu preduzimanja radnje, a na subjektivnom planu potrebno je da kod učinioca bude posebno izražena lukavost, prevarno postupanje, kao i zloupotreba poverenja žrtve ili njene bezazlenosti. Na primer, to bi moglo biti ubistvo supružnika za vreme spavanja, trovanje žrtve pozvane kao gosta, ubistvo iz zasede s tim da je žrtva na prevaran način namamljena na određeno mesto itd. U svakom slučaju, iako neki načini izvršenja ukazuju na ubistvo na podmukao način (npr. ubistvo trovanjem), to samo po sebi nije dovoljno već je neophodno da postoji i neki dodatni element koji ukazuje da je ubistvo izvršeno na podmukao način.

Postoje i specifične situacije gde se na osnovu okolnosti konkretnog slučaja može zaključiti da postoji podmuklost kao kvalifikatorna okolnost. Tako je, na primer, učinilac koji je posle fizičkog obračuna sa žrtvom, prethodno uzevši nož sa stola pokrivši nož kuhinjskom kecljom, ponudio ruku žrtvi u znak navodnog pomirenja i dok se rukovao sa tri udarca nožem lišio je života, izvršio ubistvo na podmukao način. Sudska praksa uzima da je subjektivni element ubistva na podmukao način ostvaren i onda kada učinilac smišljeno vrši krivično delo u situaciji kada se žrtva tome ne nada i kada ne može da pruži nikakav otpor. Objektivni element se sastoji i u načinu delovanja, prikrivenom postupanju, korišćenju posebnog sredstva npr. otrova koji se teško otkriva, kojim je olakšano izvršenje dela, a subjektivni element se sastoji u krajnjoj lukavosti izvršioca, prepedenosti i njegovoj dvoiličnosti, smišljenosti zbog koje oštećeni ne očekuje napad te ne može da pruži nikakav otpor. Dakle, da bi se moglo uzeti da je delo ubistva izvršeno na podmukao način, nije dovoljno da se podmuklost izvršenja dela ceni samo objektivno, tj. kroz okolnosti koje ukazuju da žrtva nije očekivala ubistvo i slično, već i subjektivno - kroz okolnosti koje ukazuju da je učinilac lukavo, prevarno, prepedeno ili smišljeno odabrao takav način izvršenja dela kojim će žrtvu lišiti života onda kada se ona tome ne nada i ne može da se brani ili da to onemogući.

Da bi postojala podmuklost, kao kvalifikatorno obeležje krivičnog dela ubistva potrebno je da se ona manifestuje u takvim postupcima koji ukazuju na zao karakter izvršioca dela. Učinilac koji drugog liši života na podmukao način pristupa izvršenju ovog krivičnog dela redovno iskorišćavajući bezazlenost i poverenje žrtve, što ne mora uvek biti slučaj. Naime, o ovom obliku ubistva radiće se i u slučaju u kome postupanje učinioca pri izvršenju dela

¹ Z. Đurđević, Krivična dela ubistva, Službeni glasnik, Beograd, 2014. godine, strana 256.

se pokazuje kao rezultat ostvarenja brižljivo i perfidno pripremljenog plana, koji je po svom kvalitetu neobičan, izuzetan i za žrtvu neočekivan, a ujedno i kao odraz negativnih karakteristika, osobina i bojazni učinioca da se sa žrtvom otvoreno obračuna, koristeći prednost iznenađenja i neočekivanosti, stavljajući žrtvu u bespomoćno stanje i nemogućnost da na napad neposredno i efikasno reaguje i da na taj način uz manji otpor ostvari najtežu posledicu.

Sudska praksa beleži različite životne događaje koje, iako na prvi pogled liče na ubistva na podmukao način, ipak to nisu. Tako na primer: „Činjenica da je ubistvo izvršeno puškom iz zasede, sama kao takva nije dovoljna da se delo pravno oceni kao krivično delo ubistvo na podmukao način. Naime, u postupanju učinioca koji je žrtvu sačekao u šumi u zasedi i ubio ga hicem iz puške, ne ogleda se dovoljan stepen podmuklosti, ili naročito poverenja žrtve prema učiniocu u svrhu omogućavanja odnosno olakšanja izvršenja ubistva da bi se takvo postupanje moglo oceniti kao podmuklo. Takođe, lišenje neke osobe na spavanju ne predstavlja već samo po sebi podmukao način izvršenja dela, bez postojanja ostalih objektivnih i subjektivnih elemenata, koje su u tom slučaju izostale. Međutim, kada je utvrđeno da je učinilac lišio života oštećenog koji je spavao, dok su spavali i ostali ukućani i da je pri tom iskoristio takvo stanje oštećenog lišenog svake mogućnosti odbrane i mogućnosti pružanja tuđe pomoći, a pre svega poverenje koje je oštećeni prema njemu imao kao svom bliskom rođaku, onda je u tom slučaju pravilno takvu radnju učinioca oceniti kao podmukao način izvršenja ubistva“¹.

Teška ubistva s obzirom na pobude izvršioca su: 1) ubistvo iz koristoljublja, 2) ubistvo radi izvršenja ili prikrivanja drugog krivičnog dela i 3) ubistvo iz bezobzirne osvete i 4) ubistvo iz drugih niskih pobuda.

Kada je reč o ovim ubistvima, bitno je obratiti pažnju na posebne motive ubistva. Ovo ubistvo može da bude izvršeno samo sa direktnim umišljajem. U ovu grupu spadaju:

- 1) Ubistvo iz koristoljublja - kada se želi steći materijalna korist ubistvom (ubistvo tetke radi sticanja nasledstva);
- 2) Ubistvo radi izvršenja ili prikrivanja drugog krivičnog dela - kada se počini ubistvo da bi se olakšalo izvršenje drugog krivičnog dela (ubija se telohranitelj kako bi se kidnapovao njegov štićenik), ili kada se prikriva drugo ranije izvršeno krivično delo (ubistvo svedoka);
- 3) Ubistvo iz bezobzirne osvete – ovo delo postoji ako je žrtva učiniocu ranije nanela bol ili patnju, koja je znatno manja od lišenja života (npr. javno ga je ponizila, pa je učinilac rešio da je ubije) i

¹ D. Jovašević, Ubistvo na svirep i podmukao način, Pravni život, Beograd, broj 9, 2006. godine, str. 105.

- 4) Ubistvo iz drugih niskih pobuda - ovim ubistvom se smatra ubistvo zbog zavisti, mržnje, pakosti, ljubomore i slično¹.

1) Ubistvo iz koristoljublja

Ubistvo iz koristoljublja je lišavanje života drugog lica u nameri da se dođe do prekomerne i nepotrebne imovinske koristi za sebe ili drugo fizičko ili pravno lice. Ta korist može da bude imovinska ili neimovinska. Postizanje materijalne koristi smatra se, kako ostvarenje materijalne dobiti, tj. uvećanje imovine, tako i sprečavanje umanjenja imovine do koga je inače trebalo da dođe.

Pobuda koja učinioca motiviše na preduzimanje radnje izvršenja se javlja u vidu pohlepe, požude za prekomernim i nepotrebnim sticanjem i uvećanjem materijalne koristi, odnosno sprečavanjem njenog umanjenja. Ovde se ne radi o ubistvu radi zadovoljenja osnovnih egzistencijalnih potreba. Za postojanje dela je potrebno da se radnja izvršenja preduzima u navedenoj pobudi, bez obzira da li je ona ostvarena u konkretnom slučaju. Za postojanje ovog, teže kvalifikovanog oblika krivičnog dela ubistva, nema značaja da li je u vreme ubistva ili kasnije željena imovinska korist i pribavljena. Dovoljno je da je motiv za izvršenje dela bila koristoljubiva namera. Takva ubistva su: kod ubistva za nagradu, zatim ubistva radi postizanja nasleđa, ubistvo poverioca da bi se izbeglo plaćanje duga, ubistvo poslovnog partnera radi uklanjanja konkurencije i sl.

2.) Ubistvo radi izvršenja ili prikrivanja drugog krivičnog dela

Ubistvo radi izvršenja ili prikrivanja drugog krivičnog dela je lišenje života drugog lica kako bi se omogućilo ili olakšalo izvršenje drugog krivičnog dela ili da bi se prikrilo ranije izvršeno krivično delo uklanjanjem nekog lica kao svedoka, saučesnika ili oštećenog. Ovo delo ima dva vida.

Prvi vid postoji kada se lišava života lica kako bi se uklonilo kao prepreka, smetnja za izvršenje planiranog krivičnog dela. Ovo drugo delo ne mora da bude izvršeno, ali njegovo ostvarenje mora da predstavlja pobudu za izvršenje ubistva. Ako je planirano krivično delo izvršeno ili pokušano, a za pokušaj se kažnjava, tada postoji sticaj između ubistva i tog drugog dela.

Drugi vid postoji kada se drugo lice (svedok, žrtva ili saučesnik) lišava života da bi se uklonilo kao svedok ranije izvršenog krivičnog dela. Za postojanje dela je bez značaja da li je ranije izvršeno krivično delo otkriveno ili nije, kao i u kom je svojstvu učinilac ovog dela učestvovao u ranijem delu: kao izvršilac ili saučesnik².

3. Ubistvo iz bezobzirne osvete ili iz drugih niskih pobuda

¹ Lj. Čumburović, *Ubistva u Novom Pazaru, Beograd, 2007. godine, str. 101 i 120.*

² M. Davidović, *Ubistvo iz koristoljublja i ubistvo pri izvršenju razbojništva, Advokatska komora Vojvodine, Novi Sad, 2001. godine, str. 121.*

Ubistvo iz bezobzirne osvete ili drugih niskih pobuda je lišenje života, kome učinilac pristupa motivisan posebnom vrstom pobude – bezobzirom osvetom ili drugim niskim pobudama bez obzira da li su ove pobude u konkretnom slučaju i ostvarene.

Ubistvo iz bezobzirne osvete je lišavanje života drugog lica iz egoističkih i samoživih pobuda, koje karakterišu učinioca kao bezosećajnu i asocijalnu ličnost.

Ovde učinilac lišava života drugo lice zato što je prethodno njemu ili njemu bliskom licu nanelo zlo, koje je po svom karakteru, obimu, prirodi i težini značajno manje od ubistva kojim ovaj uzvrća. Dakle, ovog dela nema ako je zlo koje je naneto od ubijenog bilo veliko, srazmerno posledici smrti kojom uzvrća učinilac dela, jer bezobzirna osveta znači znatnu nesrazmeru između zla koje je učinjeno i lišenja života, tako da se na osnovu takvog povoda nikako ne može opravdati¹.

Za postojanje krivičnog dela ubistva iz bezobzirne osvete, dovoljno je da je učinilac u ubeđenju da je zlo za koje se sveti naneto i da se zato odlučio na ubistvo².

Ovo delo postoji i kad se osveta vrši posle dužeg vremenskog perioda. Bezobzirnost osvete se mora procenjivati u svakom konkretnom slučaju, kako sa objektivnog, tako i sa subjektivnog stanovišta. Ubistvo iz bezobzirne osvete postoji ako se ostvari jedan od sledećih uslova: 1) ako se osveta ubistvom manifestuje kao reakcija na neko drugo delo, a ne na delo ubistva, 2) ako je objekt osvete neka druga osoba, a ne izvršilac ili saizvršilac ranije učinjenog zla, 3) ako osveta ubistvom obuhvata više osoba, bez obzira na to da li ima više saizvršilaca ili žrtava ranijeg ubistva, 4) ako ubistvo iz osvete dolazi kao reagovanje na ubistvo koje je i samo izvršeno iz osvete (osveta na osvetu)³.

Za postojanje krivičnog dela ubistva iz bezobzirne osvete dovoljno je da je učinilac u ubeđenju da je zlo za koje se sveti naneto i da se zbog toga i odlučio na ubistvo. Pravilno je prvostepeni sud, na osnovu uvida u priložene parnične i izvršne spise, utvrdio odlučne činjenice da su oštećeni i sudski izvršitelj došli u kuću okrivljenog radi naplate duga od 4.250,00 dinara, da je okrivljeni uputio oštećenom reči: „dokle ćete dolaziti, recite šta hoćete“, a kada je oštećeni počeo da beži u pravcu kapije, okrivljeni je pucao iz svog pištolja u pravcu oštećenog i usmrtio ga. Navedene kvalifikatorne okolnosti (prema kom licu se vršila osveta i povodom kog događaja se vrši osveta), ukazuju da se radi o krivičnom delu ubistva iz bezobzirne osvete. Za postojanje ovog krivičnog dela dovoljno je da učinilac stoji u ubeđenju da je zlo za koje se sveti naneto i da se zbog toga i odlučio na ubistvo.

Ubistvo iz drugih niskih pobuda postoji kada se lišenju života drugog lica pristupa radi zadovoljenja amoralnih težnji, niskih strasti i nastranosti, kao što je ubistvo iz: ljubomore,

¹ D. Jovašević, Krivična dela protiv života i državna reakcija u Republici Srbiji, Zbornik radova, Teški oblici kriminala i državna reakcija, Trebinje, 2013. godine, strana 269-287.

² Presuda Vrhovnog suda Srbije Kž. 1077/2004 od 28. septembra 2004. godine, Revija za kriminologiju i krivično pravo, Beograd, broj 1/2006. godine, strana 225.

³ N. Delić, Kvalifikovana/teška ubistva, Ubistva i samoubistva u Jugoslaviji, Kopaonik, 1998. godine, strana 80.

mržnje, pakosti, nacionalne, polne, etničke ili rasne netrpeljivosti, radi zadovoljenja nastranih seksualnih prohteva¹.

Ubistvo iz drugih niskih pobuda odnosi se na ostale slučajeve izvršenja ubistva iz amoralnih pobuda, koji ne obuhvata ubistvo izvršeno iz koristoljublja i ubistvo izvršeno iz bezobzirne osvete. Tako se, na primer, ubistvo iz drugih niskih pobuda vrši iz mržnje, ljubomore, pakosti, pohlepe, zlobe, radi dolaženja do radnog mesta ubijenog i drugo².

Teška ubistva s obzirom na okolnosti izvršenja i posledicu su: 1) ubistvo pri bezobzirnog nasilničkom ponašanju, 2) ubistvo kojim se sa umišljajem dovodi u opasnost život još nekog lica, 3) ubistvo pri izvršenju razbojništva i razbojničke krađe i 4) ubistvo više lica.

1) Ubistvo pri bezobzirnog nasilničkom ponašanju

Ubistvo pri bezobzirnog nasilničkom ponašanju smatra se težim oblikom ubistva zbog nasilničkog, siledžijskog ili huliganskog ponašanja učinioca koje je prethodilo ubistvu. Uglavnom je reč o ubistvima bez povoda, kada se ubija iz obesti i hira. Ubistvo pri bezobzirnog nasilničkom ponašanju postoji kada se ucinilac u toj meri bezobzirno nasilnički ponaša, da čak i ubije žrtvu.

Nasilničko ponašanje, ako nije došlo do ubistva, može da predstavlja posebno krivično delo. Nasilničkim ponašanjem se smatra grubo vređanje (teška povreda časti i ugleda žrtve), zlostavljanje (postupci kojima se drugom licu prouzrokuje fizička ili psihička neprijatnost ili nelagodnost poput pljuvanja, čupanja za kosu, potezanja za kragnu, kidanja delova odeće i slično), nasilje (primena fizičke sile prema drugom licu), izazivanje tuče (provociranje fizičkog sukoba sa drugim licem/licima), kao i drsko i bezobzirno ponašanje (svako ponašanje koje prilično odudara od normalnog, prosečnog ponašanja: situacije poput guranja ljudi, uništavanja kontejnera, prevrtanja i paljenja automobila i slično)³.

Pri ovom ubistvu nasilničko ponašanje mora da prevaziđe uobičajenu meru, ono mora da bude bezobzirno. Neki od načina da se proceni bezobzirnosti ponašanja jesu: da li je žrtva dala povoda za napad, pod kojim okolnostima se vrši nasilje, intenzitet nasilja, upotrebljena sredstva i slično. Važan element ovog ubistva je da se ono desilo tokom bezobzirnog nasilničkog ponašanja, a ne pre ili posle njega. Nije bitno ko je pasivni subjekt ovog ubistva, da li lice prema kome je vršeno bezobzirno nasilničko ponašanje ili prolaznik koji je zastao da pomogne takvom licu.

Ubistvo pri bezobzirnog nasilničkom ponašanju je dvoaktno krivično delo koje se sastoji iz dve nužno povezane delatnosti: a) nasilničkog ponašanja (kao krivičnog dela protiv javnog reda i mira), koje je po stepenu, težini i dužini trajanja, odnosno prouzrokovanim posledicama dobilo karakter bezobzirnog nasilničkog ponašanja i b) ubistva (kao

¹ Presuda Vrhovnog suda Srbije Kž. 1077/2004 od 28. septembra 2004. godine, Revija za kriminologiju i krivično pravo, Beograd, broj 1/2006. godine, str. 225.

² Videti: <http://pravniportal.rs/?pos=2&cat=anali&id=135>, pristup 25.04.2016. godine.

³ Pravni život, Beograd, broj 9, O ubistvima, od 1996. – 2015. godine.

krivičnog dela protiv života). Ovde se radi o lišavanju života drugog lica koje je rezultat obesti, bahatosti, bezobzornosti i osionosti koje karakterišu učinioca kao asocijalnu i rušilačku ličnost. Pre izvršenja krivičnog dela ubistva učinilac se ponaša drsko, krajnje bezobzirno, bahato, maltretira žrtvu, izaziva tuču, grubo zlostavlja i vređa žrtvu i slično, što znači da je u pitanju tipično siledžijsko ponašanje. To je, u najširem značenju, fizičko ili psihičko maltretiranje drugog lica. Tri su obeležja za pravilno određivanje sadržine ovog krivičnog dela, i to:

- postojanje nasilničkog ponašanja učinioca krivičnog dela;
- postojanje bezobzornog nasilničkog ponašanja i
- lišavanje života drugog lica pri takvom ponašanju¹.

2) Ubistvo pri kome je sa umišljajem doveden u opasnost život još nekog lica

Ovaj oblik ubistva postoji kada se pored lišenja života jednog lica u opasnost dovodi i život drugog lica ili više drugih lica. Ubistvo pri kojem je sa umišljajem doveden u opasnost život još nekog lica postoji kada je ubistvo izvršeno na takav način ili u takvim uslovima da je učinilac prouzrokovao sa umišljajem i konkretnu opasnost za život još nekog lica (na primer, ubistvo pucanjem na lice koje se nalazilo u grupi ili je ubistvo izvršeno bacanjem bombe čime su pored ubijenog bila ugrožena i druga lica). Klasični primeri za ovo ubistvo su: ubistvo bombom ili eksplozivom, ubistvo rafalom iz vatrenog oružja uperenog prema grupi lica, naletanje automobilom na grupu pešaka i slično.

Krivično delo ubistva pri kome je sa umišljajem doveden u opasnost život još nekog lica karakteristično je po opšteopasnom načinu ili sredstvu izvršenja na mestu na kojem postoji mogućnost da nastupi smrt većeg broja ljudi i poseban oblik krivice izvršioca ovog krivičnog dela. Drugim rečima, opasnost za život se sastoji u upotrebi takvog sredstva za izvršenje krivičnog dela kojim se dovodi u opasnost život još nekog lica, pri čemu opasnost mora biti konkretna².

Sličnost ovog dela postoji sa krivičnim delom ubistva više lica koje je ostalo u pokušaju. Način da se razgraniče ova dva oblika krivičnog dela jeste subjektivni element tj. umišljaj (da li je izvršilac želeo da ubije samo jedno lice ili je želeo da ubije više lica)³.

Ovde se radnja izvršenja preduzima opšteopasnom delatnošću ili opšteopasnim sredstvom na mestu ili pod okolnostima gde postoji objektivna mogućnost, opasnost da nastupi smrt većeg broja lica. Svest da će preduzetom radnjom biti prouzrokovana opasnost po život i drugih lica upotrebljenim načinom ili sredstvom mora da postoji na strani učinioca, pa on pristaje da i pored takve svesti ipak preduzme radnju. To znači da učinilac radnju lišavanja života jednog lica preduzima sa direktnim umišljajem, dok u odnosu na posledicu ugrožavanja (konkretne opasnosti) života drugih lica postupa sa eventualnim umišljajem. Da bi postojalo umišljajno dovođenje u opasnost života još nekog lica pri izvršenju

¹ J. Đ. Tahović, Krivično pravo, Naučna knjiga, Beograd, 1953. godine, str. 343.

² M. Đorđević, Đ. Đorđević, Krivično pravo, Beograd, 2003, godine, Priručnik za polaganje pravosudnog ispita, knjiga 2, strana 122.

³ S. Jakovljević, Krivično delo ubistva na svirep način, Beograd, 1975, Jugoslovenska revija za kriminologiju i krivično pravo br. 3, str. 361.

ubistva, ta opasnost za drugo lice mora stvarno i da nastupi, što znači da mora da bude konkretna, a ne apstraktna¹.

„Da bi postojalo umišljajno dovođenje u opasnost života još nekog lica pri izvršenju ubistva, ta opasnost za drugo lice mora stvarno nastupiti, što znači da mora biti konkretna, a ne apstraktna. Prvostepeni sud u razlozima presude samo ukazuje na činjenicu da se u prostoriji u kojoj je okrivljeni ispalio više hitaca iz pištolja nalazilo više lica, ali ne daje razloge na osnovu čega je zaključio da su i ta druga lica bila ugrožena, odnosno da je u odnosu na njih u konkretnom slučaju nastupila konkretna opasnost“².

Ovo delo postoji kada je optuženi ispalio sedam projektila iz pištolja u pravcu putničkog automobila, pa bude pogođen oštećeni, koji je sedeo na mestu suvozača i koji je usled nastupelih povreda preminuo. Tom je prilikom sa umišljajem doveden u opasnost i život drugog lica tj. vozača automobila³.

Isto tako, u praksi se navodi presuda Vrhovnog suda Srbije broj Kž. 211/2004 od 23. marta 2004. godine, gde stoji da: „Kada je okrivljeni pištolj prislonio na slepoočnicu oštećenom, pa ga je odgurnuo i potom uperio pištolj u grudi oštećenom na rastojanju od 1,5 metara i opalio projektil koji je oštećenog pogodio u rame i naneo mu teške telesne povrede, pa nakon prolaska projektila kroz telo oštećenog isti je pogodio drugog oštećenog u nogu i naneo mu lake telesne povrede, a sve se to dogodilo na ulazu u kafić gde je bilo više ljudi, time je izvršio krivično delo ubistva u pokušaju. Prvostepenom presudom okrivljeni je oglašen krivim zbog izvršenja krivičnog dela ubistva u pokušaju. Povodom žalbe branioca okrivljenog, drugostepeni sud je u presudi, kojom je odbijena žalba kao neosnovana, naveo da je neosnovano isticanje da se u konkretnom slučaju radi o izvršenju krivičnog dela teške telesne povrede. Naime, okrivljeni je sa umišljajem pokušao da liši života oštećenog tako što je sa umišljajem doveo u opasnost život više lica. Naime, okrivljeni je prvo došao u verbalni sukob sa oštećenim, naslonio mu pištolj na slepoočnicu, odgurnuo ga i na rastojanju od 1,5 metara uperivši cev pištolja u grudi oštećenom ispalio projektil koji je oštećenog pogodio u rame, pa je projektil koji je izašao iz tela oštećenog pogodio drugog oštećenog u nogu, kome je naneta laka telesna povreda, a sve se to desilo na ulazu u kafić u kome se nalazilo više ljudi. Dakle, radnja okrivljenog je umišljajna radnja preduzeta sa eventualnim umišljajem, a ne nehatno nanošenje teške telesne povrede kako se to ističe u žalbi“⁴.

3) Ubistvo pri izvršenju krivičnog dela razbojništva ili razbojničke krađe

Pri ovom ubistvu zakonodavac stavlja kao primarni objekt zaštite život lica, a kao sekundarni objekt zaštite imovinu drugog lica. Ubistvo pri izvršenju krivičnog dela razbojništva i rabojničke krađe je, u stvari, složeno krivično delo koje se sastoji iz razbojništva i ubistva ili iz razbojničke krađe i ubistva, pri čemu ovakav događaj Krivični

¹ Presuda Vrhovnog suda Srbije broj Kž. 885/2006.

² Presuda Vrhovnog suda Srbije Kž. 885/2006 od 17. oktobra 2006. godine, Bilten Okružnog suda u Beogradu, Beograd, broj 75/2007. godine, str. 108.

³ Presuda Vrhovnog suda Srbije broj Kž. 679/2004.

⁴ **Presuda Vrhovnog suda Srbije Kž. 211/2004 od 23. marta 2004. godine, Izbor sudske prakse, Beograd, broj 1/2005. godine, str. 37-38.**

zakonik tretira kao jedno krivično delo, za čije postojanje treba da budu ostvareni elementi za oba krivična dela, s tim da ubistvo treba da je učinjeno pri izvršenju razbojništva, odnosno razbojničke krađe. Ukoliko postoji lišenje života jednog lica pri izvršenju krivičnog dela razbojništva ili razbojničke krađe, i ukoliko postoji umišljaj učinioca, onda se može govoriti o ovom obliku teškog ubistva. Žrtva ovog ubistva može biti vlasnik od kojeg se stvar oduzima, kao i svako treće lice koje se zateklo na mestu događaja¹.

Ovaj oblik teškog ubistva je složeno krivično delo jer u sebi sadrži krivično delo razbojništva (član 206.), odnosno razbojničke krađe (član 205.) i krivično delo ubistva (član 113. i 114). Takođe, i razbojništvo je složeno krivično delo koje se sastoji iz krađe i prinude, pri čemu se upotrebom prinude oduzimaju tuđe pokretne stvari. Za postojanje ubistva pri izvršenju razbojništva potrebno je da budu ispunjena tri uslova koja se odnose na povezane delatnosti: radnja primene prinude prema nekom licu, radnja oduzimanja tuđe pokretne stvari i radnja protivpravnog lišenja života drugog lica sa umišljajem. Biće krivičnog dela ubistva pri izvršenju razbojništva se sastoji u tome da se prvo preduzima sila u nameri oduzimanja tuđe pokretne stvari, a zatim se neko drugo lice lišava života, gde se smrtna posledica javlja kao rezultat prethodno primenjene sile.

Za razliku od ubistva pri vršenju razbojništva gde primena sile prethodi vršenju krađe, kod ubistva pri razbojničkoj krađi učinilac prvo vrši krađu, a zatim prinudu u cilju zadržavanja ukradene stvari, pri čemu kao posledica primenjene sile nastaje sa umišljajem posledica smrti jednog ili više lica².

Važan element ovog ubistva je da je posledica smrti nastala tokom izvršenja krivičnog dela razbojništva ili razbojničke krađe, bez obzira na to da li je ovo delo dovršeno ili je ostalo u pokušaju. Ubistvo pri izvršenju razbojništva ili razbojničke krađe je dvoaktno krivično delo kod koga učinilac prvo preduzima silu (apsolutnu ili kompulzivnu) u cilju oduzimanja tuđe pokretne stvari, odnosno u nameri da prethodno ukradenu stvar zadrži, i potom sa umišljajem lišava života drugo lice (smrt nastupa kao posledica primenjene sile, bez obzira da li je to vlasnik ili držalac oduzete stvari ili slučajni posmatrač ili prolaznik)³. Razlika između ovog dela i ubistva iz koristoljublja je što ubistvo iz koristoljublja predstavlja lišenje života drugog lica u nameri da se dođe do prekomerne i nepotrebne imovinske koristi za sebe ili drugo fizičko ili pravno lice. Kod ubistva pri izvršenju krivičnog dela razbojništva ili razbojničke krađe učinilac prvo preduzima silu (apsolutnu ili kompulzivnu) s ciljem oduzimanja tuđe pokretne stvari, odnosno u nameri da prethodno ukradenu stvar zadrži i potom sa umišljajem lišava života drugo lice, dok kod ubistva iz koristoljublja smrt drugog lica nastupa i bez primenjene sile. Znači, razlika je u pobudi za izvršenjem krivičnog dela ubistva tj. krivičnog dela krađe, gde se kod koristoljublja javlja pobuda u vidu pohlepe, požude za prekomernim i nepotrebnim sticanjem i uvećanjem

¹ M. Radovanović, *Krivično pravo SFRJ, Opšti deo, četvrto izdanje*, Savremena administracija, Beograd, 1975. godine, strana 302.

² M. Marković, Z. Pavlović, P. Stanojević, *Ubistvo pri vršenju krivičnog dela razbojništva i razbojničke krađe, Pravo – teorija i praksa*, Novi Sad, broj 7-8, 2009. godine, str. 36.

³ Lj. Jovanović, V. Đurđić, D. Jovašević, *Krivično pravo, Posebni deo, Službeni glasnik, Beograd, 2004. godine, strana 110.*

materijalne koristi, dok kod razbojništva ili razbojničke krađe može da bude u pitanju zadovoljenje osnovnih egzistencijalnih potreba¹.

4) Umišljajno ubistvo više lica

Ovo krivično delo postoji kada izvršilac lišava sa umišljajem života najmanje dva lica. Nije neophodno da je učinilac imao svojstvo izvršioca kod svih ubistava, nego je kod nekih dela mogao biti i saučesnik (podstrekač ili pomagač). Krivično delo ubistva više lica je dovršeno ukoliko je učinilac sa umišljajem lišio života barem dva lica, jednom ili više radnji, u isto ili različito vreme.

Primer za ovo ubistvo je podmetanje bombe pod autobus koja eksplodira tokom vožnje. Ubistvo više lica je teško ubistvo s obzirom na obim i intezitet posledice kada se sa jednom ili više radnji sa umišljajem liši života više lica, a ne radi se o ubistvu na mah, ubistvu deteta pri porođaju ili lišenju života iz samilosti. Za postojanje višestrukog ubistva potrebno je ispunjenje više elemenata:

- a) da je ubistvo izvršeno u idealnom ili realnom sticaju ili u povratu,
- b) da su sva ubistva izvršena sa umišljajem,
- v) da su sva ubistva svršena dela,
- g) da nisu izvršena ubistva na mah, ubistvo deteta pri porođaju ili lišenje života iz samilosti i
- e) da je u izvršenju svih ubistava isto lice učestvovalo u svojstvu izvršioca, saizvršioca, podstrekača ili pomagača².

Pravilna je konstatacija u obrazloženju presude Vrhovnog suda Srbije broj Kž. 119/2003, gde se kaže da su troje učinilaca, u okviru zajedničkog umišljaja lišila života dvoje lica, gde je nebitno iz čijeg su pištolja nanete smrtonosne povrede. Dok se izrekom presude, koja se odnosi na gore navedeno krivično delo teškog ubistva više lica, konstatuje da izreka nije bila nerazumljiva, ako je u činjeničnom opisu dela navedeno da je okrivljeni jedno lice lišio života iz koristoljublja, a drugo da bi prikrio izvršenje prethodnog krivičnog dela, budući da je takvom izrekom ukazano na motive izvršenja krivičnog dela, te je pravilna kvalifikacija krivičnog dela kao lišenje života više lica³.

Teško ubistvo s obzirom na svojstva (osobnosti) pasivnog subjekta su: **1)** ubistvo službenog ili vojnog lica pri vršenju službene dužnosti, **2)** ubistvo deteta i ubistvo bremenite žene, **3)** ubistvo člana svoje porodice koje je prethodno zlostavljano, **4)** ubistvo sudije, javnog tužioca, zamenika javnog tužioca ili policijskog službenika u vezi sa vršenjem službene dužnosti i **5)** ubistvo lica koje obavlja poslove od javnog značaja u vezi sa poslovima koje obavlja.

1) Ubistvo službenog ili vojnog lica pri vršenju službene dužnosti

¹ M. Marković, Ubistvo iz koristoljublja, Pravo – teorija i praksa, Novi Sad, broj 9-10/2009. godine, str. 22.

² D. Jovašević, Praktikum za Krivično pravo, Posebni deo, Medivest, op. cit., str. 13-14.

³ Presuda Vrhovnog suda Srbije broj Kž. 1481/2006.

Pri ovom ubistvu pasivni subjekt mora da bude službeno ili vojno lice koje u momentu ubistva vrši službenu dužnost. Na primer, ubistvo policajca koji je u poteri za učiniocem, ubistvo vojnika na straži i slično. Ubistvo službenog lica ili vojnog lica se sastoji u umišljajnom lišenju života lica koje ima svojstvo službenog ili vojnog lica upravo u vezi sa vršenjem službene dužnosti koju obavlja. Kvalifikatorna okolnost dela je svojstvo pasivnog subjekta koje se lišava života u vezi, povodom i dok se nalazi na službenoj dužnosti. Umisljaj učinioca mora da obuhvati svest i nameru da upravo lišava života lica u vezi sa službenom dužnošću koju ovaj namerava da vrši ili je neposredno vrši.

Zbog te povećane opasnosti kojoj su izložena ova lica pojačana je i krivičnopravna zaštita njihovog života, a iz istih razloga pojačana je i zaštita njihovog telesnog integriteta. Lice prema kome se vrši ovo ubistvo može biti službeno ili vojno lice i svako drugo lice koje vrši navedene poslove i dužnosti na osnovu zakona ili drugih propisa. To predstavlja logičnu posledicu celokupnog koncepta ove inkriminacije, koja predviđa pojačanu krivičnopravnu zaštitu života svih lica koja se zbog dužnosti vršenja poslova bezbednosti izlažu posebnoj opasnosti¹.

Ovo ubistvo se može desiti u odnosu na službena ili vojna lica kada obavljaju poslove kao: otkrivanje krivičnih dela; pronalaženje i hvatanje učinilaca krivičnih dela; obezbeđenje reda i mira; kontrola nabavljanja, držanja i nošenja oružja; obezbeđenje određenih ličnosti i objekata; delatnosti koje su upravljene na otkrivanje i sprečavanje aktivnosti pojedinaca ili grupa, odnosno organizacija, koje su upravljene na podrivanje i rušenje ustavom utvrđenog uređenja naše zemlje, njene nezavisnosti itd.; čuvanje lica lišenih slobode i dr². Kao službeno lice u smislu člana 112. stav 3. Krivičnog zakonika Republike Srbije smatra se: a) lice koje u državnom organu vrši službene dužnosti, b) izabrano, imenovano ili postavljeno lice u državnom organu, organu lokalne samouprave ili lice koje stalno ili povremeno vrši službene dužnosti ili službene funkcije u tim organima, v) javni beležnik, izvršitelj i arbitar, kao i lice u ustanovi, preduzeću ili drugom subjektu kojem je povereno vršenje javnih ovlašćenja, koje odlučuje o pravima, obavezama ili interesima fizičkih ili pravnih lica ili o javnom interesu, g) lice kome je faktički povereno vršenje pojedinih službenih dužnosti ili poslova i d) vojno lice.

A kao vojno lice u smislu člana 112. stav 6. KZ smatra se profesionalni vojnik (profesionalni oficir, profesionalni podoficir, oficir po ugovoru, podoficir po ugovoru i vojnik po ugovoru), vojnik na odsluženju vojnog roka, student vojne akademije, učenik vojne škole, lice iz rezervnog sastava dok se kao vojnik nalazi na vojnoj dužnosti i civilno lice koje vrši određenu vojnu dužnost³.

2) Ubistvo deteta ili bremenite žene

¹ Član 34. Krivičnog zakonika Republike Srbije ("Sl. glasnik RS", br. 85/2005, 88/2005 - ispr., 107/2005 - ispr., 72/2009, 111/2009, 121/2012, 104/2013 i 108/2014).

² Z. Simić, Pojam niskih pobuda, Anali Pravnog fakulteta u Beogradu, br. 1, 1967. godine, strana 94.

³ Đ. Đorđević, Krivično pravo, Posebni deo, Kriminalističko policijska akademija, Beograd, 2011. godine, strana 247.

Ubistvom deteta se smatra lišenje života lica koje nije navršilo 14 godina života. Detetom se kod ovog krivičnog dela smatra, u smislu člana 112. tačka 8. KZ RS lice koje u vreme kada je lišeno života nije bilo starije od 14 godina. Ovim delom nije obuhvaćeno i maloletno lice uzrasta od 14 do 18 godina. Uzrast žrtve predstavlja kvalifikatornu okolnost, pa je za postojanje dela potrebno da je učinilac svestan da radnju lišenja života preduzima upravo prema licu koje ima ovakav uzrast i da to hoće ili, pak, pristaje na to. Ubistvo bremenite žene je protivpravno lišenje života ženskog lica koje je trudno, bremenito, što učiniocu dela mora biti poznato u vreme preduzimanja radnje izvršenja. Ubistvo bremenite (trudne) žene je lišenje života trudnice bez obzira na dužinu trudnoće. Kod ovog ubistva potrebno je da je učinilac imao direktan ili eventualni umišljaj da ubija trudnu ženu. Ukoliko nije znao za njenu trudnoću, biće reč o običnom ubistvu, ali će njena trudnoća biti cenjena kao otežavajuća okolnost.

Bremenitom ženom se, u smislu ovog dela, smatra žena koja je u vreme kada je lišena života imala u sebi začetak deteta, koja je, dakle, bila oplodena. Kod ovog krivičnog dela nije od značaja u kojoj je fazi trudnoće bila bremenita žena. Osnovni uslov za inkriminaciju predstavlja bezobzirnost i bezosećajnost učinioca, a svest o bremenitosti, kao i okolnost da se sa lišavanjem života bremenite žene uništava i njen plod, mora se desiti umišljajno.

Svojsvo pasivnog subjekta karakteriše i ovaj oblik teškog ubistva, ali je praćen posebnom subjektivnom okolnošću, bezobzirnošću i bezosećajnošću učinioca prema žrtvi².

3) Ubistvo člana svoje porodice koje je prethodno zlostavljano

Ovo delo se sastoji u ubistvo člana svoje porodice koje je učinilac kraće ili duže vreme prethodno fizički ili psihički zlostavljao. Članom porodice smatraju se supružnici i njihova deca, preci supružnika u pravoj liniji krvnog srodstva, vanbračni partneri i njihova deca, usvojlac i usvojenik, hranitelj i hranjenik, braća i sestre i njihova deca, bivši supružnici i njihova deca, roditelji bivših supružnika (ako žive u istom domaćinstvu), kao i lica koja imaju zajedničko dete ili je dete na putu da bude rođeno, iako nikad nisu živeli u istom porodičnom domaćinstvu (član 114. KZ).

Osim činjenice da učinilac lišava života člana svoje porodice, da bi postojao ovaj oblik teškog ubistva neophodno je da ga je učinilac zlostavljao u prethodnom periodu. Najčešće, to će biti radnja u okviru krivičnog dela nasilja u porodici, lake ili teške telesne povrede i slično. U svakom slučaju, zahteva se da zlostavljanje bude u dužem vremenskom periodu. Zlostavljanje predstavlja različite oblike psihičkog i fizičkog nasilja.

Zlostavljanje je prema savremenim koncepcijama posledica nasilja u porodici koje spada u najteže oblike traumatskog iskustva sa trajnim posledicama po celokupan, posebno emocionalni, razvoj čoveka.

Forme zlostavljanja mogu biti: fizičko, emocionalno, seksualno i kombinovano. Svaka od navedenih formi zlostavljanja ima podgrupe sa ishodom koji ukazuje na neophodnost primarne prevencije, ali i adekvatnih oblika zaštite i terapije, kako zlostavljenog, tako i

¹ B. Čejović, *Krivično pravo – deseto izdanje*, Dosije, Beograd, 2007. godine, strana 453.

² Z. Stojanović, O. Perić, *Krivično pravo*, Posebni deo, op. cit., str. 278.

zlostavljača. Savremeno zakonodavstvo posebno štiti zlostavljanu decu, o čemu postoje odgovarajući nacionalni i međunarodni zakonski propisi. Ovde se, dakle, radi o svojstvu pasivnog subjekta koji je član porodice učinioca dela (kao kvalifikatornoj okolnosti), koga je učinilac višekratno zlostavljao (nanošenjem fizičkog ili psihičkog bola, patnje, nelagodnosti), odnosno prema kome je učinilac ubistva preduzimao različite akte nasilja u porodici.

Porodicu čini trajna zajednica života više lica između kojih postoji srodstvo po krvi ili tazbinsko srodstvo ili neki drugi odnos. To su svi srodnici po krvi u uzlaznoj i silaznoj liniji (roditelji, deca i njihovi preci i potomci), zatim brat i sestra, supružnici, lica koja žive u trajnoj vanbračnoj zajednici, kao i bivši supružnici i njihova deca i roditelji bivših supružnika. Ovo delo postoji i kada se lišava života staralac, odnosno staranik i usvojlac, odnosno usvojenik. Kod ovog krivičnog dela postoji nanošenje fizičkih ili psihičkih patnji, ali ga zbog tih elemenata ne treba izjednačiti sa ubistvom na svirep način, jer se smatra da su te radnje vršene pre izvršenja dela, a ne u vezi sa ubistvom.

Zaključujemo da je duževremeno i nehumano postupanje prema članu porodice prethodilo ubistvu (npr. kada roditelj nečovečno postupa prema svom detetu, tuče ga, izbacuje iz kuće, uskraćuje mu hranu i sl., a zatim ga lišava života)¹.

4) Ubistvo sudije, javnog tužioca, zamenika javnog tužioca ili policijskog službenika u vezi sa vršenjem službene dužnosti

Ovo teško ubistvo karakteriše svojstvo pasivnog subjekta da je u vezi sa svojim pozivom lišeno života. Ovim ubistvom se smatra ne samo ubistvo lica dok vrši dužnost (dok sudi, zastupa pred sudom ili učestvuje u policijskoj akciji), već u bilo koje drugo vreme (dok je na odmoru, u kafiću...) ako može da se ustanovi da je lišeno života u vezi sa službenom dužnošću koju je obavljalo ili tek treba da obavlja. Ovo se delo sastoji u umišljajnom lišenju života lica koje ima posebno službeno svojstvo – svojstvo sudije, javnog tužioca, zamenika javnog tužioca ili policijskog službenika. Ovo svojstvo pasivnog subjekta mora biti poznato učiniocu dela u vreme preduzimanja radnje izvršenja².

I drugo, radnja lišenja života se preduzima prema ovim licima upravo u vezi sa vršenjem njihove službene dužnosti. Umišljaj učinioca mora da obuhvati svest o svojstvu pasivnog subjekta i nameru da ga upravo i liši života u vezi sa službenom dužnošću, koju namerava da vrši ili je neposredno vrši. Na primer, kada je službeno lice pokušano da bude lišeno života pri vršenju poslova hvatanja učinioca krivičnog dela, kada je policijska patrola obavestena da je pokušano obijanje prodavnice, pa dolaskom poremete učinioca koji pokušava da beži, a kada mu se jedan od policajaca približio, pucao je na njega iz pištolja, a potom i aktivirao bombu u pravcu policajaca koji su ga pojurili, ispravna je konstatacija sudije da je reč o krivičnom delu teškog ubistva, čija je kvalifikatorna okolnost svojstvo pasivnog subjekta, u ovom slučaju policijskog službenika³.

¹ Lj. Lazarević, Krivično pravo, Posebni deo, Beograd, 1993. godine, str. 356.

² G. Božilović, M. Petrović, Organizovani kriminal, korupcija i mito, Beograd, 2004. godine, str. 290.

³ Presuda Vrhovnog suda Srbije broj Kž. 250/2003.

Pokušaj ovog oblika teškog ubistva je moguć. Ovaj oblik teškog ubistva predviđaju i mnogi strani krivični zakoni. Tako Krivični zakon Finske predviđa kao oblik teškog ubistva i ubistvo policijskih službenika u sprovođenju zakona¹.

U Krivičnom zakonu Sjedinjenih Američkih Država kao ubistvo prvog stepena predviđeno je ubistvo policijskog službenika, kao i ubistvo sudije i ostalih službenika koji su zaposleni i rade u vezi sprovođenja zakona².

Dalje, možemo navesti Krivični zakon Rumunije koji u članu 189. predviđa kao posebno ozbiljno ubistvo za koje je propisana kazna zatvora od 15 do 25 godina zatvora ukoliko se radi o ubistvu policajca, žandara, sudije u vezi vršenja njihovih službenih dužnosti. Krivični zakon Republike Srpske u članu 149. pod teškim ubistvom predviđa i lišenje života sudije ili javnog tužioca u vezi sa vršenjem njihove sudijske, odnosno tužilačke dužnosti, kao i lišenje života službenog lica pri vršenju poslova bezbednosti ili dužnosti čuvanja javnog reda, hvatanja izvršioca krivičnih dela ili lica lišenih slobode³.

5) Ubistvo lica koje obavlja poslove od javnog značaja u vezi sa poslovima koje to lice obavlja

Prema članu 112. stav 32. KZ RS poslom od javnog značaja smatra se obavljanje profesije ili dužnosti koja ima povećan rizik za bezbednost lica koje ga obavlja, npr: javno informisanje (novinari, kamermani...), zdravlje ljudi (lekari, farmaceuti...), obrazovanje (učitelji, nastavnici, profesori...), javni prevoz (vozači, taksisti, kontrolori...), pravna i stručna pomoć pred sudskim i drugim državnim organima (advokati, notari...). I ovdje su svojstvo pasivnog subjekta – lice koje obavlja poslove od javnog značaja i preduzimanja radnje lišavanja života tog lica u vezi sa vršenjem, upravo, ovih poslova, kvalifikatorne okolnosti za koje zakon propisuje strožije kažnjavanje⁴.

Ovaj oblik teškog ubistva uveden je u naš Krivični zakonik u skladu sa potrebama prakse, a po ugledu na strane zakone gde je ovo delo sankcionisano takođe kao kvalifikovano delo⁵.

ZAKLJUČAK

Kvalifikovano ili teško ubistvo postoji kada je umišljajno ubistvo izvršeno na takav način, iz takvih pobuda, pod takvim okolnostima ili prema takvom licu koji mu daju veći stepen

¹ Krivični zakon Finske, poglavlje 21, odeljak 2, pod 4 predviđa ubistvo policijskih službenika na dužnosti.

² The United States Code, title 18, part 1- Crimes, chapter 51, Homocide, section 1121.

³ Lj. Čumburović, Ubistva u Novom Pazaru, op. cit., str. 101 i 120.

⁴ Lj. Lazarević, Krivično pravo, Posebni deo, Beograd, 1993. godine, str. 356.

⁵ D. Jovašević, Krivično pravo, Posebni deo, Dosije studio, Beograd, 2014. godine, str. 23-24, 24-30.

težine i opasnosti za koje zakon propisuje teže kažnjavanje. Objekt zaštite je život čoveka. Postoji više oblika teškog ubistva, koji se razlikuju prema: a) načinu izvršenja, b) pobudama učinioca, v) okolnostima izvršenja i posledici i g) svojstvu pasivnog subjekta. Kada se u radnjama učinioca stekne više kvalifikatornih okolnosti ubistva, od kojih su neka ostala u pokušaju, sud je dužan da u pravnu kvalifikaciju, pored toga što će uneti kvalifikovane oblike krivičnog dela, unese i da su neka od njih ostala u pokušaju.

Teška ubistva prema načinu izvršenja su: 1) ubistvo na svirep način i 2) ubistvo na podmukao način.

Teška ubistva s obzirom na pobude izvršioca su: 1) ubistvo iz koristoljublja, 2) ubistvo radi izvršenja ili prikrivanja drugog krivičnog dela i 3) ubistvo iz bezobzirne osvete ili drugih niskih pobuda.

Teška ubistva s obzirom na okolnosti izvršenja i posledicu su: 1) ubistvo pri bezobzornom nasilničkom ponašanju, 2) ubistvo kojim se sa umišljajem dovodi u opasnost život još nekog lica, 3) ubistvo pri izvršenju razbojništva i razbojničke krađe i 4) ubistvo više lica.

Teško ubistvo s obzirom na svojstva (osobnosti) pasivnog subjekta su: 1) ubistvo službenog ili vojnog lica pri vršenju službene dužnosti, 2) ubistvo deteta, 3) ubistvo bremenite žene, 4) ubistvo člana svoje porodice koje je prethodno zlostavljano, 5) ubistvo sudije, javnog tužioca, zamenika javnog tužioca ili policijskog službenika u vezi sa vršenjem službene dužnosti i 6) ubistvo lica koje obavlja poslove od javnog značaja u vezi sa poslovima koje obavlja.

Izvršilac dela može da bude svako lice, a u pogledu krivice potreban je umišljaj. Za ubistvo jednog lica saučesnici mogu biti oglašeni krivim za različite oblike teškog ubistva.

Za ovo je delo propisana kazna zatvora najmanje deset godina ili kazna zatvora od trideset do četrdeset godina.

Od najstarijih vremena do današnjih dana krivično delo ubistva je najteži oblik kriminaliteta nasilja prema ličnosti koji se ispoljava u bilo kom obliku, odnosno na bilo koji način i pod bilo kojim okolnostima, što svakako ne eliminiše ni određene karakteristike koje ovo krivično delo čini i kvalifikovanim oblikom izvršenja. S obzirom na to da je krivično delo ubistva najteže krivično delo, kako po zaprećenoj kazni, tako i po posledicama koje se ispoljavaju na žrtvi, ali koje oseća i određena društvena zajednica (porodica, radna sredina, uža i šira lokalna zajednica, celo društvo), jasno je da je zakonodavac propisivanjem osnovnog oblika ovog krivičnog dela, propisao i niz kvalifikovanih oblika usled čega osnovno krivično delo pod kvalifikovanim okolnostima prerasta u teške oblike krivičnog dela.

Međutim, koliko god odredili i zapretili kaznu za krivično delo teškog ubistva, ona nikada neće biti adekvatna, tj. srazmerna, nećemo reći delu, već učinjenom nedelu. Pored toga, treba navesti da u našem društvu, koje se više od decenije nalazi u pravnom vakumu, veliki broj krivičnih dela, ne da nije procesuiran adekvatno, već se, iz nama nepoznatih razloga, usled raznih uticaja, vode kao nerešeni. Na kraju napominjemo da ova praksa ima tendenciju blagog opadanja i da se sa izmenama i dopunama Krivičnog zakonika Republike Srbije vide naznake odlučnosti za regulisanje i procesuiranje najtežih krivičnih dela, među njima i teškog ubistva, u što kraćem zakonskom roku, a u skladu sa Zakonom o zaštiti prava na suđenje u razumnom roku.

Iz svega što smo do sada obradili, kao predmet ovog naučnog rada, možemo zaključiti da se naše društvo na odlučan način bori protiv svih oblika teškog ubistva, kao i uopšte protiv svih krivičnih dela protiv života i tela. Ovo je veoma bitno jer ovaj oblik ubistva

predstavlja poseban atak, kako na čoveka kao jedinku, tako i na samu državu. Teškim ubistvom se ugrožavaju osnovne vrednosti čoveka na najsvirepiji i najbezobzirniji način i kao takvo ne može biti tolerisano, pa naša država propisuje posebno visoke kazne za takva ubistva, koje imaju za cilj da potencijalne učinioce odvrate od eventualnog činjenja ovakvih krivičnih dela. U skladu sa tim, pored samih represivnih mera, država bi trebala da preduzme više aktivnosti na prevenciji teških ubistava, kao i uopšte krivičnih dela protiv života i tela, jer su to krivična dela koja ugrožavaju najelementarnije čovekovo pravo, a to je pravo na život, garantovano nizom univerzalnih i regionalnih međunarodnih dokumenata.

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AGGRAVATED MURDER

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ABSTRACT: *Life represents the most significant good, the value that underlies all other human values. It is the basis for the realization of the other achievements of humanity. If there was no right to human life, as a cornerstone of the corpus of other human rights, then it would not make any sense. Today, there is no legal order that does not protect the right to human life. This protection is achieved through different branches of law (medical law, environmental law, etc.), but in this respect criminal protection is the most important. Therefore, the crime of murder is one of the most serious crimes. With every murder, humanity loses one member of the community, and man is deprived of his life, which is irrevocably good. The general, social interests in this sphere take precedence over individual goods and values. The legislator in the sphere of protection of life invokes the subjective rights of the individual in order to better protect him. Yet, in addition, it is precisely the human right to life that is violated on a daily basis, human lives being extinguished, not naturally, but by violence, by force, and most often by other people, the same people who should just take the right to life as the supreme postulate of all of us.*

Keywords: *Life, human rights, right to life, legal order, criminal protection, irrevocable good, subjective rights, violence, force, supreme postulate, aggravated murder.*

IZUČAVANJE LIČNOSTI I KATEGORIZACIJA OSUĐENIH LICA U PENALNIM USTANOVAMA REPUBLIKE SRBIJE

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APSTRAKT:

U penitencijalnom sistemu Republike Srbije izučavanje ličnosti osuđenog lica vrši unutar penalne institucije po dolasku osuđenika na izdržavanje kazne, gde se primenjuje multidisciplinarni pristup uz učešće stručnjaka iz različitih oblasti, a pre svega psihologije, psihijatrije, defektologije, socijologije, pedagogije, bezbednosti i drugih, koji su zaposleni u datoj penalnoj ustanovi. Izučavanje ličnosti se provodi postupcima opservacije na antropološkim, biološkim, psihološkim i socijalnim elementima faktora uticaja i orijentacije delinkvenata. Veoma bitno je istaći i značaj bezbednosnog aspekta izučavanja ličnosti osuđenog lica jer se tu ispituje njegova sklonost ka bekstvu, ulasku u sukob sa drugim osuđenima, kao i sklonost ka samopovređivanju i svemu onom što narušava Pravilnik o kućnom redu.

Cilj izučavanja ličnosti jeste doći do saznanja o kakvoj se strukturi ličnosti osuđenika radi, te se na osnovu dobijenih rezultata tokom opservacije predlaže adekvatan program postupanja koji će, uz pomoć vaspitno-korektivnih metoda, uticati na osuđenika u korekciji njegovog ponašanja i prihvatanja društveno pozitivnih normi. Klasifikacija osuđenih lica je veoma bitna faza u individualnoj resocijalizaciji osuđenika. Pravilnom opservacijom i klasifikacijom stvaraju se dobri preduslovi za uspešnu resocijalizaciju osuđenih lica.

Cljučne reči: osuđena lica, resocijalizacija, izučavanje ličnosti, kategorizacija.

PERSONALITY STUDY AND CATEGORIZATION OF CONVICTED PERSONS IN PENAL INSTITUTIONS OF THE REPUBLIC OF SERBIA

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ABSTRACT:

In the penitentiary system of the Republic of Serbia, the study of the convicted person's personality is carried out within the penal institution after the convict arrives to serve his sentence, where a multidisciplinary approach is applied with the participation of experts from various fields, primarily psychology, psychiatry, defectology, sociology, pedagogy, security and others, who are employed in a given penal institution. The study of personality is carried out through observational procedures on anthropological, biological, psychological and social elements of factors of influence and orientation of delinquents. It is very important to point out the importance of the security aspect of studying the personality of a convicted person, because it examines his tendency to escape, entering into conflict with other convicts, as well as his tendency to self-harm and everything that violates the Rulebook on House Rules.

The goal of the personality study is to find out what the convict's personality structure is, and based on the results obtained during the observation, an adequate treatment program is proposed which, with the help of educational and corrective methods, will influence the convict in correcting his behavior and accepting socially positive norms. The classification of convicted persons is a very important stage in the individual resocialization of convicts. Proper observation and classification create good prerequisites for the successful resocialization of convicted persons.

Key words: *convicted persons, resocialization, personality study, categorization,*

1. Izučavanje ličnosti osuđenog lica

Nakon stupanja osuđenika na izdržavanje zatvorske kazne u penalnu ustanovu i smještanja u prijemno odeljenje, pristupa se fazi individualizacije i utvrđivanja adekvatnog programa postupanja prema licu kako bi se postigao što bolji efekat resocijalizacije. Tokom izučavanja ličnosti osuđenog lica u obzir se uzimaju i njegovo ponašanje tokom predistražnog postupka, kao i ponašanje za vreme sudskog postupka.

U razvijenim zemljama kod nekih penitencijalnih evropskih sistema pristupa se savremenom pristupu i izučavanju ličnosti osuđenika u specijalizovanim institucijama ili opservacionim centrima. Ovo ispitivanje ličnosti se obavlja pre stupanja osuđenika na izdržavanje kazne i njegovog dolaska u penalnu ustanovu. Proces izučavanja ličnosti u specijalizovanim opservacionim centrima sprovode stručni timovi koji su sastavljeni od stručnjaka iz raznih oblasti, a pre svega, psiholozi, pedagozi, defektolozi, socijalni radnici, kriminolozi, psihijatri itd. Na osnovu njihovog izveštaja o ličnosti osuđenika daje se preporuka u koji tip ustanove bi lice trebalo uputiti na izdržavanje zatvorske kazne, kao i

koji bi program postupanja dao najbolje rezultate u korekciji ličnosti osuđenika. Prihvatanjem ove preporuke osuđeni stiče veće šanse za puštanje na kontrolisani uslovni otpust što u svakom slučaju predstavlja veću motivaciju osuđenika za učešće u sopstvenoj resocijalizaciji.¹

Praksa našeg penitencijalnog sistema pokazuje da se izučavanje ličnosti osuđenog lica vrši unutar penalne institucije po dolasku osuđenika na izdržavanje kazne, gde se takođe primenjuje multidisciplinarni pristup uz učešće stručnjaka iz različitih oblasti koji su zaposleni u datoj penalnoj ustanovi.

Posmatrajući efekte izučavanja ličnosti u specijalizovanim centrima može se zaključiti da su ti centri izuzetno precizno i profesionalno obavili izučavanje ličnosti, ali su iziskivali velike materijalne troškove pa su neki od tih evropskih centara za izučavanje ličnosti zatvoreni, a izučavanje ličnosti prepušteno penalnim ustanovama.

Posmatrajući praksu evropskih država izučavanje ličnosti se provodi postupcima opservacije na antropološkim, biološkim, psihološkim i socijalnim elementima faktora uticaja i orijentacije delinkvenata. Postupak naučne opservacije vrši se u posebnim naučnim institucijama, dok se postupak empirijske opservacije obavlja, po pravilu, u posebnim odeljenjima ili centrima većih kazneno - popravnih ustanova. Klinički postupci su zasnovani na određenim saznanjima kriminološke ekspertize i socijalne anamneze, te kriminološke dijagnoze i prognoze koja se odnosi na pojedinačne slučajeve osuđenih lica u naučnom postupku opservacije i ispitivanja ličnosti.

Kriminološka ekspertiza je naučna metoda ispitivanja ličnosti delinkventa, radi procenjivanja budućeg ponašanja, određivanja adekvatne sankcije i tretmana za resocijalizaciju. Obavlja je grupa stručnjaka specijalista iz pojedinih oblasti (psiholozi, psihijatri, socijalni radnici), za potrebe sudskog postupka ili prevaspitanja. Radi se na osnovu mediko - psihološkog izučavanja i socijalne anamneze. Mediko - psihološka izučavanja odnose se na izučavanje ličnosti, a socijalna anamneza na sagledavanje i objašnjenje uticaja ekonomskih, socijalnih i porodičnih prilika na ličnost. Metoda je veoma važna i primenjiva kod utvrđivanja uredljivosti, stepena odgovornosti, individualizacije kazne i tretmana rehabilitacije i prevaspitanja.

Na osnovu kriminološke ekspertize radi se kriminološka dijagnoza ličnosti. U pitanju je klinička metoda utvrđivanja stepena opasnosti delinkventa. Odvija se u tri osnovne faze: utvrđivanja kriminalne sposobnosti ili temibiliteta, stepena društvene neprilagodljivosti, i dijagnoze opasnog stanja koja se dobija sintezom dva prethodna postupka. Svaka od ovih faza ima i podfaze postupke.

U logičnom sledu, treća faza u izučavanju ličnosti osuđenika je metodološki postupak predviđanja budućeg ponašanja delinkventa tzv. kriminološka prognoza. Radi se na osnovu kriminološke ekspertize za potrebe određivanja krivične sankcije optuženom i tretman resocijalizacije u odgovarajućim kazneno - popravnim ustanovama. Najpotpunija kriminološka prognoza je ona koja je izvedena kliničkim postupkom. Nešto manju vrednost imaju tipološke prognoze, koje se rade na osnovu klasifikacije delinkvenata prema stepenu inteligencije i vrsti karaktera, kao i statističke prognoze, intuitivna metoda i metoda prognostičkih tablica. Pored, ili umesto, naučnog ispitivanja u mnogim zemljama, čak u većini kazneno - popravnih sistema, postoji stručna ili tzv. empirijska

¹ Bosković, M., Bobić, A.: Kriminologija sa penologijom, NUBL, Banja Luka, 2023.

opservacija osuđenika prilikom dolaska u kazneno - popravnu ustanovu ili neposredno pre upućivanja na izdržavanje kazne zatvora. Ona se sprovodi ili u posebnim centrima za ispitivanje ličnosti ili u samoj kazneno - popravnoj ustanovi. Stručno ispitivanje ličnosti je složen, timski i interdisciplinarni (psihološki, pedagoški i medicinski) postupak, koji obavljaju stručne osobe, utvrđujući klasifikaciju i ogovarajući tretman za osuđenika.¹

Veoma bitno je istaći i značaj bezbednosnog aspekta izučavanja ličnosti osuđenog lica. Kroz ovo izučavanje dolazimo do procene stanja opasnosti koja pretili od osuđenog, kako prema vlastitoj ličnosti tako i prema drugim osuđenim. Tu se ispituje njegova sklonost ka bekstvu, ulasku u sukob sa drugim osuđenim, sklonost ka samopovređivanju i svemu onom što narušava Pravilnik o kućnom redu.²

Iz napred navedenog nedvosmisleno se može istaći da je cilj, kako naučnog, tako i empiriskog izučavanja ličnosti, doći do saznanja o kakvoj se strukturi ličnosti osuđenika radi, te se na osnovu dobijenih rezultata tokom opservacije predlaže adekvatan program postupanja koji će, uz pomoć vaspitno-korektivnih metoda, uticati na osuđenika u korekciji njegovog ponašanja i prihvatanja društveno pozitivnih normi.

2. Kategorizacija i klasifikacija osuđenih lica

Klasifikacija osuđenih lica je veoma bitna faza u individualnoj resocijalizaciji osuđenika. Pravilnom opservacijom i klasifikacijom stvaraju se dobri preduslovi za uspešnu resocijalizaciju osuđenih lica. Pojam klasifikacije u penologiji se veoma rano pojavio i to u obliku objektivne ili eksterne klasifikacije koja je, pre svega, predviđala odvajanje osuđenika po polu, vrsti krivičnog dela, starosnoj dobi (odvajanje maloletnih od punoletnih lica), dužini kazne, motivu za izvršenje krivičnog dela itd. Svi ovi elementi su se mogli lako objektivno utvrditi, sve u cilju izbegavanja pojave kriminalne infekcije i međusobne torture osuđenika. U Pravilima o domaćem redu apsenog zavedenja u Požarevcu, koji se nalazi u Krivičnom zakoniku za kneževinu Srbiju iz 1882. godine, stoji zapisano da se na izdržavanju kazne odvajaju muška i ženska lica, maloletnici od drugih, i uopšte, važilo je pravilo da se sličan sa sličnim zdržiže, kako bi se izbegli loši uticaji osuđenika jednih na druge.³ Ovaj oblik klasifikacije, koji obuhvata objektivne kriterijume u svakom slučaju nije bio zadovoljavajući, nego se moralo preći i na subjektivne kriterijume koji su se ogledali u izučavanju ličnosti samog osuđenika kao individue, gde su se primenjivale metode kriminološke ekspertize, dijagnoze i prognoze. Razradom subjektivnih i objektivnih kriterijuma stvara se realna slika o osuđeniku, te se lakše može pronaći optimalni program postupanja koji će se primenjivati tokom izdržavanja kazne zatvora.

¹ Bosković, M., Bobić, A.: Kriminologija sa penologijom, NUBL, Banja Luka, 2023.

² Bobić, A.: Društvene promene i zatvorska zajednica, Panos, Matica srpska, Novi Sad, 2012.

³ Krivični zakonik za Kneževinu Srbiju, Državna štamparija, Beograd, 1882., str.548.

U penitencijalnim sistemima gde nema centara za izučavanje ličnosti osuđenika, lica se upućuju u penalne ustanove gde se smeštaju u prijemno odeljenje. U prijemnom odeljenju lica za zadržavaju oko 30 dana u KP zavodima ili oko 10 dana u Okružnim zatvorima gde se vrši ispitivanje ličnosti i njihova klasifikacija u vaspitne grupe gde im se pojedinačno dodeljuje program postupanja. Prijemno odeljenje mora biti fizički odvojeno od drugih odeljenja, a tek dobijanjem klasifikacione grupe osuđeno lice ide na odeljenje u koje je razvrstan. Sam boravak u prijemnom odeljenju je specifičan iz razloga što se tu smeštaju svi osuđenici bez obzira na vrstu delikta, dužinu kazne, kriminološke i penološke prošlosti. Iz tog razloga neophodno je optimalnom vremenu izvršiti opservaciju lica i smestiti ga na odeljenje koje mu po njegovoj strukturi ličnosti najviše odgovara. U penološkoj literaturi najčešće se može naći podela klasifikacije osuđenika na eksternu i internu, ali se ona pokazuje kao relativna i različito shvaćena u različitim penitencijalnim sistemima.¹

Zbog nemogućnosti i neracionalnosti teško je bilo gde primeniti princip kategorizacije prema ličnim svojstvima osuđenih, već se najčešće kategorizacija obavlja prema eksternim kriterijumima. Stoga stanovišta osuđenici se prvenstveno izdvajaju na one koji izdržavaju kaznu u kazneno - popravnim domovima i zatvorima, ženskim i muškim, ustanovama za maloletnike i odrasle, za povratnike i slično.² Nasuprot tom tipu, razvijene su i interne klasifikacije u samoj kaznenoj ustanovi, s pristupom stvaranja manjih vaspitnih homogenih grupa sa sličnim karakteristikama za potrebe individualnog tretmana. Pored toga, postoje i različiti tipovi klasifikacija odraslih lica na izdržavanju kazne, koje se u osnovi svode na četiri osnovna tipa: 1) primarni delinkventi; 2) delinkventi iz navike ili profesionalni delinkventi; 3) osuđenici s poremećajima psihičke prirode; i 4) stariji osuđenici.³

Treba napomeniti da u našem ustanovama boravi veliki broj penoloških i kriminoloških povratnika, ali ipak prvi dani boravka u penalnoj ustanovi su veoma složeni jer osuđeno lice mora ponovo da se suoči sa činjenicom da će jedan vremenski interval ostati u zatvoru.⁴ Rad sa ovom kategorijom osuđenika sigurno je otežan i stoga traži maksimalnu posvećenost zatvorskog osoblja, a pre svega u procesu kategorizacije, da izvrši dobru procenu osuđenog lica, kao i eventualne razloge zašto prethodni programi postupanja nisu postigli željeni efekat i zašto je takva osoba sklona recidivu.⁵

3. Zaključak

¹ Radovanović, D.: Penologija i sistem izvršenja krivičnih sankcija, Tretman osuđenih lica (klasifikacija, opšte i stručno obrazovanje, vaspitni rad, primena stimulativnih i represivnih mera, slobodne aktivnosti, rad i zaposlenost osuđenih lica), Pravi fakultet, Novi Sad, Beograd, 2003.

² Radoman, M.: Penologija i sistem izvršenja krivičnih sankcija, Pravni fakultet, Novi Sad - Beograd, 2003

³ Bošković, M.: Osnovi penologije, Univerzitet u Novom Sadu, Pravni fakultet, Novi Sad, 2000.

⁴ Bobić, A., Pavlićević, P., Rok, H.: *Prisoners' Perception of Treatment: A Study in Serbian Prisons*, Review of criminalistic and criminology, Ljubljana, Slovenija, 2022.

Dolaskom osuđenika na izdržavanje zatvorske kazne u penalnu ustanovu i smeštanja u prijemno odeljenje, pristupa se fazi individualizacije i utvrđivanja adekvatnog programa postupanja prema licu kako bi se postigao što bolji efekat resocijalizacije. Tokom izučavanja ličnosti osuđenog lica u obzir se uzimaju i njegovo ponašanje tokom predistražnog postupka, kao i ponašanje za vreme sudskog postupka. Postupak naučne opservacije vrši se u posebnim naučnim institucijama, dok se postupak empirijske opservacije obavlja, po pravilu, u posebnim odeljenjima ili centrima većih kazneno - popravnih ustanova. Klinički postupci su zasnovani na određenim saznanjima kriminološke ekspertize i socijalne anamneze, te kriminološke dijagnoze i prognoze koja se odnosi na pojedinačne slučajeve osuđenih lica u naučnom postupku opservacije i ispitivanja ličnosti. Na osnovu kriminološke ekspertize radi se kriminološka dijagnoza ličnosti. U pitanju je klinička metoda utvrđivanja stepena opasnosti delinkventa. Odvija se u tri osnovne faze: utvrđivanja kriminalne sposobnosti ili temibiliteta, stepena društvene neprilagodljivosti, i dijagnoze opasnog stanja koja se dobija sintezom dva prethodna postupka. Svaka od ovih faza ima i podfazne postupke.

Klasifikacija osuđenih lica je veoma bitna faza u individualnoj resocijalizaciji osuđenika. Pravilnom opservacijom i klasifikacijom stvaraju se dobri preduslovi za uspešnu resocijalizaciju osuđenih lica. Zbog nemogućnosti i neracionalnosti teško je bilo gde primeniti princip kategorizacije prema ličnim svojstvima osuđenih, već se najčešće kategorizacija obavlja prema eksternim kriterijumima. Stog stanovišta osuđenici se prvenstveno izdvajaju na one koji izdržavaju kaznu u kazneno - popravnim domovima i zatvorima, ženskim i muškim, ustanovama za maloletnike i odrasle, za povratnike i slično.

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DIGITAL FOOTPRINTS IN THE COURTROOM: THE RISE OF SOCIAL MEDIA EVIDENCE IN CRIMINAL TRIALS

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ABSTRACT:

In the contemporary judicial landscape, the proliferation of social media has inaugurated a new era in evidence collection, fundamentally altering the paradigms of criminal litigation. This paper underscores the expanding role of digital footprints from platforms like Facebook, Twitter, and Instagram highlighting the judicial system's challenges of technological advancement and traditional evidentiary standards.

A significant portion of the study is dedicated to examining the legal and ethical implications of using social media as evidence. This includes a critical analysis of privacy concerns, considering the fine line between lawful evidence gathering and infringement of individual privacy rights. The paper also discusses the implications of social media evidence on the right to a fair trial, considering how such evidence can be both incriminating and exculpatory. Furthermore, the paper addresses the challenges of authenticating social media content in a legal context, where the ease of digital manipulation poses significant hurdles. It evaluates current legal frameworks and judicial precedents guiding the admissibility and reliability of such evidence.

In its conclusion, the paper reflects on the future trajectory of social media's role in criminal justice. It posits that as social media continues to permeate everyday life, its evidentiary value and challenges will only magnify, necessitating adaptive legal strategies and policies. This comprehensive analysis aims to equip legal professionals, academics, and policymakers with a deeper understanding of the complexities and ramifications of social media in criminal trials, advocating for a balanced approach that upholds justice and respects individual rights.

Keywords: Social Media, Criminal Trials, Digital Evidence, Privacy, Authentication.

Introduction

The term "electronic evidence," which is frequently referred to as "digital evidence," refers to a wider variety of data that is either kept or delivered in an electronic format. Emails, text messages, files, databases, electronic records, and data from digital devices such as desktops, smartphones, and tablets are all examples of the types of evidence that fall under this category (Murphy & Fontecilla, 2013). Electronic evidence is identified by its digital format, which involves the application of specific methods for the purposes of gathering, preservation, and analysis in order to validate the evidence's authenticity and ensure that it can be presented in court.

An whole new age of evidence collection has emerged as a direct consequence of the extensive use of social media in the contemporary judiciary, which has also brought about significant changes to the conventional methods of conducting criminal cases. Evidence gathered from social media platforms is referred to as social media evidence. As a result of the widespread use of social media platforms like Facebook, Instagram, Twitter, and LinkedIn, individuals frequently leave behind extensive digital footprints that can have an important effect in both civil and criminal proceedings. These digital footprints have proven invaluable in criminal investigations, offering insights into a suspect's actions, motives, and associations that might otherwise remain undiscovered. According to Murphy and Fontecilla (2013), the scope of social media evidence extends beyond public posts; it may also encompass private messages and metadata, which can disclose the time and location at which particular acts were carried out. This is particullary relevant in terrorism trials, social media evidence, such as tweets and Facebook posts, has become essential in reconstructing events and providing proof of involvement (Anwar, 2020).

In criminal prosecutions, social media evidence has been applied in a variety of ways, such as creating a chronology of events, supporting witness accounts, or refuting a defendant's alibi. For example, a Facebook post that places the defendant at the scene of the crime might be quite helpful in establishing their involvement. Similar to this, a suspect's intention or mental state prior to committing a crime might be inferred from their tweets or direct messages. With the continued penetration of social media into everyday life, it is projected that the effect of social media in the field of criminal justice would grow. In order to keep up with the ever-changing nature of social media platforms and the impact they have on legal proceedings, legal strategies and processes need to be continuously modified. (Tenzer, 2019). In order to guarantee that justice is served

and that it is protected, it is very necessary for legal professionals, academics, and lawmakers to have an understanding of the mechanisms that govern the use of social media evidence in criminal cases as well as the constraints that are associated with it.

Challenges

The use of evidence obtained from social media platforms in criminal cases presents substantial ethical and legal challenges that demand thorough evaluation of the potential ramifications.

One of the primary challenges of using social media evidence in criminal trials is ensuring its authenticity. Unlike traditional forms of evidence, such as physical documents or eyewitness testimony, social media content can be easily manipulated or fabricated. Social media is increasingly used in sexual harassment cases, but courts must limit the discovery of irrelevant and prejudicial evidence to avoid harming plaintiffs (Diss, 2013). The rise of "deepfakes" and other digital manipulation technologies has made it increasingly difficult to verify the accuracy and integrity of social media evidence.

Social media content is frequently presented without context, which may result in potential incorrect interpretations by judges and juries. A tweet or Facebook post may be understood without regard for the subtleties of tone, humor, or irony that may be evident in in-person communication. In *Commonwealth v. Banas* (2017), the defendant has been charged for violence, and the prosecution attempted to use evidence from his Twitter account. The evidence includes tweets that the prosecution claimed revealed the defendant's intentions and mental state at the time of the crime. The defense opposed the admission of the evidence, claiming that the tweets were unclear and could be read in a variety of ways. The court eventually permitted the evidence, determining that the tweets were relevant to the issues at trial and had been adequately authenticated. However, the court recognized the difficulties of understanding social media content, especially when the tone and context are not directly evident. This case demonstrated the relevance of circumstances in analyzing social media evidence, as well as the need to carefully evaluate how such evidence is presented and interpreted in court.

In addition, the sheer volume of social media evidence can be overwhelming during a trial, resulting in what some legal experts refer to as "information overload." Potentially, judges and juries may encounter difficulty in navigating the immense quantities of digital data, which could result in biased or inaccurate

conclusions. The use of social media evidence in courtrooms has grown significantly, with a 3933% increase in state cases using such evidence from 2007 to 2017 in California (Graves et al., 2020). However, the accessibility of social media evidence also raises concerns regarding pre-trial publicity and its potential impact on judgment objectivity. In particular, high-profile cases are vulnerable to "trial by media," which involves the potential for public opinion and social media commentary to influence the outcome of a trial prior to its commencement.

The widespread use of social media makes it impossible to establish boundaries between the public and private spheres, which creates substantial challenges with regard to the protection of individuals' rights to privacy as well as the lawful collection of evidence. In the landmark case of *People v. Johnson* (2014), the defendant was convicted of murder based in part on evidence gathered from his Facebook account. The prosecution revealed multiple posts and private messages indicating the defendant's connection to the crime. The defense claimed that the evidence was collected unlawfully and should be dismissed due to an infringement of privacy. The court ultimately determined that the Facebook post was admissible, concluding that the defendant had no reasonable expectation of privacy for information uploaded on a public site. The court also addressed the issue of verification, stating that the prosecution had presented sufficient evidence to establish the authenticity of the Facebook posts. This case established an important precedent for the acceptance of social media evidence in criminal cases, particularly with regard to privacy and authentication issues.

Striking a balance between these concerns is crucial to ensure that evidence gathering does not infringe upon individuals' privacy rights (Arshad et al., 2019), (Graves et al., 2020). Users are encouraged by social media platforms to disclose personal information, frequently under the assumption that it would be confidential or be seen only to a limited group of people. But once this data is in the public domain, law enforcement organizations can access and exploit it, frequently without the subject's authorization or permission. In order to guarantee that the gathering of evidence does not infringe upon the rights of individuals to privacy, it is of the utmost importance to find a middle ground between these concerns.

Another key consideration is the impact that evidence obtained from social media platforms might have on an individual's right to a fair trial. In addition to having the potential to exonerate or convict a defendant, such evidence has the potential to affect judicial judgments in a manner that is both complicated and possibly unexpected. Making sure that this evidence is used in a fair and reasonable manner is essential to maintaining the legitimacy of the judicial system.

There is also an enormous concern with the reliability of posts on social media platforms. Digital information can be easily manipulated, posing substantial obstacles to the reliability and legal admissibility of such evidence. Developing robust methods to confirm the authenticity of social media evidence is vital to prevent inaccurate claims and protect the rule of law (Graves et al., 2020).

Authentication and Admissibility

The authentication of social media evidence is challenging, with courts employing different standards. The forensic collection of social media evidence must adhere to legal and scientific standards to maintain its integrity. This process faces challenges due to the dynamic nature of social media and privacy rights (Arshad et al., 2019).

When acquiring evidence from social media platforms and electronic devices, there are a few essential actions that must be taken to ensure its reliability and admissibility in court. Among these processes are the identification of pertinent evidence, the maintenance of the evidence in its original form to prevent alteration, the extraction of the data through the use of forensic methods, and the analysis of the data to generate conclusions that are useful. Particularly crucial is the preservation of digital data since it is so simple to erase or change digital information. Professionals in the legal field are required to adhere to strict rules in order to keep the chain of custody intact and to record every phase of the process of handling evidence. According to Georgiou and Schafer (2019), this ensures that the evidence can survive scrutiny during legal disputes over its validity and integrity.

The evidence must be substantiated by testimony or other forms of verification that verify its integrity and origin in order to establish its authenticity. This frequently necessitates the involvement of a digital forensics specialist who can verify the collection, preservation, and analysis methodologies deployed. These standards are significantly affected by international legal frameworks, including the Budapest Convention on Cybercrime. The Budapest Convention, the first international treaty to address crimes committed via the internet and other computer networks, establishes exhaustive guidelines for the collection and preservation of electronic evidence across borders. It underscores the significance of preserving the integrity of digital evidence and guaranteeing that it is collected in a manner that is in accordance with both legal and human rights standards.

In addition to the Budapest Convention, the European Union's General Data Protection Regulation (GDPR) also influences the admissibility and collection of electronic evidence. Evidence that is collected in violation of the privacy rights of individuals may be declared inadmissible, as GDPR's stringent data protection requirements mandate that any evidence collection must comply with these principles.

The legality of evidence acquisition, especially with regard to confidentiality issues, must also be taken into account by the courts. In general, evidence that was gathered without proper legal authorization or in opposition to privacy rights is inadmissible. The collection and preservation of evidence in accordance with legal standards, including the preservation of a correct chain of custody to prevent contamination or tampering, are essential in this context, and digital forensic procedures are essential for this purpose. Courts are likely to exclude any evidence that does not adhere to these stringent standards, thereby protecting the rights of all parties.

Conclusion

The legal framework governing the acquisition of social media evidence is still in the process of developing. In certain jurisdictions, courts have determined that there is no reasonable expectation of privacy regarding content that is shared on public social media platforms. This viewpoint is predicated on the idea that individuals sacrifice their privacy rights when they voluntarily disclose information in a public forum. Nevertheless, this perspective is not universally embraced, and there are persistent discussions regarding the extent to which social media content can be classified as private, particularly when it is shared with a restricted audience.

The ethical implications of utilizing social media evidence are equally intricate. In order to obtain access to private social media content, law enforcement agencies may implement deceptive strategies, including the creation of fabricated profiles. Although these practices may be permitted by law, they raise ethical concerns regarding the transparency and integrity of evidence collection in criminal investigations. Furthermore, the pervasive utilization of social media evidence has raised concerns regarding "digital surveillance," in which individuals experience an ongoing perception of monitoring and governing online.

Legal standards and regulations regulate the admissibility of electronic and social media evidence in court. The evidence must meet these standards by being

relevant, authentic, and impartial, and its integrity and origin must be verified through testimony or other means. The techniques employed for the collection, preservation, and analysis of evidence are validated by digital forensics professionals, who are indispensable in this process. The Budapest Convention on Cybercrime and the European Union's General Data Protection Regulation (GDPR) are significant international agreements that significantly influence these guidelines. This underscores the necessity of preserving the integrity of evidence while also protecting human rights and privacy. The legality of the method by which evidence is obtained, particularly in relation to privacy laws, must also be evaluated by the courts. Evidence that is garnered without proper authorization or in violation of privacy rights may be dismissed. This legal framework guarantees that electronic evidence presented in court is technically credible and legally compliant, in accordance with the rights and freedoms safeguarded by international and regional regulations.

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***HUMANITIES: PHILOSOPHY, PHILOLOGY, HISTORY,
THEOLOGY***

PROFESIONALNO-KONTEKSTUALNI INDIKATORI IZRAŽENOSTI PROFESIONALNOG IDENTITETA

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SAŽETAK:

Profesionalni identitet, kao deo šireg socijalnog identiteta pojedinca, predstavlja onaj deo selfa koji se razvija obavljanjem profesionalnih uloga i zadataka. To je višestruk entitet na čiji razvoj, pored psiholoških, utiču i mnogi društveno-istorijski i kulturni faktori. Cilj ovog rada jeste da se sistematizuju dosadašnja saznanja o profesionalnim i kontekstualnim uslovima koji potpomažu ili stopiraju razvoj jasnog profesionalnog identiteta pedagoga. U ranijim istraživanjima, identifikovani su sledeći indikatori: profesionalna socijalizacija kao proces internalizacije vrednosti profesionalne grupe u identitet pojedinca; radno iskustvo; aktivitet pojedinca u profesionalnoj i društvenoj zajednici; karakteristike radnog okruženja i zadovoljstvo poslom, odnosima u kolektivu i klimom u radnom okruženju. Slično, Brot i Majers (1999) su identifikovali tri kategorije uslova profesionalnog konteksta koji su relevantni za razvoj profesionalnog identiteta školskog pedagoga: 1) Iskustvo, pri čemu prave razliku između dužine radnog staža i radnog iskustva koje donosi znanje stečeno kroz rad u neposrednom radnom okruženju i aktivnosti u zajednici; 2) Karakteristike stručne službe u školama, posebno pitanje raspodele vremena i obaveza među stručnim saradnicima i da li je onda uopšte moguća; 3) Osnove rada, operacionalizovane kroz razvojne karakteristike i potencijalne probleme kod učenika i očekivanja rukovodstva škole/donosioca odluka. Rezultati analize prethodnih istraživanja pokazuju da su kvalitativni indikatori (školska klima, kvalitet angažovanosti pedagoga u profesionalnim zajednicama), relevantniji indikatori profesionalnog identiteta od kvantitativnih indikatora (dužina radnog staža, geografske i strukturalne karakteristike škole). Neophodno je imati u vidu da profesionalni identitet predstavlja mnogostruk entitet i da nije moguće predvideti apsolutno sve njegove determinante, što govori da ovo predstavlja gotovo neiscrpnu temu za buduća istraživanja.

Ključne riječi: profesionalni identitet, socijalni identitet, pedagog, radno okruženje

1. UVOD

Profesionalni identitet kao deo šireg socijalnog identiteta pojedinca, predstavlja onaj deo selfa koji se razvija obavljanjem profesionalnih uloga i zadataka. Usled kompleksnosti ovog konstrukta, veoma je teško pronaći njegovo konačno određenje, a u izvorima koji se bave ovom tematikom ne postoji konsenzus ni o strukturi ovog konstrukta, tačnije o komponentama koje sačinjavaju profesionalni identitet pojedinca. Kakvo će biti određenje i struktura profesionalnog identiteta u velikoj meri zavisi od toga koja je profesija u pitanju. U pojedinim profesijama gde postoji jasna distinkcija između profesionalaca različitih profila, čak i unutar same profesije, kao što je slučaj sa medicinom ili pravom, pitanja proučavanja konstrukta profesionalni identitet nisu aktuelna, niti su neophodna. Međutim, u profesijama koje su mlade, ili u profesijama u kojima dolazi do preklapanja profesionalnih uloga i dužnosti, kao što je slučaj sa pomagačkim profesijama (pedagozi,

nastavnici, socijalni radnici, psiholozi, itd.), takvu jasnu distinkciju je teško napraviti, čak i na nivou sistema i čitavog društva. Stoga je veoma kompleksno dati konačne i jasne odgovore na pitanja kao što su: Ko sam ja kao profesionalac?; Koje su moje uloge i koje su kompetencije neophodne za uspešno izvršavanje tih uloga?; Zbog čega je moje profesionalno delovanje jedinstveno i vredno za društvenu zajednicu?; itd. (Slijepčević i Zuković, 2019: 120). Kada se tome pridruži činjenica da je profesionalni identitet višestruk entitet na čiji razvoj utiču psihološki, ali i mnogi društveno-istorijski i kulturni faktori (Cooper & Olson, 1996; Rogers & Scott, 2008), kako na individualnom nivou, tako i u domenu mikro, mezo i makro struktura društvenog konteksta (Day et al., 2006), jasno je da je potrebno kontinuirano (re)definisati i određivati kako posmatramo ovaj konstrukt. Sve to sa ciljem identifikovanja onih faktora koji mogu da doprinesu razvoju snažnog, jasnog i izraženog profesionalnog identiteta, ali i onih koji mogu da vrše njegovu supresiju. Stoga, cilj ovog rada jeste da se sistematizuju dosadašnja saznanja o profesionalnim i kontekstualnim uslovima koji potpomažu ili osujećuju razvoj jasnog profesionalnog identiteta stručnjaka iz oblasti pomagačkih profesija, sa posebnim fokusom na profesiju pedagoga.

2. PROFESIONALNI IDENTITET - STRUKTURA I INDIKATORI IZRAŽENOSTI

Profesionalni identitet predstavlja deo šireg socijalnog identiteta pojedinca, a socijalni identitet je važan element pojedinčevog ukupnog self-koncepta. U relevantnoj literaturi ne postoji jedinstveno određenje profesionalnog identiteta, ali postoji nekoliko njegovih odrednica koje je moguće pronaći u većini izvora. Naime, profesionalni identitet predstavlja konstrukt koji upućuje na stalno redefinisavanje (Rogers & Scott, 2008) i koji je dinamičan proces trajnog (re)interpretiranja iskustava koji se stiču u socijalnom okruženju pri čemu je pojedinac u tom procesu aktivan subjekt (Brott & Myers, 1999; Goodson & Cole, 1994; Lamote & Engels, 2010). Ono što je još specifično za ovaj konstrukt je njegova vezanost kako za profesionalnu sferu ličnosti, dakle individualno, tako i za karakteristike same profesije, to jest kontekstualno, ali i međusobna isprepletenost i međuzavisnost ovih aspekata (Spasenović & Hebib, 2014). Formiran profesionalni identitet omogućava kreiranje referentnog okvira za bolje razumevanje sopstvenih profesionalnih uloga i odgovornosti, kao i za podizanje opšteg zadovoljstva poslom i osećajem ponosa zbog obavljanja te profesionalne uloge (Beijaard et al., 2004; Brott & Myers, 1999; Woo et al., 2018). Jasno je da postojanje takvog referentnog okvira i osećanje zadovoljstva u vezi sa svojom profesijom doprinosi i kvalitetnijem ispunjavanju svojih profesionalnih uloga (Sun et al., 2022).

Ne postoji saglasnost među autorima koji teorijski i empirijski izučavaju konstrukt profesionalni identitet ni kada je reč o određenju dimenzija ili komponenti od kojih je ovaj konstrukt sačinjen. Na nivou teorijskog razmatranja profesionalnog identiteta, izdvojile su se tri opšte, veoma široko postavljene, komponente ovog konstrukta (Adams et al., 2006; Gibson et al., 2010; Spasenović i Hebib, 2014): (1) Samoodređenje sebe kao profesionalca koji se odnosi na individualni doživljaj sebe tokom obavljanja svojih profesionalnih uloga; (2) Integracija kompetencija i vrednosti važnih za ispunjavanje profesionalnih uloga; (3) Pozicija i status koji profesija zauzima u društvenom kontekstu, tačnije kako je profesija vrednovana i pozicionirana u profesionalnom i širem društvenom okruženju. Međutim, sa

početkom empirijskog izučavanja profesionalnog identiteta, ove komponente su se morale konkretizovati i operacionalizovati kako bi se mogle kvantitativno meriti. Osim toga, često se komponente profesionalnog identiteta različito određuju u zavisnosti od toga o kojoj profesiji je reč. Sve navedeno ukazuje na široke mogućnosti teorijskog i empirijskog izučavanja ove tematike, a neujednačenost određenja konstrukta profesionalnog identiteta i njegove strukture, kao i činjenica da je izgradnja ovog dela self-koncepta pojedinca dinamičan, kontinuiran i stalan proces, onemogućava da se saznanja do kojih se tim izučavanjem došlo uzmu kao konačna.

Sa ciljem sveobuhvatnijeg izučavanja ovog veoma kompleksnog konstrukta, istraživači su se morali usmeriti i na ispitivanje svih potencijalnih indikatora koji ukazuju na razvijenost i izraženost profesionalnog identiteta i koji mogu uticati na taj razvoj. S obzirom da je već ukazano na isprepletenost profesionalnog, individualnog i kontekstualnog u razmatranju ovog dela self-koncepta, deluje opravdano pokušati razvrstati ove indikatore na personalne (lične) i profesionalno-kontekstualne. Kada je reč o profesionalno-kontekstualnim indikatorima u ranijim istraživanjima se poseban fokus stavlja na važnost adekvatne rane profesionalne socijalizacije (Adams et al., 2006), kao i aktivne participacije mladih stručnjaka u aktivnostima u radnom okruženju (Cohen-Scali, 2003). Pritom, aktivna participacija u profesionalnoj zajednici, ali i široj društvenoj zajednici, nije važna samo na početku karijere, već takva praksa tokom čitave karijere predstavlja veoma važan indikator razvijenog profesionalnog identiteta pojedinca (Crossley & Vivekananda-Schmidt, 2009). Takođe, pri istraživanju ovog konstrukta potrebno je uzeti u razmatranje i karakteristike neposrednog okruženja u kom pojedinac obavlja svoju profesionalnu delatnost, s obzirom da su veoma različite prakse stručnjaka u oblasti obrazovanja koje se odvijaju u gradu i selu, u ekonomski razvijenom i osiromašenom društvu, u multikulturalnom i relativno homogenom društvu i slično.

2.1. Profesionalno-kontekstualni indikatori profesionalnog identiteta pedagoga

U ovom delu rada fokus je stavljen na razmatranje profesionalno-kontekstualnih indikatora profesionalnog identiteta pedagoga, kao posebno izazovne pomagačke profesije koja se već decenijama suočava sa problemima nedovoljno precizno definisanih uloga i kompetencija, nedovoljno prepoznatljivom profesijom u društvu, kao i niskim društvenim statusom i ugledom profesije (Staničić, 2017). U tako otežanim uslovima građenja profesionalnog identiteta ovih stručnjaka, neophodno je razmotriti koje profesionalne karakteristike pripadnika ove profesije i karakteristike njihovog profesionalnog okruženja, mogu ukazati na jači profesionalni identitet. Drugim rečima, one karakteristike koje mogu potencijalno doprineti jačanju njihove slike o sebi kao profesionalcu, njihovih kompetencija i profesionalnih vrednosti, i naposljetku slike o profesiji pedagoga koju ima stručna i šira društvena javnost. Ovde je posebno značajno istraživanje koje su Brot i Mejers (1999) sprovedi sa ciljem teorijskog utemeljenja koncepta profesionalnog identiteta školskih savetnika (stručnjaka koji je po ulogama i kompetencijama srodan školskim pedagozima kod nas) u kom su izdvojili tri kategorije uslova profesionalnog konteksta koji su značajni za profesionalni identitet ovih stručnjaka:

1. *Iskustvo* predstavlja kategoriju koja se ne odnosi samo na dužinu radnog staža već i na znanje koje je pojedinac stekao tokom rada u neposrednom radnom okruženju, ali i angažmanom koji ima u profesionalnoj i široj društvenoj

zajednici. Istraživanja su pokazala da pojedinci sa dužim radnim stažom bolje umeju da odrede šta spada u domen njihovog profesionalnog delovanja i koje profesionalne kompetencije su potrebne za ispunjavanje svojih uloga (Crossley & Vivekananda-Schmidt, 2009; Scarborough & Culbreth, 2008).

2. *Odlike stručne službe u školama* se odnosi na zastupljenost i raznovrsnost stručnih saradnika što, između ostalih faktora, utiče i na mogućnost raspodele vremena i obaveza. Osim mogućnosti podele obima posla, prisustvo drugih stručnjaka iz iste ili slične oblasti u neposrednom radnom okruženju omogućava konfrontaciju mišljenja, arbitražu i kolaboraciju što dovodi do sagledavanja problema sa različitih aspekata, kreativno pristupanje njegovom rešavanju i naposljetku, kvalitetnijem radu stručne službe (Brott & Myers, 1999). Svakako, postojanje velikog broja stručnih saradnika nije jedini kriterijum koji je potrebno ispuniti za postizanje visokog kvaliteta rada, ali jeste preduslov toga.
3. *Osnove rada*, kao poslednja kategorija, koju je moguće podeliti u dve potkategorije. Prva se odnosi na karakteristike populacije sa kojom pedagog radi, konkretnije, razvojne odlike populacije, specifičnosti i potencijalne probleme sa kojima se učenici suočavaju. Potvrdu važnosti ove karakteristike konteksta u kom pedagog radi je moguće pronaći u ranijim istraživanjima koja su identifikovala razlike između pedagoga koji rade u osnovnim i srednjim školama u tome kako procenjuju svoje kompetencije (Ledić i dr., 2013), kao i koliko im je profesionalna delatnost usklađena sa idejama o poželjnoj profesionalnoj praksi (Scarborough & Culbreth, 2008). Druga potkategorija se odnosi na očekivanja koje rukovodstvo škole i donosioci odluka imaju od pedagoga - stručnih saradnika.

Data kategorizacija uslova je obuhvatila značajan opus potencijalnih profesionalno-kontekstualnih indikatora profesionalnog identiteta pedagoga, međutim, u njoj su neopravdano zanemareni odnosi u kolektivu, kao i celokupna klima u školi. Školsku klimu nije jednostavno definisati pošto je u pitanju veoma kompleksan fenomen koji oblikuju mnogi faktori, a najuopštenije ga je moguće opisati kao kvalitet školskog života. Mnoga istraživanja su povezala zadovoljstvo poslom, odnosima u kolektivu i generalnom klimom na radnom mestu sa različitim konstruktima srodnim profesionalnom identitetu: posvećenosti profesiji i ustanovi zaposlenja (Bogler & Somech, 2004), verovatnoćom retencije na trenutnom radnom mestu (Cohen, Michelli & Pickeral, 2009), kao i percipiranom samoeфикасноšću (Bardhoshi & Um, 2021). Shodno tome, neopravdano je izostaviti školsku klimu iz razmatranja indikatora profesionalnog identiteta.

3. ZAKLJUČAK

U radu su predstavljeni i sistematizovani nalazi ranijih teorijskih i empirijskih razmatranja profesionalnog identiteta, sa posebnim fokusom na identifikovanje profesionalnih karakteristika pedagoga, kao i karakteristika njihovog neposrednog radnog okruženja koji potencijalno doprinose razvijenijem i izraženijem profesionalnom identitetu ovih stručnjaka. Indikatori koji se u mnogim istraživanjima izdvajaju kao posebno važni govore o važnosti aktivne participacije pojedinca u oblasti svoje profesije, kako u toku pripreme

za profesiju (inicijalno obrazovanje), tako i tokom čitave karijere. U radu je istaknuta i važnost postojanja široke mreže mentora i profesionalnih uzora, što je, ponekad, kada je reč o profesiji pedagoga teško obezbediti u neposrednom radnom okruženju s obzirom da je pedagog neretko jedini stručni saradnik - pedagog u školi. Stoga, moguće je zaključiti da posebnu važnost u obezbeđivanju takve mreže imaju profesionalna udruženja pedagoga i fakulteti za obrazovanje pedagoga, koji moraju predstavljati oslonac pedagozima u njihovom radu. Kada je reč o karakteristikama konteksta, moguće je primetiti da su ranija istraživanja povezanosti ovih indikatora i profesionalnog identiteta neopravdano zanemarila pozitivnu školsku klimu kao potencijalni indikator, te je preporuka da neka buduća istraživanja detaljnije ispituju ove relacije. Naravno, u ovom radu nisu predstavljeni svi mogući indikatori iz kategorije profesionalno-kontekstualnih karakteristika pedagoga i njegovog/njenog neposrednog radnog okruženja, ali jesu sistematizovani oni koji su se u dosadašnjim radovima na ovu temu pojavljivali i ponavljali. Stoga, smatramo da ovaj rad može da posluži kao inspiracija za naredna istraživanja ove problematike.

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THE PROFESSIONAL-CONTEXTUAL INDICATORS OF PROFESSIONAL IDENTITY

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ABSTRACT: (10 pt, font Times New Roman Bold, Italic)

Professional identity, a part of the broader social identity, develops by performing professional roles. It's a multifaceted entity whose development, in addition to psychological factors, is influenced by many socio-historical and cultural factors. The goal of this paper is to systematize previous research on professional-contextual conditions that support or hinder the development of pedagogues' professional identity. Earlier research identified following indicators: professional socialization as a process of internalizing the professional group's values into the individual's identity; work experience; activity in the professional and social community; characteristics of and satisfaction with the work environment and relationships. Similarly, Brot and Myers (1999) identified three categories of professional-contextual conditions that are relevant to the development of the school pedagogues' professional identity: 1) Experience, distinguishing between length of service and work experience that brings knowledge acquired through working in schools and through community activities; 2) Characteristics of school counseling services, especially the issue of distribution of time and duties among counselors and whether any distribution is possible; 3) Basics of work, operationalized through developmental characteristics and potential problems among students and expectations of school management/decision makers. The results of this analysis show that qualitative indicators (school climate, quality of pedagogues' engagement in professional communities) are more relevant indicators of professional identity than quantitative indicators (length of service, geographical and structural characteristics of the school). However, professional identity represents a multiple entity and it is not possible to predict absolutely all its determinants, which means that this is an almost inexhaustible topic for future research.

Keywords: *professional identity, social identity, pedagogue, work environment*

PRAGMATICS OF METAPHOR: A FULL CIRCLE*

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ABSTRACT:

In this paper we explore the pragmatic treatment of metaphoric expression since the very onset of pragmatics as a linguistic discipline. We shall firstly present the Gricean approach – the implicature analysis, long since abandoned but still relevant in recent cognitive-inferential studies. Following the modified implicature analysis, the two current approaches will be explored – explicature analysis and modified explicature analysis. However, special attention will be dedicated to those aspects of the theory that treat certain metaphoric expressions of special poetic nature as contributing to the implicit content only. This approach seems to indicate that pragmatics has made a full circle to the implicature analysis, at least when extended literary metaphors are in question.

Keywords: *metaphor, pragmatics, Relevance Theory, implicature, explicature*

1. INTRODUCTION

The present paper deals with the inferential approaches to the investigation of metaphoric expressions. Inferential approach originated from Paul Grice and his implicature approach was the first pragmatic account of metaphor. Neo-Gricean and Post-Gricean approaches diverge greatly from the implicature account. However, the debate about metaphor has had a longstanding history, not only within the field cognitive pragmatics, but in other areas of linguistic investigation, and this has led to the creation of various accounts that differ among themselves. This was the motivation behind the research done in this paper. Namely, certain cognitive-inferential accounts of metaphor interpretation come very close to the initial Gricean approach and we believe that all of these various approaches correctly capture different aspects of metaphor interpretation. Hence, the structure of the paper follows the development of Post-Gricean accounts of metaphoric expressions – modified implicature analysis, explicature analysis (together with a brief comparison to a similar

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Neo-Gricean approach) and modified explicature analysis which bears resemblance to a Post-Gricean approach that treats certain metaphoric expressions as encoded concepts contributing to the implicit part of communication – much like Grice envisaged.

This “full circle” does not indicate that, after forty years of research, pragmatic theories have not developed significantly when it comes to treatment of metaphoric expressions. Quite the contrary – the emergence of these “different” accounts merely points to the necessity of turning the attention to the levels of metaphoricity and how this correlates to the interpretation mechanisms employed.

2. GRICEAN APPROACH

Gricean pragmatics is based on the Cooperative Principle of communication and the accompanying Conversational Maxims. The Cooperative Principle states that interlocutors, being rational participants in communication, contribute to communication with utterances that are in accordance with the requirements of the communication act in question, at the stage at which it occurs, and by the accepted purpose or direction of the talk exchange (Grice 1989: 26). Conversational maxims further contribute to cooperativeness by providing specific instructions (Maxim of Quality, Quantity, Relation and Manner). For Gricean approach to metaphor interpretation, the key maxim is that of quality – *try to make your contribution one that is true* (Grice 1989: 27), as well as the two adjoining submaxims – *do not say what you believe to be false* and *do not say that for which you lack adequate evidence*.

Not all maxims are equally important in communication (Grice 1989: 27). If a person spoke too broadly about a topic, it is certainly less harmful to the communicative process compared to intentionally stating what is not true. Moreover, the first submaxim of quality has to be observed in order to consider the observing of all other maxims.¹

When it comes to metaphoric expressions, the implicature analysis (IA) implies that on the basis of the encoded content, the hearer concludes that the speaker is intentionally violating the maxim of quality. If the assumption that the cooperative principle is observed stands, the hearer assumes that the speaker intends to communicate something different from what s/he is saying, which results in generation of implicature. We shall illustrate with the following example (adapted from Mišković-Luković 2013: 48–49):

- (1) Perica is a computer.
+>² 'Perica is intelligent above average'

The encoded content of the utterance in (1) being obviously untrue (a person cannot be equated with a machine), the maxim of quality is violated, which is recognized by the hearer. In order for the cooperative principle to be retained, the conversational implicature 'Perica is intelligent above average' is generated.

¹ The examples of violation of this maxim are irony, metaphor, meiosis and hyperbole (Grice 1986: 34).

² „+>” represents the symbol for conversational implicature.

2. POST-GRICEAN APPROACHES

In the field of pragmatics, metaphoric expressions have been thoroughly dealt with within the relevance-theoretic approach (Sperber and Wilson 1986/95, 1987; Carston 2002) and this is the reason for choosing precisely post-Gricean perspective as relevant. In this section, we shall first present the modified implicature analysis (MIA), then, the explicature analysis (EA), which is the predominant approach to metaphor within the field of pragmatics, and finally the modified explicature analysis (MEA).

2.1. Modified Implicature Analysis (MIA)

The relevance-theoretic approach diverges greatly from the assumptions of the Gricean pragmatics. The foundations of pragmatics were set by the introduction of the term *implicature* by Paul Grice. However, it was not contrasted with the notion *explicature*, but with the notion *what is said*. Grice acknowledged merely two pragmatic processes contributing to *what is said* – reference assignment¹ and disambiguation (when it comes to semantically or syntactically ambiguous expressions/constructions).

On the other hand, relevance theory is based on two principles – cognitive and communicative principle of relevance and the balance between cognitive effort and cognitive effects. The cognitive principle states that human cognition is geared towards maximization of relevance, while according to the communicative principle, each act of ostensive communication carries the presumption of its own optimal relevance (Sperber and Wilson 1986/95). When defining optimal relevance, Sperber and Wilson (1986/95) state that ostensive stimulus is optimally relevant to the hearer if and only if it is relevant enough to be worth the hearer's cognitive effort and the most relevant in accordance with the speaker's abilities and preferences. In sum, for a concrete communicative act, this has the following implications (Mišković-Luković 2013: 49, our translation):

When it comes to production, the speaker, according to her abilities and preferences, forms an utterance in a manner that reduces the hearer's interpretative effort. When it comes to utterance interpretation, the hearer follows the path of least interpretative, forming the contextual assumptions according to the level of their accessibility, and stopping the interpretative process when the speaker's utterance satisfies the expectation of relevance (or when it cannot be found at all).

According to this approach, the inferential processes involved in the interpretation of metaphoric expressions rely on generating strong and weak implicatures² - falling on the implicit side of communication. When "standard" metaphors are in question (expressions that are common in a language community) during the interpretative process, a very limited number of contextual assumptions (available from the encyclopedic entry of the

¹ For instance, in the previous example, reference should be assigned to the subject.

² The wider the spectrum of possible conclusions, the weaker the implicature and the greater the responsibility of the hearer for deriving these conclusions.

conceptual address in the mental vocabulary of a language user) is accessed. We shall illustrate with the following example (taken from Sperber and Wilson 1986/95: 236):

(1) This room is a pigsty.

The utterance in (1) in a stereotypical context (e.g. that pigsties are normally dirty and messy) generates the strong implicature that the said room is dirty and messy. If the speaker didn't intend to convey this implicature, s/he would have formulated the utterance differently.

The situation is somewhat different when interpretation takes place outside of a stereotypical context (example taken from Sperber and Wilson 1986/95: 236):

(2) Robert is a bulldozer.

The result of the interpretative process of the expression in (2) can be a whole range of contextual implications (some of which will be discarded due to contradictoriness). The relevance of this expression lies in attaining cognitive effects since there is no strong implicature. Instead, a greater number of weak implicatures is generated related to Robert's qualities – e.g. that he is persistent, stubborn etc. Furthermore, depending on the context, different implicatures may be generated concerning Robert's physical appearance (e.g. big, obese etc.).

2.2. Explicature Analysis (EA)

Current position in relevance-theoretic approach to communication is the explicature analysis (Carston 2002a). Namely, metaphor is seen as a special case of a wider linguistic phenomenon – that the meaning of sentences (utterances) is fragmentary and that the intended meaning significantly surpasses the linguistically encoded meaning¹. Figurative use of language clearly illustrates the difference between what is encoded and what is communicated².

Basic assumptions of this approach to metaphoric expressions are a) metaphoric expressions are part of a continuum of loose use of language (including, for example, approximation and hyperbole); b) the interpretation of metaphoric expressions is entirely inferential process that does not involve associative mapping from one domain to another; c) the formation of emergent property does not involve special interpretative mechanisms compared to the interpretation of literal expressions (Wilson and Carston 2008).

EA is a model of lexical-pragmatic approach within the relevance theory that postulates that pragmatic processes of narrowing (strengthening)³ and broadening

¹ Here we primarily mean the underdetermination hypothesis (see Mišković-Luković 2018).

² According to relevance theory *communicated* means that the speaker committed to the truth of the propositional constituent.

³ As a result of the pragmatic process of strengthening, the denotation of the communicated concept is narrower than that of the encoded concept.

(weakening)¹ are treated the same – as means of pragmatic enrichment of the basic proposition of an utterance (Mišković-Luković 2013: 50). We shall illustrate with the following example (taken from Wilson and Carston 2008):

(1) Caroline is a princess.

According to this approach, where both pragmatic processes – strengthening and weakening – are treated equally as contributing to the explicit part of the communication, the following explicature is generated:

(1a) CAROLINE_X IS A PRINCESS**

The sign "X" that stands with the subject is a symbol for the pragmatic process of reference assignment while the symbol "**" by the lexeme *princess* marks the process of *ad hoc* concept formation which is the result of the pragmatic processes of strengthening and weakening. Namely, if Caroline is not a member of a royal family, the broader concept PRINCESS* is generated, the denotation of which includes all females. At the same time, accessing the encyclopedic assumptions available based on the context and the encoded concept PRINCESS, and assuming that Caroline is a member of the subset of females that these encyclopedic assumptions can apply, it is possible to arrive at sufficient number of contextual implications that will make the utterance relevant in the expected way. Adopting these assumptions strengthens the encoded concept, so that the communicated concept PRINCESS** is narrower in the sense that it applies only to the subset of real princesses (that are, for example, spoiled, demanding etc.). Hence, the following contextual implication (1b) and explicature (1c) are generated:

(1b) PRINCESS** IS SPOILED, DEMANDING (etc.)

(1c) CAROLINE_X IS SPOILED, DEMANDING (etc.)

Similar to this post-Gricean approach is a neo-Gricean approach put forward by Bach (1994, 1999, 2001, 2007). According to Bach, at least some sentences express a minimal proposition so he proposes a different construct – implicature. Implicature is a pragmatically enriched version of Gricean semantic construct, a third category of speaker's meaning – between *what is said* and *what is implicated*. It is in fact what is implicit in what is said. Implicature is not the semantic content of the minimal proposition, but of some other sentence that is not explicated.² Namely, semantically underdetermined sentences require enrichment in order to become fully fledged propositions. If the sentence lacks at least one constituent (e.g. *She is too old* [for what]), then the enrichment process

¹ As a result of the pragmatic process of weakening, the denotation of the communicated concept is broader than that of the encoded concept.

² The verb *implicite* means to say something partially, while the verb *implicate* means to say something and intend to say something else.

is completion. The other process of implicature generation – expansion – occurs when a sentence lacks elements that are part of speaker’s meaning even if the sentence expresses a minimal proposition (e.g. *You are not going to die* [from that cut]). Implicature has to do with sentence nonliterality and Bach refers to figurative language as constituent nonliterality (1994: 135). After undergoing the process of expansion, metaphoric expressions are constituents of the implicature (for detailed discussion see Manojlović 2023) and since the notion of implicature can be viewed as a parallel notion to that of explicature, it can be said that the described neo-Gricean approach has certain traits in common with the EA approach within the post-Gricean cognitive-inferential theory.

2.3. Modified Explicature Analysis (MEA)

MEA was first put forward by Mišković-Luković (2013) and further developed and implemented in a paper that contrasts cognitive pragmatic and cognitive linguistic approach to metaphoric expressions (Rasulić & Mišković-Luković 2021). According to this approach, metaphor is an instance of interpretative language use (same as irony) instead of descriptive language use as was the case with EA. This way metaphoric expressions lose the truth-conditional constraint (Mišković-Luković 2013: 54). Repetition of certain metaphoric expressions (i.e. routinization) can contribute to them being cognitively stored, hence such expressions can be accessed inferentially (depending on the level and frequency of exposure to the said expression that certain interlocutors have), which in turn reduces the cognitive effort in utterance interpretation (Mišković-Luković 2014: 353). According to this approach, the encoded concept PRINCESS in (1) (section 2.2.) would be interpreted as attributive and the basic proposition (and explicature) would be:

(1c) ‘Caroline_x is a „princess” (as one would say or think)’

Implicatures would be contextually driven and generated in the same manner as was the case with the descriptive approach to metaphoric expressions (EA). The difference is in the elegance of the analysis since attributive approach reduces the number of inferential ”steps”.

3. THE LEVEL OF METAPHORICITY AND CLOSING OF THE ”CIRCLE”

There is plenty of evidence that there are different levels of metaphoricity and suggestions that these expressions are interpreted differently. For instance, Carston (2010) notes that there is a vast range of instances of metaphors and that the utterances containing them have more or less clear propositional content. Vega Moreno (2007) highlights the existence of a continuum of the underdeterminacy – from highly conventional use on one end and novel and poetic expressions on the other. Wilson and Carston (2019: 31) state that by the use of creative metaphors, unspecified content is communicated that can best be described as a vague impression, i.e. an array of weak propositional effects.

What is interesting for the topic of this paper are the expressions that Carston (2010) calls *extended literary/poetic metaphors*. Within these expressions, the constituents

of the utterance are used literally, and the relevance lies in generating the implicatures that are *probably* intended by the speaker (Carston 2010: 310). She distinguishes between two types of metaphor processing (Carston 2010: 310) – 1) an online process of *ad hoc* concept formation which is in accordance with other contextual adjustments of lexical (encoded) concepts within the loose and figurative language use, and 2) a process that retains the literal meaning of the metaphorically used expression within the metarepresentation of that meaning in context, therefore assuming a slower and more thoughtful inference process that selects those implications that are likely intended by the speaker. In the cases of extended or poetic metaphors, the *ad hoc* concept formation process that should be conducted quickly and online requires too much cognitive effort, so in these instances there is no explicitly communicated propositional content other than the encoded (literal) meaning metarepresented in a context that draws attention to it (Carston 2010: 309). One of the examples she uses is a part of the Emily Dickinson poem (Carston 2010: 311):

My Life had stood - a Loaded Gun -
In Corners–

In the case of the metaphor above, instead of forming an *ad hoc* concept LOADED GUN*, it seems more likely that the encoded meaning is retained. The literal meaning ‘loaded gun’ is metarepresented as ‘LOADED GUN’ which suggests a deliberate cognitive process. This process involves accessing implications and associations that this conceptual representation conveys and selecting those that can, with great certainty, be characteristic of human life, especially one that stands 'IN CORNERS' (Carston 2010: 311).

3. CONCLUSION

In the present paper we have explored the treatment of metaphoric expressions since pragmatics was established as an independent linguistic field. Firstly, the Gricean implicature analysis was presented, an approach that assumes that the use of metaphoric expression triggers implicature generation. The paper also explores the modified implicature analysis and explicature analysis which is currently widely regarded as the leading approach within the field of cognitive pragmatics. Finally, the modified explicature analysis was presented, followed by considerations regarding the level of metaphoricity – entertaining the idea that certain metaphoric expressions are interpreted literally and that the relevance of utterances containing them lies in the generation of implicature(s) in a way circles back to the Gricean approach – the implicature analysis.

Level of metaphoricity is an important and yet unresolved issue. Further research in the area of cognitive pragmatic treatment of metaphoric expressions might discover that more than one approach presented in this paper is adequate, depending on the metaphoricity of expressions.

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THE MANY-FACETED 20TH-CENTURY EXPERIMENTAL THEATRE: WHERE IS THE THEATRE HEADED?

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ABSTRACT:

The paper follows the development of the experimental theatre in the first half of the 20th century as it traces various ways in which drama had evolved in the forms of different types of artistic movements that mostly sought to “de-literarise” theatre. The evolution of avant-garde performances will be shown through examples that belong to five forms of theatre: Expressionist Theatre, Epic Theatre, Theatre of Cruelty, Theatre of the Absurd, and Poor Theatre. The goal of the paper is to examine the value of these innovations in performance styles and to make conjectures about the future of the theatre based on the reached conclusions.

Keywords: *experimental theatre, expressionism, avant-garde, performance art.*

1. INTRODUCTION

Of the three major literary forms—poetry, prose, drama—, the latter is the truest to life since it is written to be performed. Theatregoers witness literary texts come to life before their eyes and find in the actions of actors (also of puppets, dancers, opera singers, mimes¹) mirror images of their own actions, because the purpose of performing a literary text has always been, as Hamlet expounds, to hold a mirror up to nature, virtue, vice, and the spirit of the age that engendered the work. These three basic activities that drama relies upon—imitation, performance (storytelling), spectatorship—are summarized by Eric Bentley in a basic formula of drama: “A impersonates B while C looks on”, which Marvin Carlson improves by saying: “A imitates B *performing an action* while C looks on” (Carlson 2014: 23).

Following this formula, medieval English drama began in the church, with characters (usually nuns, priests, choirboys, who did not see themselves as actors) acting out scenes from the Bible, especially during the festivals of Christmas and Easter, and

¹ This paper deals only with the Western tradition of drama, which usually excludes opera, dance, pantomime, and puppetry from the study of theatre. However, it should be noted that these art forms were and have been part of the theatrical tradition in many countries, such as Italy, China, Japan, and India. See: Marvin Carlson, *Theatre: A Very Short Introduction*, Oxford: Oxford University Press, 2014.

later during the Corpus Christi festival¹. Popular miracle plays, mystery plays, and morality plays were first moved into the churchyard, then into the marketplace, and were also performed on pageant wagons. Each scene of the play would be set on a different wagon, and once the scene had been played out, the wagon would move to the next location where spectators were waiting for that scene. Sometimes these pageants would last from sunrise until late in the evening, when darkness would put a stop to them. These open-air performances continued to be a common practice even after the first theatres (also open to the elements) were built in England in the 16th century². In such circumstances and lacking in modern technologies, Renaissance productions relied heavily on costumes to denote a certain age or rank, objects such as candles or nightgowns to signify nighttime, inscriptions on a piece of wood or cardboard to identify the setting (a battlefield, a country, a city, a forest, etc.), but they relied mostly on the text itself and the imagination of the Elizabethan spectators, who were “going to “*hear*”³ a play, not to see it” (Dickson 2009: 502). For example, in *Macbeth*, when Banquo and his son Fleance cannot determine the time of day, Banquo says: “There’s husbandry in heaven; / Their candles are all out”, suggesting that the spectators should *imagine* a “pitch-black” sky with no stars, since the play was performed during daytime in Elizabethan England. As the darkest of all Shakespeare’s plays, *Macbeth* abounds with similar pleas to the audience to use their imagination and envision darkness even in the dazzling sunshine. Sometimes, Shakespeare would give straightforward instructions to the viewers, for instance in the words of Chorus from *Henry V*: “Think when we talk of horses, that you see them / Printing their proud hoofs i’ the receiving earth; / For ‘tis your thoughts that now must deck our kings, / Carry them here and there...” (*Henry V*, Prologue). English Renaissance playwrights continued to rely on spectators’ ‘thoughts’ even after the performances moved to indoor theatres, starting with Blackfriars in 1609, but as decades went by, they also began to make use of the new technology available in theatres. By the Victorian Age, candlelight was replaced with gaslight and eventually with electric lighting in 1881, first used at the Savoy Theatre in London. Lavish sets and props, designed to portray ‘reality’ with which the Victorian Age was preoccupied, decorated Victorian performances, but the plays themselves were somehow “wearisome”, as Oscar Wilde described them in “The Decay of Lying” (1889)—they did not “succeed in producing that impression of reality at which they [owned]” (Wilde 1905: 24-25). The diverse range of genres that emerged in the 19th century⁴ proves that theatre was a popular pastime, and out of its versatility emerged many different forms of theatre in the 20th century, most of which can be described as experimental. This paper will give a brief overview of some of these theatrical forms and artistic movements, it will

¹ The Corpus Christi festival was established in 1264, and it is held in May or June, eight weeks after the Catholic Easter.

² The Red Lion in 1567, the Theatre in 1576, the Rose in 1587, the Globe in 1599, etc. See Dickson 2009: 494-510.

³ My italic.

⁴ “Victorian drama is diverse and voluminous. It comprises a range of genres, including the ever-popular melodramas, serious or ‘problem’ theatre, comedy, renderings of Shakespeare, dramatic readings of Alfred Lord Tennyson’s poetry, adaptations of the work of famous novelists such as Walter Scott and Charles Dickens, pantomime, farce, burlesque, extravaganzas, harlequinades, opera and music hall.” (Purchase 2006: 163)

attempt to examine the value of the innovations in performance styles and try to make conjectures about the future of the theatre based on the reached conclusions.

2. PERFORMING IN THE 20TH CENTURY

*“To save the theatre we must destroy it...
We shall build the Theatre of the Future...
an art which says less yet shows more than all...”*

(Gordon Craig, quoted in Roose-Evans 1970: 34)

Up to the 20th century, Western European theatre traditionally relied and was dependent on dramatic texts. However, with the rise of the new era, there came a need for the “de-literarisation” of theatre, which is best seen in the avant-garde movement. As Erika Fischer-Lichte explains, the “bold liberation of theatre from the chains of literature was certainly linked to an oft repeated distrust of language at the time” (284), which led to our inability to communicate, described by Nietzsche as “the sickness of civilization” (285). Moreover, theatre needed to be distinguished from drama as a separate artistic form, since drama “as a work of literature, uses words”, whereas theatre “uses material ... which consists of movement, scenic design and voice” (285). Now, as art *sui generis*, theatre should cease “to imitate nature and produce an illusion of reality” (286) but start to be creative and experimental in its own right. Consequently, the realistic drama and theatre (although still practiced by many major playwrights of the 20th century, such as Bernard Shaw and Arthur Miller) was being challenged by the non-realistic drama and theatre, which found expression in many different theatrical forms.

2.1. Expressionist Theatre

The best example of the de-literarisation of theatre can be seen in the transition of style of August Strindberg (1849-1912), the most important Swedish playwright of the age, whose later works, such as *A Dream Play*, *The Dance of Death*, and *The Ghost Sonata*, differ significantly from his earlier plays, most notably from *Miss Julie* (1888), a play that follows the realistic and naturalistic demands of the 19th century. By overcoming his naturalistic phase, Strindberg became “a leader of the symbolists and an inspiration to the expressionists” (Carlson 2014: 62) and influenced future prominent playwrights. Eugene O’Neill (1888-1953), the first American playwright to win the Nobel Prize for Literature (1936), praised Strindberg’s expressionist style and his efforts to break through “the restraints of realism to find “some form of ‘super-naturalism’” (Carlson 1984: 362). To achieve that, expressionists focused less on the text and more on the role of the director¹, who “sought to explore the mysteries of inner life” (346) rather than the external realistic features, to represent the angst of the age and the emotions of characters through specific use of light and sound, while setting the plays in a dreamlike ‘reality’. Dukore and Gerould assert that “Expressionism and surrealism, the two major movements of the period in painting and in drama, unite subjective and social, dream and revolution, in the

¹ See Carlson 2014: 41-42.

aim of transcending and transforming reality by releasing the subconscious and leveling all social barriers” (Dukore and Gerould 1969: 1). Expressionism “allows the characters to express themselves without analysing themselves” (Pavis 2013: 13) and it does so through specific techniques: the plays are set in dreams, nightmares, memories, flashbacks; the episodes are often disordered and non-linear; the characters tend to be nameless stereotypes (White Man), representatives of a class (Judge, Priest), or large impersonal forces (Law, Church); the text is often fragmented, unreal, dreamlike; sound and light are used to express characters’ emotions (for example, light may throw shadows over the body of a character to represent prison bars and express guilt and claustrophobia); actors do not follow the realism of Stanislavsky, but deliberately exaggerate their speech, movements, emotions (Styan 1981: 1-7). Apart from Strindberg in Sweden, the forerunners of expressionism in Germany were Georg Büchner and Frank Wedekind. The most significant expressionists were Georg Kaiser and Ernst Toller in Germany, Vsevolod Meyerhold¹ in Soviet Russia, Eugene O’Neill in America (and after him Tennessee Williams, Arthur Miller, and Elmer Rice), and the later Sean O’Casey in Ireland². Some of the best-known expressionistic plays include Kaiser’s *From Morn to Midnight*, Toller’s *Man and the Masses*, O’Neill’s *The Hairy Ape*, Rice’s *The Adding Machine*, etc.

2.2. Epic Theatre

In Germany, during the first two decades of the 20th century, the Austrian-born theatre director Max Reinhardt (1873-1943) wanted “to free the theatre from the shackles of literature” and to offer “theatre for theatre’s sake” (Roose-Evans 1970: 48). Erwin Piscator (1893-1966), another famous German theatre director and producer, followed in his footsteps and became the leading advocate of epic theatre, a form of theatre that deals with social and political issues and invites the audience to scrutinize the problems presented on stage. Today, epic theatre is usually associated with Bertolt Brecht (1898-1956), a German playwright who developed its techniques and style. According to Dukore and Gerould, Brecht used expressionistic techniques—“abstract characters, moral debate, and choral speech” (1969: 11)—to “create an anti-expressionistic drama that evolved into epic theatre” (3); he discarded expressionistic “atmospheric lights and shadows” (11) and opted for “sharp, bright light to show the objective world clearly, rather than to create a mood” (12). Unlike expressionistic dreamlike reality, Brecht does not want the audience to dream, but to act. However, Brecht’s ‘reality’ is not the reality advocated by the 19th-century realism and naturalism: he emphasizes that this is reality as seen on a stage and demands that his actors “perform with full realization that they [are] on a stage” (12), i.e. “the performer *demonstrates* the character rather than *becoming* the character” (Shank 1982: 58). They achieve this by wearing overstated make-up, using unusual visuals, or breaking the fourth wall and addressing the audience directly. Rather than being emotionally involved, as in previous theatrical movements, the audience is urged to objectively and rationally judge the social injustices presented on stage, and after the

¹ Meyerhold was a Russian director famous for the 1926 expressionist production of Nikolai Gogol’s *The Government Inspector* (aka *The Inspector General*).

² For more details on each, see J. L. Styan’s study *Modern Drama in Theory and Practice, Volume 3: Expressionism and Epic Theatre*.

performance, to “act upon their new understanding” (Dukore and Gerould 1969: 12). Hence, we should *think*, not feel; *survive*, not simply live. Brecht managed to convey his Marxist viewpoint through the technique of alienation / *Verfremdungseffekt*:

In order to ‘alienate’ the audience, to create an effect of distancing, he would terminate a scene before its climax; at appropriate intervals slides would be projected, bearing a message which served to underline the point of a scene. In various ways he would constantly interrupt the action, and the low white curtains would be drawn across at the end of every scene. By means of this ‘alienation’ the spectator, so he maintained, would be enabled to ponder the action, draw his own conclusions, and so become a more useful member of society. (Roose-Evans 1970: 51)

Thus, epic theatre became *a theatre of social change*, which would influence other theatrical movements, especially in the 1960s and 1970s, with its idea that Man is changeable and able to change the world. Brecht’s notable plays include *Mother Courage and Her Children*, *The Caucasian Chalk Circle*, *Life of Galileo*, *The Good Person of Szechwan*, etc.

2.3. Theatre of Cruelty / Ecstasy

Brecht’s socially-oriented theatre was developing concurrently with the Theatre of Cruelty, whose postulates were formulated by Antonin Artaud (1896-1948) in a series of essays written between 1931 and 1936 and published collectively as *The Theatre and Its Double* in 1938. Like Brecht, Artaud “viewed the drama as an instrument of revolution” (Carlson 1984: 392), but as Carlson points out, his vision “was of a theatre that would change man not socially but psychologically, by setting free the dark, latent forces festering in the individual soul” (Ibid). While Brecht’s epic theatre urged the audience to rationally analyse the social problems presented on stage, Artaud’s idea was to awaken “the body’s inner spirit” (393), which he did by using ritualistic practices that had ‘magic power’, such as he had found in the dancing and music of the Balinese theatre. Fischer-Lichte suggests that Artaud wanted to “re-theatricalise theatre” by transforming it “into a magical ritual which will initiate a process of healing in the spectator” and “conjure up a new state of consciousness ... a new way of being” in the spectator (Fischer-Lichte 2002: 295). She describes a typical method to achieve this:

The audience would take their seats on revolving chairs in the centre of the room and the ‘stage event’ would occur around them, ‘in all four directions’ both in the auditorium as well as on a gallery running around the whole room. In this way, the spectator would not be able to take up the perspective of either a distanced – or empathetic – observer, but would find himself in the middle of the event, encircled on all sides and directions by events of noise and movement. The events of noise and movement would be organised in such a way that they would draw the

spectator into the desired trance state and alter his subconscious so that the healing process could begin. (Ibid)

The 'trance' state thus created becomes cathartic, which is why some critics prefer to call Artaud's idea of theatre 'a theatre of ecstasy' (see Roose-Evans 1970: 53-62). Carlson informs us that Artaud selected the term 'cruelty' after he had "considered and rejected "absolute", "alchemical", and "metaphysical" (Carlson 1984: 394), but 'cruelty' is not used in its usual denotation as an act of violence, infliction of pain, anguish, or distress. Rather, Artaud uses it to denote a hunger for the brutalities of life, which, having been shown to the spectators through the above-described methods (bright lights, extreme noise, making the spectator uncomfortable, etc.), may cure them. In the Preface to *The Theatre and Its Double*, he compares theatre to the plague and explains its link to cruelty:

If fundamental theatre is like the plague, this is not because it is contagious, but because like the plague it is a revelation, urging forwards the exteriorization of a latent undercurrent of cruelty through which all the perversity of which the mind is capable, whether in a person or a nation, becomes localized. ... In theatre, as in the plague, there is a kind of strange sun, an unusually bright light by which the difficult, even the impossible, suddenly appears to be our natural medium. (Artaud 2010: 20)

Like his predecessors and his contemporaries, Artaud wanted to "de-literarise" theatre because theatre "uses all languages (gestures, words, sound, fire and screams)" (7), and confining it to *one* language, whether that is written text, speech, lighting, or sound, "heralds its imminent ruin" (Ibid). Artaud's surrealist ideas belonged more to the future than to his present: the principles of his theatre of cruelty were illustrated in only one of his plays, *Les Cenci*¹, which premiered in 1935 at the Théâtre des Folies Wagramin, in Paris. However, his view of humanity as being in need of a cure because it is sick from the burdens of life, as well as his proposition that theatre should cure humanity, majorly influenced the 20th-century theatre, including the theatre of the absurd, the poor theatre, and the living theatre. Artaud claimed that "Like the plague, theatre is a crisis resolved either by death or cure" (Artaud 2010: 21); although his ideas were never fully realized and consequently died, they did help cure the crisis in humanity that occurred in the aftermath of the world wars.

¹ Artaud was not completely satisfied with the realization of the play's production, which in fact closed after 17 performances. Erika Fischer-Lichte describes the production of *Les Cenci*: "For this production, a wide range of recorded sounds were used: the bells of the cathedral at Amiens, machine noises, trumpet fanfares, steps, metronomic beats, birds twittering and voices calling out 'Cenci' with increasing and decreasing volume, supported by an electronic instrument with monodic claviature. These sound recordings were sent out from different directions through loudspeakers: the loudspeakers were set in all four corners of the auditorium so that the spectator was totally surrounded by sound and could be moved towards a trance-like state." (Fischer-Lichte 2002: 297)

2.4. Theatre of the Absurd

The three types of theatre that have been described all challenged the way theatre had been seen: by focusing less on the dramatic text and more on the dynamics between the players and the watchers, they examined the boundaries of theatrical performances. According to Shank, this 'new theatre' had "two energizing forces": "the moral energy of social causes and the spirit of artistic exploration" (Shank 1982: 3), the first looking outward, "exploring human beings in society", like in the Epic Theatre, the second looking inward and considering "how we perceive, feel, think" (Ibid), like in the Theatre of Cruelty. The Theatre of the Absurd seemingly merged the two energizing forces by expressing "the absurdity of life in the 1950s at a time of social and political complacency while governments were adding to their stockpiles of nuclear weapons" (7), but also by reflecting "the philosophical alienation of the individual" (3). In his influential study *The Theatre of the Absurd*, Martin Esslin identifies the major theme of absurdist plays as the "sense of metaphysical anguish at the absurdity of the human condition" (Esslin 2001: 20), but he adds that the same theme obsessed other, earlier writers who do not belong to this type of theatre because they try to explain the irrationality of the world with rational arguments. The Theatre of the Absurd, however, "strives to express its sense of the senselessness of the human condition and the inadequacy of the rational approach by the open abandonment of rational devices and discursive thought" (Ibid). Accordingly, the word 'absurd', as Eugène Ionesco defined it, is used to describe something that is "devoid of purpose", not 'ridiculous', or 'out of harmony': "Cut off from his religious, metaphysical, and transcendental roots, man is lost; all his actions become senseless, absurd, useless" (quoted in Esslin 2001: 19). The prominent practitioners of the Theatre of the Absurd include Samuel Becket, Arthur Adamov, Eugène Ionesco, Jean Genet, and Harold Pinter. They put emphasis on the purposelessness of language (thus continuing to de-literalise theatre) by focusing on the silences and pauses, on the "superb use of the comma", and on "syntax full of reservations and uncertainties" (Cronin 1996: 337). Comparing himself to James Joyce, Beckett told one of his biographers: "I realised that Joyce had gone as far as one could in the direction of knowing more, [being] in control of one's material. He was always adding to it; ... I realised that my own way was in impoverishment, in lack of knowledge and in taking away, in subtracting rather than in adding" (Knowlson 1996: 319). This language impoverishment is the key feature of Beckett's famous plays *Waiting for Godot* (1953), *Endgame* (1957), *Krapp's Last Tape* (1958), etc., together with all the epithets that critics use to describe them: Kirsten E. Shepherd-Barr refers to the bleak Beckettian view of the world as "obliterated, entropied, with humankind at its last moments before extinction" (Shepherd-Barr 2015: 47); Fischer-Lichte claims that Beckett portrayed the "dissolution and dismemberment of the individual ... as a standstill, as a perpetual end condition" (Fischer-Lichte 2002: 333); Pavis asserts that Beckett's plays "obstinately refuse to 'mean anything'" (Pavis 2013: 184). Beckett's existential absurdity was shared with the other mentioned playwrights in their works. Ionesco's *The Bald Soprano* (1950) instigated The Theatre of the Absurd¹, while other

¹ Additionally, the tragic farces of an Italian dramatist and Nobel Prize winner Luigi Pirandello (1867-1936) are often quoted as being the true forerunners of the Theatre of the Absurd, particularly his play *Six Characters in Search of an Author* (1921).

plays worth mentioning include *Le Ping-Pong* (1955) by Arthur Adamov, *The Balcony* (1956) by Jean Genet, *The Dumb Waiter* (1957) by Harold Pinter.

2.5. Poor Theatre

In his Polish Laboratory Theatre, the Polish director Jerzy Grotowski (1933-1999) further challenged the traditional concept of theatre and brought the actor-spectator relationship to extremes by rejecting “all forms of theatre save his own, which he calls the Poor Theatre” (Roose-Evans 1970: 62). Grotowski came to rival his Russian predecessor and the most famous theorist of acting, Konstantin Stanislavsky¹ (1863-1938), since “no one, since Stanislavsky, [had] written of the actor craft with such authority, insight and vision” (Ibid). The ‘poor’ theatre rejects everything that belongs to the ‘rich’ theatre: makeup, lighting, costume, sound effects, lavishly decorated stage, etc². Like in the renaissance theatre, the stress is on imagination, but both the audiences’ and the actors’, so that the props that are lacking on stage can be envisioned through simple objects: “the floor can become the sea; a table, a boat; the bars of a chair, a prison cell”, and so on (63). Compared to Brecht’s Epic Theatre, which wants to make the audience think, Grotowski’s Poor Theatre wants to disturb the spectators (64), which is closer to Artaud’s Theatre of Cruelty. Furthermore, he chooses a “special” audience for his performances (Ibid), one that is willing to analyse the established myths and deconstruct the taboos put on stage. This return to the myth that “inhabits and nourishes” any story and is its “essential core” was crucial for Grotowski, who “sought the hard kernel”, as Pavis explains, “the link of the myth to the individual or collective unconscious” (Pavis 2013: 211). He did this by staging Polish classics in unexpected ways, for example by moving the action from its original setting to Auschwitz, which he did in staging *Akropolis*³, the poetic drama written by Stanislaw Wyspianski:

The production is set on a large rectangular stage standing in the middle of the audience. The platform is piled high with scrap metal. A ragged violinist appears and summons the rest of the cast, who hobble on in sacks and wooden boots. The action takes the form of daydreams in the breaks between work. The seven actors attack the mound of rusting metal, hammering in unison, and fixing twisted pipes to struts over the audience’s heads. (Roose-Evans 1970: 64)

Thus, actors and spectators are merged, fiction and reality are intertwined, and the boundaries between theatre and life are irrevocably blurred in this type of theatre⁴. To understand it, one should refer to Grotowski’s article “Towards a Poor Theatre” (1965),

¹ See Carlson 1984: 454.

² Although these supposedly rejected properties are actually credited for every one of his productions. See Roose-Evans 1970: 63.

³ The avant-garde theatre production of *Akropolis* by Teatr Laboratorium, Wroclaw, was shot and made into a TV movie in 1969. Interestingly, this television broadcast was hosted by Peter Brook (1925-2022), one of the greatest English theatre directors of all times.

⁴ Although the ritualistic form of the Theatre of Cruelty attempts to do the same.

in which he explains that “the personal and scenic technique of the actor” should be considered “the core of theatre art” (Grotowski 2002: 15). The poor theatre continues to diminish the importance of the dramatic text, because “the text per se is not theatre, ... it becomes theatre only through the actors’ use of it - that is to say, thanks to intonations, to the association of sounds, to the musicality of the language” (21). Grotowski’s student Eugenio Barba examines the meaning of the word ‘theatre’ in his article “The Theatre’s New Testament” (1964) and claims that it has different meanings for different people—the academic, the average theatregoer, the actor, the stage designer, the producer, all have their own idea about what theatre is for them (28-31). Since “the number of definitions of theatre is practically unlimited”, Barba suggests that one must “eliminate, not add” elements to it: “Can the theatre exist without costumes and sets? Yes, it can. Can it exist without music to accompany the plot? Yes. Can it exist without lighting effects? Of course. And without a text? Yes; the history of the theatre confirms this” (32). This is what Grotowski means by “the acceptance of poverty in theatre”: that it should be “stripped of all that is not essential to it” (21).

3. CONCLUSION

Despite their differences, these five forms of theatre are also similar because each of them stems from the previous one, while some develop at the same time. They all point to a deep distrust of language that dominated the first half of the 20th century and continued to deepen in the following decades. The consequences are seen in the ‘de-literarisation’ of theatre in each of these artistic forms, albeit in a slightly different manner. They don’t want the spectators to be passive, indifferent observers, but want to make them feel, think, act, be disturbed. In that way, they all challenge the traditional concept of theatre seen as a place to have fun, to be seen, to relax. Many subsequent playwrights and directors were heavily influenced by the major practitioners of the described forms of theatre that new forms kept emerging. In the second half of the 20th century, theatrical forms worth mentioning are Peter Schumann’s Bread and Puppet Theatre, the Guerilla Theatre, Augusto Boal’s Theatre of the Oppressed, Richard Foreman’s Ontological-Hysteric Theatre, the Living and the Open Theatre, In-Yer-Face Theatre, and so on. They all follow on the ideas of their predecessors by using theatre as a place that inspires action, external or internal, not (only) with dramatic texts but also with the techniques that are inherent to theatre, even if it means stripping it bare of everything as Grotowski desired. The future of the theatre is thus kept exciting because if there is an unlimited number of definitions of theatre then the possibilities for its development are also endless.

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TRANSFORMATION OF MEANINGS IN THE SCREEN VERSION OF FAIRY STORY IN RUSSIAN CINEMA.

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ABSTRACT:

The article examines the issues of transformation of value guidelines in fairy tale films of Russian cinema for children. Film products from the 30-40s of the last century to the present are analyzed. The issues of the influence of ideology on the semantic dominants of children's cinema are considered. The issues of the peculiarities of the mythologization of the main character of fairy tales in cinema are explored. The influence of world cinema on the fairy tales of Soviet and modern Russian cinema is examined using specific examples. For example, correlation, parallels and allusions with the film by German director Fritz Lang "Nibelungen" and the film - fairy tale by director Alexander Rowe "Kashchei the Immortal" (1945), where the image of the main character of the Soviet film, like Siegfried in "Nibelungen", is built on the strict canons of heroism -mythological narrative. Moreover, A. Rowe uses Lang's film not so much for the purpose of conscious manipulation with someone else's text in the system of the author's, individual culture, but as a model, a source of successful, ready-made solutions that the creators of folklore traditions naturally and without any reflection borrow from each other. The experience and features of creating joint fairy tale films after World War II, in the creation of which countries from different socio-economic systems took part, are considered. The reasons for the success of films on screens in the USSR, but also abroad are analyzed, demonstrating the successes of domestic cinema in artistic and technical terms, promoting the best examples of folk culture and literary classics of Russia in the 50-60s of the last century, as well as the reasons for the decline of this genre in the 80s. 90 and the reasons for the revival of interest in this genre and the successful experience of modern Russian filmmakers in the last 10 years.

Keywords: cinema,. Russian children's cinema, fairy tale film, meanings, tradition, mythology.

A qualitative analysis of children's film production from the late 20s to the 40s of the last century in Soviet Russia is not possible without taking into account the influence of ideology on the semantic dominants of children's cinema. After the 1917 revolution, children's cinema became a means of educating children and teenagers.

It should be noted that films for children in Russia appeared at the very beginning of the cinematic era. Progressive-minded Russian teachers immediately drew attention to

“moving photographs” as a tool in education and upbringing. In the early 1910s, short film adaptations of excerpts from Russian fairy tales were created - “The Frog Princess”, “Grandfather Frost” and others. In the same years, Vladislav Starevich directed the puppet cartoon “Beautiful Lyukanida, or the War of the Mustache and the Horned Horns.” Unfortunately, this process was interrupted in 1914 with the outbreak of World War I, when children's films were not made in Russia. At the end of the revolution and civil war, after a long break, the first children's feature films were created: “Alyoshkina's pipe” based on a Russian folk tale and “The Little Match Girl” and “The King's New Dress” based on the fairy tales of H. C. Andersen.

The leadership of the Soviet country paid great attention to the issues of children's and school cinema: cinematization of schools began, special cinemas for young people were built, the number of screenings for children in ordinary cinemas increased, thematic and genre boundaries expanded, cinema expanded its thematic and genre boundaries, not only feature films and documentaries, but also animated films. After the creation of the Soyuzdetfilm film studio in 1936, the number of children's films doubled. The following directors worked in children's cinema: A. Rowe, A. Ptushko, L. Kuleshov, M. Barskaya; writers: L. Kassil, V. Kataev, E. Schwartz and others [1].

In the 1930s, with the advent of sound cinema, the genre of film fairy tales especially developed. Technical innovations make it possible to demonstrate on the screen transformations, flights and other miracles that are mandatory attributes of fairy tales. In 1935, director A. Ptushko created the film “The New Gulliver,” where dolls and real actors interact on the screen. This film, despite its revolutionary narrative, was well received not only in our country, but also abroad, where it received a high award at a film festival in Italy. His 1939 film based on A. Tolstoy's fairy tale “The Golden Key” also used acting in combination with hand-drawn and three-dimensional animation.

Director Alexander Rowe in the late 30s and early forties made the films “At the Command of the Pike” and “The Little Humpbacked Horse,” and in 1945 “Kashchei the Immortal,” where friendship and hard work defeat evil forces and where justice triumphs. In these fairy tales, the image of the main character with the people is connected only by his origin, which is declared for ideological reasons, but is used mainly to show the monumental scale of the main character's accomplishments and achievements at the end of the journey. The image of the main character is extremely mythologized. This is the hero of the film - the fairy tale “Kashchei the Immortal” (1945) directed by Alexander Rowe. It is no coincidence that some researchers point to parallels and allusions with the film of the German director Fritz Lang “Nibelungen”: “... whatever his (A. Rowe's) initial intentions, he uses Lang's film not so much as an object of parody, polemic or rethinking - that is, conscious manipulations with someone else's text in the system of the author's, individual culture - as much as as a model, a source of successful, ready-made solutions that the creators of folklore traditions naturally and without any reflection borrow from each other” [2,56]. In this film, the image of Nikita Kozhemyaka, like Siegfried in “Nibelungen”, is built on the strict canons of heroic-mythological storytelling. Only a supporting hero can be truly popular, simple in words and actions, who is the faithful assistant of the main character - Bulat Balagur. Even a faithful friend can have such a human element without a “bronze” touch. For example, Katenka from the film - fairy tales by director Alexander Ptushko “The Stone Flower (Ural Tale)” (1946), but not the master Danila himself.

The film fairy tale “Sadko” by Alexander Ptushko (1952) actually continued this tradition. The following year, the film “Sadko” received the “Silver Lion” at the Venice International Film Festival, and Sergei Stolyarov, the leading actor, was included by the festival judges in the list of the best actors in the world for the half-century history of cinema. The international-mythological character of the main character of this era manifested itself here too. It is no coincidence that in the USA this film by A. Ptushko was shown at the box office under the title “The Magic Voyage of Sinbad”. Significantly shortened and with the names of the characters changed, the film did not cause problems with the perception of the main characters among American viewers and brought good profits to American producers.

Only the author of the film, a fairy tale of this period, “Cinderella” (1947), can refuse the ponderous and ceremonial main character. To do this, it was necessary to radically change the style of presenting the material. Director Nadezhda Kosheverova managed to do this, largely thanks to the talent of the great storyteller Evgeniy Schwartz. Here the main character, in her essence, cannot be like a bronze statue. But the rejection of the basic canons of the character of the protagonist (heroine) influenced the very image of this character. M. Romm accurately noticed this during the discussion of the footage: “I liked the fairy tale. Perhaps the only drawback is that the main character somehow has no character. The King and the Stepmother have character, but Cinderella herself does not...” [3,103]. Director and screenwriter Ya. B. Fried expressed himself even more radically: “... In the image of Cinderella, I did not detect an active love of work, just as I did not detect traditional charm in other images. All the other characters surrounding Cinderella are surprisingly unlikable faces. Garin is degenerate and does not evoke sympathy; the prince is unpleasant - a rickets with a liquefied brain. Why should Cinderella love him like that? All this acts in such a way that you begin to worry about all the material due to the fact that, from my point of view, it is vicious” [3,105]. Such critical speeches indicate how heated debates flared up during the discussion of even minor deviations from the usual style and standard form of presentation of material. The transcript of the discussion demonstrates rather impartial assessments of colleagues in the cinematic workshop. However, the discussion ended favorably for the authors and, after speeches in support of Nadezhda Kosheverova’s film “Cinderella” by famous directors, in particular G. Kozintsev, the material was approved.

The sixties were quite fruitful for filmmakers working in the fairy tale film genre. These films also played an important role in the ideological struggle. In the late fifties and early seventies, A. Ptushko made a number of fairy tale films in an original style, which played an important role in propaganda both within the country and abroad. The Soviet-Finnish film “Sampo” occupies a special place here. Alexander Ptushko, the great Soviet director and storyteller, was the first and only one who filmed the Karelian-Finnish epic “Kalevala” in 1958 [4]. After World War II, the Finnish leadership understood the need to stabilize and establish economic relations with the USSR, but not the entire population. The country then considered it necessary to improve relations with the Soviet country. Therefore, a special program of cultural interaction was developed, within the framework of which it was decided to make a joint film. In 1959, the Soviet-Finnish film “Sampo” was released; the film was based on the Karelian-Finnish epic “Kalevala”, which played an important role in the formation of the ideology of the Finnish nation. Considering the importance of the film, enough money was allocated for the production of the film. The

epic film was amazing with its technical effects, costumes, not to mention the excellent acting. It was the first joint film after the war, in which countries from different socio-economic systems took part. The film was shot in two languages at once and was shown not only in the camp of socialist countries, but also in capitalist countries. In the American box office, it was subjected to serious processing and received the title “The Day the Earth Froze,” which can be translated as “The Day the Earth Froze.” Despite such a pessimistic translation, the very fact of the possibility of collaboration in cinematography spoke of a departure from the harsh confrontation of the Cold War period. Alexander Ptushko, the great director and storyteller, immortalized the first (and only) this work in the world.

A. Ptushko’s next film, “Scarlet Sails” (1961), was also notable for its novelty and originality. This was the first film adaptation of A. Green’s work, which did not fit into the format of socialist realism at all. His works did not contain anything socialist and had a very indirect relationship to existing reality. Nevertheless, the “thaw” trends rehabilitated the author of the fairy tales, and it was no coincidence that his brightest and most optimistic story was chosen at that time. It is not clear why some foreign researchers believe that the filmmakers destroyed Green’s style of the story by transferring it “to the plane of a familiar fairy tale - an epic of the Stalinist type.” Some social and class aspects were introduced into the storyline of the film, which was quite “in the spirit of the times and traditions, of which the director himself was a part.” One can blame the authors for the fact that sixteen-year-old Anastasia Vertinskaya sometimes creates the image of an overly enthusiastic heroine, and Vasily Lanovoy is sometimes overly pathetic in the image of Arthur Gray. In general, these moments did not spoil either the lyrical style or the general romantic spring atmosphere of his work. In 2022, Pietro Marcello will film an adaptation of Alexander Green’s work “Scarlet Sails”. In the French original it was called “Take Off”, and in the US box office it was called “The Scarlet Color”. Russian critics highly appreciated this film work. So Denis Korsakov noted in his review: “... Marcello does not treat the source material so casually: all the main plot motifs of “Scarlet Sails” are preserved, just carefully modified. But until the very end you are not sure that everything will end as happily as Green’s. From this director, judging by the very intonation of his narration, you can expect any surprises (and in any case, you don’t have a very good idea of what the sails on the plane will look like). But overall, it’s a joy to see a new film adaptation of Green’s “extravaganza” in just such a performance” [5]. However, the Russian film “Scarlet Sails” is the best adaptation of the works of A. Green, and the main thesis of the work “to do miracles with your own hands” is quite in the spirit of the great film storyteller Alexander Ptushko, who shot such masterpieces of Russian cinema as “The Tale of Tsar Saltan” (1966), “Viy” (1967), “Ruslan and Lyudmila” (1972). Almost all of A. Ptushko’s films were shown with great success both in the country and abroad.

Another Soviet film storyteller A. Rowe also worked in a more traditional style, but also successfully during these years. His film works were largely addressed to the Soviet audience. Films such as “Marya the Mistress” (1959), “The Kingdom of Crooked Mirrors” (1961), “Morozko” (1964), “Varvara – Beauty, Long Braid” (1968) and other films of this period touch on themes of family and childhood, love, friendship. In the films - fairy tales of Alexander Arturovich Rowe there are many interesting and original solutions. There are quite a lot of special effects in his films, but they are presented in moderation and always play a subordinate role. Sometimes special effects can be quite large-scale, like the

episode of Vakula's journey to St. Petersburg in the film "Evenings on a Farm near Dikanka," but they are necessarily subordinated to the storyline of the film. Mentioning the directors of this genre, it is necessary to say about the director of the Lenfilm film studio, Nadezhda Nikolaevna Kosheverova, who, continuing the success of her film "Cinderella" in the sixties and seventies, shot such wonderful fairy tales as "An Old, Old Tale" (1968), "Shadow" (1971) and others. During these years, films appeared - fairy tales, which differ in a number of parameters from other works in this genre. A film directed by Vladimir Bychkov based on T. Grabbe's play "City of Masters" (1965) looks like a very unusual phenomenon in the fairy-tale film world. The play, written by blockade survivor Tamara Gabbe during the difficult war years, is more like a fairy tale than a film. Liking a film depends not only on the integrity of the plot, acting and cinematography, but also on the authenticity achieved by the work of costume designers and set designers. At the end of Vladimir Bychkov's fairy tale "City of Masters" it is said that "it is unknown when this story happened." Although it was the temporary immersion into the past that the director and artistic staff of the film were especially successful in.

The famous film critic, editor-in-chief of the magazine "Soviet Screen" Dmitry Pisarevsky noted this film as an undoubted success of Soviet children's cinema: "To the success of the director's and visual decisions of the film, one must add the emotionality of its music, excellent poems by S. Marshak [6, 286]" Very dynamic, A film adaptation by A. Batalov of Y. Olesha's fairy tale "Three Fat Men" (1966) was a bold film work in concept. B. Rysarev's film "Aladdin's Magic Lamp" (1966) became a unique and striking phenomenon in the world of fairy tale cinema, combining oriental flavor, excellent special effects and subtle humor. These films were a huge success not only among children, but also among their parents and are still interesting and loved by viewers.

Unfortunately, further technological development of domestic cinema was practically stopped. Fairy tale films on the big screen of the last two decades of Soviet power looked hopelessly behind the world level in technical terms. Currently, young Russian directors are actively turning to this complex genre. The difficulties of creating such paintings for the most impressionable viewers are not only in technical terms, but also in the use of artistic forms that correspond to the interests and specific interests of young viewers. Over the past decade, many fairy tale films have been released on Russian screens, which have been well received by young viewers and highly praised by critics.

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ANALYSIS OF PARAMETERS THAT INFLUENCE THE EFFECTIVENESS OF TEAMWORK

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SAŽETAK:

Timski rad postaje sve važniji aspekt organizacione dinamike i stoga je neophodno razumeti faktore koji doprinose ili ograničavaju produktivnost timova. Cilj istraživanja je da se analizira kako različiti parametri, kao što su komunikacija, liderstvo, motivacija, raznolikost članova tima i organizaciona kultura, utiču na efikasnost timskog rada. U istraživanju su korišćene različite metodologije, uključujući ankete zaposlenih, analizu internih dokumenata i studije slučaja. Rezultati istraživanja ukazuju da su parametri kao što su otvorenost komunikacije, podrška lidera i različitost u timu ključni faktori koji pozitivno utiču na produktivnost i inovativnost timova. Takođe, otkriveno je da organizaciona kultura igra ključnu ulogu u oblikovanju dinamike tima i da je važno uskladiti vrednosti organizacije sa ciljevima tima.

Ključne riječi: timski rad, efikasnost, produktivnost, komunikacija, liderstvo, motivacija

1. UVOD

Savremeno poslovno okruženje je složeno tkivo promenljivih faktora i dinamičnih izazova koji zahtevaju da organizacije budu agilne, prilagodljive i konkurentne [1]. Jedan od ključnih elemenata koji doprinosi sposobnosti organizacija da postignu uspeh i zadrže vodeću poziciju na tržištu je efektivnost timskog rada. Timski rad nije samo trend u poslovnom svetu; to je neophodnost koja omogućava organizacijama da ostvare svoje ciljeve, inoviraju i odgovore na brze promene. U cilju razumevanja i optimizacije faktora koji utiču na efikasnost timskog rada, ovaj rad će se baviti analizom četiri ključna parametra: liderstvo, upravljanje ljudskim resursima, motivacija i upravljanje konfliktima. Liderstvo kao faktor konkurentske prednosti jedan je od osnovnih elemenata uspešnog timskog rada. U svetu postoje brojni primeri odličnog timskog rada. U tom smislu, *Apple*, tehnološki gigant, može predstavljati primer kako liderstvo oblikuje organizacionu kulturu i strategiju koja omogućava kompaniji da se istakne kao lider u industriji. Analizom *Apple*-ovog menadžmenta, može se videti način kako vrhunski lideri mogu da utiču na inovacije, kvalitet proizvoda i lojalnost kupaca. Upravljanje ljudskim resursima igra ključnu ulogu u privlačenju, razvoju i zadržavanju talentovanih zaposlenih. Kompanija *Netflix*, poznata po svojoj agilnoj kulturi, daje primer kako efikasno upravljanje ljudskim resursima može

da stvori okruženje koje privlači visokokvalifikovano osoblje i omogućava brzo prilagođavanje promenama. Analizirajući pristup upravljanju ljudskim resursima u *Netflix*-u, može se utvrditi kako organizacije mogu da izgrade timski kapacitet kroz pažljivo planiranje i upravljanje ljudskim resursima. Motivacija je ključni faktor koji utiče na produktivnost i angažovanost članova tima [2]. Kompanija *Walt Disney* je poznata po svojoj sposobnosti da inspiriše i motiviše svoje zaposlene da stvaraju magična iskustva za svoje klijente. Analizirajući Diznijevu motivacionu kulturu, autori će predstaviti način na koji organizacije mogu da koriste kreativne metode da podstaknu svoje timove da rade najbolje što mogu. U savremenom poslovnom okruženju koncept timskog rada postaje sveprisutan i ključni element za postizanje uspeha i sticanje konkurentске prednosti za mnoge organizacije (). Ovaj koncept nije samo još jedna teorija menadžmenta, već je suština njegovog značaja duboko proživljena u izreci koja je postala mantra poslovnog sveta – „jedinstvo je snaga“. U nastavku ovog teksta produbiće se razumevanje potrebe i značaja timskog rada u poslovnim organizacijama, fokusirajući se na njegove brojne prednosti i implikacije, ali će se prednost dati najznačajnijem faktoru – faktoru motivacije.

2. KOMUNIKACIJA U TIMU

Mnogi autori ističu da je komunikacija ključ uspešnog timskog rada [3,4]. Timovi treba da omoguće članovima da iskreno izraze svoja mišljenja, emocije i brige vezane za posao kako bi održali produktivnost i međuljudske odnose. Otvorena komunikacija ukazuje na dobru atmosferu i međusobno poverenje, što je neophodno za uspeh timova. Takođe, omogućava efikasno rešavanje konflikata, koji su prirodni u svakom timu. Pored olakšavanja interne dinamike tima, komunikacija omogućava timovima da se povežu sa drugim timovima i integrišu različite ideje. Otvorena i spontana komunikacija je ključna za postizanje zajedničkih timskih ciljeva, bez obzira na hijerarhiju ili organizacionu strukturu. Važna pravila za uspešnu komunikaciju u timu uključuju zajedničko razmišljanje, odricanje od individualne dominacije, pažljivo slušanje drugih, fleksibilnost u pristupu, razmišljanje o idejama i otvorenost za različite perspektive. Ove ideje naglašavaju ključnu ulogu komunikacije u podršci efikasnom timskom radu i pozivaju na otvorenost i saradnju kako bi se postigao timski uspeh [5]. Komunikacija se može opisati kao proces uspostavljanja zajedničkog razumevanja između dvoje ili više ljudi kroz razmenu poruka. Ova dvosmerna interakcija zahteva od primaoca ne samo da primi poruku, već i da je razume u smislu sadržaja i njenog značenja kako je nameravao pošiljalac. Uspešna komunikacija podrazumeva tačno razumevanje informacija koje je pošiljalac želeo da prenese. Komunikacija je složen socijalno-psihološki fenomen koji se odvija u društvenom okruženju i zavisi od mnogih psiholoških procesa kao što su percepcija, učenje, pamćenje, motivacija i emocije. Proces komunikacije uključuje prenošenje i razumevanje informacija, gde jedna strana šalje poruku, a druga prima i razume. Povratne informacije igraju ključnu ulogu u merenju nivoa razumevanja poslate poruke. Važno je napomenuti da komunikacijski proces može ometati buka u kanalu komunikacije, kao što su fizičke prepreke ili buka. Ključni delovi komunikacijskog procesa uključuju pošiljaoca, kodiranje poruke, poruku, komunikacioni kanal, dekodiranje, primaoca, šum i povratnu informaciju.

Uspešna komunikacija zavisi od odabira pravog kanala komunikacije, efikasnog slušanja i povratnih informacija [5].

Na kraju, važno je razumeti da komunikacija uključuje verbalnu i neverbalnu komunikaciju, uključujući gestove, izraze lica i druge pokrete tela.

Komunikacija je ključna za uspešan timski rad. Postoje različite vrste komunikacije unutar timova, a njihovu efikasnost možemo sagledati kroz nekoliko aspekata (Vidović, 2017):

- Formalna i neformalna komunikacija: Formalna komunikacija je planirana i usklađena sa potrebama organizacije, dok je neformalna komunikacija spontana i često odražava percepciju zaposlenih o organizaciji.
- Vertikalna i horizontalna komunikacija: Vertikalna komunikacija se odvija između ljudi na različitim hijerarhijskim nivoima, dok se horizontalna komunikacija odvija između ljudi na istom organizacionom nivou.
- Centralizovana i decentralizovana komunikacija: Centralizovana komunikacija podrazumeva da se informacije šalju određenom centralnom organu, dok je decentralizovana komunikacija otvorenija i omogućava direktan kontakt između članova tima.

Bočna ili horizontalna komunikacija, posebno u timskom okruženju, olakšava razmenu informacija, poboljšava razumevanje i pomaže u rešavanju problema. Ova vrsta komunikacije odvija se između kolega i saradnika na istom organizacionom nivou.

Da bi komunikacija bila uspešna, važno je voditi računa o očuvanju zvaničnog sistema komunikacije, voditi računa o nezvaničnoj komunikaciji, podržavati i vertikalnu i horizontalnu komunikaciju i omogućiti onlajn komunikaciju.

U timskom okruženju transparentna i iskrena komunikacija igra ključnu ulogu. Informacije treba deliti otvoreno tako da svi članovi tima budu informisani i da se osećaju uključenim. Pored toga, komunikacija treba da bude iskrena i jasna kako bi se izbegli nesporazumi i održali pozitivni odnosi unutar tima. Konflikte i nesuglasice treba odmah rešavati kako bi se održala produktivna komunikacija u timu [5].

2.1. Liderstvo u timu

Termini „liderstvo“ i „tim“ su uobičajeni u organizacionom kontekstu, ali zanimljivo je da je malo istraživanja posvećeno dubljem razumevanju uloge liderstva unutar timova u organizacijama. Većina istraživanja o liderstvu se fokusirala na individualne lidere, dok je pažnja na liderstvo u timovima bila ograničena. Uloga lidera u poboljšanju efikasnosti timskog rada je ključna komponenta uspešnog poslovanja u savremenom poslovnom okruženju. Lideri imaju sposobnost da oblikuju dinamiku tima, inspirišu članove tima i usmere ih ka postizanju zajedničkih ciljeva. Ovo poglavlje će istražiti važnost liderstva u kontekstu timskog rada, analizirajući konkretan primer kompanije *Apple*. Kroz ovu analizu razmotrićemo kako su čelnici ove renomirane kompanije doprineli njenom uspehu i kako su njihove liderske veštine i strategije oblikovale efektivnost tima. Proučavanjem primera *Apple*-a otvaramo vrata dubljem razumevanju uloge lidera u postizanju izuzetnih rezultata kroz timski rad u savremenom poslovanju [6]. Lider nije isto što i menadžer. Menadžer ima ulogu lidera koji vodi računa o svim aspektima organizacije i osigurava da sve teče glatko. S druge strane, lider teži da oblikuje viziju organizacije i motiviše ljude da budu efikasniji u obavljanju svojih poslova. Razlika između menadžera i lidera može se ilustrovati tabelom 1.

Tabela 1. Razlike između menadžera i lidera

RAZLIKA IZMEĐU MENADŽERA I LIDERA		
MENADŽER	LIDER	
Prihvata	ODGOVORNOST	Traži
Odgovara položaju	STATUS	Odgovara ugledu
Izbegava gde god može	RIZIK	Preuzima gde se isplati
Vodi	PODREĐENE	Inspiriše
Izvršava njihova naređenja	PRETPOSTAVLJENI	Sukobljava se sa njima – ako treba
Prema instrukcijama	PLANIRA	Kroz timski rad
Direktivama i naredbama	ORGANIZUJE	Inspirišući druge i sinergizmom
Na osnovu analize i iskustva	ODLUČUJE	Konsenzusom
Važna i vidljiva	TITULA	Nevažna – ne ističe je
Strah	IZAZIVA	Poštovanje
Ko je krivac	POKAZUJE	Šta je pogrešno
Kako je nešto urađeno	ZNA	Kako nešto uraditi
Traži	RESPEKT	Zaslužuje
Prihvata	REALNOST	Istražuje
Na sisteme i strukture	FOKUS	Na ljude
Kako? Kada?	PITA	Šta? Zašto?
JA	KAŽE	MI
RADI STVARI NA PRAVI NAČIN		RADI PRAVE STVARI

3. MOTIVACIJA ČLANOVA TIMA

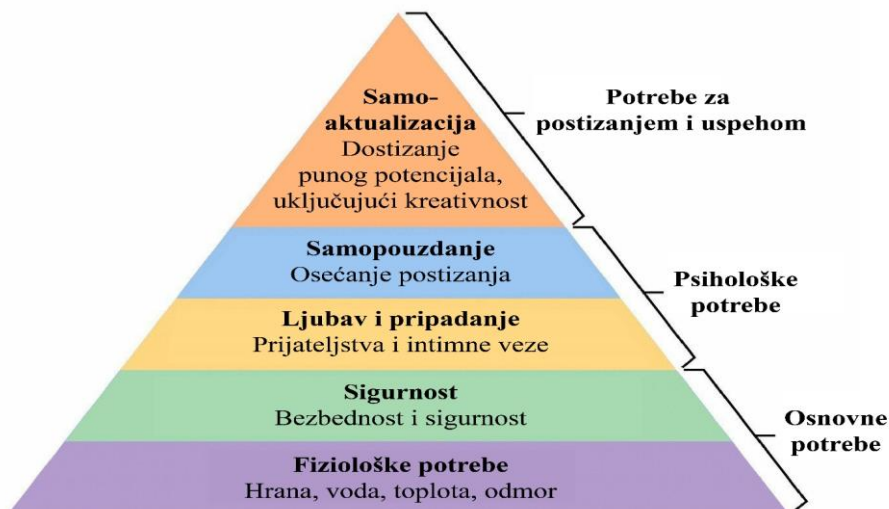
Mnogi faktori, uključujući okruženje, kapital i ljudske resurse, imaju značajan uticaj na performanse organizacije. Međutim, ljudski resursi se često smatraju ključnim faktorom koji najviše utiče na uspeh organizacije. Iz tog razloga, opravdano je raspravljati o potrebi organizacije da motiviše svoje zaposlene da bi ostvarila svoje deklarirane ciljeve i ciljeve. U ovom poglavlju biće detaljno razmotrena motivacija kao ključni aspekt upravljanja ljudskim resursima. Motivacija je složen pojam koji se u literaturi često različito tumači. Mnogi istraživači su pokušavali da formulišu koncizne teorije motivacije, ali su doneli različite ideje i pristupe. Ova raznolikost teorija motivacije rezultat je dubokih i raznovrsnih psiholoških, društvenih i ekonomskih faktora koji utiču na to kako ljudi reaguju na motivaciju. Stoga, da bismo razumeli motivaciju na radnom mestu, važno je istražiti različite teorije i pristupe koji su oblikovali naše razumevanje ovog koncepta. Hercebergova teorija motivacije, koja je prvi put predstavljena 1959. godine, i danas nastavlja da ima značajan uticaj na praksu upravljanja ljudskim resursima. Prema Stavu (1976), Herzberg je bio pionir u razlikovanju unutrašnje i ekstrinzične motivacije. Unutrašnja motivacija se odnosi na unutrašnji motiv pojedinca da obavlja određene zadatke ili aktivnosti radi ličnog zadovoljstva i interesa, dok se ekstrinzična motivacija odnosi na spoljašnje podsticaje kao što su nagrade, priznanja i kazne. Ova razlika je

pomogla da se bolje razumeju faktori koji utiču na motivaciju zaposlenih na radnom mestu i omogućila je razvoj strategija za efikasno motivisanje radne snage. Pored Herzbergove teorije, postoje brojne druge teorije motivacije koje su se razvijale tokom vremena, uključujući Maslovovu hijerarhiju potreba, teoriju očekivanja i teoriju samoeфикаsnosti. Sve ove teorije nude različite perspektive o tome kako ljudi pronalaze motivaciju za rad i kako organizacije mogu poboljšati motivaciju svojih zaposlenih [7]. Razumevanje i primena ovih teorija motivacije su od suštinskog značaja za uspešno upravljanje ljudskim resursima u organizacijama. Motivisani zaposleni su ključni resurs za postizanje organizacionih ciljeva i održavanje konkurentne prednosti na tržištu. Zbog toga je važno istražiti i primeniti najnovija saznanja iz oblasti motivacije kako bi se stvorilo produktivno i zadovoljavajuće radno okruženje.

Tabela 3 Herzbergova dvofaktorska teorija (Nduka, 2016)

Motivatori (dovode do zadovoljstva)	Higijena (dovode do nezadovoljstva)
<ul style="list-style-type: none">• Dostignuće• Prepoznavanje• Sam rad• Odgovornost• Napredovanje• Rast	<ul style="list-style-type: none">• Politika kompanije• Nadzor• Odnos sa šefom• Radni uslovi• Plata• Odnos sa vršnjacima• Bezbednost

Herzberg (1959) je predstavio čuvenu teoriju motivacije, nazvanu Teorija dva faktora, gde je opisao razliku između faktora motivacije i faktora higijene u svojoj teoriji. On je istakao da faktori mogu biti ili motivacioni ili higijenski faktori, ali nikada ne mogu biti oba u isto vreme (tabela 2). Maslov je 1943. godine tvrdio da ljudi imaju unutrašnje potrebe koje ih usmeravaju ka samoispunjenju i ličnoj superiornosti. Slika 1 prikazuje Maslovovih pet hijerarhijskih nivoa potreba [7].



Slika 1. Maslovljeva hijerarhija potreba (Nduka 2016)

Maslov je ocenio da postoji pet jedinstvenih nivoa potreba i da kada zadovoljimo potrebu na jednom nivou hijerarhije, to će uticati na naš stav. Na tom nivou naš stav počinje da opada, a mi dajemo veći uticaj na potrebe na sledećem nivou hijerarhije. Za bolje razumevanje faktora motivacije zaposlenih, ključno je postaviti jasna pravila i politike nagrađivanja unutar organizacije kada zaposleni postignu poslovne ciljeve. Ovo omogućava stvaranje sistema nagrađivanja koji nije samo fer, već i pouzdan, što je neophodno za izgradnju poverenja između zaposlenih i kompanije. Važno je zapamtiti da ljudi imaju različite potrebe i motivatore koji ih pokreću. Ne postoji jedinstven motivator za sve, pa je neophodno koristiti kombinaciju materijalnih i nematerijalnih metoda motivacije kako bi se zadovoljile različite potrebe zaposlenih [8].

4.1. Motivacija na primeru kompanije Walt Disney

Kompanija Walt Disney jedna je od najprepoznatljivijih i najuticajnijih medijskih korporacija u svetu zabave. Osnovani su ga 16. oktobra 1923. godine u Los Angelesu u Kaliforniji braća Walt i Roy Disney. Tokom decenija, kompanija se razvila u globalnog lidera u industriji zabave sa prisustvom u različitim sektorima, uključujući film, televiziju, tematske parkove i proizvodnju proizvoda vezanih za likove iz Disneyjevih animiranih filmova. Trenutno zapošljava oko 180.000 ljudi širom sveta. Jedan od ključnih trenutaka u Disneyjevoj istoriji koji ilustruje liderstvo i motivacione tehnike dešava se tokom ranih 60-ih i uključuje Majka Vens, zaposlenog u kompaniji. Ovaj primer pruža dublji uvid u vođstvo Wolta Disneyja i kako je primenio različite motivacione strategije da bi rešio izazove sa kojima se kompanija suočavala. Walt Disney je pozvao Majka Vensa u svoju kancelariju da podeli problem koji je mučio kompaniju u to vreme - njegov brat Ron je odbijao da obezbedi finansiranje za proizvodnju filmova. Walt je zamolio Majka za pomoć da reši ovaj problem. Majk Vens je, kao odgovor na ovaj izazov, okupio tim od sedam članova i zajedno su analizirali situaciju. Prvo što su primetili je činjenica da su tematski

parkovi Diznilenda otvoreni samo od srede do nedelje. Da bi povećali prihode, razmatrali su mogućnost otvaranja parkova i ponedeljkom i utorkom. Međutim, Irma, članica tima, predložila je alternativni pristup - otvaranje parkova ponedeljkom i utorkom samo članovima Kluba Magic Kingdom, programa lojalnosti koji je već postojao. Ovaj program je omogućio različite popuste i promocije članovima. Ova inovativna kombinacija otvaranja parkova i ekskluzivnog pristupa za članove kluba značajno je povećala posete parku i prodaju proizvoda u parku. Volt Dizni je takođe koristio tehnike direktne materijalne motivacije da ohrabri tim. Na Božić, svaki član tima dobio je posebne bonuse koji su uključivali 100 akcija kompanije *Walt Disney Company*, 25.000 dolara i ličnu poruku od samog Volta Diznija. Ova direktna materijalna motivacija nagradila je tim za uloženi trud i doprinela daljem radu na rešavanju finansijskih problema [9]. Irma je dodatno doprinela kreativnim rešenjima. Analizirajući dnevne aktivnosti u parkovima, uočila je slobodne sate četvrtkom uveče i predložila uvođenje „Matarske večeri“ za srednjoškolce. Ova inovativna ideja dodatno je povećala posećenost parka i prodaju hrane i pića. Nakon što je Irma napustila kompaniju, članovi tima su predložili zapošljavanje novog člana, koji je nedavno stekao zvanje magistra menadžmenta. Novi član je zatim predložio „direktni marketing“ kao strategiju za promociju proizvoda kompanije. Ova ideja je bila toliko uspešna da je novom članu ponuđeno mesto potpredsednika kompanije [9].

Ovaj primer ilustruje kako je vođstvo Volta Diznija bilo ključno u rešavanju problema i postizanju uspeha u kompaniji. Dizni je prepoznao važnost motivacije, inovativnosti i prepoznavanja vrednosti zaposlenih. Direktna materijalna motivacija, kreativne ideje i nagrađivanje rezultata odigrali su ključnu ulogu u ostvarivanju ciljeva kompanije. Ova studija slučaja potvrđuje hipoteze o značaju motivacije i liderstva zaposlenih u postizanju organizacione efektivnosti i efikasnosti. Analizirajući tehnike liderstva i motivacije u Dizniju, možemo naučiti vredne lekcije o tome kako liderstvo može da oblikuje organizacionu kulturu i doprinese uspehu kompanije[9].

4. KONFLIKTI U TIMU

Konflikt se često doživljava kao negativan termin, obično povezan sa neprijatnim iskustvima i lošom reputacijom. Kada se većina ljudi pita o konfliktu, prvo što im padne na pamet su neprijatne emocije i neprijatne situacije. Opšta definicija konflikta uključuje neslaganja u stavovima, verovanjima, vrednostima ili interesima među pojedincima, grupama ili organizacijama. Konflikti su neizbežan deo ljudskog života sa kojim ćemo se pre ili kasnije susresti, a način na koji se nosimo sa njima i razumemo ih može rezultirati pozitivnim ili negativnim promenama. Definicija konflikta opisuje konflikt kao nesklad između tendencija i akcija unutar pojedinca, grupe ili nacije, ili između pojedinaca, grupa ili nacija u situacijama kada postoji konkurencija ili korporativna dinamika. Ova definicija razlikuje dve osnovne vrste sukoba: intrapersonalne (sukobi unutar pojedinca) i interpersonalne sukobe (sukobi između pojedinaca). Razlikuju se i sukobi unutar i između grupa, kao i sukobi na nacionalnom i međunarodnom nivou. Konflikti se opisuju kao razlike u željama, potrebama, interesima, osećanjima i postupcima pojedinaca. Fric dalje pravi razliku između različitih tipova sukoba, uključujući unutrašnje, eksterne, latentne, prikrivene i mešovite sukobe, kao i sukobe sa prihvaćenim ili izbegavanim sukobima. Unutrašnji sukobi nastaju kada smo suočeni sa dva privlačna sadržaja („mučni izbor“),

dva različita odbojna sadržaja („zamka“) ili privlačnošću i odbojnošću prema istom sadržaju („sve ima dve strane“). Nasuprot tome, spoljni sukobi uključuju nesuglasice između više pojedinaca sa različitim željama i aktivnostima. Latentni sukobi nastaju kada ljudi nisu svesni svojih razlika. Mešoviti sukobi su kombinacija unutrašnjih i spoljašnjih konflikata, dok se sukobi sa prihvaćenom ili izbegnutom konfrontacijom nazivaju međusobnim sukobima, gde pojedinac ima moć da odluči da li će se direktno suočiti sa konfliktom ili ga izbeći. Pored ovih definicija, ukazuje se i na postojanje različitih tipova konflikata, uključujući unutarstemske i međustemske sukobe, situacione i socijalne sukobe, konstruktivne i destruktivne sukobe, sukobe zasnovane na suprotnosti i neprijateljstvu, svesne i nesvesnih sukoba, kao i sukoba koji eskaliraju i neeskaliraju. Ovo različito razumevanje sukoba pomaže nam da bolje razumemo prirodu i složenost ovog fenomena u društvu i organizacijama. Intragrupni sukobi, poznati i kao unutargrupni i međugrupni sukobi, predstavljaju različite vrste sukoba unutar organizacija i grupa. Intragrupni sukobi su oni koji se javljaju unutar same grupe ili tima, odnosno sukobi između članova iste grupe, organizacione jedinice, projektnog tima i sl. Kao i u drugim sferama, unutar grupe postoje određena pravila i norme ponašanja kojih se svaki član treba pridržavati da bi grupa normalno funkcionisala. Ako se jedan od članova ne pridržava ovih pravila i normi, postoji velika verovatnoća da će doći do sukoba unutar grupe. Takođe, kako pojedinac unutar grupe dobija više moći i uticaja, sukobi će biti sve teže rešiti, u zavisnosti od nivoa moći i položaja koji pojedinac zauzima u grupi. Konflikt ima veoma veliki uticaj na grupno ponašanje ljudi u organizacijama. Menadžeri najviše vremena troše na rešavanje konflikta [10].

5. ZAKLJUČAK

Ljudi su oduvek osećali potrebu da se udruže u zajednice kako bi zajedno radili na postizanju svojih ciljeva, rešavanju izazova, stvaranju novih ideja, unapređenju svojih veština i oblikovanju svog okruženja. Ovaj suštinski nagon za zajednicom i saradnjom seže u daleku prošlost ljudske civilizacije. Bilo da se okupljaju radi lova, obrade zemlje ili izgradnje skloništa, ljudi su oduvek razumeli da je timska snaga neophodna za prevazilaženje izazova i postizanje ciljeva. U savremenom poslovnom okruženju timski rad dobija poseban značaj i postaje jedan od najupečatljivijih i najvažnijih modela rada u 21. veku. S obzirom na sve složenije izazove sa kojima se suočavaju organizacije i kompanije širom sveta, sposobnost timova da efikasno sarađuju i koordiniraju svoje aktivnosti postaje od suštinskog značaja. Timski rad postaje kamen temeljac uspešnih organizacija, bez obzira na njihovu veličinu ili delatnost. Ključni element uspešnog timskog rada je koordinacija između članova tima. Ova koordinacija podrazumeva usaglašavanje ciljeva, odgovornosti i aktivnosti svakog člana tima u cilju postizanja zajedničkog cilja. Kroz dobru koordinaciju, timovi mogu efikasno da iskoriste raznovrsnost veština, znanja i iskustva svojih članova, što rezultira boljim donošenjem odluka i efikasnijim rešavanjem problema. Ključnu ulogu u timskom radu ima faktor motivacije, koji je najviše bio zastupljen u radu.

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ANALYSIS OF PARAMETERS THAT INFLUENCE THE EFFECTIVENESS OF TEAMWORK

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ABSTRACT:

Teamwork is becoming an increasingly important aspect of organizational dynamics and therefore it is necessary to understand the factors that contribute to or limit the productivity of teams. The aim of the research is to analyze how different parameters, such as communication, leadership, motivation, diversity of team members and organizational culture, affect the effectiveness of teamwork. Various methodologies were used in the research, including employee surveys, analysis of internal documents and case studies. The results of the research indicate that parameters such as openness of communication, leader support and diversity in the team are key factors that positively influence the productivity and innovation of teams. Also, it was discovered that organizational culture plays a key role in shaping team dynamics and that it is important to align the organization's values with the team's goals.

Keywords: *Teamwork, efficiency, productivity, communication, leadership, motivation.*

POETSKO-EGZEGETSKE KARAKTERISTIKE MARIJINE PESME (LK. 1, 46–55)¹

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SAŽETAK:

U radu predstavljamo osnovne poetsko-egzegetske karakteristike Marijine pesme iz Jevanđelja od Luke (1, 46–55) sa posebnim osvrtom na sledeća problemska mesta: pitanje autorstva (da li pesma pripada Mariji ili Jelisaveti), na pitanje pozicioniranosti Marijine pesme u Jevanđelju od Luke spram ostalog jevanđelskog ali i šireg biblijskog tekstualnog materijala, na pitanje strukture same pesme, na njen bogoslužbeni karakter, na postupke poetizacije molitvene ekstaze, te na teme koje se u datoj pesmi obrađuju: pesničko proslavljanje Boga, smirenje, poslušnost, socio-hrišćanske postavke, zajedništvo čoveka i Boga, što otvara i pitanje žanrovskog određenja Marijine pesme kao 'poetske molitve'. Teopoetski posmatrano, Marijina pesma, budući da naznačuje hrišćanstvo pre nego što se Mesija rađa i pre nego što će hrišćanstvo uopšte započeti, dobija karakter anuncijacije, odnosno, pesničkog predukusa dolazećeg hrišćanstva, te se može zaključiti da mesto pesme, na poetskom planu Lukinog jevanđelskog teksta, postaje mesto konstituisanja same istine hrišćanstva kao takvog.

***Ključne riječi:** Bogorodica, Marijina pesma, književna mariologija, biblijska književnost, teopoetika*

1. NOVOZAVETNA LIRIKA

Za razliku od starozavetne književnosti, koja je u žanrovskom smislu raznovrsnija u odnosu na novozavetnu, posebno zaračunavajući, što je nama ovde važno, istaknutije prisustvo lirskih književnih vrsta², u Novom zavetu takvih pesničkih tekstova daleko je manje, čak se može reći da se pojavljuju tek uzgredno. Za razliku od npr. Psaltira ili Pesme nad pesmama, starozavetnih poetskih knjiga prvog reda, lirski mozaik Novog

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² Među lirske biblijske književne vrste Drago Šimundža (2007: 261–263) ubraja: psalme, dramske recitale (npr. Pesma nad pesmama), himne, molitve, poeme, pohvale, tužbalice, zahvalnice, blagoslove, kao i proroštva.

zavet minijaturan je i fragmentaran, te se za njega može reći da nastaje tek u pukotinama apostolskih narativnih tekstova. Dakle, lirski pasaži, bolje reći, lirske minijature, tek su posredno prisutni u tekstualnom svetu Novog zaveta i to u onim mestima kada je autoru konkretne knjige, ili pak junaku u konkretnoj knjizi, potrebno da egzaltirano zapečati, posebno naglasi, ali i estetizuje konkretan događaj. Jedno od najupečatljivijih takvih mesta jeste kratka lirska pesma, koju na Hristovom rođenju pevaju anđeli: „Slava Bogu na visini i na zemlji mir među ljudima koji su po Božijoj volji“ (^{EC}Lk. 2, 14¹), odnosno, „Slava na visini Bogu, i na zemlji mir, među ljudima dobra volja“ (^SLk. 2, 14). Dakle, čin rađanja Boga na zemlji toliko je važan da je, na poetskom planu jevanđelskog teksta, potrebno da posebno bude istaknut time što biva propraćen ni manje ni više nego pesmom samih nebesa.

Molitvene himne postaju najomiljenija lirska vrsta Novog zaveta, te se u apostolskim poslanicama, posebno kod apostola Pavla, one inkorporiraju, bez ikakvog posebnog izdavanja, u celinu poslaničkog teksta. Jedna od najpoznatijih takvih molitvenih himni data je u Poslanici Filipljanima (2, 6–11), gde, bez bilo kakvog eksplicitnog upućivanja na žanrovsku smenu, apostol Pavle svoj diskurs produžava u pesmu: „Imajte u sebi istu misao koju Hristos Isus ima“ (^{EC}Fil. 2, 5), što se dalje nastavlja u: „on, koji je u obličju Božijem, nije smatrao kao nešto prigrabljeno – to što je jednak Bogu“ (^{EC}Fil. 2, 6) i dalje. Dato je vidljivo i na drugim mestima u drugim poslanicama: Kol. 1, 15–20; 1Pt. 1, 18–21; 2, 21–25; 3, 18–22; Jevr. 5, 7–10; Ef. 1, 3–14 (v. Šnele 2015: 138–139). Jedan od razloga ovakvog inkorporiranja jeste liturgijski karakter datih himni, zbog kog u svom egzaltirano-omilitičkom tonu apostoli koriste postojeće bogoslužbene pesme kako bi s jedne strane estetizovali svoju propoved i obraćanje pastvi, dok sa druge strane i svojim propovedima dali liturgijski kontekst².

Udo Šnele (2015: 138–139) ističe zajedničke poetske karakteristike nabrojanih himni: „1. citati (1Kor 11 23a; 15 3a) 2. participski stil (Rim 1 3b–4a; 3 25) 3. relativni stil (Rim 3 25; 4 25) 4. Parallelismus membrorum (Rim 1 3b–4a) 5. redak i jedinstven vokabular (Rim 1 3b–4a; 3 25) 6. struktura u strofama (Fil 2 6–11) 7. jedinstvene teološke predstave (Rim 1 3b–4a).“ Takođe, na istom mestu napominje Šnele, ni u jednoj o otkrivenih novozavetnih himni ne postoje sve pobrojane poetske karakteristike, ali „ako se više ovih kriterijuma sretnu u jednom tekstu, tada se sa velikom sigurnošću može govoriti o određenom tradicionalnom kompleksunošću može govoriti o određenom tradicionalnom kompleksu“, koji upućuje na evidentne pesničke tragove. Dakle, citatna zagledanost u ostatak biblijskog teksta, od starozavetnih do novozavetnih knjiga, posebnost u stilskim i jezičkim rešenjima, formalna odličja i posebni teološki naglasci postaju ključne karakteristike novozavetne lirike. U tom smislu, iako je ostala zapamćena na grčkom jeziku, novozavetna poezija svoje biće duguje starozavetnoj, a, kako su osnovne karakteristike pesništva Starog zaveta celovitost i zaokruženost predstavljene

¹ U radu koristimo različite prevode Biblije na srpski jezik, te indeksom ispred kratice za biblijsku knjigu upućujemo na prevodioce.

² O tome govori Udo Šnele (2015: 137): „Ranohrišćanske zajednice su svoju veru u sotiriološki značaj krsta i vaskrsenja izrazile u pesmama, himnama i ispovedanjima vere. Ove forme su naročito ušle u novozavetnu epistolografiju; one pružaju važne podatke o bogoslužbenom životu prve zajednice.“

misli, ritmičnost, prisustvo paralelizama (v. Burney 1925), tako se date osobine mogu naći i u novozavetnim pesmama.

Posebno mesto u razmatranju novozavetne lirike zauzima Jevanđelje od Luke, budući da je to jedino jevanđelje u Novom zavetu gde se žanrovska smena između naracije i pesme jasno naznačava. Kao tri Lukine pesme izdvajaju se Marijina pesma (Lk. 1, 46–55), Zaharijina pesma (Lk. 1, 68–79), u kojoj Zaharija s početka peva zahvalnost Bogu Izrailjevom, veličajući ga, dok u drugom delu pesme menja ton u proročki, govoreći o Hristu, te „Sada otpuštaš“, pesma, ako se može reći, o smrti i spasenju, koju peva Simeon uzevši dete Hrista u svoje naručje.

Sve tri Lukine pesme pokazuju značajan intertekstualni upliv ka Starom zavetu. U radu ćemo se ovim pitanjem detaljnije baviti glede Marijine pesme, međutim, ovde napominjemo sledeću zajedničku karakteristiku Lukinih pesama povodom njihovog odnosa prema Starom zavetu.

Date pesme izrastaju kao poetizacija susreta Starog i Novog zaveta, odnosno, prekomponovanjem Starog u Novi. Marijina pesma, budući da naznačuje hrišćanstvo pre nego što se Mesija rađa i pre nego što će hrišćanstvo uopšte započeti, dobija karakter najave, odnosno, pesničkog predukusa dolazećeg hrišćanstva. U „Zaharijinoj pesmi“ starozavetno-novozavetna sinteza snažno je istaknuta, budući da se u njoj jasno mogu odvojiti dva različita dela: prvi, koji je upućen na istoriju Starog zaveta, na Boga koga je opevao prorok David, kome se 'zakleo Avraam', dok se u drugom delu pesme, započetom invokacijom: „A ti dete“ (E^CLk. 1, 76), ispisuje istorija Jovana Krstitelja kao preteče Novog zaveta. Poslednja među pesmama, ona koju je izgovorio Simeon, pesma je, kako rekosmo, o smrti jednog čoveka, njenog autora, te s njim prestaje i dotadašnja istorija, da bi započela nova. Anuncijativni karakter Marijine pesme pretače se u apokaliptički ton Zaharijine pesme, da bi dato svoje finale dobilo u Simeonovoj pesmi, koja na određeni način proširuje završetak Zaharijine pesme, te govori o svetlosti-Hristu, koji postaje istina dolazeće realnosti, odnosno, realnosti koja je već tu. Dakle, iako smo to tek u najkraćim crtama naznačili, sve tri pesme, na različite načine, konstituišu Hristov identitet. Stoga je sasvim jasno što se date pesme nalaze upravo u Luke. Za razliku od ostalih jevanđelista jedino Luka opširno izveštava o Hristovom rođenju, te date pesme postaju poetski ambijent u kom je smešten narativ o Hristovom rođenju.

2. „MAGNIFICAT“

Posebno mesto među pesmama Jevanđelja od Luke zauzima Marijina pesma.

U ovom radu upravo se bavimo datim pesničkim tekstom, sa posebnim osvrtom na sledeća problemska mesta: pitanje autorstva (da li pesma pripada Mariji ili Jelisaveti), na pitanje pozicioniranosti Marijine pesme u Jevanđelju od Luke spram ostalog jevanđelskog ali i šireg biblijskog tekstualnog konteksta, na pitanje strukture same pesme, na njen bogoslužbeni karakter, na postupke poetizacije molitvene ekstaze, te na teme koje se u datoj pesmi obrađuju: pesničko proslavljanje Boga, smirenje, poslušnost, socio-hrišćanske postavke, zajedništvo čoveka i Boga. „Magnifikat“ se žanrovski može odrediti kao poetska molitva. Valentina Avramovna Maslova (2019: 56) ističe da se poetska molitva „razlikuje [...] od sakralne; koristeći religiju i tradicionalna crkvena načela ona prelazi u oblast umetnosti, započinje samostalan život prema zakonima poetske umetnosti“, dok kod Tanje Rončević (2016: 6) nalazimo da je poetska molitva „umetnički

izraz obraćanja Bogu i Bogorodici na temelju dijaloškog karaktera teksta uz uzvišene jezičke elemente i demonstraciju religioznosti pesnika”.

„Magnifikat“ je celovit pesnički tekst koji svoju primenu ima u bogoslužjenju i Istoče i Zapadne hrišćanske crkve, gde se u službenom životu Pravoslavne crkve Marijina pesma peva na svakom jutrenju, pri čemu joj se dodaje pripev arijina pesma peva na svakom jutrenju, pri čemu joj se dodaje pripev „Časnija od heruvima...“, što je još jedna, možda i najzastupljenija crkvena pesma koja proslavlja Mariju, dok se u Rimokatoličkoj crkvi u zavisnosti od različitog monaškog reda upotrebljava u različitim službama, najčešće u večernjoj (o tome v. Pandžić 2019: 8–9). Rečeno ovaj poetsko-molitveni tekst čini jednim od najzastupljenijih u životu hrišćanske crkve, te se može reći da se nalazi u samom vrhu bogoslužbene poezije.

2.1. Autorstvo

Tradicionalno se pesma o kojoj govorimo pripisuje Mariji, Hristovoj majci. Međutim, kako se može uočiti u kritičkom izdanju novozavetnog teksta Nestle-Aland (2012: 180), najraniji rukopisi Jevanđelja od Luke na mestu „Καὶ εἶπεν Μαριάμ“, što je uvod u datu pesmu, donose drugo ime, Jelisavetino. Različite su postavke o opravdanosti jednog ili drugog rešenja, pre svega kontekstualni, jezički, stilski (v. Duda 1966: 27). Po kontekstu radije je da stihovi originalno pripadaju Jelisaveti, jer se u jevanđeljskim alejama neposredno pre same pesme govori o Jelisavetinom rađanju. Kao sasvim logičan sled pojavljuje se pesma koja bi pripadala upravo Jelisaveti i u tom smislu jasno je zašto je upotrebljen veznik „καὶ“ – „i“. Napominjemo da se u sinodalnom prevodu na datom mestu nalazi suprotan veznik „a“, što stvara drugačiji kontekst u odnosu na originalni. Takođe, dati prevod je nastao na osnovu carigradskog izdanja Novog zaveta a koji se smatra najautoritativnijim izdanjem Novog zaveta u Pravoslavnoj crkvi (v. *Η Καινή Διαθήκη* 1904), u kome stoji slično kao i u Nestle-Alandovom izdanju: „Καὶ εἶπε Μαριάμ“. U Čarničevom prevodu, koji je nastao prema Merkovom kritičkom izdanju Novog zaveta, nalazimo proširenje u vidu dodate reče „pak“, koja opet stvara kontekst u kom se Marija prikazuje kao autor pesme: „Marija pak reče“, što se izvorno kod Merka (1992: 191) ne nalazi – „Καὶ εἶπεν Μαριάμ“. Veznik „a“ i čestica „pak“ ne odgovaraju inicijalnom tekstu.

Posebno problematično mesto koje ide u prilog čitanju da je Jelisaveta ispevala datu pesmu jeste aleja koja sledi posle završetka „Magnifikata“: „A Marija osta s njom oko tri meseca, pa se vrati svojoj kući“ (^ELk. 1, 56); „I ostade Marija sa njom oko tri meseca, i vrati se domu svome“ (^SLk. 1, 56) – „Ἐμεινεν δὲ Μαριάμ σὺν αὐτῇ ὡς μῆνας τρεῖς, καὶ ὑπέστρεψεν εἰς τὸν οἶκον αὐτῆς“ (Nestle-Aland). Dakle, Čarničev je prevod tačniji, posredi je veznik „a“, grč. „δέ“, umesto „i“, grč. „καὶ“. Nastavak pripovesti takođe je vezan za Jelisavetu i odnosi se na njeno rađanje. Dakle, elementi koji se nalazi oko same pesme upućuju da je autor „Magnifikata“ Jelisaveta, dok sadržaj same pesme upućuje da je njegov autor Marija, o čemu kazujemo sledeće.

Za 'slobodne' prevode ne može se reći da su slobodni u pravom smislu te reči, jer je nastojanje prevodilaca bilo iskazivanje onog stanovišta koje je bilo prihvaćeno i potvrđeno predanjem same Crkve. Još od Origena, iako je i on bio svestan datih jezičkih nesuglasica (v. Duda 1967: 27), pesma je pripisivana Mariji. U tom smislu, u opitu Crkve Marija je priznata kao autor pesme.

Ukoliko se naznačena jezička diskrepancija ostavi po strani, budući da može predstavljati i propust u redakciji/redakcijama, te, ako se preciznije osmotri sadržina same pesme, postaje daleko jasnije da pesma pripada Mariji – odnosno, zašto je Crkva prepoznala Mariju kao njenog autora. Pre Marijine pesme, Jelisaveta govori o svom ushićenju pred time što Marija dolazi u njen dom, te pohvaljuje samu Bogorodicu: „I blažena je ona koja je poverovala da će se ispuniti što joj je Gospod rekao.“ (E^CLk. 1, 45) Istu leksemu nalazimo tri aleje niže: „od sada će me svi naraštaji smatrati blaženom“ (E^CLk. 1, 48). Dakle, nelogično bi bilo da u razmaku od svega tri aleje ista leksema bude iskorišćena kao karakterizacija različitih osoba: Jelisavete i Marije, pritom bi se njihov značaj i značaj njihovog rađanja izjednačio, što nikako ne bi bilo moguće. Stoga, isprva Jelisaveta „povika uzvišenim glasom i reče“ (S^LLk. 1, 42) svoju tekstualnu deonicu (Lk. 1, 42–45), u kojoj iznosi pohvalu Bogorodice, nazivajući je blaženom. Jelisavetin diskurs biva prekinut: „Καὶ εἶπεν Μαριάμ“, da bi se sada čule reči Marijinog odgovora Jelisaveti.

Dakle, kontekst same pesme može se različito razumeti: ili Jelisaveta u oba slučaja referiše na sebe, što sa eklesiološkog i predanjskog stanovišta ne bi bilo opravdano, ili Jelisaveta u svom govoru upućuje na Mariju, da bi u sledejućoj pesmi Marija uputila na sebe. Sa druge strane, problem nastaje glede same gramatike, gde tekstualni konektor „καὶ“ predstavlja nastavak prethodnog teksta. Međutim, osim nastavljanja, dati konektor može povezivati dve veće celine: Jelisavetin govor i Marijinu pesmu, te u tom smislu ne bi bilo nikakvog problema u određenju autorstva date pesme. Upravo zbog toga nastaju i prevodi koji ne ponavljaju doslovno prevodni tekst, već samo prevođenje postaje i određeni oblik tumačenja. Dato tumačenje, ponovo napominjemo, potiče iz eklesiološkog predanja, a ono prepoznaje Mariju kao autorku date pesme.

2.2. Arhitekst

Kao što smo već naglasili u uvodnom delu, novozavetni tekstovi, a posebno novozavetna lirika, nastaje na arhitekstualnoj starozavetnoj bazi, te je u literaturi o „Magnifikatu“ (Brown 1993: 357, Jahn 1997, Drejn 2004: 73, Pandžić 2019: 8) kao prethodnica Marijine pesme u prvom redu prepoznata Anina zahvalna pesma usled rođenja sina Samuila, ali i druga mesta iz Starog zaveta, najvećma iz Psaltira. Gotovo da se može govoriti o doslovnom preuzimanju određenih stihova, te tako početak Anine pesme:

- „Veseli se, srce moje, u Gospodu“ (DM1. Sam. 2, 1) > „Obradova se duh moj Bogu, mome spasitelju“ (E^CLk. 1, 47);
- „Koji su bili siti unajmljuju za hleb, a ko je gladovao, ne gladuje više. Nerotkinja rađa sedam puta, a bogata sinovima malaksa“ (DM1. Sam. 2, 5) > „gladne nasiti dobrima, a bogate otpusti prazne“ (E^CLk. 1, 53);
- „Gospod čini siromašnim ili bogatim, obara i uzdiže. Siromaha podiže iz praha i ubogog izvadi iz bunjišta da ih posadi sa knezovima i da im odredi počasna mesta“ (DM1. Sam. 2, 7) > „Zbaci vladare s prestola i uzvisi ponizne“ (E^CLk. 1, 52);
- „Satreće se oni koji se suprotstavljaju Gospodu“ (DM1. Sam. 2, 10) > „razbi ohole u mislima njihovog srca“ (E^CLk. 1, 51);

- „Ne pobeđuje čovek svojom snagom“ (DM1. Sam. 2, 9) > „Svojom rukom učini silu“ (EČLk. 1, 51), itd.

Slične paralele se mogu povući i između psalama i „Magnifikata“. Džan (1997) daje iscrpnu tabelu u kojoj predstavlja i veze sa drugim starozavetnim knjigama, npr. Knjigom proroka Isaije, koja je važna i za apostola Mateja, budući da on upravo u Isaiji pronalazi obećanje o devičanskom rađanju Mesije.

2.3. Struktura. Tematski slojevi

Važna su zapažanja i Rejmonda Brauna (1993: 356–357) o strukturi „Magnifikata“ koja zapravo odražava raspored pesničkih elemenata u psalmima. Prvi uvodni deo posvećen je proslavljanju Boga, drugi je centralni i u njemu su predstavljeni razlozi samog pevanja-moljenja, dok se u završnom delu nalazi poenta, rekapitulacija glavnog motiva ili blagoslov. U Marijinoj pesmi nalazi sve pobrojano.

Prvi stih: „Veliča duša moja Gospoda“ (EČLk. 1, 46; u nastavku koristimo Čarničev prevod) upravo je ostvarena kao snažno molitveno proslavljane i uzdizanje same divinizirane instance, kojoj se molitveni glas obraća – „Ekvivalent *veličati* uvodi nas dakle u semantičko polje naglašena i uzvišena hvaljenja s izrazitim estetskim i emotivnim intenzitetom.“ (Garvanović-Porobija 2009: 323) Bonaventura Duda (1966: 28), kako bi jasnije istakao značenje prvog stiha, daje njegov prepev: „Sva mi duša pjeva: Velik si Gospodine!“ Septuaginski prevod „μεγαλύνει“ dolazi namesto jevrejske lekseme „gdI“, koja znači „intenzivno hvaliti Gospodina zbog njegove veličine, koju pokazuje njegovo, osobitno spasiteljsko djelovanje“ (Duda 1966: 28). Otuda, početak „Magnifikata“ ostvaren je kao proslavljanej Boga, što u formalnom smislu predstavlja poetičku zadatost psalama, dok sa druge strane izranja i iz Marijinog ličnog doživaljaja Božije veličine.

Upravo je centralni deo Marijine pesme ostvaren kao poetizacija molitvene ekstaze, kao uzvišeno i nadahnuto iskazivanja zadivljenosti pred dobrim delima koja čini Gospod. U prvom redu, najveći deo pesme obuhvata socio-hrišćanska tematika, odnosno, stihovi u kojima se prikazuju novi socijalni odnosi koji dolaze sa dolaskom hrišćanstva. Otuda su tri glavna poetska aktera u „Magnifikatu“ Gospod, koji je označen kao aktivni i odlučujući princip, njegove sluge, odnosno, oni koji su Njemu ponizni, smireni i poslušni, te oholi, s mržnjom u srcu (v. Garvanović-Porobija 2009: 324–327). Jasno je da Marijina oduševljenost Božijim kažnjavanjem vladara i bogatih biva praćena oduševljenjem koje podrazumeva nagradu u vidu božanske milosti prema Izrailju, prema gladnim i prema „onima koji ga se boje“. međutim, iza ove oštre opozicije izranja nešto deliaktnije. Kako to Džon Drejn (2004: 52–53) detaljno obrazlaže, budući da je Josif bio stolar, ili uopšte zidar, zanatlija, sasvim je moguće da njegova porodica nije pripada siromašnijem delu jevrejskog društva. – „Važnije od ovoga, sa stanovišta vere, jeste to da su oni kao obični radni ljudi smatrani nedovoljno kvalifikovanim za razumevanje Jevrejskih svstih spisa i za šihovo tumačenje u svstlu savremenih zbivanja, a u cilju razotkrivanja volje Božijs u pogledu njegovog naroda.“ (Drejn 2004: 52) Marijina posebna ushićenost potiče upravo što je ona po svakom kriterijumu tadašnjeg društva bila jednostavna, obična, svakidašnja devojkica, slična mnogim drugim svojim vršnjakinjama. „Sve glavne ličnosti iz priča o rođenju“, nastavlja Drejn (2004: 53) „bile su skromni ljudi. Prvi koji su čuli najavu da će se Isusovim rođenjem ispuniti davna obećanja bili su neki pastiri u judejskim brdima.“

„Magnifikat“ u svom centralnom delu upravo iznosi pretpostavku, za tadašnje rimsko-judejsko društveno uređenje krajnje radikalnu, pa i apokaliptičnu, da svu svi ljudi jednaki i da je data jednakost zagarantovana od samog Boga. U tom smislu „Magnifikat“ predstavlja novu pesmu o novom svemu, posredi je apokaliptički pesnički tekst koji upravo u prošlim događajima vidi naznake dolazeće realnosti, u prošlosti iščitava one tragove koji nagoveštavaju novi oblik pravde, te radosno klikće nad objavom da data pravda neposredno započinje. Odnosno, da je već započela, budući da je jedna od mnogih poniznih i poniženih, prostih i jednostavnih, Marija, već zadobila Božiju milost: „I obradova se duh moj Bogu, mome spasitelju, što pogleda na poniznost svoje služiteljke.“ Pri ovome, važno je uputiti i na stav Đurđice Gavranović Porobija (2009: 323) koja smatra da je upravo stoga što Marijina pesma toliko računa na niži sloj tadašnjeg društva moguće „Magnifikat“ sagledati i kao odraz tadašnje folklorne pesme: To bi u jednoj dubinskoj perspektivi i opravdalo toliku zastupljenost „Magnifikata“ u crkvenim bogoslužjenjima. Fragmente date pesme su protohrišćani donosili u svoje agapijanske zajednice, jer su u njoj upravo nazirali i pevali o jednakosti i društvenoj pravdi koju je Hristova propoved obećavala. U tom smislu „Magnifikat“ postaje i jedan od eklesioloških fudamenata, jer je „Marijino iskustvo arhetip iskustva Crkve, koja bi po tomu imala zašto klikatati i argumentirano progovoriti o Bogu koji je unio čudesan preokret u život izgubljenih ljudi“ (Garvanović-Porobija 2009: 328).

Osnovni pesnički mehanizam pomoću kog je ostvarena Marijina pesma jeste kontrast: „Tekst *Magnificata* opisuje radikalni prevrat, koji je predočen hijazmom s motivima A – silni (moćni), B – neznatni (slabi) / B' – gladni (slabi), A' – bogati (moćni).“ (Garvanović-Porobija 2009: 329) Upravo je kontrastiranje snažno poetsko sredstvo kojim Marija naglašava sukobljenost između dva različita sociološka poretka, razliku između dve vrste ljudi, onih koji su oholi u srcu i smirenih. Takođe, upravo korišćenjem kontrasta Luka posebno izdava Mariju iz ostatka judejskog naroda, jer upravo njoj, posebno se naglašava, Gospod čini „velika dela“. Pored kontrasta, Luka koristi i paralelizme, npr.: „Svojom rukom učini silu, razbi ohole u mislima njihovog srca“ ili „Zbaci vladare s prestola i uzvisi ponizne, gladne nasiti dobrima, a bogate otpusti“, i sl.

Završni deo pesme svojevrsna je poetsko-molitvena rekapitulacija i zaokruženje celokupnog Božijeg domostroja spasenja, budući da u stihovima: „Prihvati Izrailja, svoga slugu, da se seti milosti, kao što reče našim očevima, Avraamu i njegovom potomstvu dovek“ Marija povlači jasnu liniju od konkretnih događaja iz Starog zaveta ka Božijem sotiriološkom obećanju koje traje „doveka“. Marija, dakle, zaokružuje svoju molitvenu pesmu, poentirajući da se Božija milost i dalje nastavlja.

3. ZAKLJUČAK

Na osnovu ovog kratkog poetsko-egzegetskog pogleda u Marijinu pesmu iz Jevandolja od Luke ističemo da ona ima poseban značaj na tekstualnom planu Lukinog jevandolja, budući da uveliko doprinosi svečanosti narativnog uobličenje Mesijinog rođenja, te da stoga „Magnifikat“ dobija karakter anuncijacije, odnosno, pesničkog predukusa dolazećeg hrišćanstva, te se može zaključiti da mesto pesme, na poetskom planu Lukinog jevandoljskog teksta, postaje mesto konstituisanja same istine hrišćanstva kao takvog.

4. LITERATURA

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**POETIC-EXEGETICAL CHARACTERISTICS OF MARY'S SONG (LUKE
1:46–55)**

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ABSTRACT:

In the paper, we present the basic poetic-exegetical characteristics of Mary's song from the Gospel of Luke (1, 46–55), with a special focus on the following problematic areas: the question of authorship (whether the song belongs to Mary or Elizabeth), the positioning of Mary's song in the Gospel of Luke in relation to other Gospel and broader biblical textual material, the structure of the song itself, its liturgical character, the processes of poeticizing prayer ecstasy, and the themes addressed in the song: poetic glorification of God, humility, obedience, socio-Christian principles, the unity of man and God, which also raises the question of the genre determination of Mary's song as a 'poetic prayer.' From a theopoetic perspective, Mary's song, as it indicates Christianity before the birth of the Messiah and before Christianity begins at all, takes on the character of annunciation, a poetic prelude to the upcoming Christianity. It can be concluded that the place of the song, on the poetic level of Luke's Gospel text, becomes the place of constituting the truth of Christianity itself.

Keywords: *Theotokos, Mary's Song, Literary Mariology, Biblical Literature, Theopoetics*

SOCIJALNI FEMININATIVI IZ PERSPEKTIVE KNJIŽEVNOJEZIČKE I ZAKONSKE NORME

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SAŽETAK:

U radu se razmatra status imenica ženskog roda tvorbenosemantičke kategorije nomina agentis et professionis iz ugla lingvističke i zakonske regulative. Derivatološka obrada socijalnih femininativa u najreprezentativnijim gramatikama objavljenim u drugoj polovini 20. i početkom 21. vijeka, poredi se s njihovim tretmanom u savremenim referentnim publikacijama. Zaključci se potom dovode u vezu sa segmentom nacionalne legislative namijenjene obezbjeđenju rodne ravnopravnosti, koji se odnosi na preveniranje i suzbijanje polne diskriminacije u jeziku putem obavezivanja njegovih korisnika na upotrebu feminalnih i apsolutno izbjegavanje generičkih formi kada se referiše na ženska lica. Cilj istraživanja je eksplikacija (ne)kompatibilnosti normativnopravnih i lingvističkih pravila o upotrebi naziva za zvanja, zanimanja i titule žena.

Ključne riječi: imenice ženskog roda, socijalni femininativi, generička forma, Zakon o rodnoj ravnopravnosti

1. UVOD

Socijalni femininativi definišu se obično kao izvedene imenice ženskog roda kojima se označavaju zvanja, zanimanja i titule, odnosno imenice koje imaju značenje profesionalnog statusa žene (*učiteljica, premijerka, psihološkinja*), mada se mogu odnositi i na druge društvene uloge (npr. *hrišćanka*). Posmatrano u užem smislu, to su feminalne imenice iz semantičke kategorije nomina agentis et professionis nastale procesom derivacije, tj. dodavanja sufiksa na odgovarajuću tvorbenu osnovu. U posljednje vrijeme ove imenice, posebno neke forme, izazivaju žestoke reakcije lingvističke javnosti koja im, jednim svojim dijelom, negira ispravnost i smatra ih nepotrebnim, a drugim ih snažno afirmiše. Da nevolja bude veća, i nestručna javnost je podijeljena i, još više, zbunjena, jer je u jeziku medija suočena s povišenom frekvencijom socijalnih femininativa, a istovremeno ti isti mediji prenose da se brojni autoriteti, iz lingvističke struke i izvan nje, oštro suprotstavljaju njihovoj upotrebi. Treba imati u vidu i to da se mnoge žene uvrijede kada im se titula navede u ženskom rodu, dok druge upravo insistiraju na takvoj formi. Primjećujemo i da poneki šaljivi komentar na račun tzv. novih, a zapravo samo manje uobičajenih formi često ne dovodi do mirenja, već do još žučnije i, kako bi se to danas reklo, viralne konfrontacije, za šta su „zaslužne“ društvene mreže koje nerijetko služe kao arena u kojoj ne važe gotovo nikakva pravila, tj. gdje je u verbalnim sukobima sve dozvoljeno jer su se odgovornost i čovjekoljublje odavno povukli s medijskog poprišta, i ne samo odatle.

Kako je došlo do formiranja oprečnih mišljenja u vezi s predmetnim nazivima i da li se lingvistička i zakonska regulacija njihove upotrebe podudaraju – pitanja su na koja

želimo da ponudimo odgovor u svom istraživanju. Da bismo to učinili, potrebno je da prvo izvršimo analizu stanja zatečenog u referentnoj starijoj i recentnoj lingvističkoj literaturi, a potom i u Zakonu o rodnoj ravnopravnosti koji s normativno-pravne strane tretira ovo globalno aktuelno društveno i lingvističko pitanje.

1. LINGVISTIČKA KODIFIKACIJA SOCIJALNIH FEMININATIVA

Jedna od najreprezentativnijih gramatika druge polovine 20. vijeka, a vjerovatno i najpoznatija, jeste ona čiji je autor Mihailo Stevanović, čuveni lingvista i dugogodišnji profesor beogradskog univerziteta. Njegov udžbenik „Savremeni srpskohrvatski jezik“ iz 1964. godine i danas se nalazi na spisku obavezne univerzitetske literature, kako zbog temeljnog i egzaktnog teorijskog pristupa pojavama fonetskog, morfološkog i tvorbenog nivoa, tako i zbog brojnosti primjera i minuciozne analize njihove strukture dominantno iz sinhronijske, a po potrebi i iz dijahronijske perspektive. Imajući u vidu da je izvođenje riječi putem sufiksacije, tj. dodavanja određenih nastavaka na osnovu motivne riječi, „jedan od najuobičajenijih načina za građenje novih reči u srpskohrvatskom jeziku“ [1], autor pomenute knjige derivaciji posvećuje i najveći dio svog istraživanja tvorbe riječi kao jednog segmenta nauke o jeziku koji je u ovoj publikaciji obrađen. Tako sufiksacija obuhvata skoro dvije trećine ukupne analize, odnosno 170 strana, dok svi ostali načini tvorbe zapremaju manje od 60 strana, ili nešto više od trećine. Na samom početku odjeljka o izvedenim imenicama Stevanović napominje da sufiksi, kao nastavci kojima se grade izvedene riječi, nemaju sopstveno značenje, ali da najčešće unose posebno, određeno značenje u novu riječ, i te novonastale riječi prema semantici dijeli na: imena vršilaca radnje i imalaca zanimanja, imena radnje, imena imalaca osobine, imena mjesta, imena oruđa, imena životinjskih vrsta, imena određenog pola i imena za označavanje subjektivnog odnosa: hipokoristici, pejorativi, deminutivi i augmentativi [1]. Napominje da klasifikaciju izvedenih imenica, a i ostalih vrsta riječi, radi preglednosti vrši prema nastavcima datim po azbučnom redu suglasnika koji sadrže. Za našu temu zgodnije bi bilo da je razvrstavanje išlo po značenjima koja je naveo, kako su to činili neki drugi lingvisti, no bez obzira na način na koji je obradio temu koja nas zanima, činjenica je da je Stevanović, prije više od pola vijeka, priznao književnojezički status socijalnim femininativima. Učinio je to u dijelu u kojem se bavio sistemom roda, broja i lica u jeziku koji se u ono vrijeme nazivao srpskohrvatski, a što važi za sve jezike nastale raspadom te, uslovno rečeno, jezičke zajednice. Stevanović, naime, kaže da je rod kod imenica dvojak, prirodni i gramatički, tj. da su neke imenice kao *čovjek*, *dječak*, *Milan*, *otac*, *drug*, *prijatelj* prirodnog muškog roda jer označavaju lica muškog pola, a da su npr. *žena*, *majka*, *Mara*, *drugarica*, *prijateljica* imenice prirodnog ženskog roda jer označavaju bića ženskog pola, a sve one imaju odgovarajući oblik. Međutim, kaže isti autor, vrlo često se bića i muškog i ženskog roda označavaju istom imenicom. To je slučaj s imenicama koje referišu na vrstu, poput *sisar*, *ptica*, *žaba* i sl., kao i imenicama koje označavaju dužnost, zvanje ili zanimanje, npr. *ministar*, *rukovodilac*, *pisac*, *sekretar*, *starešina* i sl. Dakle, imenice za zvanja i zanimanja, prema Stevanoviću, nemaju prirodni već gramatički rod, koji se određuje prema njihovom obliku i drugim gramatičkim osobinama, a ne prema „prirodi onoga što označavaju“ [1]. Ali isti autor već na sljedećoj strani svog udžbenika tvrdi da se od imena zanimanja „dosta često posebnim nastavkom grade imenice koje obeležavaju prirodni rod“. Tako se od imenica *blagajnik*, *sekretar*, *ministar* posebnim nastavcima grade imenice koje označavaju ženska lica na pomenutim dužnostima: *blagajnica*,

sekretarica, ministarka. On opet podvlači da forme *blagajnik, sekretar, ministar* u tom obliku u našem jeziku mogu označavati lica oba pola, te da je sasvim obično kada se kaže *drugarica ministar*, s tim što izostavlja bitnu činjenicu da je u nekadašnjim sintagmama koje pominje, *drugarica blagajnik, drugarica, sekretar, drugarica ministar*, imenički atribut *drugarica* preuzeo ulogu oznake pola, odnosno prirodnog roda lica na koje se u datoj jezičkoj situaciji referiše. Njegovo objašnjenje uzroka uopštavanja imenica gramatičkog muškog roda i za označavanje osoba ženskog pola doskorašnjim društvenim položajem žene sasvim je prihvatljivo. Ali bismo postavili i jedno pitanje: zašto samo imenica u muškom gramatičkom rodu može denotirati profesiju, tj. odnositi se i na lice ženskog pola s tom profesijom. Bez obzira na retoričku prirodu pitanja, odgovorićemo jer smatramo da je još uvijek neophodno: budući da je ženama dugo vremena u prošlosti obrazovanje bilo zabranjeno ili nedostupno, za gotovo sve poslove, za sva zanimanja obrazovali su se muškarci te su ih i obavljali samo oni i time sticali i pravo na upravljanje i odlučivanje, što je ženama, koje su bile vezane za kuću i porodicu, bilo uskraćeno. Odavde je jasno da su prvo bile formirane imenice koje su denotirale ne samo vrstu posla već i muško lice koje ga je obavljalo, te su zato *morale biti* i gramatičkog i prirodnog muškog roda. Dakle, stanje u jeziku je samo refleksija nekadašnjeg patrijarhalnog poimanja ženske uloge u društvu. O poražavajućoj potčinjenosti žene svjedoči upravo pisac pomenute gramatike kada konstatuje da se „novi oblici za označavanje prirodnog roda uvode posle promene socijalnog položaja žene, posle njenog izjednačenja s čovekom – muškarcem“ [1], što se počelo dešavati tek u vijeku za nama. On tvrdi da u savremenom društvu u kojem i žene vrše ministarsku funkciju, imenica *ministarka* označava ženu na toj funkciji, iako se ranije upotrebljavala samo da označi ministrovu suprugu [1]. Ovo naglašavamo stoga što se i danas, šezdeset godina nakon upravo navedene Stevanovićeve konstatacije, ova imenica pominje kao jedan od spornih socijalnih femininativa baš zato što je njeno značenje nekad bilo rezervisano za suprugu ministra [2]. A zapravo se u tom značenju ona danas upotrebljava isključivo u ironičnom ili podrugljivom kontekstu, odnosno sa aluzijom na čuvenu Nušićevu komediju, dok je postala sasvim uobičajena, sudeći makar po crnogorskim medijima, za označavanje ženske osobe na ministarskoj dužnosti.

Hrvatska gramatika grupe autora na čijem je čelu poznata lingvistkinja Eugenija Barić, nudi nešto drugačiju tvorbenosemantičku podjelu izvedenih imenica, a gramatički rod definiše kao gramatičku kategoriju koja se ogleda u slaganju imenica s pridjevim riječima. Tamo se napominje da imenice koje označavaju stvari ili bića kod kojih se ne zna pol ili „nije važno da se zna, imaju rod prema svom obliku, tj. prema završetku“ [3]. Autori svoj prikaz imeničkih derivata daju prema tvorbenom značenju. Tako oni izvedene imenice dijele na imenice koje znače osobu, na etnike, imenice koje znače životinju, imenice za biljke, imenice za stvari, mjesne imenice, mislene imenice, glagolske imenice, umanjenice, uvećanice, imenice odmila, zbirne imenice i pojedinačne značenjske skupine. Imenice sa značenjem osobe dijele u tri skupine: imenice koje znače mušku, koje znače žensku i koje podjednako znače mušku i žensku osobu. Grupu imenica koje znače mušku osobu dijele na četiri podskupine: imenice sa značenjem vršitelja radnje, imenice koje znače nositelja osobine, imenice sa značenjem pripadnika neke organizacije ili sljedbenika nekog pravca, ideje, shvatanja i ostale imenice koje znače mušku osobu a koje su uglavnom stilski obilježene poput *aferaš, logoraš*, ili imaju značenje porijekla poput *sestrić, tetkić* [3]. Pošto nas posebno zanimaju imenice koje označavaju žensku osobu,

napominjemo da autori ove gramatike kažu da su imenice ove kategorije motivisane najčešće imenicama koje znače mušku osobu i tada imaju isto tvorbeno značenje kao i imenica u osnovi, tj. mogu označavati „vršiteljicu radnje“ (npr. *krojač – krojačica*) i „nositeljicu osobine“ (*čudak – čudakinja*) [3]. Bitno je naglasiti da u imenice koje podjednako znače mušku i žensku osobu, ne ubrajaju imenice koje znače zanimanja, zvanja i titule, već stilski obilježene imenice koje se najčešće završavaju na *-lo*, *-ica* i *-lica* (npr. *blebetalo, izdajica, varalica*) i imenice koje znače mladu mušku ili žensku osobu a izvedene su nastavkom *-če* (*pastirče, nahoče, dače*) [3]. Dakle, ova gramatika u potpunosti podržava tvorbu i upotrebu socijalnih femininativa.

Slične tvrbnosemantičke klasifikacije drži se i Stanojčić u „Gramatici srpskog jezika“ koju je objavio u koautorstvu s Ljubomirom Popovićem. Ovaj popularni udžbenik, namijenjen srednjoškolskoj i univerzitetskoj nastavi, prošle godine doživio je svoje 19. izdanje. Izvedene imenice ovdje su podijeljene u sljedeće razrede: imenice sa značenjem lica (osobe), imenice sa značenjem životinja i biljaka, imenice za označavanje predmeta, imenice za označavanje mjesta ili prostora, glagolske i apstraktne imenice, imenice subjektivne ocjene i imenice izvedene gramatičkim sufiksima. Zatim se imenice koje znače osobu dijele na podrazrede: muška lica, ženska lica, muška i ženska lica, mlada muška i ženska lica, imena i prezimena. Nakon toga se imenice sa značenjem ženskog lica dijele na one koje označavaju „žensko lice – vršioca radnje, imaoca zanimanja“, imenice sa „značenjem žene – nosioca stanja, osobine i slične“ i imenice sa značenjem „pripadnice naroda, veroispovesti, stanovnice i sličnog“ [4]. Stanojčić tvrdi da se imenice koje označavaju vršiteljku radnje ili imateljku osobine odgovarajućim sufiksima izvode od glagola (npr. *vračara*) ili od imenica (npr. *mlinarka, učiteljica*) i napominje da se prema posljednjem tvorbenom modelu, tj. od imenica muškog roda grade brojne imenice poput *pekarka, profesorka, ministarka, profesorica, vaspitačica* i dr., „koje imaju isto značenje kao i imenice m. r. koje su im motivne reči, uz informaciju da je reč o ženi – vršiocu radnje, odnosno imaocu zanimanja“ [4]. Za našu temu je vrlo značajno to što Stanojčić kao standardne, odnosno gramatički ispravne navodi socijalne femininative koji se izvode od imeničkih osnova na *-ist(a)* i *-log* sufiksom *-kinja* (*slavist – slavistkinja, stomatolog – stomatološkinja*), tj. upravo one forme čija se pravilnost, sistemnost problematizuje u pojedinim savremenim gramatikama. Objašnjava da se suglasnik *g* u dodiru sa sufiksom *-kinja* zamjenjuje suglasnikom *š*, tj. radi se o tvorbeno uslovljenoj alternaciji, čiji se književnojezički status ne dovodi u pitanje [4]. Posljednje potcrtavamo zato što se upravo tvorba i upotreba formi tipa *stomatološkinja, psihološkinja* smatraju usiljenim [2], iako su prije više od trideset godina ove imenice eksplicirane kao ispravne i uvedene u književnojezičku normu kao imenice koje istovremeno nose oznaku nomina agentis et professionis i oznaku ženskog roda, gramatičkog i prirodnog, kao što imenice koje stoje u njihovoj osnovi nose oznaku zanimanja i muškog roda, gramatičkog i prirodnog. Napominjemo da isto naglašava i Stanojčić kada povodom imenica izvedenih gramatičkim, odnosno mocionim sufiksima kaže: „Ovaj način tvorbe produktivan je i u tvorbi imenica za označavanje ženskih osoba koje se bave istim poslovima kojima i muške osobe, označene imenicama (prirodnog i gramatičkog) muškog roda“ [4].

Svakako valja pomenuti i „Kratku preglednu gramatiku srpskog jezika“ koja je među pripadnicima i pripadnicama crnogorske studentske populacije omiljena, a takođe je doživjela više izdanja. Zbog prirode same publikacije koja je naznačena naslovom, u njoj su prezentovane teorijske osnove tvorbe riječi, tj. koncizno su objašnjeni osnovni

principi tvorbe (izvođenje, slaganje, kombinovana tvorba, pretvaranje i pozajmljivanje), pri čemu je dat kratak osvrt na značenje i funkciju pojedinih sufiksa, uz ekscipciju mocionih o kojima nije bilo riječi [5].

Eufemistično rečeno, najsazetijeg karaktera je „Gramatika crnogorskog jezika“ grupe autora koju predvodi Adnan Čirgić, za koje, bez obzira na kompletan izostanak teorijske obrade teme, ipak možemo konstatovati da su naklonjeni ženskim formama jer kod imenica koje označavaju lica u potkategorijama imenica sa značenjem vršioica radnje, nosioca svojstva, trpioica stanja i imenica sa značenjem stanovnika, pripadnika naroda i država – primjere prema sufiksima klasifikuju u dvije grupe, muška i ženska lica. Kategorija roda kod imenica predstavljena je neuobičajeno šturo na pola stranice [6].

Istom problemu Piper-Klajnova „Normativna gramatika srpskog jezika“ iz 2013. godine posvećuje mnogo više pažnje. Tamo se objašnjava da je kategorija imeničkog roda selektivna kategorija budući da se imenice ne mogu mijenjati po rodu kao što je slučaj s pridjevima, već da su, prema rodu kojem pripadaju, razvrstane u imeničke klase. Osnovna uloga oblika za imenički rod, odnosno gramatički muški, ženski ili srednji rod imenica, nije da obilježe pol, već da putem kongruencije (atributa ili predikata sa subjektom, odnosno imenicom) signaliziraju semantičke i sintaksičke veze između rečeničnih djelova. Katkad se gramatički rod podudara s polom pojma označenog imenicom i tada se, kako tvrde autori, „značenje pola ponekad naziva prirodni rod“, a katkad to nije moguće s obzirom na to da se imenicama denotiraju i predmeti ili neživo, odnosno pojmovi koji nemaju pol. Takođe se kaže da se gramatički rod ne poklapa s muškim ili ženskim polom kod naziva životinja (*som, vrabac, zmija, komarac*), kao što je to slučaj i s brojnim imenicama koje se odnose na ljude, za šta navode primjere *astronom, oficir, hirurg*. Autori tvrde da se u slučaju imenica za ljude, oblik muškog roda upotrebljava „kada je pol nebitan, i „kada bi insistiranje na polu bilo neumesno“, što ilustruju primjerom *Studenti su dužni da dolaze na predavanja*, u kojem se imenica *studenti* odnosi i na muške i na ženske osobe koje studiraju [7], tj. predstavlja generičku formu jer referiše na lica oba pola. U ovoj gramatici, dakle, prednost se daje imenicama gramatičkog muškog nad imenicama ženskog roda i za lica ženskog pola u situaciji u kojoj se ne referiše na konkretno žensko lice, što se obrazlaže tvrdnjom da bi insistiranje na polu bilo „bespredmetno“ i neekonomično. Međutim, kada je riječ o konkretnim upotrebnim situacijama, tj. kada se imenica odnosi na određenu žensku osobu, autori ne postupaju principski, već u pojedinim slučajevima uz upotrebu imenica muškog dopuštaju i upotrebu imenica ženskog roda kao normativnu (*studentkinja*), a u drugim slučajevima femininalne forme isključuju iz „dobrog književnog jezika“ jer, po njihovim riječima, nijesu „dobro uklopljene“ u savremeni jezički sistem budući da nijesu uzualizovane, tj. nemaju širu upotrebu već su nastale kao politička nužnost. Autori doslovno kažu: „Prilikom ocene normativne prihvatljivosti novih socijalnih femininativa treba ih razmatrati ponaosob, jer stepen i oblik njihove uključenosti u jezički sistem, posebno u sistem funkcionalnih stilova nije u svakom pojedinom slučaju isti“ [7]. Zatim navode čitav niz femininativa izvedenih od stranih osnova za koje konstatuju da predstavljaju imeničke neologizme koje afirmišu predstavnici pojedinih političkih partija, a čija je sistemnost upitna (npr. *agentkinja, astrološkinja, atašeica, inženjerka, monterka, ombudsmanka, filološkinja, hirurškinja*). Na kraju ipak zaključuju da se novi socijalni femininativi, ukoliko se ispostavi da su neophodni, iz funkcionalnih stilova u kojima su već prisutni (razgovorni, književnumjetnički, publicistički), mogu vremenom proširiti i na ostale stilove [7].

Pretpostavljamo da su time mislili da će uopštavanjem konačno dobiti i normativni status, odnosno postati odlika onoga što ovi autori nazivaju „dobar književni jezik“. Razmatranje normativnog statusa imenica „ponaosob“, na šta upućuje Klajn, svakako ne bismo mogli pozdraviti jer smo već iznijeli mišljenje da normativna literatura (gramatike, pravopisi, rječnici) treba da se temelji na principskom a nikako na egzemplarnom pristupu [8], te nam i neke od smjernica za rješavanje pitanja upotrebe socijalnih femininativa iz pomenute gramatike koja u nazivu ima odrednicu normativna, djeluju kontraproduktivno. Tim prije što je vrlo mudra uputstva za njihovu upotrebu u opštim i konkretnim situacijama još osamdesetih godina prošlog vijeka prezentovala Eugenija Barić. Ona je u jednom od svojih radova na ovu temu pokazala da u svakoj jezičkoj situaciji u kojoj se misli na određeno žensko lice, treba upotrijebiti imenicu ženskog roda, a u neutralnim, opštim situacijama kakve su konkursi, štampani obrasci i sl., tj. kada se misli na lica oba pola, jezička ekonomija nalaže upotrebu tzv. generičke forme, tj. imenice gramatičkog muškog roda [9]. Takođe, što se tiče spornih imenica poput *astrološkinja*, *filološkinja* koje Klajn navodi kao neologizme, tj. nove femininative, vidjeli smo da imenice istog tvorbenog modela, tj. nastale dodavanjem sufiksa *-kinja* na strane osnove muškog roda sa sufiksoidom *-log* (*stomatološkinja*), Stanojčić još prije više od dvadeset godina smatra normativnim, i usuđujemo se da zaključimo, već tada uobičajenim [4]. Ove se imenice stoga ne mogu smatrati novim, ni sa temporalnog, ni sa derivatološkog stanovišta. Zvučace nevjerojatno, ali u „Rečniku srpskohrvatskoga književnog jezika“ Matice srpske i Matice hrvatske pronašli smo da je imenica *lovkinja*, koja se obično smatra neuobičajenom i novoformiranom, zabilježena u 19. vijeku, još davne 1887. godine, u značenju „ženska osoba lovac“ [10]. Iznošenjem ovog podatka želimo reći da bi valjalo biti na oprezu prilikom kvalifikovanja pojedinih socijalnih femininativa nazivima poput pomodni neologizmi, politička nužnost, ili tvrdnjama da nijesu u duhu jezika. U odjeljku o tvorbi riječi Piper-Klajnovе gramatike imenički derivati klasifikovani su prema značenjima sufiksa koji su podijeljeni u sljedeće grupe, sufiksi za vršioca radnje, sufiksi za zanimanja, za osobine ljudi, sufiksi sa značenjem društvene pripadnosti, etnički sufiksi, mocioni sufiksi, zbirni (kolektivni) sufiksi, deminutivni i hipokoristični, augmentativni i pejorativni sufiksi, sufiksi za sprave i oruđa, sufiksi za mjesta i prostorije, razni sufiksi za nežive pojmove, sufiksi sa apstraktnim i uopštenim značenjem, sufiksi na *-nje* i *-će* i sufiksoidi. Samo se kod sufiksa koje su nazvali etničkim, daju paralelno muški i ženski oblici, npr. *Azijac – Azijka*, *Mađar – Mađarica*. U uvodnom dijelu autori iznose zapažanje da se među sufiksima za ljudska bića, većina odnosi na muškarce, te da se odgovarajući nazivi za ženska lica najčešće grade dodavanjem mocionih sufiksa na imenice muškog roda. A zatim dodaju napomenu neočekivane sadržine s obzirom na naučno-udžbeničku prirodu publikacije: „Ima pojedinačnih pokušaja da se uvedu posebni oblici za ženski rod i tamo gde ih u jeziku nema (npr. *akademica*, *vojnkinja*, *filološkinja*), a da se oni koji te oblike ne upotrebljavaju oglašavaju osobama sa politički nekorektnim ponašanjem. To su ipak pokušaji veštačkog menjanja gramatike prema političkim uverenjima“ [7]. Ovo je naročito značajno za našu temu jer, ako umijemo da čitamo između redova, radi se o implicitnoj polemici s nastojanjima predstavnika vladajućih političkih struktura da na povećanje frekvencije socijalnih femininativa djeluju putem usvajanja normativno-pravnih dokumenata koji obavezuju na njihovu upotrebu, bez konsultovanja šireg kruga lingvиста o pitanju koje je prvenstveno lingvističko. Napomenu zaključuju konstatacijom sličnom onoj koju su iznijeli u odjeljku o imeničkom rodu, a to je da budućnost socijalnih

femininativa zavisi od društvenih promjena, koje ne treba ni sputavati ni vještački ubrzavati [7], na šta su ranije skrenuli pažnju i vrlo ugledni proučavaoci ove tematike, poput Boža Čorića [2].

2. SOCIJALNI FEMININATIVI U KONTEKSTU ZAKONSKE REGULACIJE UPOTREBE RODNO NEDISKRIMINATORNOG JEZIKA

Kako se izbjegavanje socijalnih femininativa može shvatiti kao vid verbalnog seksizma, odnosno povrede ljudskih prava, pitanje rodne ravnopravnosti u jeziku značajno je i sa stanovišta njegove pravne regulacije [11]. Na osnovu rješenja koja zatičemo u nacionalnoj legislativi jasno je da postoji nekompatibilnost između lingvističkog i normativno-pravnog pristupa pitanju kojim se bavimo. Diskriminaciju po osnovu bilo kog ličnog svojstva (a time i pola) tretira „Zakon o zabrani diskriminacije“ Član 2 stav 2 [12], ali je temi polne diskriminacije i upotrebe rodno nediskriminatornog/senzitivnog jezika posvećen drugi pravni akt, „Zakon o rodnoj ravnopravnosti“, koji je u Crnoj Gori usvojen 2007. godine. Njegova dopunjena verzija i danas je na snazi, a na upotrebu rodno osjetljivog jezika odnosi se Član 4. Ovdje je diskriminacija po osnovu pola definisana kao svako „neposredno ili posredno pravljenje razlike ili nejednako postupanje, odnosno propuštanje postupanja prema jednom licu, odnosno grupi lica jednog pola u odnosu na lica drugog pola“ [13]. Diskriminacija podrazumijeva i ograničavanje prava licima jednog pola, odnosno onemogućavanje uživanja i ostvarivanja prava i sloboda u političkoj, ekonomskoj, socijalnoj, kulturnoj i svim drugim oblastima javnog i privatnog života, a davanje prednosti licima drugog pola. Polna diskriminacija po ovom „Zakonu“ uključuje i seksualno i svako drugo uznemiravanje po osnovu pola, podsticanje, pomaganje, davanje instrukcija i najavljeni namjeru da se neko lice ili više njih diskriminišu po pomenutoj osnovi, kao i stavljanje pojedinih osoba (zbog trudnoće, materinstva, promjene pola) u nepovoljniji položaj prilikom zapošljavanja ili ostvarivanja prava po osnovu socijalne zaštite.

Diskriminacijom se, konačno, smatra i „korišćenje riječi u muškom rodu kao generički neutralne forme za muški i ženski rod“ [13]. Dakle, prema navedenoj zakonskoj normi (Član 4 stav 4), upotreba socijalnih femininativa je obavezna, dok se upotreba tzv. generičkih formi, tj. imenica muškog roda za označavanje ženskih lica smatra diskriminatornom, pa time i zabranjenom. Na upotrebu rodno osjetljivog jezika ovaj „Zakon“ obavezuje državne i organe državne i lokalne uprave, medije, privredna društva i druga pravna lica, preduzetnike i preduzetnice, odnosno sve one koji izdaju javne isprave, akta o imenovanjima, izborima u akademika i druga zvanja, ugovore o radu i sl. Njima se nalaže da „sve nazive radnih mjesta, zanimanja, zvanja i funkcija izražavaju u prirodnom rodu (muškom ili ženskom) lica“ na koje se pomenuti dokumenti odnose (Član 13a). Za pravna i odgovorna lica koja u svom radu ne koriste rodno osjetljivi jezik na način utvrđen Članom 13a, predviđene su novčane kazne u iznosu od 150 do 5000 eura (Član 33a).

3. ZAKLJUČAK

Iz svega navedenog možemo zaključiti da je lingvistička norma mnogo fleksibilnija od zakonske. Generacije su kroz sistem obrazovanja upoznate s lingvističkom materijom koja se bavi pitanjima naziva za zvanja i zanimanja, te im zakonska rješenja moraju djelovati rigidno, nametnuto i protivrječno onome što su naučili iz maternjeg jezika i što su godinama praktikovali u komunikaciji. Nijedna od razmatranih gramatika ni eksplicitno ni implicitno ne zabranjuje upotrebu tzv. generičkih formi za referisanje na

ženska lica, ali istovremeno gotovo svaka afirmiše upotrebu socijalnih femininativa. Generičke forme imaju drugu tradiciju i nije mudro, niti je moguće proskribovati ih, ali i ženske forme imaju respektabilan kontinuitet upotrebe. Ozbiljni predstavnici nauke o jeziku svjesni su da se jezičke navike sporo mijenjaju. Njihove stručne preporuke da se u neutralnim ili opštim upotrebnim situacijama koriste generičke forme kao ekonomičnije, a u konkretnim ženske forme jer se referiše na određeno lice ženskog pola – vrlo su svrsishodne i ne bi bilo loše da ih zakonodavac oslušne i usvoji. Ovo stoji ukoliko nam je cilj da imamo zakonske propise koji će se poštovati i koji će uz ravnopravnost obezbijediti mir i toleranciju društvu mentalitetski sklonijem antagonizmu nego prihvatanju. Jedno je sasvim sigurno: socijalni femininativi će u najvećem broju slučajeva opstati, a u zavisnosti od razvoja društva i vrsta zanimanja i multiplicirati se, bez obzira na to ko će pružiti, a ko uskratiti podršku njihovoj tvorbi i upotrebi.

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IMPROVING COMMUNICATION AS A KEY STRATEGY FOR ACHIEVING GOALS OF PROJECT TEAMS

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ABSTRACT:

This paper explores the significance of communication in achieving success within project teams. Through an analysis of available literature and research, we highlight the central role of communication in shaping team dynamics and performance. We examine how transparent, open, and continuous communication within teams contributes to a better understanding of goals, tasks, and expectations for each team member. Additionally, we investigate how communication can mitigate the risk of misunderstandings and conflicts within teams. We analyze the impact of different communication channels and technologies on the effectiveness of teamwork, emphasizing the need for adaptability and timely information delivery. By examining specific examples of best practices, we explore concrete strategies such as regular meetings and clear objectives that can enhance communication within project teams. Finally, we emphasize the importance of continuous development of communication skills within teams as a key factor for the long-term success of projects.

Keywords: *communication, project teams, teamwork, organization, communication channel*

1. INTRODUCTION

In the contemporary business environment, projects serve as pivotal drivers of innovation and development, thereby becoming the cornerstone for achieving organizational competitive advantage. Effective communication among project team members, as well as with relevant stakeholders outside the organization, becomes a crucial element for achieving project objectives.

This paper explores the importance of enhancing communication as a key strategy for achieving success in project team work. Communication serves as a vital instrument in achieving efficient coordination, motivation, and decision-making within project teams. The absence or inadequate quality of communication can result in numerous challenges and obstacles in project execution, including misunderstandings, delays in execution, and

lack of synergy among team members. Therefore, it is essential to recognize communication as a strategic tool for goal achievement and optimal project management.

By analyzing strategies, tools, and approaches that can enhance communication within project teams, several key elements can be identified. Establishing clear communication channels enables efficient flow of information within the team, while promoting openness and transparency encourages the exchange of ideas and opinions. Developing listening and expression skills within teams ensures that each team member is adequately engaged and that their perspectives are considered in decision-making.

Improved communication contributes to better coordination of activities within teams, motivation of team members, and higher-quality decision-making. Through effective communication, team members gain a better understanding of project objectives, comprehend their roles and responsibilities, and are motivated to contribute to achieving those objectives. Additionally, quality communication facilitates the decision-making process, reducing the likelihood of misunderstandings and conflicts among team members.

This paper provides deeper insight into the role of communication in the context of project management and offers guidelines for the implementation of effective communication strategies in practice. The aim is to emphasize the crucial role of communication as a vital success factor in projects and to encourage further research and application of these concepts in the broader context of project management. Effective communication is not merely a means of transmitting information but is a key element that enables synergy among team members and the achievement of desired outcomes in project initiatives.

2. HUMAN RESOURCE MANAGEMENT

In the context of project management, human resource management entails the organization, management, and leadership of project teams. The project team consists of individuals assigned specific tasks and responsibilities for the successful completion of the project. The structure of the project team and the number of members often change during project development, requiring flexibility and adaptation (Kerzner, 2021).

It is crucial to emphasize that, regardless of clearly defined roles and responsibilities within the project team, the involvement of team members in the planning and decision-making process significantly impacts project success. Early involvement and participation of team members contribute expertise during the planning phase and enhance their personal connection to the project (Heerkens, 2017; Broza, 2012).

An important resource in project management is the human resource plan, which includes processes for identifying and documenting project roles, responsibilities, and required skills. This plan identifies individuals with the necessary skills for project success and defines the project organization structure, as well as staffing and dismissal schedules. It is also included in the project schedule as an integral part (Heldman, 2019; Forsyth, 2018).

However, a common challenge faced by project managers is securing desired individuals with appropriate profiles for the project. The unavailability of certain individuals can significantly impact project planning and execution. The human resource plan should offer solutions to this challenge to ensure the efficiency of project activities (Harned, 2017, Forsyth, 2018).

The selection of project teams is a complex process that requires balancing technical skills and interpersonal relationships. The project manager must have the ability to accurately assess project needs and form a team with appropriate capacities. In this process, there is always a present risk, which further complicates personnel divisions according to importance in the project. The typical division of personnel in projects includes the core team, client team, and contractual team, with each team having specific roles and responsibilities towards the project. This division is crucial for establishing clear lines of communication and accountability within the project framework (Pinto, 2020).

Therefore, human resource management in projects requires careful planning, efficient management, and flexibility in adapting to changes during project development. This area represents a key component of successful project management and requires the integration of theoretical concepts with practical challenges of project environments.

3. FORMATION OF PROJECT TEAMS AND STRATEGIES FOR EFFECTIVE PROJECT MANAGEMENT

In the context of teams, the evolution of teamwork manifests on two key levels - individual and group. Here, the importance of project management in fostering this process and enhancing the skills of each individual is emphasized. Additionally, the importance of creating an environment that fosters continuous learning and progress for both individuals and the team as a whole is highlighted. According to Hill, the development of specific skills is a crucial aspect of successful team formation and progression. These skills include leadership, interpersonal skills, as well as professional abilities such as time management and decision-making. The author emphasizes that each member of the project team should be aware of their personal leadership style and understand how that style impacts the effectiveness of teamwork, and how to adapt to improve overall team productivity (Hill, 2007).

The project office or human resources department plays a crucial role in supporting team development. Through the application of various tools and techniques, such as team development workshops, team progress assessments, and evaluation of communication and collaboration, efforts are made towards continuous growth and improvement of team efficiency. In addition, motivational techniques and team recognition techniques are used to maintain the motivation and engagement of team members. The author also highlights a range of activities that contribute to the development of the project team. These activities include training on group dynamics and interpersonal skills, exercises aimed at strengthening team spirit, reflection on past experiences, and self-assessment of both individual and group effectiveness. Additionally, role reviews within the team are

conducted to prevent potential misunderstandings, while mentoring and counseling are provided to support the personal development of team members. Although the guidelines mentioned are crucial for team improvement, the author emphasizes that obstacles (challenges) are inevitable (Kerzner, 2021; Harned, 2017)

Challenges in team development represent problematic situations or behaviors that may arise during team formation or project execution. Recognizing these challenges and actively addressing them is crucial to avoid potential issues, conflicts within the team, or deviation from project objectives. However, challenges should be viewed as an integral part of the team-building process and achieving project results, as they are inevitable in reality (Daft, 2010).

The organization, project manager, and team members should collectively decide how to perceive obstacles that arise during project execution. This includes deciding whether to interpret obstacles as opportunities to strengthen the team and as challenges that will improve future projects or as problems to avoid. One of the main challenges is diversity of perspectives, priorities, and interests within the team. Each team member brings their professional experience and goals, and reconciling these differences can be crucial to achieving common objectives. Role conflicts also present a challenge. Lack of clear role definition or overlapping responsibilities can lead to conflicts within the team. It is important to recognize and resolve these conflicts early to maintain harmony and team efficiency. Clearly defined project goals and expected outcomes are essential. Unclear goals can lead to confusion and misunderstandings within the team, making it difficult to achieve results. The dynamic project environment brings additional challenges. Constant changes in the project environment can affect scope, objectives, and available resources. Teams that are willing to adapt to these changes are more likely to succeed. Support and leadership also play a crucial role. Strong leadership and support from senior management create a sense of security and motivation within the team, which is important for maintaining enthusiasm and dedication throughout the project. Communication is another important factor. Open and effective communication facilitates the exchange of ideas, reduces the possibility of misunderstandings, and helps maintain a positive work atmosphere. Each of these challenges presents an opportunity for the team to grow, develop, and become more efficient (Kerzner, 2021).

Considering the above, strategies for overcoming conflicts include: Diverse perspectives, priorities, and interests: It is important to thoroughly explain the project scope and rewards brought by successful project completion and try to align individual interests with overall project objectives. Role conflict: Role conflicts in the project should be resolved early, roles and responsibilities should be defined, and status checks should be regularly conducted in meetings. Unclear project goals/outcomes: Ensure that all parties understand the project purpose and establish regular communication with senior management and the client. Dynamic project environment: It is crucial to reach an agreement on key project directions and educate senior management and the client about the negative impacts of unnecessary changes on the project. Team leadership challenges: Establish strong project manager role and define clear roles and responsibilities to minimize competition for leadership. Lack of team definition and structure: It is crucial to establish clear roles and

responsibilities and regularly review and adjust the team structure throughout the project lifecycle.

Team member selection: Team member selection should be transparent and fair, and selection criteria should be clearly defined to reduce the perception of injustice. Lack of senior management support: It is crucial to educate senior management about the importance of the project and regularly report progress to maintain their support. Lack of team member commitment: It is important to identify and address the causes of lack of commitment, such as insecurity or misunderstandings about project goals. Communication problems: Establish open and transparent communication within the team and regularly check understanding of messages and information (Meredith, Shafer & Mantel, 2017; Lencioni, 2010; Kerzner, 2021).

Recognizing and overcoming these challenges is crucial for project success and building an effective and productive team. It is important for project managers to be aware of these challenges and apply appropriate strategies to address them to ensure successful project completion.

4. KEY ASPECTS OF COMMUNICATION IN PROJECT MANAGEMENT AND IMPLEMENTATION OF COMMUNICATION PLAN

One of the primary factors for the success of any project lies in effective communication. Without clear information transfer and regular interaction among team members, projects often face numerous challenges. Therefore, it is crucial to emphasize not only the importance of communication in general but also its various aspects and methods of implementation within project teams. While some individuals naturally possess outstanding communication skills, others may not be equally adept at expressing their thoughts and ideas. However, regardless of individual predispositions, every team member must be aware of the significance of communication and its impact on project success. The following section will consider some of the key aspects of communication in the context of project management (Horine, 2009; Goetsch & Davis, 2019).

One of them is managing expectations. The quality of communication among team members and project stakeholders directly affects their perception of the project and its progress. Besides managing expectations, communication also plays a crucial role in team leadership. Conflicts are another common problem that can arise due to a lack of or ineffective communication. Misunderstandings, lack of information, or misinterpretation can lead to conflicts within the team or with project stakeholders. Therefore, it is important to ensure that communication is clear and precise to avoid unnecessary conflicts. Timely delivery of information is also of utmost importance. Information should not be conveyed too early or too late, as this can lead to missing important details or information becoming outdated. In addition to timeliness, it is important to ensure that information is clear and understandable. Inaccurate or unclear information can lead to misunderstandings and misinterpretations, which can negatively impact the project's progress (Horine, 2009; Goetsch & Davis, 2019).

When analyzing communication methods, it is crucial to select those that align most effectively with the particular demands of the project and the preferences of team members (Sharma et al., 2020; Cleland, 2004; Engelhard & Wind, 2017; Tian, 2020; Gido & Clements, 2008; Wysocki, 2011).

As emphasized, communication can strengthen or weaken a team, and creating an environment where information is exchanged timely increases the chances of project success and accelerates the development of an efficient team.

4.1. Strategies of Communication in Project Implementation Activities

Project planning is a crucial phase in project management, providing a structured framework for achieving project objectives. This process involves a series of activities, such as defining goals, identifying tasks, allocating resources, estimating time and financial requirements, as well as identifying potential risks and challenges. Project planning ensures a clear roadmap for project management, reducing uncertainty and risks, and facilitating its successful implementation (Lee, 2021; Oh & Choi, 2020).

Objectives should be measurable, realistic, and achievable, while the project scope should precisely describe what will be covered by the project. After setting goals and defining the project scope, the next step is to break down the project into specific activities and tasks. This phase requires precise planning, where each activity has clearly defined objectives, responsibilities, and a timeframe for execution. After identifying activities, an assessment of the required resources (people, materials, equipment) and the time needed for their implementation is conducted. This enables planning the project schedule and budget. Project planning also involves identifying potential risks and issues that may affect its execution. Strategies for managing risks and addressing any issues that may arise are defined (Zuo, Zhao & Gao, 2018).

In the context of communication in projects, it is important to emphasize its crucial importance for efficient information exchange among all participants. Regular communication, presentations, and information sharing play a key role in project success (PMI, 2014). In doing so, it is important to consider several important factors: Communication Objective: Communication should be aimed at supporting the realization and successful completion of the project, avoiding unnecessary information that could hinder understanding. Audience and Purpose of Communication: Different project participants require an adapted approach to communication, involving all relevant parties such as team members, sponsors, customers, and other stakeholders, and meeting their specific communication needs. Message, Format, and Content: It is important to carefully select messages and their format to ensure that relevant information is timely delivered to the appropriate individuals. Communication Channel: Defining an appropriate communication strategy, including channel selection, timeframe, and frequency, is crucial for successful information transmission (Zerfass et al., 2020; Schwalbe, 2016).

Creating a communication plan is a key component of the project planning process, aimed at ensuring efficient information exchange within the team. The RACI matrix is used as a useful tool for defining responsibilities and communication within the project team. The RACI matrix defines the following roles:

- **R (Responsible):** This degree denotes the person responsible for carrying out specific activities or tasks within the project. They perform concrete tasks and execute necessary actions.
- **A (Accountable):** This degree denotes the person ultimately responsible for the final project outcomes and decision-making. They take the main responsibility for project success and represent the "owner" of the entire process.
- **C (Consulted):** This degree denotes persons whose expertise and knowledge are required before making decisions or carrying out specific activities.
- **I (Informed):** This degree denotes persons who need to be informed about the progress or decisions related to specific activities, although they do not actively participate in their execution.

The process of creating a communication plan using the RACI matrix involves identifying key activities and tasks within the project, as well as defining responsibilities for each of them. Each role within the project team has its specific combination of RACI responsibilities, depending on the nature of the activity (Effron & Ort, 2010; Степанов, 2022).

5. THE IMPORTANCE OF COMMUNICATION IN PROJECT MANAGEMENT CONTEXT

Communication serves as the foundation of every successful project. The lack of clear information transfer and regular interaction among team members can lead to numerous challenges in project implementation (Zulch, 2014; Schwalbe, 2016; Nyandongo & Davids, 2020).

Project management requires coordination and collaboration among various team members, participants, and relevant stakeholders. This process emphasizes the importance of coordination, efficiency, team engagement, stakeholder relationships, as well as project risk and challenge management (Pellegrinelli et al., 2007).

Effective communication within project organizations enables coordination and synergy of activities and tasks. Timely sharing of information allows teams to collaborate towards goals, avoiding duplication of work and confusion. Communication fosters synergy among team members, enabling them to act as a whole and contribute to project success. When team members are well-informed about goals and tasks, efficiency and productivity significantly increase. Communication facilitates idea exchange, problem-solving, and decision-making, accelerating project progress. Clear and precise communication reduces the risk of errors and misunderstandings, saving time and resources. Quality communication maintains a high level of team engagement and motivation. Well-

informed teams feel important and valued, increasing their commitment and dedication to the project. Communication encourages sharing of ideas and opinions within teams, fostering creativity and innovation. Regular and transparent communication with stakeholders ensures their support and trust, reducing the likelihood of conflicts. Communication also plays a crucial role in project risk management. Timely reporting of identified risks enables appropriate measures to be taken, reducing their impact on the project. Managing information exchange in projects involves processes of planning, gathering, distributing, reporting, and coordinating information. Project managers spend a significant amount of time communicating with team members and other participants, making effective communication crucial for successful project management (Zidane & Olsson, 2017).

Developing and maintaining a communication plan is essential for successful project management. Communication within project organizations provides the basis for coordination, synergy among teams, increased efficiency, and maintaining team engagement. Furthermore, establishing good relationships with stakeholders and managing risks are also key aspects achieved through quality communication. Changes in schedules, resources, or priorities require adjustments in the communication plan to ensure all team members are informed and involved in the project. Key elements of a good communication plan include communication management approach, identification of participants and their communication needs, methods and technologies, communication matrix, communication diagram, and escalation procedure for issue resolution (Portny & Portny, 2022).

6. CONCLUSION

In today's business environment, there is a noticeable increase in the use of project organization as a standard approach for the production and enhancement of organizations. Therefore, this paper highlights key factors of project organization with the aim of emphasizing an approach that significantly enhances the chances of achieving project objectives while respecting constraints. In this context, special attention is paid to the human factor as a crucial element for business success and project management. By initially highlighting the role of project managers and the responsibilities that fall on them, the author seeks to underscore the importance of successful project team leadership. Project managers play a crucial role in every phase of the project, from start to finish, and in the development of the project team. Special emphasis is placed on selecting the leadership style of project managers, highlighting their importance in improving the development of project teams.

Additionally, by highlighting the numerous advantages of teamwork over its disadvantages, it is clear that a team-oriented approach is crucial for contemporary business success. The social and psychological aspects of team dynamics must be carefully considered in all aspects of team approaches. In this context, the roles within the team reflect the psychological characteristics of potential project team members and serve as the basis for selecting team members, whose role is of great importance for the further progress of the project.

As already mentioned, the dynamism of modern business often disrupts the ideal course of development of project teams, posing obstacles to their development. However, these obstacles should be viewed as challenges that, if approached correctly, can contribute to team strengthening. Conflict situations in projects represent a challenge, but also an opportunity to strengthen team spirit, enrich experience, and strengthen connections among team members.

Finally, communication is highlighted as an essential element of every successful project. Open, timely, and clear communication enables projects to avoid many pitfalls and challenges and to achieve their goals in the best possible way.

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ULOGA DIREKTORA U MOTIVACIJI ZAPOSLENIH

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SAŽETAK:

Motivacija je složen i kontinuiran proces, stoga zahtjeva interdisciplinarni pristup rukovodioca. Rukovodioci –direktori moraju ulagati u znanje i vještine, kako bi mogli da „vode“ svoje zaposlene, kao i da djeluju u promjenljivoj okruženju. Motivirati zaposlene osnova je kvalitetnog i uspješnog upravljanja nekim timom. Da bi uspješno mogao da vodi zaposlene, rukovodilac mora da posjeduje odgovarajuću moć. Izvori moći su različiti, zavise od samih rukovodilaca i od njihove uloge u organizaciji: legitimna moć – zasnovana na autoritetu i hijerarhiji same funkcije; moć nagrađivanja – nagrađivanje poželjnog ponašanja u vidu zarada, napredovanja, nagrada; moć prinude – uticaj putem kazni; referentna moć – uticaj na zaposlene putem ličnog primjera; stručnjačka, ekspertna moć – zasnovana na stručnom znanju rukovodioca. S tim u vezi i u istraživanju koje ćemo predstaviti, ispitivali smo da li je motivacija za rad kod zaposlenih uslovljena ulogom direktora i njegovim pristupom u radu. Imajući u vidu da se stepen aspiracije razlikuje kod svakog pojedinca i na njega utiču različiti faktori, polje interesovanja u ovom radu jeste i koja je ključna uloga direktora, uloga u upravljanju, koja su to znanja, vještine i sposobnosti koje direktor treba da poseduje, ne bi li utjecati na povećanje motivacije zaposlenih u kolektivu kojim upravlja.

Ključne riječi: Motivacija, director, rukovodilac, zaposleni, menadžer.

1 UVOD

Škole su specifične po tome što su u osnovi svih procesa u njima ljudi. Menadžment ljudskih resursa u obrazovanju može dati najbolje rezultate, jer su ljudi presudan element od kojeg zavisi uspjehnost i ugled škole. Direktor mora da poznaje zaposlene i omogućiti im da pokažu šta znaju kako bi školi pružili najbolje od sebe. Ovaj rad je posvećen vođenju ljudi, jer nikako se ne sme zanemariti važnost liderstva u školi kao organizaciji s osjetljivom i specifičnom djelatnošću. Velika je odgovornost koju nastavno osoblje ima prema učenicima i ona treba da bude svakako ispred liderske, odnosno, u ovom slučaju, direktorske moći. Ali to ne umanjuje odgovornost direktora – on mora da bude lider, a to znači da na svaki način mora da se bori i da usmjerava i tako osigura uspješnu realizaciju obrazovnog rada u školi. Svaki menadžer u svojoj organizaciji ima za osnovni cilj da najpovoljnije iskoristi resurse te organizacije. Pošto su u školama ljudi osnovni resurs, oni za direktora moraju biti prioritet. (<https://scindeks-clanci.ceon.rs/data/pdf/0353-7129/2012/0353-71291201045S.pdf>)

Koncept liderstva nastavnika pokušava da ukine ovu barijeru tako što nastavnike ohrabruje da svoja iskustva i savjete dijele s ostalim radnim kolegama, pa cjelokupnom zajednicom nastavnika u svijetu putem pisanja stručnih radova. „Vođenje u stvarnom (suštinskom) značenju -pretpostavlja preokret u organizaciji kako bi ona mogla ostati konkurentna pri stalnim promjenama okruženja. Vođenje organizacije znači usmjerevanje, komuniciranje sa saradnicima o zajedničkim ciljevima, motivisanje i inspirisanje. Liderstvo treba da ostvari kulturu vođenja u organizaciji, da pokrene proces učenja kroz izazove”. (Anđevski, 2007:79).

Direktorski poslovi vezani za menadžment neophodni su za organizaciju svakodnevnog života škole i odnose se na planiranje, analiziranje, organizaciju i nadzor, a poslovi vezani za vođstvo vezuju se za ljude, njihovo ponašanje, stil rada, komunikaciju i motivisanje. Dok se menadžment odnosi na stvari, vođstvo se odnosi na ljude. Menadžerski stil direktora je racionalan, a liderski emocionalan. Direktor menadžer često u praksi vlada ljudima tražeći poslušnost, a lidera ljudi slijede na osnovu njegovih kvaliteta i na osnovu ličnog izbora jer on pokreće emocije i raspiruje strasti. Menadžer održava sisteme, oslanja se na kontrolu i kratkoročnije promatra stvari. Funkcija direktora kao menadžera je da zapovijedi i kontroliše koristeći formalne procedure i racionalne metode. Za njih je karakteristično da slijede propise i poslovnu politiku nadređenih. Direktor sa liderskim crtama je vođa. Vođenje uvijek karakteriše uticaj na ljude, njihovo pridobijanje i podsticanje na aktivnost. On motiviše, podstiče, daje energiju, posmatra stvari dugoročno i ima viziju, izaziva postojeće stanje na promjenu. U timskom radu pokušava objasniti smjer promjena i pridobija članove organizacije u učestvovanju u procesu tih promjena. Direktori-lideri uvijek slijede ličnu intuiciju i stalno opodstiču inovacije. (<https://aseestant.ceon.rs/index.php/sinteze/article/view/8497/3336>).

Direktor nije uvijek ekspert za sve, ali treba biti istrajan, odlučan, originalan i otvoren za promjene. Nije mu više dovoljno znanje iz samo njegove matične struke, odnosno temeljno obrazovanje. On danas rješava složene probleme koji liče na probleme velikih preduzeća. Škola se mjenja, od ustanove za učenje učenika, u školu koja uči (Resman, 2004:115). U skladu sa tim svaki direktor treba kontinuirano da uči i sistemski da se razvija u području vođenja. Njegova odvažnost i menadžersko-liderski pristup, kao i harizmatična ličnost trebalo bi da u svima pobuđuju osjećaj sigurnosti i odlučnosti

I TEORIJSKI DIO

1. POJAM MOTIVACIJE

Sila koja potiče naše ponašanje u svrhu ispunjenja želja i potreba zove se motivacija. To je snažna i veoma složena sila koja nas potiče na djelovanje, izgrađuje volju i utiče na odlučivanje (Prema: Jakšić, J. 2003:5). To je složen koncept vezan za nagon, podsticaj ili energiju da se nešto uradi, pa je zato definišemo kao proces pokretanja, usmjerenja i regulisanja određenih aktivnosti .

Motivi su pokretači svrhovite ljudske djelatnosti. Motiv je zajednički naziv za različite unutarnje biološke i psihološke pobude i dinamičke snage. U motive spadaju: potrebe, nagoni, težnje, namjere, želje, impulsi ili poticaji, porivi i slično. Iza nekog oblika ponašanja mogu se skrivati različiti motivi. Motiv je sve ono što »iznutra« potiče čovjeka

na aktivnost, upravlja ga prema određenim ciljevima i zadacima, te mu podržava ustrajnost u započetoj aktivnosti. Motivi se u prvom redu zasnivaju na potrebama čovjeka, pa mogu biti rezultat njegova fiziološkoga nasljeđa, mogu biti stečeni životom u određenoj društvenoj sredini ili su pak rezultat individualnog razvoja pojedinca. odlučivanje (Prema: Jakšić, J. 2003;6).

Na osnovu navedenog zaključujemo da je motivacija veoma značajna u svakodnevnom životu čovjeka, jer ga podstiče na aktivnost i djelovanje, osnažuje ga u ostvarivanju postavljenih ciljeva, doprinosi postizanju uspjeha i osjećaja ličnog zadovoljstva.

Motivacija zaposlenih predstavlja poseban izazov u radu. Motivacija je moćna sila koja stoji u osnovi brojnih aktivnostikoje radimo (ili ne radimo). Uvijek smo u potrazi za nečim što bi nas podstaklo, pokrenulo, nadahnulo da idemo ka određenom cilju.

Motivisan radnik je produktivan radnik, zbog čega je veoma značajno da zaposleni znaju da je njihov rad cijenjen i vrednovan. Motivacija zaposlenih najbolje se gradi sljedećim metodama: razvijanjem osjećaja bliskosti, sistemom nagrađivanja i redovnom razmenom informacija.

Zdrava motivacija, štiti kolektiv od pojave opasnosti kao što su obeshrabrenost i nezainteresovanost za rad. Kada je, u kontekstu teme kojom se bavimo, u pitanju uloga direktora institucije (škole), potrebno je posebno ukazati na njegovu kompetetivnost i ulogu u motivisanju mastavnika i svih ostaklih uposlenika na postizanje zato ćemo se u daljem tekstu baviti tim pitanjima.

2. KOMPETENCIJE DIREKTORA

Kompetentnost direktora često je tema (broj jedan) različitih rasprava u praksi i analiza u naučnim krugovima, kako bi se definisale osobine neophodne za uspješno rukovođenje. Ipak to u potpunosti nije moguće, jer kvalitet rada jednog direktora određuje individualnost i sposobnost empatije prema ljudima, a ponajviše lišenost sujete, ali i snažan karakter koji zavređuje poštovanje i povjerenje svog tima.

Kompetencije direktora definisane su kao funkcionalno integrisana znanja, sposobnosti, vještine i sistem vrijednosti koji su osnova za uspješno obavljanje poslova i zadataka u ustanovama predškolskog, osnovnog i srednjeg obrazovanja i vaspitanja. Standardi kompetencija direktora utvrđuju one kriterijume kojima se obezbjeđuje uspješno upravljanje, organizovanje, rukovođenje, izvršavanje i kontrolisanje rada navedenih ustanova. Standardi kompetencija detaljno opisuju ključne aktivnosti za koje direktor mora biti osposobljen kako bi uspješno rukovodio ustanovom i obezbedio ostvarivanje njenih ciljeva. (<https://ivololaribar.edu.rs/download/kompetencijedirektora.pdf>)

Weihrich i Koontz (1994), koji smatraju da efektivni menadžer mora imati četiri osnovne vještine u svojoj ulozi i danas su to: konceptualne vještine, vještine rada s ljudima, tehničke vještine i vještine oblikovanja.

Konceptualne vještine označuju sposobnost da se vidi i razumije „šira slika“, u kontekstu poduzeća, što podrazumijeva sposobnost menadžera da sagleda organizaciju kao cjelinu, procesuiru informacije i osmisli planove. Ove vještine također uključuju sposobnost prepoznavanja i analiziranja bitnih elemenata u određenoj situaciji te razumijevanje međusobnih veza i odnosa između tih elementa. Upravo ova vrsta vještine se smatra najvažnijima na svim razinama menadžmenta, a posebno je važna na razini vrhovnog

menadžmenta koji mora razumjeti kako su različite poslovne jedinice povezane jedna s drugom i kako ih uklopiti u globalni koncept djelovanja. (Gutterman, 2023; 4).

Menadžer treba razumjeti potrebe, snage i slabosti ljudi te njihovu motivaciju. Ovo razumijevanje se očituje kroz kvalitetan odnos s ljudima, gdje menadžer motivira, pomaže, koordinira, vodi, komunicira i rješava konflikte. Na taj način potiče se otvorena komunikacija i omogućava suradnicima da iznesu svoja mišljenja o najboljem načinu organiziranja radnih aktivnosti (Buble, 2010; 5).

Tehničke vještine obično su najvažnije za menadžere na nižim razinama i imaju tendenciju da postanu manje važne kako se ide prema vrhu organizacijske hijerarhije. Za srednju razinu menadžmenta one su važne za područje marketinga, financija, ljudskih resursa ili proizvodnje, odnosno vezane su za specijalizirano znanje potrebno za područje njihova rada (Gutterman, 2023; 3).

Vještina oblikovanja, prema predloženom od strane Wehrich-a i Koontz-a, predstavlja dodatnu kategoriju koja se fokusira na sposobnost menadžera da na temelju prethodne analize osmisli najprikladnije rješenje, uzimajući u obzir različite kriterije. To znači da menadžer ima sposobnost oblikovanja poslovnih rješenja koja će najviše koristiti poduzeću i omogućiti mu da efikasno rješava poslovne probleme (Rupčić 2018; 13).

Kod analize posebnih menadžerskih vještina postoje različita gledišta i sistematizacija, međutim (Buble 2010;6) je u svojoj literaturi Menadžerske vještine, sistematizirao pet osnovnih funkcija sukladno vještinama menadžmenta: vještine planiranja, vještine organiziranja, vještine upravljanja ljudskim potencijalom, vještine vođenja i vještine kontroliranja

Planiranje je proces u kojem menadžer ima ulogu odabrati između alternativnih pravaca djelovanja organizacije te definirati koje aktivnosti i resurse će koristiti u ostvarenju odabranog pravca. Kvaliteta planiranja ovisi o pažljivoj analizi vanjskih čimbenika, smjeru njihovog utjecaja i razumijevanju njihovog intenziteta. Kroz proces planiranja, menadžment utvrđuje ciljeve i identificira aktivnosti potrebne za njihovo ostvarenje. Ovaj proces završava izradom proračuna koji kvantitativno izražava postavljene ciljeve i pruža kriterije za kontrolu ostvarenih rezultata. Na taj način planiranje omogućuje organizaciji da se usmjeri prema svojim ciljevima te osigura učinkovitu i kontroliranu realizaciju postavljenih zadataka. Planiranje se javlja i u procesima kao što su: upravljanje promjenama, uvođenje unapređenja, inovacije i upravljanje projektima, stoga je važno da menadžment ima razvijenu ovu vještinu upravo kako bi ostvario produktivnost u svom djelovanju (Rupčić, 2018; 156

Organiziranje podrazumijeva podjelu i koordinaciju rada kako bi se određeni ciljevi ostvarili. U procesu organiziranja definiraju se svi potrebni resursi vezani za obavljanje poslovnog procesa, dijele se zadatci koje se trebaju obaviti, povezuju se zadatci i ljudi te se usklađuju individualne i grupne aktivnosti sa ciljevima organizacije (Alibabić, Miljković, 2020; 11). Menadžment ima odgovornost za oblikovanje i prilagodbu organizacijske strukture, što zahtijeva od menadžera da posjeduje određen skup vještina kako bi učinkovito obavljao kompleksne zadatke. Među ovim vještinama spadaju dijagnosticiranje i oblikovanje organizacije, redizajniranje radnih mjesta te modifikacija organizacijske kulture. Ove sposobnosti omogućuju 14 menadžerima da stvaraju organizacijske okvire koji su optimalni za postizanje ciljeva, prilagođavaju poslove prema potrebama i promjenama te oblikuju kulturu koja podržava uspjeh i kontinuirani razvoj organizacije (Buble, 2010;7).

Pod vještinom upravljanja ljudskim potencijalima u obrazovnoj organizaciji stavlja se naglasak na razvijanje vještina kao što su: vještine stvaranja zdrave radne klime i dobrih međuljudskih i suradničkih odnosa (kao što su vještine rješavanja problema sagorijevanja na poslu i rješavanje konflikta u organizaciji); vještine motiviranja zaposlenika; vještine planiranja, poticanja i vrednovanja profesionalnog razvoja zaposlenih (Alibabić i Miljković, 2020; 83).

Upravljanje ljudskim potencijalom uključuje dodjeljivanje različitih uloga unutar organizacije osobama koje su najbolje kvalificirane za njih. To se postiže identificiranjem raspoloživih talenata, regrutiranjem novih kadrova, provođenjem selekcijskog procesa, pružanjem profesionalne orijentacije, planiranjem karijere te osposobljavanjem i kontinuiranim usavršavanjem zaposlenika. Ove vještine omogućuju menadžmentu da učinkovito upravlja ljudskim potencijalom, što je ključno za uspjeh organizacije u postizanju svojih ciljeva (Buble, 2010; 8).

Vještina vođenja kao funkcija menadžmenta zahtijeva da se menadžer aktivno angažira u različitim situacijama: pojašnjavajući ciljeve i zadatke, motivirajući zaposlenike da budu učinkoviti, pružajući potrebne informacije te rješavajući konflikte među njima. Ove vještine omogućuju menadžerima da uspješno obavljaju ulogu vođenja i ostvaruju optimalne rezultate u upravljanju ljudima i procesima unutar organizacije (Buble, 2010; 141).

Kontroliranje je jedna od funkcija menadžmenta koja uključuje niz međusobno povezanih aktivnosti usmjerenih na analizu i procjenu ostvarenja planova. . Ove vještine omogućuju menadžerima da učinkovito prate i upravljaju performansama organizacije, identificirajući potencijalne probleme i prilagodbe koje su potrebne kako bi organizacija bila na pravom putu prema uspjehu (Alibabić, Miljković, 2020; 11)

3. ULOGA DIREKTORA U MOTIVACIJI ZAPOSLENIH

Za motivisanje zaposlenih, direktori treba da budu dobri psiholozi, analitičari, ekonomisti, pravnici, rukovodioci, posebno, empatični, socijalno osjetljivi, prilagodljivi, spremni da potisnu sujetu, ali uz sve to da održe autoritet.

Kod motivacije zaposlenih, direktori treba da imaju na umu da je motivacija dio kulture i organizacijske structure u školi. Ona je stalna varijabla koja odražava atmosfer u učionici. Potrebno je kontinuirano motivisati zaposlene i to uz pomoć materijalnih i nematerijalnih faktora.

Direktor treba da bude primjer i autoritet koji dobro poznaje svoje zaposlene. Ljude će najlakše motivisati rukovodioc koji teži radu i redu i koji i sam obavlja zadatke na efikasnom i efektivnom nivou, ali i koji cijeni njihov rad i trud, da pohvali i da nagradi svoje zaposlene. Direktor treba da poštuje i uvažava ličnost svojih zaposlenih, kao i da se založi za iste.

4. Odabir teme za istraživanje - razlozi

Školska zgrada u Karajukića Bunarima izgrađena je 1992. godine. Svojom površinom i arhitektonskim rješenjima odgovara pedagoškim propisima i zahtjevima ove sredine. Škola broji 22 odeljenja i 264 učenika. Niži razredi su smješteni u kombinovanim odeljenjima 1 -3 i 2-4 razreda, izuzev odeljenja Rasno, gdje su čisti razredi i odeljenja.

U ovoj školskoj godini za svoj obrazovno vaspitni rad škola je koristila sljedeće školske objekte i zgrade: školsku zgradu u Karajukića Bunarima, Rasnu, Doliću, Tuzinju, Uglu, Cetanoviću i Buđevu.

Sprovodeći istraživanja u okviru samovrednovanja u školskoj 2022 – 23 godini, ispitivali smo svih šest oblasti samovrednovanja. Na osnovu dobijenih rezultata, došli smo do zaključka, da je zaposlenima potrebna intezivnija razmjena informacija, te da nemaju svi isti odnos prema poslu, ali i da im je potrebna dodatna motivacija za rad, jer je većina kolega iznijela stav, da smatraju da je profesija prosvetnih radnika prilično degradirana.

S tim u vezi, a na osnovu rezultata samovrednovanja, došli smo na ideju da ispitamo motivaciju kod zaposlenih i da utvrdimo da li ista zavisi od uloge i stave direktora i sveukupnog rada director aškole, a sve u cilju da se unaprijedi rad directora škole, koji bi ujedno uticao i na sveukupni kvalitet rada obrazovne ustanove i na povećanje motivacije kod zaposlenih.

S tim u vezi, još jedan od razloga za ispitivanje motivacije kod zaposlenih i uloge direktora u motivaciji, jeste upravo rad u vanrednim okolnostima, kada je motivacija značajno manja zbog sveukupnih izmijenjenih uslova rada.

II METODOLOŠKI DIO

1. Problem istraživanja

Motivacija zaposlenih postala je neizbježan faktor u stvaranju lanca vrijednosti svake ustanove. Pošto direktori smatraju da je motivacija process zadovoljenja individualnih potreba, zato se postavlja pitanje koje je problem ovog istraživanja: *“Kakva je uloga direktora u podsticanju motivacije zaposlenih?”*

2. Predmet istraživanja

S tim u vezi, proizilazi idefincija predmeta istraživanja koja glasi: Stavovi nastavnika o ulozi direktora za motivaciju zaposlenih.

3. Cilj istraživanja

Cilj istraživanja je da direktor motiviše još više svoje zaposlene kako bi povećali svoj radni elan i motivisanost, tako što će naučiti da primjenjuju savremene tehnike motivisanja, a time istovremeno unaprediti obrazovno-vaspitne procese u školi i uspješno ostvariti ciljeve u stanove.

4. Zadaci istraživanja

1. Ispitati relijabilnost skale
2. Ispitati kako pol ispitanika utiče na stavove nastavnika o ulozi direktora za motivaciju zaposlenih
3. Ispitati kako godine radnog staža utiču na stavove nastavnika o ulozi direktora za motivaciju zaposlenih

4. Ispitati kako godine radnog staža utiču na stavove nastavnika o ulozi direktora za motivaciju zaposlenih
5. Ispitati stavove nastavnika na koji način ih direktor motiviše da se posvete poslu
6. Ispitati da li direktor primjenjuje Pravilnik o nagrađivanj uzaposlenih
7. Ispitati nastavnike na koji način pohvala utiče na njihovu motivaciju i koliko ih direktor motiviše (obeleženo ocjenom od 1 do 10)

5. Hipoteze istraživanja

1. Pretpostavlja se da je skala relijabilna
2. Pretpostavljamo da pol nastavnika utiče na njihove stavove o ulozi direktora za motivaciju zaposlenih
3. Pretpostavljamo da godine nastavnika utiču na stavove o ulozi direktora za motivaciju zaposlenih
4. Pretpostavljamo da radni staž utiče na stavove nastavnika o ulozi direktora za motivaciju zaposlenih
5. Pretpostavljamo da direktor nastavnike motiviše stručnim usavršavanjem
6. Pretpostavljamo da direktor primjenjuje Pravilnik o nagrađivanju zaposlenih
7. Pretpostavljamo da pohvala pozitivno utiče na povećanje motivacije na stavnika I da su ocjenili ocjenom 9 koliko ih director motiviše

6. Varijable istraživanja

Nezavisne varijable:

1. Pol	2. Godine starosti	3. Godine radnog staža
Muški	25-35 preko 45	0-10 preko 20
Ženski	36-45	11-20

Zavisne varijable: Stavovi nastavnika o ulozi direktora za motivaciju zaposlenih.

7. Metode, tehnike i instrumenti istraživanja

Koristili smo metodu teorijske analize. Takođe i deskriptivnu metodu. Instrument koji smo osmislili za potrebe ovog istražanja je skala procjene Likertovog tipa koja je petostepena i glasi:

- 1 – uopšte se ne slažem 2 – uglavnom se slažem 3 – nisam siguran/a*
4 – uglavnom se slažem 5 – upotpunosti se slažem

Ali se u okviru ovog instrumenta nalazi i pitanje otvorenog tipa koje se odnose na 4. 5. i 6. zadatak istraživanja.

8. Populacija i uzorak istraživanja

Uzorak istraživanja čine nastavnici OŠ “Rifat Burdžović Tršo” u Karajukića Bunarima i to 66 ispitanika, od ukupno 70 zaposlenih u školi.

9. Organizacija i tok istraživanja

Istraživanje je realizovano tokom marta mjeseca 2024. Godine u osnovnoj školi „Rifat Burdžović Tršo“ u Karajukića Bunarima. Zaposleni su bili ažurni kada je popunjavanje upitnika u pitanju, tako da je istraživanje proteklo bez problema.

10. Statistička obrada podataka

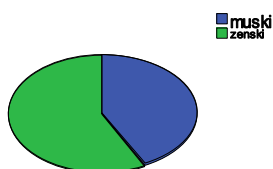
Podatke koje smo dobili u ovom istraživanju su obrađeni putem progama SPSS i statistička obrada podataka obrađivana je preko programa SPSS, a rezultati su prikazani preko tabela i grafikona. Korišćeni su sljedeći statistički parametri: frekvencije (f), iproceniti (%), aritmetička sredina (M) i standardna devijacija (sd).

III ANALIZA I INTERPRETACIJA REZULTATA I STRAŽIVANJA

Cronbach's Alpha	N
0,778	16

Tabela 1. Relijabilnost skale kojom se ispituje nastavnik

Relijabilnost predstavlja merljivost instrumenta. Ukoliko su rezultati dobijeni Cronbach' a Alpha testom veći od 0,7 znači da je upitnik dobro postavljen, odnosno da mjere upravo stavove ispitanika, do kojih smo željeli da dođemo, sprovodeći ovo istraživanje. Na osnovu tabele dolazimo do zaključka da skala koja ispituje stavove nastavnika o ulozi direktora u motivaciji kod zaposlenih, posjeduje sve metrijske karakteristike, s obzirom na to da je vrijednost Cronbach' a Alpha testa na 0,778. Na osnovu toga zaključujemo da je skala relijabilna (vrijednost Cronbach' a Alpha testa >0,7), samim tim potvrđujemo prvi zadatak i prvu hipotezu istraživanja.



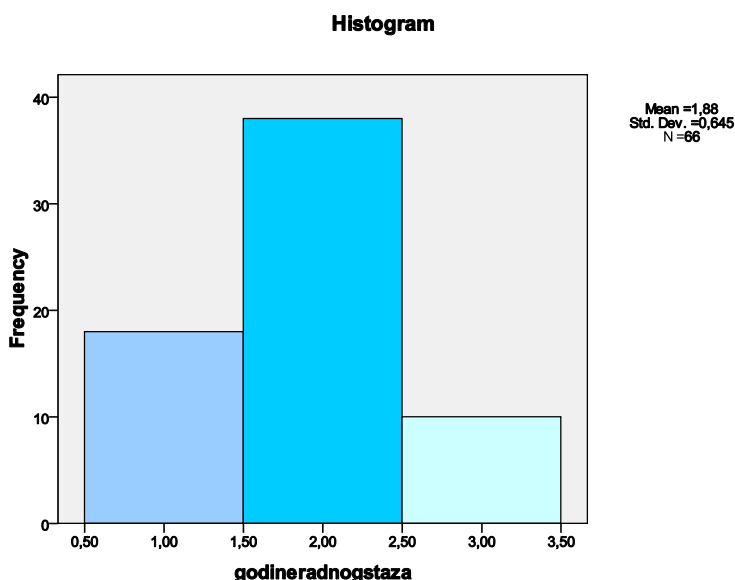
Grafik 1. Pol ispitanika

U grafikonu broj 1. Prikazan je broj ispitanika prema polu, tako da vidimo da preovladava ženska populacija sa ukupno 38 ispitanika i 28 muških ispitanika, dok je ukupan broj ispitanika 66.

Tabela 2. Godine ispitanika

GODINE			
		Frequency	Percent
	25-35	17	25,8
	36-45	38	57,6
	preko 46	11	16,7
	Ostalo	0	0
	Ukupno	66	100,0

U tabeli 2. Vidimo da su ispitanici podijeljeni i prema godinama, tako da imamo najmanje onih koji su preko 46 godina, njih 11, dok najviše ima ispitanika od 36-45 godina, čak 38 ispitanika, što nam govori da u našoj školi prevladava uglavnom srednji kadar nastavnika u mlađu grupu ispitanika od 25-35 godina spadaju 17 nastavnika.



Grafik 2. Radni staž ispitanika

U grafikonu broj 2. Najmanje je ispitanika sa radnim stažom preko 20 godina (10), zatim sa radnim stažom do 10 godina (18), a najviše je ispitanika sa radnim stažom od 11 do 20 godina (38).

Tabela 3. Stavovi nastavnika o ulozi direktora za motivaciju

TVRDNJE	N	Uopšte se ne slažem	Uglavnom se ne slažem	Nisams iguran/a	Uglavnom se slažem	U potpunosti se slažem
	66	4	11	13	16	22

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1. Direktor uvažava i poštuje sve zaposlene bez favorizovanja pojedinih			6,1%	16,7%	19,7%	24,2%	33,3%
2. Direktor je lider sa kojim se često identifikujemo u radu, jer svojim odnosom prema poslu motiviše i nas da se dodatno angažujemo	2	66	4	13	11	15	23
			6,1%	19,7%	16,7%	22,7%	34,8%
3. Direktor nas kontinuirano podstiče da se stručno usavršavamo u skladu sa profesionalnim potrebama	3	66	5	11	11	15	24
			7,6%	16,7%	16,7%	22,7%	36,4%
4. Direktor ima otvoren odnos sa svojim zaposlenima	4	66	2	9	11	19	25
			3,0%	13,6%	16,7%	28,8%	37,9%
5. Radoznalost je moja jača strana kad je posao u pitanju	5	66	4	8	12	14	28
			6,1%	12,1%	18,8%	21,2%	42,4%
6. Naš director se stalno profesionalno usavršava	6	66	3	8	11	17	27
			4,5%	12,1%	16,7%	25,8%	40,9%
7. Direktor podstiče dobru radnu atmosferu u školi	7	66	4	10	14	15	23
			1,6%	15,2%	21,2%	22,7%	34,8%
8. Direktor odgovorno pristupa svim radnim zadacima samim time motiviše zaposlene da budemo odgovorniji	8	66	3	8	17	13	25
			4,5%	12,1%	25,8%	19,7%	37,9%
9. Direktor nas motiviše da u većoj mjeri njegujemo horizontalno učenje (ogledni i ugledni časovi, saradnja među kolegama)	9	66	1	8	15	15	27
			1,5%	12,1%	22,7%	22,7%	40,9%
10. Direktor nas redovno informiše o koracima koje planira I o profesionalnom razvoju škole	10	66	1	5	15	18	27
			1,5%	7,6%	22,7%	27,3%	40,9%
11. Direktor zajedno sa zaposlenima učestvuje u planiranju događaja koji su od važnosti za školu (dokumentacija, projekti, javna izlaganja, marketing škole)	11	66	1	7	16	20	22
			1,5%	10,6%	24,2%	30,3%	33,3%
12. Direktor je mentor zaposlenima u ustanovi	12	66	4	8	14	15	25
			6,1%	12,1%	21,2%	22,7%	37,9%
13. Direktor njeguje timski rad i često se konsultuje sa zaposlenima	13	66	3	9	19	14	21
			4,5%	13,6%	28,8%	21,2%	31,8%
14. Direktor je motivisan da napreduje u poslu	14	66	3	7	17	15	24
			4,5%	10,6%	25,8%	22,7%	36,4%
15. Radoznalost novim sadržajima motiviše da radim	15	66	2	7	17	18	22
			3,0%	10,6%	25,8%	27,3%	33,3%
16. Nemam ambiciju i motivaciju da nešto mijenjam u svom pristupu kada je posao u pitanju	16	66	3	6	17	16	24
			4,5%	9,1%	25,8%	24,2%	36,4%

Iz priložene tabele možemo vidjeti da je procenat ispitanika uvijek iznad 30% odgovorilo da se u potpunosti slaže sa navedenim tvrdnjama, što nam ukazuje da nastavnici imaju pozitivne stavove o ulozi direktora za motivaciju zaposlenih. 33,3% ispitanika je odgovorilo da direktor uvažava i poštuje svoje zaposlene, dok se sa direktorom identifikuje 34,8% ispitanika. 36,4% ispitanika je odgovorilo da ih direktor podstiče da se stalno stručno usavršavaju, samim tim ovaj podatak ide u prilog činjenici, da direktor ima ulogu u motivaciji kod zaposlenih, te je najveći procenat ispitanika odgovorio da se i sam direktor stalno profesionalno usavršava. Preko 30% ispitanika je odgovorilo da radoznalo pristupaju radnim zadacima, te da direktor ima otvoren odnos prema zaposlenima i da podstiče dobru radnu atmosferu na poslu. 57,6% ispitanika smatra da direktor odgovorno pristupa radnim zadacima, dok 63,6% ispitanika izjavljuje da ih direktor motiviše, da u svom radu sprovode horizontalno učenje. Većina ispitanika je informisana o planiranim koracima rukovodstva, kada je posao u pitanju, takođe većina ispitanika izjavljuje da su uključeni u planiranje događaja koji su važni za školu. 60,6% ispitanika je izjavilo da im je direktor mentor u ustanovi, te da njeguje timski rad.

Tabela 4. Korelacija nezavisnih varijabli sa zavisnim varijablama
Korelacija

		pol	Godine starosti	Godine radnog staža	Odgovori nastavnika
Pol	Pearson Correlation	1	,022	-,019	-,153
	Sig. (2-tailed)		,863	,880	,221
	N	66	66	66	66
Godine starosti	Pearson Correlation	,022	1	-,210	,017
	Sig. (2-tailed)	,863		,090	,890
	N	66	66	66	66
Godine radnog staža	Pearson Correlation	-,019	-,210	1	,053
	Sig. (2-tailed)	,880	,090		,671
	N	66	66	66	66
Odgovori nastavnika	Pearson Correlation	-,153	,017	,053	1
	Sig. (2-tailed)	,221	,890	,671	
	N	66	66	66	66

Na osnovu rezultata statističke obrade podataka zaključujemo da je prva hipoteza potvrđena, ali da druga hipoteza nije potvrđena, te da se stavovi nastavnika ne razlikuju značajno po polu. Takođe, treća i četvrta hipoteza nisu potvrđene, što ide u prilog činjenici da se uloga direktora u motivaciji kod zaposlenih ne mijenja u odnosu na godine starosti i godine radnog staža, odnosno da direktor doprinosi motivaciji kod zaposlenih i sa kraćim, ali i dužim radnim stažom. Peta hipoteza je potvrđena, jer je stručno usavršavanje bilo jedan od zastupljenijih odgovora na pitanje na koji način Vas motiviše direktor, ali tu su

se javili isljedeći odgovori: svojim primjerom i načinom rada, pohvalama, svojim odnosom prema poslu, redom, radom i disciplinom, stalnom podrškom, konstruktivnim savjetima, učešćem na seminarima. Kao što smo i pretpostavljali direktor primjenjuje Pravilnik o nagrađivanju zaposlenih tako da i šestu hipotezu možemo potvrditi. Sedmu hipotezu potvrđujemo, jer pohvala pozitivno utiče na povećanje motivacije nastavnika i da ih motiviše, preovladavala je ocjena 9 koliko ih direktor motiviše.

ZAKLJUČAK

Jedan od najvećih problema motivacionih sistema je otpor samih radnika koji često ne vjeruju u sistem stimulativnog nagrađivanja u njegovu objektivnost i pravednost. Kao najvažniji aspekt ukupnih kompetencija direktora ističu se, stavovi prema zaposlenima, otvorenost u komunikaciji i sposobnost procjene i reakcije u specifičnim situacijama.

Jasno je da su uz te kompetencije, neophodna stručna znanja i vještine, te iskustvo i praksa direktora, jer se okruženje u kojem djelujemo stalno mijenja. Direktor i treba da poznaje sve segmente posla koji mu ko vode, kao i da su eksperti u upravljanju. Direktor treba da ima odlike šefa, stručnjaka, inovatora i kreativca, psihologa, lidera, kohezijskog predvodnika i autoritativnog vođe.

Kada je u pitanju motivacija, direktor igra značajnu ulogu, jer direktor koji motiviše, nastoji da osigura homogenost svih zaposlenih unutar škole, što stvara dodatne sinergijske efekte na učinak i razvoj nove sposobnosti kod zaposlenih, poput samousmjerenja i organizacije i međusobnog motivisanja, kao posljedica razvoja klime unutar obrazovno-vaspitne ustanove.

Pristup direktora u odnosu prema zaposlenima, najviše utiče na motivaciju, satisfakciju i potrebu zaposlenih da unapređuju svoje kompetencije. S tim u vezi, najvažnije odrednice u pristupu direktora koji ima ulogu u motivaciji kod zaposlenih, su sljedeće:

Pažljivo i aktivno slušanje svojih zaposlenih – Bez obzira na umor ili zatrpanost poslom, umorni, neophodno je da slušamo ono što nam zaposleni poručuju, ne samo putem razgovora i drugih kanala komunikacije, već i neverbalno i putem različitih ponašanja.

Vodenje računa o karijeri i stručnom usavršavanju i napredovanju zaposlenih - Ovo znači da je zaista važno da ciljevi svakog zaposlenog budu usklađeni sa ciljevima škole. Jako je velika razlika između osobe kojoj je stalo do toga da posao obavlja odgovorno i savjesno i one koja će posao da otalja. Osnovna razlika među njima suštinski je u njihovoj motivaciji.

Nagrađivanje zaposlenih – Prva asocijacija većine ljudi na termin „nagrađivanje“ je – novac. Iako je tačno da novac, odnosno bonusi mogu biti odličan motivator, to ne znači da ne postoje i drugi. U moćne motivatore spadaju i pohvale koje se često prenebegnu, pa tako zaposleni kada napravi grešku biva opomenut ili kažnjen, ali kada posao uradi odlično, pohvala često izostane, jer se ona „podrazumijeva“.

Napominjemo da je ovo istraživanje otvorilo neke nove vidike, te da ćemo se kao škola u buduće fokusirati na različite projektne aktivnosti koje će doprinijeti poboljšanju motivacije kod zaposlenih, te pružanja većih mogućnosti za individualno napredovanje nastavnog kadra. Na osnovu cjelokupne analize, možemo zaključiti da direktor škole u kojoj se sprovodi istraživanje, svoj posao obavlja odgovorno i posvećeno i da ima ulogu u motivaciji kod zaposlenih.

Kao preporuke za dalji rad, planiramo da nastavimo sa dobrom nastavnom praksom, pa da se s tim u vezi bavimo prije svega usavršavanjem zaposlenih, shodno interesovanjima pojedinaca i potrebama škole.

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THE ROLE OF THE SCHOOL PRINCIPAL IN EMPLOYEES'

MOTIVATION

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SUMMARY:

Motivation is a complex and continued process; therefore, it requires an interdisciplinary approach of the manager. Managers – school principals must invest in knowledge and skills so that they can “lead” their employees, as well as act in a changing environment. To motivate the employees is the basis of quality and successful managing of a team. To lead employees successfully, the manager must have the appropriate power. The sources of power are different, depending on the managers themselves and their role in the organization: legitimate power – based on the authority and hierarchy of the function itself; the power of rewarding – rewarding desirable behaviour in the form of earnings, promotion, rewards; coercive power – influence through punishment; referential power – influence on employees through personal example; professional, expert power – based on the professional knowledge of the manager. Regarding this and in the research that we will present, we examined whether the motivation to work among employees is conditioned by the role of the school principal and his approach to work. Bearing in mind that the degree of aspiration differs for each individual and is influenced by various factors, the field of interest in this work is what is the key role of the school principal, the role in management, what are the knowledge, skills and abilities that the school principal should possess, so it could influence the increase in the motivation of employees in the collective he manages.

Key words: *Motivation, school principal, leader, employees, manager*

THE IMPORTANCE OF EMPATHY IN EFFECTIVE LEADERSHIP

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ABSTRACT:

The 2022 global leadership study by Harvard Business Publishing Corporate Learning highlights that the best leaders are those highly motivated to create positive changes for their employees, organizations, and society as a whole. Through various research methods, such as focus groups, interviews, and literature review, ten key abilities for leaders at all levels have been identified. However, the research indicates that successful leadership cannot be fully explained solely through abilities, skills, and micro-skills. Seven character qualities, termed “leadership superpowers” have been identified as key human traits or values that shape and motivate truly effective leaders.

Empathy, a basic emotion expressed by simply acknowledging someone else’s experience, is ranked as one of the most important superpowers. Although 77% of senior leaders consider empathy important, most respondents said their leaders do not consistently express empathy. The data suggest that employees now expect greater empathy from their leaders and that organizations practicing empathy see deeper employee engagement. However, only 47% of senior leaders in the survey think their organizations value empathy.

Empathy is central to building trust and authentic leadership, making it important for the development of today’s leaders. However, the lack of consensus and clarity in defining this competence is an obstacle to their practical application. The aim of this paper is precisely to explore the role and nature of the competence of empathy in leadership through a review of specific knowledge, attitudes, and skills needed for its development, which can be useful for professional development, hiring, and leadership education program design.

Keywords: *Empathy, Leadership, Engagement, Trust, Professional Development*

1. INTRODUCTION

Empathy is a crucial aspect of 21st-century leadership and can no longer be ignored if we want to prevent a continuation of ethical catastrophes in the business world ([Holt, Marques, 2011](#)). Empathy is considered vital in contemporary leadership because these "soft" skills lead to significant business outcomes and should not be underestimated ([McDonald, 2008](#)). Among the specific qualities of the new business leader, [Donaldson \(2008\)](#) identifies clear vision (to navigate increased uncertainty), empathy (to interact with a wide range of stakeholders), and humility (to acknowledge mistakes and avoid the detrimental effects of arrogance).

However, what exactly does it mean to be empathetic, and what competencies differentiate empathetic leaders from those who are not? In line with the above, this research aims to explore the role and nature of empathy competence in leadership. This exploration will involve examining the specific knowledge, attitudes, and skills necessary for developing empathy. The findings will be valuable for professional development, recruitment, and leadership education program design.

2. DEFINING EMPATHY

An individual's natural ability to understand the emotions and feelings of others, regardless of whether they have personally experienced them, seen them in a photograph, read about them in a book, or simply imagined them, represents the phenomenal experience of empathy ([Decety & Jackson, 2004](#)). This "everyday mindreading" ([Ickes, 2003](#)), isn't something that needs to be learned, but rather the opposite – it's developed through interaction with others. Humans are truly social beings, and nearly all their actions (including thoughts and desires) are directed towards others or arise as a response to them ([Batson, 1990](#)). Knowing how someone else feels plays a fundamental role in interpersonal relationships.

The concept of empathy has a long history marked by disagreements and varying interpretations. Despite being studied for centuries, there are numerous definitions of empathy, almost as many as there are researchers in the field ([Decety & Jackson, 2004](#)). The original German word *Einfühlung*, literally translated into English as empathy ([Titchener, 1909](#); [Wispié, 1991, str. 78](#)), means "feeling into." [Lipps \(1903\)](#) described it as a process where perceiving another's emotional gesture directly activates the same emotion in the observer, without any intermediary processes of labeling, association, or cognitive perspective-taking. Since then, the core debate about the structure of empathy has centered on examining all the necessary components for its definition. While some viewed empathy solely as an affective experience (affective empathy), others attributed a cognitive nature to empathy (cognitive empathy).

Theories defining empathy through emotions (affective empathy) dominated until the mid-20th century. Social and clinical psychologists offered varying definitions, with some like [Eisenberg and Fabes \(1990\)](#) focusing on a matched emotional response, while others offered broader definitions encompassing emotional reactions to others' states ([Baron-Cohen & Wheelwright, 2004](#)). This broader view often included sympathy (compassion) - an emotional response with a desire to help - and personal distress - an aversive reaction to another's suffering ([Eisenberg & Fabes, 1990](#)). Lična nevolja je averzivani emocionalni odgovor na tuđu nevolju ([Eisenberg & Fabes, 1990](#)). Social psychology offered different perspectives. [Allport \(1937\)](#) defined empathy as directly sharing another's mental state and mimicking their physical expressions. Significant contributions to the study of the conscious mechanisms of empathic sharing were offered by [Mead and Mind \(1934\)](#). They defined empathy as the ability to take another's perspective, which laid the groundwork for studying the thinking side of empathy.

Since the 1960s, empathy's meaning became primarily cognitive. Research focused on the role of thought in understanding others' perspectives. Empathy became synonymous with "role-taking," a purely cognitive skill that does not require (simultaneously) feeling the emotions of others ([Hogan, 1969](#)).

Since the 80s, emotions and cognition are seen as working together in empathy. Empathy goes beyond just understanding another's perspective. Bodily responses ([Levenson & Ruef, 1992](#)), and non-conscious brain mechanisms ([Shamay-Tsoory, 2014](#)) suggest a more complex interaction. Empathy is seen as a multi-faceted phenomenon with both emotional (affective) and thinking (cognitive) components working together. [Strayer \(1987\)](#) suggests affective empathy is the emotional experience, while the cognitive component is understanding the other's situation. Empathy can be automatic, but we can also consciously analyze and respond ([Lamm, Batson and Decety \(2007\)](#)). [Hoffman \(1987, str. 479\)](#), a leading scholar in this field, defines empathy as an emotional response that is "more appropriate to the other person's situation than one's own." Feeling empathy doesn't mean experiencing exactly what the other person does, but rather understanding and/or indirectly sharing their emotions and needs. [Bischof-Köhler \(1991\)](#) defines empathy as the ability to both cognitively understand and emotionally share another's feelings, while remaining aware that your own emotions are a reflection of theirs. This separates true empathy from emotional contagion and purely cognitive processes. [Ickes \(1997\)](#) defines empathy as complex reasoning that combines observation, memory, and knowledge to understand others' emotions. It goes beyond recognition, involving experiencing (or imagining) their feelings. This captures empathy's multifaceted nature and highlights key mental abilities.

In real-world interactions, empathy involves both emotional understanding and cognitive reasoning ([Zaki & Ochsner, 2012](#)). These multi-factor models see empathy as integrating both aspects to understand another's state and respond accordingly.

3. COMPONENTS NECESSARY FOR CREATING EMPATHY

[Decety and Jackson \(2004\)](#), [Decety and Lamm \(2006\)](#) proposed a key model of empathy. It emphasizes the need to recognize both similarities and differences between self and others. Empathy requires mental flexibility to take another's perspective. Three interacting components create empathy, and no single aspect fully explains it. [Decety and Jackson \(2004\)](#) propose three key components for empathy::

1. Affective Sharing with Others: This relies on a "mirror neuron system" where observing another's emotions activates similar areas in our own brain. We share feelings and emotions based on facial expressions, tone of voice, body language, and other cues that help us understand their emotional state.
2. Self-Other Awareness: This involves distinguishing ourselves from others while recognizing their emotions, thoughts, and perspectives. We can understand they are separate individuals with their own experiences.

3. **Mental Flexibility and Emotion Regulation:** This allows us to see the world from another's viewpoint and manage our emotional responses. We can understand their feelings without being overwhelmed by them.

Affective sharing is mostly automatic, but the other two empathy components are conscious skills. These involve self-awareness, perspective-taking, and managing emotional responses. Like other skills, they can be learned and improved ([Decety & Lamm, 2006](#)). Leaders can benefit from training to manage their empathy to connect with a wider range of people and avoid burnout ([Eisenberg, 2000](#)).

3.1. Affective Sharing with Others

The core of affective empathy is simply detecting another's emotions ([Trevarthen & Aitken, 2001](#)). Research shows we're wired to connect with others from birth ([Trevarthen, 1979](#)) and have an early capacity for emotional resonance, a key foundation for empathy ([Hoffman, 2000](#)). The core empathy skill, affective sharing, motivates care for others and is separate from mind-reading. Seen in many species and developing very early ([Cheng, Chen & Decety, 2014](#)), it's distinct from emotional contagion. Emotional contagion is automatically mimicking another's emotions to connect. Affective sharing is simply detecting their emotional state, triggering an appropriate response like care or help.

[Michael \(2011\)](#) proposes two minimum requirements for emotional sharing: (a) the person expresses their emotional state (verbally or otherwise) and (b) the observer perceives that expression. Author, adds several important points: non-verbal cues like facial expressions, body language, or tone of voice can also be shared; the expression doesn't have to be intentional or conscious; the observer can perceive the expression even unconsciously. However, for empathy, perceiving the emotion needs to lead the observer to a similar emotional state and an awareness of the other's feelings. Empathy can also arise by imagining someone's emotional experience, not just directly perceiving it.

Observing or imagining others' emotions activates similar brain regions in us, along with related physical responses. This can induce similar emotions in the observer ([Preston & de Waal, 2002](#)). Facial expressions play a role in this. Seeing an emotion on someone's face can trigger subtle movements in our own face, even unconsciously ([Dimberg, Thunberg, & Elmehed, 2000](#)). Making facial expressions can also change our nervous system and influence our emotions ([Ekman, Levenson, & Friesen, 1983](#)). This mechanism can even be used deliberately to feel emotions, as Edgar Allan Poe hinted at in his story "The Purloined Letter" (1845). He wrote: "When I desire to ascertain the ingenuity of a my opponent, I arrange my features (quite unintentionally of course) in accordance with the expression of cunning premeditation which I conceive to be his own. Then I wait to see what thoughts or sentiments arise in my mind responsive to the expression."

True empathy requires careful observation, not analysis or theorizing. Leaders need to fully focus on their employees' behavior, facial expressions, voice tone, word choices, etc. This is pure empirical observation. In other words, leaders simply need to see and hear

their employees' actions, gestures, expressions, and stories (including word choice, tone, and content) to share their emotions. This is called "perception-action coupling" ([Kaplan & Iacoboni, 2006](#)).

In this context, a leader's empathy skills involve active listening, understanding nonverbal cues, paraphrasing, and using open and closed-ended questions to gather more information. But most importantly, the leader must be motivated and able to accurately perceive and interpret employees' expressive and situational cues that reveal their reactions and internal states.

Leaders should cultivate openness and curiosity towards their employees' perspectives and experiences. This creates an environment that fosters empathy and emotional connection. To achieve this, leaders can benefit from knowledge of emotional states, their expressions, and causes. Additionally, understanding individual employees or general human motivators allows leaders to more precisely assess their team members' internal states.

3.2. Self-Other Awareness

Empathy requires shared experience, but you also need to separate your own emotions from the other person's. Otherwise, it can lead to anxiety and avoidance. [Decety i Lamm \(2006, str. 1146\)](#) define empathy as understanding others' feelings "without confusing yourself with others."

The concept of human consciousness is linked to the "self vs other" dynamic, making it inherently social ([Thompson, 2001](#)). Self-awareness is the foundation for the theory of mind, which allows us to understand others' mental states through inference. While "self" and "other" are recognized as connected, they differ in perspective.

Self-awareness, defined as the ability to be the object of your own attention, allows you to experience a sense of psychological continuity across time and space ([Gallup, 1998](#)). Any organism capable of self-recognition would likely have introspective awareness of its own mental states and the ability to attribute mental states to others. This is an adaptive trait favored by natural selection because it benefits those who possess it ([Humphrey, 2002](#); [Mandler, 2002](#)). Furthermore, the emergence of self-representation in development is crucial for empathy.

The concept of self-identity encompasses all the attributes that make up our self-image, including personality traits, values, beliefs, preferences, emotions, social roles, and other relevant aspects ([Markus, 1977](#)). Clarity of self-identity ([Lodi-Smith & DeMarree, 2017](#)) refers to how well-defined, internally consistent, and stable over time our concept of self is. It basically measures how clear our self-image is.

Early research shows a link between self-concept and behavior, supporting its validity as a psychological construct. Our self-concept isn't just how we perceive ourselves, but also reflects, to some extent, how we actually behave in different situations. Current research ([Lewandowski & Nardone, 2012](#)) suggests clarity of self-identity is linked to self-

awareness. People with a less clear self-identity show lower agreement with close circles about their personality traits and have a harder time predicting their own future behavior.

Research on emotional empathy ([Bird & Viding, 2014](#); [Decety & Jackson, 2004](#)) emphasizes the importance of distinguishing self from other for an effective response. This means recognizing the source of the emotional experience as external, not internalizing the other person's feelings. This ability to discriminate between self and other has significant implications for the motivational consequences of empathy. Batson et al. ([Batson et al., 1987](#); [Batson, Sager et al., 1997](#)) found that difficulty in differentiating self from others increases susceptibility to "empathic personal distress." This self-centered reaction is characterized by withdrawing from empathy-evoking situations to reduce one's own discomfort. In contrast, "empathic concern" is an other-oriented emotional state linked with the altruistic motivation to alleviate another's suffering. This is widely accepted as the more mature and desirable outcome of the emotional arousal triggered by empathy. Importantly, Batson et al.'s earlier work ([Batson, Sager et al., 1997](#)) showed a correlation between self-other differentiation and greater empathic concern. This suggests that the ability to distinguish oneself from others and attribute the emotional state causally to the other person is crucial for developing emotional empathy.

Our conceptualizations of ourselves and others can also hinder empathy due to rigidity and a lack of contextual sensitivity. [Atkins i Parker \(2012\)](#) explored how judgments about ourselves and others can impede compassionate responses. For instance, judging someone as personally responsible for their situation might make us feel anger rather than empathy. Similarly, judging someone as irrelevant to our lives might lead to apathy instead of empathetic engagement. Finally, if we believe we can't handle the unpleasant emotions that might arise from interacting with a suffering person, we're more likely to avoid the situation altogether. Judgments and projections about the other person can also obstruct empathy. Making quick assumptions about someone's personality, preferences, goals, and values is prone to error. Therefore, empathetic responses based on a "static" view of the other person need to be tempered by paying attention to the dynamic cues available in each moment, treating the other as a "process" in flux.

Leaders who struggle to differentiate between themselves and others can find the reflective aspects of empathy unbearable. Without clear boundaries between themselves and their employees, they risk internalizing emotional responses like anger, depression, anxiety, or joy, experiencing them as their own.

On the other hand, clear self-other boundaries allow leaders to respond altruistically to employee suffering. Without such boundaries, facing others' pain can lead to significant emotional exhaustion for leaders. This conceptual blurring of self and other's emotions works both ways. Leaders with weak self-other differentiation can not only experience others' emotions as their own, but also project their own motives onto employees, leading to misinterpretations of their perspectives. This doesn't foster deeper empathic understanding, but rather confusion and misunderstandings due to a presumptuous identification with employees.

Leadership programs need to debunk the myth that deep empathy equates to emotionally merging with others. Emotional neuroscience research ([Decety & Lamm, 2006](#)) clearly shows the opposite: well-developed self-awareness is crucial for effective empathy.

Only when leaders can clearly distinguish their own emotions from those of their employees can they avoid "burnout" stemming from an overload of shared emotional states. On the other hand, strong self-awareness allows leaders to make cognitive inferences about employees' mental states and perspectives. Therefore, instead of being overwhelmed by emotions, leaders with a clear sense of self can adopt the analytical and strategic perspective needed to provide optimal support to their team members.

3.3. Mental Flexibility and Emotion Regulation

[Decety i Jackson \(2004\)](#) emphasize that managing cognitive processes is crucial for empathy. They argue empathy requires emotional regulation to navigate interactions effectively. Unregulated emotional responses would lead to distress, not empathy. [Decety i Jackson \(2004\)](#) identified emotional regulation as a key component of empathy. It's defined as the process of initiating, avoiding, inhibiting, maintaining, or modulating the form, intensity, or duration of an internal emotional state.

Emotional regulation plays a crucial role in managing our own emotions to prevent them from becoming overwhelming and hindering our ability to feel positive concern for others. Traditionally, emotional regulation has been viewed as managing our emotions as they arise, are experienced, and are expressed ([Gros, 2015](#)). This perspective highlights its importance for empathy. Emotional regulation allows us to distinguish our own emotions from those of others. When expressing empathy, we need to regulate our elicited emotions to avoid emotional overload. Such overload could negatively impact prosocial behavior, helping, and cooperation.

Absolutely, emotional regulation is essential for any good leader. A leader who can't "turn on" empathy for others' experiences will never bridge the gap in understanding. Conversely, a leader who can't "turn off" excessive empathy for employees' negative emotions (like despair or anxiety) will quickly face burnout. Self-control involves the conscious and deliberate effort to manage one's thoughts, emotions, and behaviors. Most theorists agree that consciously observing and actively changing one's behavior is key ([Baumeister et al., 1994](#)). Research shows that mindful self-observation is crucial for controlling one's emotions ([Langer, 1989](#)). Trying to force a desired feeling is less effective than taking a neutral observer position towards your own emotions.

4. CONCLUSION

Empathy is not a new concept in leadership, but recent research and interdisciplinary findings confirm its crucial value. Studies underscore the importance of empathy, our inherent capacity for it, the need to actively use it, and the possibility of further developing it.

This work proposes the key knowledge, skills, and attitudes of empathetic leaders, encompassed within three core components for developing and strengthening empathy: affective understanding (recognizing and responding to emotions), self and other awareness, and emotional regulation/mental flexibility. Actively developing these aspects will enhance leaders' empathic abilities.

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REQUIREMENTS FOR SUSTAINABLE LEADERSHIP

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ABSTRACT:

In the business environment of the modern era, the key challenge that stands out more and more is related to the concept of sustainability. Accordingly, leaders are required to develop specific competencies in order to effectively direct the organization towards the practice of sustainable development. This paper presents a systematic review of the literature that focuses on the key competencies of sustainable leadership, offering insights from different perspectives. The analysis of previous research shows the diversity of approaches and categorization of key competencies of sustainable leadership. The most frequently mentioned competencies are systemic thinking, anticipation, normative, strategic and interpersonal competence. However, the lack of consensus and clarity in defining these competencies is an obstacle to their practical application. Further research is necessary to identify the key components of sustainable leadership and their interrelationships. Also, it is important to consider the context and specific requirements of organizations in different industries in order to develop tailored strategies for developing sustainable leaders. This paper contributes to a better understanding of the key competencies of sustainable leadership, while highlighting the need for further discovery and development of clear guidelines for developing leaders capable of leading organizations towards a more sustainable future.

Keywords: Sustainable leadership, Key competencies, Systemic thinking, Anticipation, Normative competence.

1. INTRODUCTION

The exploration of sustainable leadership unveils a series of noteworthy conceptual definitions. One of the earliest contributions comes from [Hargreaves and Fink \(2004\)](#), who proposed that this form of leadership strives to fulfill the needs of contemporary society without jeopardizing the ability of future generations to thrive. [Ferdig \(2007\)](#) offered a definition that characterizes a sustainability leader as someone who "takes responsibility for understanding and acting on sustainability challenges, regardless of whether they hold formal leadership positions or not. They lead „with,“ not „over,“ others, in ways that illuminate the long-term sustainability of complex, interconnected living systems" (p. 25). [Avery and Bergsteiner \(2011\)](#) argued that "sustainable leadership necessitates a long-term perspective in decision-making; fostering systemic innovations geared towards increasing

customer value; cultivating a skilled, loyal, and highly engaged workforce; and offering high-quality products, services, and solutions" (p. 5).

By synthesizing these conceptual definitions, a set of common characteristics emerges that cohesively differentiate this leadership approach ([Hallinger, Suriyankietkaew, 2018](#)):

- **Emphasis on Leadership:** As opposed to a singular leader, it highlights a collective leadership style.
- **Long-Term Vision:** Sustainable leadership prioritizes a long-term perspective.
- **Broader Goals:** It fosters a connection between organizations and the wider society through broader goals.
- **Ethical Conduct:** Ethical behavior is a cornerstone of sustainable leadership.
- **Social Responsibility:** It emphasizes the social responsibilities of both leaders and organizations.
- **Innovation Capacity:** The ability to drive innovation is crucial.
- **Systemic Change:** Sustainable leadership seeks to achieve systemic change.
- **Stakeholder Inclusion:** It actively includes stakeholders in the process.
- **Stakeholder Capacity Building:** Empowering stakeholders is a key aspect.

The realization of sustainable leadership is achieved through collective or distributed efforts. These efforts focus on shaping organizational culture, inspiring people to work with purpose and satisfaction, and redesigning work systems to achieve new objectives.

2. THE CONCEPT OF SUSTAINABLE LEADERSHIP

The concept of sustainable development within the realm of organizational management has its roots in the work of the Brundtland Commission. Established in 1983 by the United Nations, this commission was formally known as the World Commission on Environment and Development. Their 1987 report, titled "Our Common Future," introduced the now widely adopted definition of sustainable development: a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This concept laid the groundwork for the emergence of sustainable leadership within organizations.

[Elkington \(2000\)](#) proposed the Triple Bottom Line framework for sustainable development. This framework suggests that social, environmental, and financial indicators are all necessary methods for measuring an organization's overall performance. In other words, organizations should consider three key aspects:

1. **Financial Performance:** This refers to the traditional profit or loss of the organization.
2. **Social Impact:** This considers the impact the organization has on people, including labor practices, community engagement, and social justice issues.
3. **Environmental Impact:** This refers to the organization's effect on the environment, encompassing pollution, resource depletion, and overall environmental sustainability.

The Triple Bottom Line framework emphasizes that organizations should not solely focus on profit margins. They must also consider their environmental and social responsibility to minimize the negative aspects of economic growth and promote long-term sustainability.

However, with growing social and environmental problems stemming from economic development, a significant imbalance exists between economic benefits, social responsibility, and environmental protection in organizational operations. Overcoming this imbalance and achieving improved performance, resilience, and sustainability have become critical areas of shared concern in both practical and theoretical circles.

To fully consider the wider spectrum of stakeholders, leaders must embrace the concept of sustainable development. This requires integrating it into organizational culture and actively demonstrating sustainable leadership behaviors. Leadership is, after all, the cornerstone of transforming organizations. ([Avery, 2005](#)).

[Avery \(2005\)](#) is credited with pioneering the concept of sustainable leadership within organizational management. Her research identified 19 key elements focused on:

1. Long-term decision-making: Sustainable leaders prioritize long-term considerations in their decision-making processes.
2. Fostering systemic innovation: They actively encourage innovation that addresses the entire system, not just isolated components.
3. Developing loyal employee teams: Building strong, loyal teams is a crucial aspect of sustainable leadership.

According to Avery, sustainable leadership achieves a balance between "people, profit, and planet" through appropriate management practices. These practices cultivate a self-evolving leadership system that prioritizes the organization's long-term sustainability. This is achieved through a balanced approach that emphasizes innovation, integrity, and social responsibility.

Following Avery's groundbreaking work, sustainable leadership has become a subject of research across diverse environments and contexts. [Hargreaves and Fink \(2004\)](#), [Davies \(2007\)](#) and [Lambert \(2011\)](#) specifically explored sustainable leadership within the educational sector, examining its application at the organizational level.

[Hargreaves and Fink \(2004\)](#) examine sustainable leadership within the context of shared responsibility. Their perspective emphasizes leadership that avoids overtaxing human or financial resources and strives to preserve and improve the educational and social environment. This type of leadership is characterized by active engagement in building an educational environment that fosters organizational diversity and promotes the creation of good ideas and successful practices through collaborative learning and development. Their definition suggests seven principles of sustainable leadership:

1. Creating and Maintaining Sustainable Learning: This principle emphasizes the importance of fostering a culture of continuous learning within the organization.

2. Ensuring Long-Term Success: Sustainable leaders prioritize strategies for achieving long-term success for the organization.
3. Building and Maintaining Trust: Earning and maintaining trust is a crucial aspect of sustainable leadership.
4. Promoting Social Justice: Sustainable leadership actively works to create a more just and equitable environment.
5. Optimizing Human and Material Resources: This principle highlights the importance of using resources effectively and efficiently.
6. Cultivating Diversity and Organizational Capacity: Sustainable leaders value diversity and work to build the organization's overall capacity.
7. Actively Advocating for Environmental Improvement: This principle emphasizes the leader's role in championing positive environmental change.

Similar to Similar to Hargreaves and Fink (2004), [Davies \(2009\)](#) examines the concept of sustainable leadership within the context of compulsory education and long-term school development. This approach highlights the need for leaders with a high degree of resilience and adaptability in the face of challenges. Therefore, taking measures to ensure responsible leadership with a long-term perspective is crucial. The concept of sustainable leadership goes beyond focusing solely on personal development. It considers the broader effects of leadership on individuals within educational institutions, communities, and the wider social environment. In recent years, it has also extended its scope to include the environment. By incorporating an ecological perspective, sustainable leadership aims for a deeper understanding of the impact of leaders' decisions on the environment. It strives to strike a balance between human progress and the preservation of natural resources

[Lambert \(2011\)](#) emphasizes that achieving measurable impact through sustainable leadership within an organization requires commitment at all levels. This commitment helps build a culture where leadership skills can flourish. Lambert proposes a sustainable leadership framework comprising the following elements:

1. Capacity Building: Develops sponsors' ability to cultivate their best leadership and management practices.
2. Strategic Dissemination: Enables individuals at all levels to engage in leadership for sustainable improvement.
3. Consolidation of Available Learning: Aims to work collaboratively to ensure that educational opportunities meet faculty needs.
4. Bridging Long-Term and Short-Term Goals: Creates synergy between the faculty's long-term vision and the short-term requirements of financial institutions.
5. Diversity: Learns from diversity, promoting social inclusion and cohesion.
6. Preserving the Past: Respects and learns from the past to create a better future.
7. These elements collectively contribute to fostering sustainable leadership that balances human progress with environmental preservation and societal well-being.

In their work “A New Paradigm for Leadership Development,” [Casserley and Critchley \(2010\)](#) delve into the development of sustainable leadership from an individual perspective. The authors’ research reveals that leaders’ performance stems from the integration of three fundamental processes:

1. **Reflective Action (Learning Through Practice):** This process involves continuously developing knowledge and skills based on practical experience. Leaders who actively reflect on their actions and their consequences enhance their leadership.
2. **Psychological Intelligence (Clarity of Personal Purpose and Awareness of Assumptions and Motivations):** Psychological intelligence pertains to a leader’s self-understanding, primarily encompassing values, goals, and motives. Leaders with developed psychological intelligence are aware of their strengths and weaknesses, enabling them to lead others more effectively.
3. **Physiological Well-Being (Effective Stress Management and Self-Care):** Unlike many leadership development programs that neglect or marginalize this aspect, Casserley and Critchley’s research underscores the significance of physiological well-being. Leaders who effectively manage stress and prioritize their physical and mental health are more resilient and capable of maintaining high performance over the long term.

The integration of these three key processes, coupled with their alignment with the organizational culture, constitutes the essence of effective sustainable leadership, according to the authors. Leaders who have developed in these areas are more likely to contribute to creating a sustainable organization.

In addition to the aforementioned perspectives, [Armani, Petrini and Ana \(2020\)](#) recently provided a more comprehensive view of sustainable leadership. Their aim was to understand which characteristics contribute to organizational changes in entities striving for sustainability and how these attributes are interconnected. Establishing a link between individual and organizational values, according to the authors, can serve as a crucial foundation for integrating sustainability practices across all corporate levels. Notably, the role of sustainable leadership evolves in alignment with an organization’s maturity regarding sustainability. The research results highlight two distinct perspectives on sustainable leadership:

Organizational Perspective:

1. Attributes closely tied to the organization, such as business vision, sustainability orientation in strategy, attention to stakeholders, and understanding cultural diversity, fall within this category.
2. The business vision is the sole attribute from this perspective that holds importance across all organizations.
3. Other attributes are identified primarily in organizations with the highest level of sustainability maturity.

Individual Perspective:

1. This perspective encompasses attributes that all managers consider vital, including engagement capability and change orientation.
2. Engagement capability results from the convergence of two literature-identified attributes: leadership and interpersonal skills.
3. Attributes related to sustainability focus, alignment with organizational culture, values, and moral principles impact both personal aspects of managers and the organizational context, mutually influencing each other.

3. SUSTAINABILITY COMPETENCY FRAMEWORKS

A significant portion of the literature on sustainability leadership attributes emphasizes the importance of competencies required by such leaders. However, the term “competency” can have different meanings in various contexts ([Wesselink, Blok, van Leur, Lans, & Dentoni, 2015](#)). Nevertheless, there is a general consensus that a comprehensive view of competency extends beyond cognitive and functional dimensions alone. It also includes attitudes, motives, values, and ethics.

According to the definition by [Wiek, Withycombe and Redman \(2011\)](#), competency is a “functionally connected complex of knowledge, skills, and attitudes that enables successful task performance and problem-solving.” In the context of sustainability, the purpose of competencies is clearly linked to tasks or problems related to sustainability. Key sustainability competencies represent an integrated and multifunctional competence, consisting of several sustainability competencies that are functionally interconnected. This competence allows for achieving successful outcomes that enhance sustainability (based on what is known, valued, and aspired to at a given moment), while addressing specific sustainability challenges and opportunities across various contexts.

According to [UNESCO \(2017\)](#) competencies for sustainability leadership encompass a multifaceted blend of knowledge, skills, and attitudes. These competencies enable successful task performance and effective problem-solving related to sustainability:

1. Systems thinking: The abilities to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty
2. Anticipatory: The abilities to understand and evaluate multiple futures – possible, probable, and desirable; to create one’s own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes The abilities to understand and reflect on the norms and values that underlie
3. Normative one’s actions and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions
4. Strategic action; The abilities to collectively develop and implement innovative actions to further sustainability at the local level and further afield

5. (Emphatic) collaboration; The abilities to learn from others to understand and respect the needs, perspectives, and actions of others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving
The abilities to question norms practices and opinions; to reflect on one's own
6. Critical thinking values perceptions and actions, and to take a position in the sustainability discourse
7. Self-awareness; The abilities to reflect on one's own role in the local community and global society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.
8. Integrated problem-solving; The overarching ability to apply different problem-solving frameworks to complex sustainability problems; and develop viable inclusive and equitable solution options that promote sustainable development, integrating the abovementioned competencies

The most influential study on sustainability competencies was conducted based on an extensive review of literature by [Wiek, Withycombe and Redman \(2011\)](#). This study focuses on key sustainability competencies for the development of academic programs and is often used as a foundation for subsequent frameworks, where new competencies are added or original titles of key competencies are slightly modified. The authors of this study specifically emphasized sustainability competencies, as opposed to “common” or foundational competencies that have broader applicability, such as critical thinking, communication, pluralistic thinking, research, and data management (p. 211). They highlighted that these “common” competencies are equally important for sustainability but can be learned through regular academic education and are not exclusive to sustainability education. According to their understanding, sustainability education should enable students to analyze and solve sustainability problems, anticipate and prepare for future sustainability challenges, and create and leverage opportunities for sustainability. The five key competencies that constitute their framework are: systems thinking competency, anticipatory competency, normative competency, strategic competency, and interpersonal competency. According to their perspective, rather than being a mere “list of competencies,” these competencies are interconnected and interdependent, as each contributes to addressing sustainability challenges.

Subsequently, ([Osagie, Wesselink, Blok, Lans, & Mulder, 2016](#)) added a sixth key competency (integrated problem-solving competency), which, as they claimed, was already implicit in the 2011 study:

1. Systems Thinking Competency: The ability to collectively analyze complex systems across various domains (society, environment, economy, etc.) and at different levels (from local to global). This involves considering cascading effects, inertia, feedback loops, and other systemic characteristics related to sustainability issues and problem-solving frameworks.
2. Anticipatory Competency: Relates to the ability to collectively analyze, assess, and create comprehensive “pictures” of the future related to sustainability issues.

3. Normative Competency: The ability to collectively map, specify, apply, reconcile, and negotiate values, principles, goals, and objectives of sustainability.
4. Strategic Competency: The ability to collectively design and implement interventions, transitions, and transformative management strategies toward sustainability.
5. Interpersonal Competency: A combination of collaboration, participation, communication, and motivation for problem-solving, requiring a comprehensive understanding of different cultures, social groups, communities, and individuals in various situations.
6. Integrated Problem-Solving Competency: A metacompetency that involves meaningfully using and integrating the five key sustainability competencies to drive sustainable development. It encompasses applying diverse problem-solving frameworks to complex sustainability challenges and developing sustainable solution options while thoughtfully integrating problem analysis, sustainability assessment, visioning, and strategy building.

In 2020, fourteen international experts in sustainability education conducted a Delphi study to achieve consensus on key sustainability competencies based on the original framework by Wiek, Withycombe, and Redman ([Brundiers, Barth, Cebrián, Cohen, Diaz, 2020](#)). The experts agreed with the initial framework but added two new competencies to expand it. Let's explore these competencies:

1. Intrapersonal Competency: This competency relates to the ability for self-assessment, reflection, emotional intelligence, and awareness of personal values and attitudes related to sustainability. It emphasizes the significance of personal development and inner transformation to support sustainable actions and decisions.
2. Implementation Competency: This competency pertains to the collective ability to realize planned sustainable solutions, monitor and evaluate the implementation process, and adapt to new challenges that arise during that journey.

Ten years after their 2011 study, [Redman and Wiek \(2021\)](#) further refined a comprehensive framework of key sustainability competencies based on an extensive literature review. To achieve transformative sustainability, these competencies must be intrinsically interconnected and integrated, rather than viewed as a mere "list of skills:" systems thinking competency, futures thinking competency, values thinking competency and strategic thinking competency contributing to the creation of sustainability action plans can lead to positive outcomes if successfully implemented (implementation competency). Key sustainability professional skills, such as interpersonal and intrapersonal competencies, ensure collaboration and self-care, which are essential for long-term success. The integration competency enables coherent blending of efforts in

sustainable planning and implementation. Beyond core sustainability competencies, several other skillsets play a vital complementary role. These include:

1. **General competencies:** These are the fundamental abilities developed through higher education, such as critical thinking, creativity, communication, and lifelong learning.
2. **Technical expertise:** This refers to specialized knowledge in a particular field relevant to sustainability, such as climate change, water management, or energy efficiency.
3. **Professional skills:** These encompass additional capabilities needed for effective leadership, including advanced communication skills emphasizing empathy and responsible project management.

In addition to the most influential frameworks, numerous scholars have attempted to contribute to the debate on key sustainability competencies. They are identified empathy and perspective change, inclusive and interdisciplinary work, tolerance for ambiguity and frustration, life cycle thinking and the triple bottom line, creative use of existing resources, continuous learning and questioning, sustainable entrepreneurial behavior, justice, ethics and diachronic and differentiated responsibility, concern for the common good and knowledge of the state of the planet.

3. CONCLUSION

Sustainable leadership faces a multitude of intricate challenges in the contemporary business landscape. It necessitates the seamless integration of social, environmental, ethical, human rights, and consumer considerations into core operational strategies. These multifaceted issues present significant obstacles, demanding exceptional leadership with the capacity to address climate change and resource constraints. Within organizations functioning as complex adaptive systems, sustainability leaders must navigate the demands of dynamic change and continuous adaptation. To effectively guide organizations towards a sustainable future, they require a comprehensive repertoire of skills and attributes. This includes the ability to comprehend and anticipate complex systems, engage in critical thinking, leverage emotional intelligence, and foster engagement with diverse stakeholder groups within the organization.

While academic interest in sustainable leadership is demonstrably increasing, a clearly defined and universally accepted nomenclature that precisely outlines the "requirements" for sustainable leadership remains elusive. Past research has exhibited variations in focus, ranging from a broader perspective on sustainability as an element of corporate strategy to a more targeted concentration on specific leader characteristics. There is a growing recognition of the need for a holistic and comprehensive approach to understanding sustainable leadership. By establishing clear linkages between leader characteristics, behaviors, skills, abilities, attitudes, and roles within the context of sustainability, we can cultivate a deeper comprehension of how leaders can positively contribute to the sustainability of organizations and society at large. Despite limitations and inconsistencies within existing research, the ongoing interest in sustainable leadership presents a valuable

opportunity for further exploration and the development of more refined guidelines. Integrating diverse perspectives and fostering a more nuanced nomenclature can contribute to the creation of a robust framework. This framework will serve to support and empower leaders in effectively confronting sustainability challenges and driving positive outcomes for both society and the planet.

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***SUSTAINABLE DEVELOPMENT, ECOLOGY, ENERGY
EFFICIENCY AND RENEWABLE ENERGY SOURCES***

THE NORTH ATLANTIC OSCILLATION AND ITS INFLUENCE IN THE MEDITERRANEAN REGION

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ABSTRACT:

The North Atlantic Oscillation (NAO) is dominant low-frequency atmospheric oscillation in the northern hemisphere. It has extensive and pronounced climate impacts around the globe. The NAO is highly seasonal oscillation with two distinct phases defined by a positive and negative NAO indices. We present the NAO influence on the climate parameters in the Mediterranean region. This influence, especially on the amount of precipitation, is more pronounced in the winter than in the summer part of the year. A positive NAO phase leads to a decrease in precipitation over the Mediterranean and Southern Europe (south of 45°N) and an increase over Northern Europe. A negative NAO phase affects these regions in the opposite way. Switches from negative to positive NAO phases are followed by noticeable changes in the average precipitation of the Mediterranean basin, such as the decrease observed between the mid-1960s and the 1990s. Montenegro is part of the Mediterranean and the influence of the NAO is recorded especially in the winter part of the year from November to April.

Keywords: *The North Atlantic Oscillation, Mediterranean, precipitation, temperature*

1. INTRODUCTION

Climate change is associated with widespread changes in weather patterns, especially over the past 50 years. Scientific studies indicate that extreme weather events such as heat waves and large storms are likely to become more frequent or more intense which can significantly affect public health, agriculture, water supplies, energy production, land use and development, and recreation worldwide [1]. The climate system consists of the atmosphere, land, oceans, cryosphere, and biosphere which is a complex and highly coupled environment. Climate models are used for a variety of purposes from studying the dynamics of the weather and climate system to providing projections for future climate. However, the spatial and temporal uncertainties of climate models are large, and prediction and prevention of extreme events is still out of reach [2]. Therefore, a multidisciplinary approach is needed to solve these problems and make progress in climate science.

The main topic of this article include the study of climate change/variability in the Mediterranean region in connection to the dynamical properties of the atmosphere. One of the most dominant low-frequency atmospheric oscillation in the northern hemisphere is the North Atlantic Oscillation (NAO). The NAO was first identified in the 1920's by

Sir Gilbert Walker [3], [4]. Over the middle and high latitudes of the northern hemisphere, especially during the cold season months (November-April), the most prominent and recurrent pattern of atmospheric variability is the NAO. It is the large-scale atmospheric circulation in the North Atlantic sector characterized by westerly winds that result from the meridional pressure gradient between the Azores high in the south and the Icelandic low in the north, Figure 1. As the strength of this pressure gradient varies over time, also the strength of the westerlies varies. In periods of strong north-south gradient, the westerlies are more pronounced and vice versa when the gradient is weak. Fluctuations between these different states are known as the North Atlantic Oscillation. Though NAO is active throughout the year, it is most pronounced during winter.

The influence of the NAO on climate has been assessed by the NAO index defined as the difference in atmospheric pressure at sea level between the Azores and Iceland [5]. A positive NAO index (or positive NAO phase) is associated with warmer conditions and an increase in precipitation in northern Europe and cooler conditions and a decrease in precipitation over the Mediterranean [6], [7]. During the negative NAO index (or negative NAO phase) warm moist air enters the Mediterranean region and cold air enters northern Europe, Figure 1.

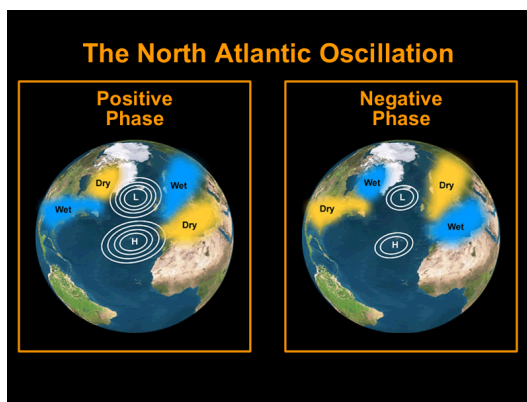


Figure 1. The North Atlantic Oscillation.

The NAO exerts a dominant influence on wintertime temperatures across much of the northern hemisphere. Surface air temperature and sea surface temperature across wide regions of the North Atlantic Ocean, North America, the Arctic, Euro-Asia and the Mediterranean are significantly correlated with NAO variability. These changes, along with related changes in storminess and precipitation, have significant impacts on a wide range of human activities as well as on marine, freshwater and terrestrial ecosystems.

2. MEDITERRANEAN REGION

The Mediterranean region has a highly distinctive climate due to its position between 30 and 45°N to the west of the Euro-Asian landmass, Figure 2. The strait of Sicily separates Mediterranean basin into two main sub-basins, the western and eastern Mediterranean. With respect to the global atmospheric system, it lies between subtropical high pressure

systems to the south, and westerly wind belts to the north. In winter, as these systems move equatorward, the Mediterranean basin lies under the influence of, and is exposed to, the westerly wind belt, and the weather is wet and mild. In the summer, the Mediterranean lies under subtropical high pressure systems, and conditions are hot and dry, with an absolute drought that may persist for more than two or three months in drier regions [8].

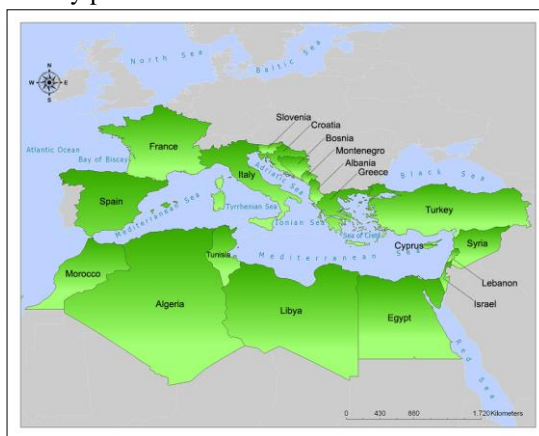


Figure 2. Mediterranean region.

The influence of the Mediterranean Sea means that the Mediterranean-type climate of the region extends much further into the continental landmass than elsewhere, and is not restricted to a narrow sea-facing strip. Nevertheless, within the Mediterranean region climate is modified by position and topographic influences can be important. The proximity of the western Mediterranean to the Atlantic Ocean gives its climate a maritime flavour, with higher rainfall and milder temperatures throughout the year. The eastern Mediterranean lies closer to the truly continental influences of central Europe and Asia. Its climate is drier, and temperatures are hotter in summer and colder in winter than in the west. The southern shore of the Mediterranean Sea is drier and hotter than the northern shore. Altitude also plays an important role and climate can change dramatically moving inland from the coast. Snow and freezing conditions are rare in low-lying areas, but in mountainous regions such as the Apennines of Italy and Pindus of Greece winters can be severe, and thick snow is common, with glaciers present in both the Pyrenees and Apennines. Indeed, there are places in the Mediterranean where tourists can spend the morning skiing and the afternoon on the beach. One of them is Montenegro. The NAO has been found to influence rainfall amounts, especially in winter, in the north-western Mediterranean and, more remotely, in the eastern Mediterranean [5], [6], [7]. Positive NAO phases are associated with an increase in the pressure levels over most parts of continental Europe and Mediterranean sea. Both poles, the Azores high and Iceland low, are intensified, modifying the direction of the westerlies and associated storm tracks, thus leading to a decrease in the precipitation over the Mediterranean and south Europe (south of 45°N) and an increase over northern Europe. On the other hand, negative NAO phase generates negative sea level pressure anomalies in southern Europe and the Mediterranean basin, increasing the precipitation in these regions [9], [10], [11]. Switches from negative

to positive NAO phases are followed by noticeable changes in the average precipitation of the Mediterranean basin, such as the decrease observed between the mid-1960s and the 1990s.

3. NAO INFLUENCE IN MONTENEGRO

Montenegro is part of the Mediterranean region and is subject to the NAO influences. These influences are most pronounced in the winter part of the year, from November to April, while they have a much smaller effect on temperature and precipitation in the summer part of the year, from May to October. The amount of precipitation in the winter period is correlated with the NAO; when NAO indices are negative, the amount of precipitation is above the average value, and vice-versa [12]. Montenegro is located on the border of the different NAO influences and therefore it is scientifically justified to analyze the NAO effect on the climate variables. This is especially important in the northern part of Montenegro where the National park Durmitor is located. Namely, the national park is the least susceptible to human influence, and the natural causes of climate variability are the most pronounced.



Figure 3. Montenegro and Durmitor region.

3.1 The winter influence of the NAO

For the assessment of temperatures and precipitation in the region of Debeli Namet Glacier the data from Žabljak meteorological station of the Institute for Hydrometeorology and Seismology of Montenegro (Zavod za hidrometeorologiju i seizmologiju Crne Gore) in the period from 1991 to 2021 were used. Data show that years with very low winter precipitation, 30%–60% lower than average, were: 1991, 1992, 1993, 1998, 2002, 2008, 2014, 2017 and 2019. They are characterized by positive NAO indices for this season. Years with the highest winter precipitation, 20%–90% higher than average, were: 1996, 2001, 2005, 2006, 2009, 2010, 2011, 2013, 2018 and 2021. These years are mostly characterized by negative NAO indices [13]. In the last 30 years there is a moderate negative correlation (Spearman's correlation $r_s = -0.55$, $p = 0.002$) between winter

precipitation and NAO index. This means that the rising/declining precipitation trend in the Durmitor Massif is related to the negative/positive NAO index.

Relationship between winter temperatures and NAO indices shows that the temperatures are mostly lower than average in the positive NAO phase. Namely, the years with the temperatures which are more than 1°C lower than average for winter period, were: 1992, 1993, 2000, 2003, 2005, 2006, 2012. In these years the NAO indices are mostly positive. The highest temperatures in the winter period should be expected in the years with the negative NAO, but this is not the case. Years with the highest temperatures in this period, more than 1.5 °C higher than average, were: 1994, 2001, 2007, 2014 and 2016. Only in 2001 a negative NAO was recorded while other years were with a positive NAO index. Therefore, correlation between temperatures and NAO index is low and statistically insignificant (Spearman's correlation, t-test shows $p = 0.52$).

3.2 The summer influence of the NAO

As we have already said, in the Mediterranean region the NAO influence in the summer period is less pronounced than in the winter period. Years with precipitation 30%–50% higher than average for the summer period, were: 1995, 2006, 2007, 2014 and 2020. Years with precipitation 20%–44% lower than average for the same period, were: 1991, 1993, 1994, 1997, 2010, 2012, 2015, 2017 and 2021. These years are mostly characterized by negative NAO indices. It can be said that a negative NAO is the leading factor that determines extreme precipitation in the ablation period.

Temperatures in the summer season rose slightly in the considered 30-years period [12]. For the temperatures which are more than 0.5 °C higher than average in summer, the NAO indices are mostly negative. Years with these temperatures were: 1998, 1999, 2003, 2007, 2010–2012, 2015, 2017, 2019 and 2021.

Years with the temperatures more than 0.5 °C less than average for the summer season, are mostly with the positive NAO indices. These years were: 1991, 1995–1997, 2005 and 2016. It can be concluded that in the summer period extreme precipitation and highest temperatures are mostly characterized by a negative NAO.

In the last 30 years there were 21 years with the positive NAO indices and only nine with the negative NAO index values. This means that about 2/3 of the considered period was characterized by the precipitation lower than average for the winter season.

4. CONCLUSION

Although the influence of the NAO in the Mediterranean is visible throughout the year, its most important effect on climate variables is in the winter season. This especially applies to the amount of precipitation. When the NAO is in a positive phase the amount of winter precipitation is usually lower than average; when the NAO is in a negative phase, the amount of winter precipitation is usually higher than average. This is the so-called negative correlation.

Temperature is not as well correlated with the NAO. Namely, temperature variations are associated not only with the NAO but also with some other climate patterns such as El Niño/La Niña, the Mediterranean Oscillation, the East Atlantic pattern and the East

Atlantic-West Russia climate pattern. Therefore, there is no statistically significant temperature-NAO correlation.

As mentioned earlier, the NAO influence is opposite for regions south of 45°N and north of 45°N. Durmitor mountain with its position 43°N, 19°E is located at the border of these different influences. Therefore, it is scientifically justified to analyze the impact of the NAO on climate variables in this area. We found that the NAO affects precipitation and temperature in the Durmitor region in a similar way as in the entire Mediterranean, even though it is located on its border. We believe that this is a representative conclusion because the Durmitor mountain is a national park in Montenegro, an area with little human influence on the natural environment.

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EFFECT OF CHELATING AGENTS ON SELECTED METALS IN VINEYARD SOILS

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ABSTRACT:

Contamination of soils with potentially toxic metals is a well-known current global problem. Numerous technologies have been developed for remediation of land contaminated with toxic metals. The aim of this research is to show the general ability of natural chelating agents to extract selected metals from contaminated soil. The following chelators were used: EDTA, salts of carboxylic acids (CA) and amino acids (AA). The following metals were tested: Al, Cr, Mn, Fe, Ni, Zn and Pb. Aluminium, Cr, Mn, Fe, Ni showed the following decreasing complexation trend: EDTA>CA>AA and for Zn, Pb, that trend is: EDTA>AA>CA. Lead showed the highest chelating ability, while Al, Fe and Mn showed the weakest.

Keywords: soil, metals, remediation, chelators, complexation

1. INTRODUCTION

Viticulture is an important agricultural activity in many countries worldwide. The world's wine-growing regions are mostly located in climatic areas that are, however, favorable for the occurrence of fungal diseases. Regular use of fungicides for plant protection that are required for healthy plant growth [1] may exceed the limits imposed in the EU for agricultural soils [2]. In addition to fungicidal and bactericidal agents, a significant addition of metals to the soil can occur by adding contaminated waste and organic and mineral fertilizers [3].

Numerous technologies have been developed for the remediation of metal-contaminated vineyard soil. Among remediation techniques, ex-situ soil washing processes have been successfully applied for many years due to their high metal removal efficiency, wide application and economic feasibility [4-6]. EDTA is a powerful synthetic metal-chelating agent widely used in soil washing processes [4, 7].

Research on natural amino acids, especially proteinogenic amino acids as chelators for land remediation, has recently begun. Metal-amino acid interactions are common in living

organisms and are vital for life. Metalloproteins, which involve the interaction of amino acid residues with metal ions, make up over a third of all known proteins [8].

Natural, low-molecular organic acids are natural products of root exudates, microbial secretions and decomposition of plant and animal remains in the soil [9-10]. Therefore, dissolution of metals by organic acids is probably more representative of the mobile metal fraction available to biota [11]. Chelated organic carboxylic acids are able to displace exchangeable, carbonate and reductive fractions of heavy metals by leaching procedures [12].

Although many chelating compounds have been evaluated for heavy metal mobilization, uncertainties remain regarding the optimal choice for full-scale application. Our study represents a comprehensive investigation investigating EDTA, 10 structurally and functionally diverse amino acids and 4 carboxylic acid salts as potential remediation agents, applied to 3 different vineyard soil samples. The study was focused on the extraction of Al, Cr, Mn, Fe, Ni, Zn and Pb.

2. MATERIALS AND METHODS

2.1. Study area

Three vineyard plots from the area of Pješivci (Montenegro) were examined (Figure 1). The area has a maximum length in the north-south direction of about 24 kilometers, and a width of about 12 kilometers. The vineyards are located on an area of about 45 hectares. The most common varieties are vranac and kratošija, the so-called American grapes and the traditional variety of rosaklia, and as far as viticulture is concerned, the best conditions are found in the areas around the plain itself. Necessary agrotechnical measures are used on the vineyards, with "drop by drop" irrigation, a good yield with appropriate quality is achieved [13].



Fig. 1. Locations of the sampling stations

Sampling was performed using the Eijkelkamp soil sampling kit. The vineyards are about 500-1000 m apart. Composite samples were made by mixing cross-collected soil from a layer 20 cm deep, with a distance of 2.5 m between sampled locations. Stones and coarse plant material were mechanically removed. The soil samples were placed in plastic boxes, carefully labelled and transferred to the laboratory for further analysis.

2.2. Batch extraction of metals

In our study, investigated metals from vineyard soils was extracted with amino acids, Na-salts of carboxylic acids (acetate, oxalate, tartrate, citrate) and complexing reagent (EDTA). The following amino acids were used: glycine (Gly), alanine (Ala), valine (Val), leucine (Leu), phenylalanine (Phe), serine (Ser), threonine (Thr), histidine (His), arginine (Arg) and the dipeptide glycyl-glycine (Gly-Gly).

In order to determine the optimal metals leaching conditions, the following were examined: soil particle size (0.5, 1.0, 1.5 and 2.0 mm); concentration of washing agent (0.05, 0.1 and 0.2 moldm⁻³); contact time (0.5 h, 1.0 h and 2.0 h); soil/solution ratio, w/v, (1:25, 1:50 and 1:100). The pH of the extraction solution was not adjusted, and in all metals extraction experiments the mixtures were buffered after a few moments to the pH of the tested soil samples. After preliminary tests, we decided on the following experimental conditions: soil particle size 0.5 mm, concentration of metal solution for extraction 0.1 moldm⁻³, extraction time 1 h and soil/solution ratio 1 g/50.0 cm³.

2.3. Sample analysis

The soil samples were dried in air and then in an oven at 75 °C for 48 hours. The dried sediment samples were ground in an agate mortar and sieved through sieve. Approximately, 0.5 g (± 0.0001 g) of each sample was mineralized under pressure and high temperature and microwave digested with a mixture of HCl:HNO₃ (3:1). After digestion, the solutions were diluted using 2 M HNO₃ to a final volume of 100 cm³.

The soils samples were prepared in triplicate and their average value was assessed. Blank solutions were added to the series of samples and measured after every tenth sample determination. The concentrations of the heavy metals (Al, Cr, Mn, Fe, Ni, Zn and Pb) were determined by the AAS technique using a atomic absorption spectrometer (PinAAcle 900, Perkin Elmer). Basic standard solutions of Al, Cr, Mn, Fe, Ni, Zn and Pb concentrations of 1 g/kg were made from Merck chemicals. The standard solutions were diluted with deionized water to bring the element concentrations to a suitable concentration range.

The accuracy and precision of the method were evaluated using the relevant standard for trace elements in the soil (SRM 2709). The reproducibility of the results was within 10 % of the certified values.

3. RESULTS AND DISCUSSION

The results of the extraction of the examined metals with EDTA are given in Table 4 in mg/kg and in wt.% in relation to the pseudo total metal content. Expressed in mg/kg, the most extracted were Mn, Fe and Al. The reason for this is their many times higher content

in the tested soils compared to the other metals. Expressed in wt.% in relation to the pseudo-total content, Pb (76.2 %) and Zn (61.3 %) showed the highest chelating ability. Fe (0.60%) and Al (0.54%) were the least extracted.

Table 1. Amounts of Cu extracted by EDTA in mg/kg and wt.% from the tested sites

Metals	Pseudo-total (mg/kg)	EDTA extraction (mg/kg)	% EDTA vs. pseudo-total
Al	38000	205.4	0.54
Cr	38.0	1.38	3.63
Mn	1611	349.4	21.7
Fe	39555	236.5	0.60
Ni	31.0	6.75	21.8
Zn	89.0	54.6	61.3
Pb	12.6	9.60	76.2

In the work of Naghipoor Khalkhaliani et al. [14] soil samples containing variable levels of Pb, Zn, Cd were treated with ethylene diamine tetra-acetic acid (EDTA) and the extraction of heavy metals was found to vary, ranging from 54.5 to 100%. Na₂-EDTA 0.1M primarily extracted lead over cadmium and zinc. The most effective washing occurred using 0.1 M EDTA at the lowest pH.

Wuana et al. [9] found that ethylenediaminetetraacetic acid removed most of the tested metals were associated in non-residual sediment fractions. Batch soil washing experiments performed on 1.0 g portions of the spiked soil using 0.05 M EDTA at a solid:liquid ratio of 1:25 showed that washing metals efficiencies varied in the order: copper (70%) > nickel (62%) > zinc (60%) > cadmium (56%) > lead (50%).

Table 2 shows the extracted amounts of tested metals with carboxylate anions in mg/kg.

Table 2. Extraction with Na-salts of carboxylic acids (c=0.1 M; t= 1h; soil granulation <0.5 mm), mg/kg

	Al	Cr	Mn	Fe	Ni	Zn	Pb
acetate	20.5	0.85	3.23	19.5	1.01	2.9	0.85
oksalate	19.2	0.91	2.25	23.2	2.94	3.05	0.39
tartarate	61.7	0.39	6.17	31.6	0.56	1.95	1.21
citrate	108	0.76	18.3	52.1	0.89	2.5	0.65

Chromium, Ni and Zn are mostly extracted with oxalate. The most Pb was extracted with tartrate and with citrate: Al, Mn and Fe. The descending order of extractability of the examined metals was as follows: citrate > oxalate > tartrate > acetate.

In the work of Wuana et al. [9] soil contaminated with Ni, Cu, Zn, Cd and Pb was leached with citrate and tartrate. A significantly high degree of decontamination was achieved by serial soil washing with carboxylate anions. Pseudototal metal content in washed soils is significantly reduced compared to unwashed soil. They extracted the investigated metals in the range of 35-50 wt.% with citrate and 17-30 wt.% with tartrate. Metal extraction yields typically following the sequence, copper > nickel > zinc > cadmium > lead.

Table 3. Quantities of tested metals extracted by amino acids in mg/kg relative to pseudo-total content

	Al	Cr	Mn	Fe	Ni	Zn	Pb
Gly	24.1	0.20	4.06	17.4	1.14	8.95	0.55
Ala	8.80	0.20	0.85	8.75	1.04	3.12	0.21
Val	29.7	0.20	5.25	19.8	0.71	5.45	2.36
Leu	11.4	0.20	23.1	57.2	0.86	6.74	1.41
Ser	36.8	0.20	7.58	23.3	0.85	7.52	1.09
Phe	30.4	0.20	5.97	21.5	0.60	5.92	2.44
Gly-gly	17.2	0.20	4.82	17.2	0.89	4.52	1.04
Thr	33.3	0.20	6.52	19.2	0.93	7.78	1.22
His	60.1	0.20	15.1	34.9	2.19	13.2	1.10
Arg	12.4	0.20	2.74	10.4	1.39	1.79	0.48

Table 4. Quantities of tested metals extracted by amino acids in wt.% relative to pseudo-total content

	Al	Cr	Mn	Fe	Ni	Zn	Pb
Gly	0.06	0.53	0.25	0.04	3.68	10.1	4.36
Ala	0.02	0.53	0.05	0.02	3.35	3.51	1.67
Val	0.08	0.53	0.32	0.05	2.29	6.12	18.7
Leu	0.03	0.53	1.43	0.14	2.77	7.57	11.2
Ser	0.10	0.53	0.47	0.06	2.74	8.45	8.65
Phe	0.08	0.53	0.37	0.05	1.94	6.65	19.4
Gly-gly	0.04	0.53	0.30	0.04	2.87	5.08	8.25
Thr	0.09	0.53	0.40	0.05	3.00	8.74	9.68
His	0.16	0.53	0.94	0.09	7.06	14.8	8.73
Arg	0.03	0.53	0.17	0.03	4.48	2.01	3.81

The descending order of extractability of 10 amino acids for the tested metals were:

Al: His > Ser > Thr > Phe > Val > Gly > Gly-Gly > Arg > Leu > Ala,
 Mn: Leu > His > Ser > Thr > Phe > Val > Gly-Gly > Gly > Arg > Ala,

Fe: His > Ser > Phe > Val > Thr > Gly ~ Gly-Gly > Arg > Ala > Leu,
 Ni: His > Arg > Gly > Ala > Thr > Gly-Gly > Leu ~ Ser > Val > Phe,
 Zn: His > Gly > Thr > Ser > Leu > Phe > Val > Gly-Gly > Ala > Arg,
 Pb: Phe > Val > Leu > Thr > His ~ Ser > Gly-Gly > Gly > Arg > Ala.

Based on the above, collectively for all metals, the descending order of extraction ability of the tested amino acids is: His > Ser > Thr ~ Leu > Phe > Gly > Val > Gly-gly > Arg > Ala.

In the work of Dolev et al. [15] extraction of Ni by amino acids (AA) varied from 16.17% to over 30%. Almost all but three AAs showed equal or better Ni extraction results compared to EDTA (23%). Zn extraction by AA ranged from 9% (Ala) to 38% (Cys), depending on the specific AA. Cys performed better than EDTA (38% vs. 30%), while extraction with Phe, Thr, Asp, and Trp reached or exceeded 20%. The extraction of Pb by AA was generally less than 10%, except for 63–70% in the case of Cys, which was equal to the EDTA result (71%). The extraction of Cr by PAA also appeared to be limited (2–12%). However, these results were comparable to that of EDTA (6%). Furthermore, in their work Dolev et al. [15] reported that the activity of some AAs could be comparable to that of EDTA. On the other hand, neither the specific AA group showed an obvious advantage as a metal extraction agent. Structurally and chemically different Phe, Thr, Asp and Cys showed better metal extraction activity compared to other PAAs.

Table 5. Comparative presentation of extracted amounts of tested metals with EDTA, amino acids and carboxylate anions

Metals	AA extraction (mg/kg)	% AA vs. total	% AA vs. EDTA	CA extraction (mg/kg)	% CA vs. total	% CA vs. EDTA
Al	26.4±15.4	0.07	12.8	52.4±42.0	0.14	25.5
Cr	0.20	0.53	14.5	0.73±0.23	1.92	52.9
Mn	7.60±6.63	0.47	2.17	7.49±7.39	0.47	2.14
Fe	22.9±14.0	0.06	9.68	31.6±14.6	0.08	13.4
Ni	1.06±0.45	3.42	15.7	1.35±1.08	4.35	20.0
Zn	6.50±3.21	7.30	11.9	2.60±0.49	2.92	4.76
Pb	1.19±0.74	9.44	12.4	0.78±0.34	6.19	8.12

Aluminium, Cr, Mn, Fe, Ni showed the following decreasing complexation trend: EDTA > CA > AA and for Zn, Pb, that trend is: EDTA > AA > CA. The lead showed the highest chelating ability, while Al and Fe showed the weakest.

Heavy metal assay [9] of harvested biomass of maize grown on unwashed and washed soil samples indicated that metal transfer coefficients, decreased in the order of treatment: ethylenediaminetetraacetic acid < citric acid < tartaric acid < unwashed soil. Ethylenediaminetetraacetic acid and citric acid appeared to offer greater potentials as

chelating agents to use in remediating the high permeability soil. Tartaric acid, however, is recommended in events of moderate contamination.

4. CONCLUSION

The highest chelating ability with EDTA was shown by Pb (76.2%) and Zn (61.3%). The least extracted were Fe (0.60%) and Al (0.54%).

The descending order of extractability of the examined metals was as follows: citrate > oxalate > tartrate > acetate. Chromium, Ni and Zn are mostly extracted with oxalate. The most Pb was extracted with tartrate and with citrate: Al, Mn and Fe.

The descending order of extraction ability of the tested amino acids is: His > Ser > Thr ~ Leu > Phe > Gly > Val > Gly-gly > Arg > Ala.

Aluminium, Cr, Mn, Fe, Ni showed the following decreasing complexation trend: EDTA > CA > AA and for Zn, Pb, that trend is: EDTA > AA > CA. The lead showed the highest chelating ability, while Al and Fe showed the weakest.

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SPECIFIČNI IZAZOVI I POTENCIJALNI NEGATIVNI UTJECAJI OBNOVLJIVIH IZVORA NA OKOLIŠ

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SAŽETAK:

Proizvodnja energije iz obnovljivih izvora ima za cilj smanjenje emisije stakleničkih plinova posebice s aspekta očuvanja okoliša. Iako obnovljivi izvori energije općenito imaju manji negativan utjecaj na okoliš u usporedbi s fosilnim gorivima, nisu potpuno bez utjecaja. U radu će se prikazati specifični izazovi i potencijalni negativni utjecaji obnovljivih izvora na okoliš.

U suočavanju s klimatskim promjenama razvidno je kako proizvodnja električne energije iz fosilnih goriva uzrokuje niz prijetnji okolišu. Proizvodnja električne energije iz obnovljivih izvora ima prioritet u rješavanju globalnih klimatskih promjena i njihovog utjecaja na okoliš. Također, cilj je potaknuti ekološku svijest, koja je neophodna u daljnjem razvoju tehnologija. Investiranjem u znanstvena i tehnološka istraživanja otvara se mogućnost rješavanja globalnih problema te se potiče korištenje obnovljivih resursa.

Budući da svi izvori nemaju isti utjecaj na okoliš istražuju se razlike i traže prihvatljiva rješenja. Tako su istraživanja pokazala kako npr. geotermalna energija ima najmanje emisije CO₂. Međutim, kako bi se očuvala neutralnost, u odnosu na druge resurse, potrebno je postići 100% recikliranje procesne vode.

Naime, cilj ovog rada je prikazati potrebe razvoja ekološke svijesti suvremenog društva. Neovisno o tome koji oblik izvora energije (obnovljivi i/ili neobnovljivi) eksploatirali na neki način utječemo na okoliš i budućnost Planete u cjelini.

Cljučne riječi: ekološka svijest, obnovljivi izvori energije, klimatske promjene, proizvodnja, emisija CO₂

1. UVOD

Klimatske promjene predstavljaju ozbiljan globalni izazov uzrokovan povećanim razinama stakleničkih plinova u atmosferi, često posljedicom ljudske aktivnosti poput sagorijevanja fosilnih goriva, deforestacije i industrijske proizvodnje.

Obnovljiva energija sve više postaje ključni faktor u borbi protiv klimatskih promjena zbog svoje sposobnosti smanjenja emisija stakleničkih plinova i očuvanja okoliša. Ona se dijeli na tradicionalne (poput biomase i energije dobivene iz velikih hidroelektrana) i nove

obnovljive izvore energije (poput energije vjetra, Sunca, geotermalne energije te kinetičke energije plime i oseke, morskih valova i energije mora).

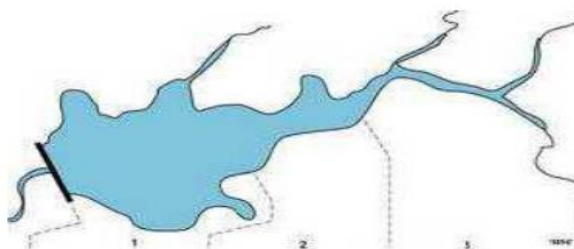
Iako obnovljivi izvori energije generalno imaju manji negativan utjecaj na okoliš u usporedbi s fosilnim gorivima, nisu potpuno bez posljedica. U ovom radu ćemo istražiti specifične izazove i potencijalne negativne utjecaje obnovljivih izvora na okoliš. Kroz kontinuirano ulaganje u znanstvena i tehnološka istraživanja te poticanje korištenja obnovljivih izvora, nastojimo pronaći održiva rješenja za globalne ekološke izazove.

2. ENERGIJA VODE

Krajem 18. stoljeća energija vode omogućila je početak industrijske revolucije. Sunčevo zračenje podržava konstantno kruženje vode u prirodi, pa se smatra obnovljivim izvorom. Danas se u svijetu oko 16% električne energije dobiva u hidroelektranama. [1]

Energija vode (hidroenergija) je obnovljivi izvor energije koja se proizvodi pretvorbom iz kinetičke energije vode. Energija vode se pretvara u električnu u hidroelektranama. Izgradnjom hidroelektrane znatno se mijenja okoliš u njenoj blizini. Tako se izgradnjom velikih hidroelektrana uključuje preusmjeravanje, blokiranje ili promjena toka riječnih sustava. Blokiranjem toka rijeke blokiraju se i migracijski putevi za ribe što dovodi do naglog smanjenja riblje populacije. Kod nekih postrojenja koriste se riblje staze i ljestve kako bi ribe mogle migrirati, ali nažalost često nisu učinkovite.

Formiranjem akumulacija i gradnjom brana dolazi do promjene prirodnog toka rijeka (slika 1.) s promijenjenim životnim uvjetima u odnosu na početne. Shodno tome treba odrediti ekološki prihvatljiv protok, odnosno biološki minimum. [2]



Slika 1. Prikaz prekinutog kontinuiteta rijeke i cijelog slivnog područja pregradnjom brane [1]

Porastom nanošenja nečistoća u rijeku zbog promjena u protoku smanjit će se bistrina vode. Također, moguće je isparavanje vode. Različiti tokovi ugrožavaju stabilnost riječne obale. Uslijed povećanog protoka moguće su poplave što je problem za okolno područje. Prilikom punjenja akumulacijskog jezera potapa se sve što se nalazi ispod površine jezera. U potopljenoj vegetaciji može se nalaziti živa koja se s bakterijama pretvara u metil-živu. Taj spoj ulazi u hranidbeni lanac, a ribe se hrane tom vegetacijom. Tako su i ljudi izloženi opasnosti unosa otrovnog spoja u organizam.

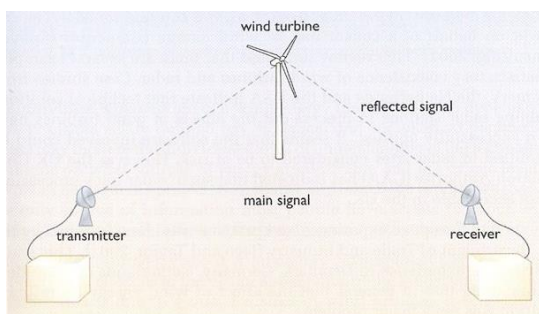
Tijekom izgradnje hidroelektrana dolazi do uklanjanja vegetacije i površinskog dijela tla, što znači i gubitak staništa. Tijekom izgradnje buka, vibracije, emisije prašina i ispušnih plinova, rad strojeva također utječu na uvjete života, ali utjecaj nije značajan jer je prisutan

kratkotrajno. Mogućnost izlivanja ulja i goriva iz mehanizacije u vodu također mogu izazvati ugrozu. Zato se upotrebljavaju šahte za sakupljanje ulja te nepropusni kanali. Kvantificiranje emisija hidroelektrana je zahtjevno i specifično za svaki pojedini slučaj. Nekoliko studija je pokazalo da rezervoari nastali gradnjom brana, doprinose emisiji stakleničkih plinova u atmosferu. Akumulacije postaju izvori CO₂ i metana koji znatno pridonose efektu staklenika.

2. ENERGIJA VJETRA

Energija vjetra predstavlja obnovljivi izvor energije koji se generira korištenjem kinetičke energije zračnih struja ili vjetra. Ova energija se pretvara u električnu energiju putem vjetroturbina koje se nalaze u vjetroelektranama ili vjetroparkovima. Iako su vjetroturbine ekološki prihvatljiv način proizvodnje električne energije, postoje određene potencijalne opasnosti i izazovi povezani s njihovom upotrebom

Vjetroturbine mogu utjecati i poremetiti elektromagnetske signale koji se koriste u telekomunikacijskim, radarskim i navigacijskim uslugama kako je prikazano na slici 2.



Slika 2. Pojava elektromagnetskih smetnji

Problem se može otkloniti ugradnjom pojačala signala, aktivnim deflektorima, relejnim odašiljačima ili uvođenjem kablске televizije [3].

Tijekom rada vjetroagregata stvara se buka koja nastaje prilikom okretanja lopatica rotora. Ljudi koji žive u blizini turbina mogu imati glavobolje, nesanicu i druge probleme zbog stalne izloženosti.

Vjetroturbine, posebno visoki vjetrogeneratori, tornjevi i rotirajuće lopatice, mogu biti opasni za ptice i šišmiše koji se mogu sudariti sa njima. Dobrim planiranjem poduzimaju se mjere za odvrćanje ptica i šišmiša od vjetroturbina. Gdje je prikladno, koriste se zvučni ili ultrazvučni sustavi ili se postavlja posebna značajka koja sprječava rotor da se okreće u vremenu kada ptice ili šišmiši lete preblizu.[4]

VE su dosta velike konstrukcije smještene na uzvišenjima te time utječu na vizualnu sliku okoline. Najveći utjecaj na estetiku krajolika ima izgradnja pristupnih puteva.

Tijekom građenja vjetroelektrane nastaje neopasni i opasni otpad od ostataka građevnog materijala i ambalaže, te komunalni otpad. Odlaganjem otpada na lokaciji zahvata može doći do nepovoljnih utjecaja na okoliš u cjelini. Za sve vrste otpada treba osigurati

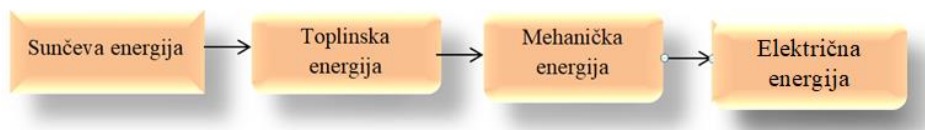
postupanje sukladno Zakonu o otpadu i na temelju njega usvojenim Pravilnikom o vrstama otpada i Pravilniku o gospodarenju otpadom [5].

U lancu energije vjetra najviše se nesreća povezuje s proizvodnjom i prijevozom sastavnih dijelova te izgradnjom postrojenja, dok su nesreće u pogonu malo vjerojatne. Postoji i izvjestan rizik u okolišu radi mogućnosti loma lopatica turbine kod olujnog vjetra ili otkidanja nakupljenog leda na lopatici. [6]

Treperenje sjene (*shadow flicker*) je pojava promjene intenziteta svjetlosti u ovisnosti o tome kako lopatice i stupovi vjetroelektrane bacaju sjenu na okolno područje. Treperenje sjene je pojava koja se može spriječiti izgradnjom vjetroelektrana na dovoljnoj udaljenosti od stambenih objekata te naselja. Moguće je ukloniti tako što se zaustavi vjetroagregat koji stvara sjenu kada je moguća pojava treperenja sjene.

3. ENERGIJA SUNCA

Energija Sunca, ili solarna energija, predstavlja obnovljivi izvor energije koji se proizvodi iz svjetlosti i topline Sunca (slika 3.). Ona igra ključnu ulogu u tranziciji ka održivim oblicima proizvodnje električne energije. Solarna energija je jedan od najčistijih i obnovljivijih izvora energije i igra ključnu ulogu u tranziciji ka održivim oblicima proizvodnje električne energije. [3]



Slika 3. Slijed pretvorbe energije u solarnoj termoelektrani

Iako iskorištavanje energije Sunca donosi brojne prednosti, ima i svoje nedostatke. Projekti solarnih elektrana mogu imati negativan utjecaj na faunu i floru, uključujući ptice i druge životinjske vrste. Postavljanje solarnih panela i pripadajuće infrastrukture može narušiti prirodne ekosustave.

Veliki solarni projekti zahtijevaju značajne površine zemljišta za postavljanje solarnih panela, što može rezultirati gubitkom poljoprivrednih površina ili uništenjem prirodnih staništa. Prilikom izgradnje solarnih elektrana, mogući su problemi poput otpada, curenja maziva i pogonskih goriva, iako su ti problemi obično kratkotrajni i ne predstavljaju značajan dugoročni utjecaj.

Što se tiče utjecaja na okolno stanovništvo, jedini utjecaj se može pripisati mogućem oštećenju vida zbog intenzivnog reflektiranog zračenja i utjecaju kemikalija u prijenosnom fluidu kod sustava s centralnim tornjem.

Utjecaj na kvalitetu zraka javlja se prilikom izgradnje solarnih elektrana. Stvara se prašina prilikom nasipavanja, iskopavanja zemljišta i prijevoza građevinskog materijala. Navedeni utjecaj je neizbježan, ali je privremenog karaktera. Problemi se javljaju i prilikom proizvodnje samih solarnih ćelija što je povezano s proizvodnjom poluvodiča, a njihova proizvodnja ima otrovne nusproizvode. Stvaraju se znatne količine plinova od

kojih su neki vrlo toksični (PH₃, SiF₄) ili zapaljivi (H₂, CH₄). No direktnog utjecaja zbog rada solarnih elektrana na kvalitetu zraka nema, jer nema nikakve emisije štetnih plinova.

4. GEOTERMALNA ENERGIJA

Geotermalna energija koristi toplinu koja se nalazi duboko ispod površine Zemlje za proizvodnju električne energije i toplinske energije za različite svrhe. Iako geotermalna energija spada među čiste i obnovljive izvore energije, i sama ima potencijalne negativne utjecaje na okoliš i zajednicu.

Rad geotermalnih postrojenja može rezultirati emisijom nekondenzirajućih plinova u atmosferu. Ti plinovi uključuju ugljikov dioksid, metan, dušik, bor, sumporovodik i amonijak, koji su otopljeni u geotermalnoj tekućini.

Tablica 1. Usporedba emisije CO₂ kod različitih energenata za proizvodnju električne energije [7]

Energetski izvor	Emisija CO ₂ [kg/kWh]
Geotermalna energija	0.09
Prirodni plin	0.6
Nafta	0.9
Ugljen	0.95

Geotermalna postrojenja vodu koriste i za hlađenje i ponovo ubrizgavanje. Većina geotermalnih postrojenja ponovo ubrizgava vodu u ležište nakon upotrebe da bi se spriječilo slijeganje tla i onečišćenje okoliša. Međutim, dio vode se izgubi u vidu pare. Kako bi se održao stalan volumen vode u spremnicima treba dodati vode izvana. Količina te vode ovisi o veličini elektrane i tehnologiji te se može koristiti otpadna voda koja nije pogodna za piće. Buka se javlja prilikom izgradnje postrojenja te prilikom stvaranja bušotina. To su uglavnom zvukovi motora i ostale potrebne opreme i strojeva. Razina buke varira i nije stalna.

Geotermalne elektrane grade se neposredno uz nalazište jer bi se transportom na veću udaljenost smanjili tlak i temperatura fluida. Na lokaciji treba osigurati prostor za bušotine i cjevovode uključujući rashladne tornjeve i rasklopno postrojenje. Korištenjem zemljišta utječe se na sam izgled okoline i na bioraznošću.

Pretežito se nalaze među geozirima, vrućim izvorima i sličnim turističkim atrakcijama. Kao posljedica uklanjanja vode s površine dolazi do pojave slijeganja tla. Slijeganje je intenzivnije u nalazištima s pretežnim udjelom tekućine. Ovaj se problem uglavnom rješava ponovnim ubrizgavanjem vode u podzemni rezervoar te se sprječava održavanjem tlaka u nalazištu. [3]

Osim toga, postoje dokazi da geotermalna postrojenja mogu dovesti do veće učestalosti potresa, obzirom da se nalaze na geološkim žarištima. Vruće stijene kao geotermalni izvor potrebno je izlomiti pod visokim tlakom, što ima također utjecaj na pojavu manjih potresa.

To se može umanjiti postavljanjem postrojenja na odgovarajuću udaljenost od glavnih linija rasjeda.

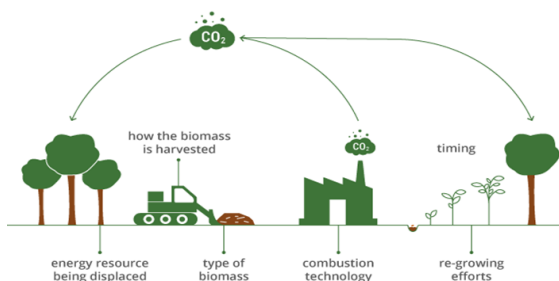
5. BIOMASA

Biomasa je vrsta obnovljive električne energije koja obuhvaća materiju biljnog i životinjskog podrijetla, ostatke nastale proizvodnim procesima u industrijama i otpad u smislu komunalnog otpada. Energija dobivena iz biomase može biti u čvrstom stanju (ogrjevno drvo, drveni otpad, slama, pelet, itd.), tekućem (bioetanol, biometanol, biodizel) te plinovitom (plin iz rasplinjavanja biomase, bioplin, deponijski plin,).

Iako je biomasa obnovljivi izvor energije, također ima potencijalne negativne utjecaje na okoliš i zajednicu. Na primjer, drvo i drveni ostaci često se koriste kao biomasa za proizvodnju energije, ali krčenje šuma radi prikupljanja biomase može imati ozbiljan negativan utjecaj na staništa i bioraznolikost.

Intenzivna upotreba biomase za proizvodnju energije može dovesti do degradacije tla, smanjenja plodnosti tla i erozije.

Sagorijevanjem biomase mogu se oslobađati staklenički plinovi, uključujući CO₂ i metan. Na ciklus ugljikovog dioksida (slika 5.) utječu vrsta korištene biomase, način skupljanja biomase, vrijeme, način iskorištavanja biomase, napor uloženi u sadnju novih biljaka, rast novih biljaka. Tako za primjer, sagorijevanjem drveta ispušta se ugljikov dioksid u atmosferu, ali drveće ponovo raste i uzima ugljikov dioksid koji mu je potreban. No, šumama je potreban velik vremenski period za oporavak, a samim time i za iskorištavanje ugljikovog dioksida.



Slika 5. Faktori koji utječu na CO₂ neutralnost biomase [8]

Osim emisije ugljikovog dioksida, postoje emisije dušikovih i sumporovih oksida no, u vrlo malim količinama. Dušikovi oksidi su neizbježni u procesu izgaranja, obzirom da četiri petine zraka čini dušik. Do povećanja koncentracije dušikovih oksida može doći zbog visokih temperatura u pećima ili motorima s unutarnjim izgaranjem. Dodatan problem je i emisija prašine, koja se stvara zbog prisutnosti pepela.

6. ZAKLJUČAK

Svaki od izvora obnovljive energije ima specifične izazove i potencijalne negativne utjecaje na okoliš. Potencijalno negativni aspekti hidroenergije: promjena u ekosustavu, migracija riba, erozija obala, potencijal za poplave, promjene u kvaliteti vode.

Potencijalno negativni utjecaji solarnih elektrana su: promjena pejzaža, potreba za zemljištem, utjecaj na floru i faunu, otpad i reciklaža. Potencijalno negativni aspekti geotermalne energije: izbijanje štetnih tvari, geotermalni fluidi, povećan rizik od potresa. Potencijalno negativni utjecaji biomase: krčenje šuma, degradacija tla, emisija stakleničkih plinova.

Važno je napomenuti da, iako obnovljivi izvori energije imaju potencijalne negativne utjecaje na okoliš, ti utjecaji obično imaju manji opseg su u usporedbi s štetnim posljedicama fosilnih goriva, uključujući one povezane s emisijom stakleničkih plinova i kvalitetom zraka. Tehnološki napredak i stroga regulativa pomažu minimiziranju negativnih utjecaja obnovljivih izvora energije na okoliš. Također, mnogi od tih izazova mogu se rješavati putem boljih praksi u planiranju i izgradnji obnovljivih projekata.

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SPECIFIC CHALLENGES AND POTENTIAL NEGATIVE EFFECTS OF RENEWABLE SOURCES ON THE ENVIRONMENT

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ABSTRACT:

The goal of energy production from renewable sources is to reduce greenhouse gas emissions, particularly in terms of environmental preservation. Although renewable energy sources generally have a smaller negative impact on the environment compared to fossil fuels, they are not entirely without impact. This work will present specific challenges and potential negative environmental impacts of renewable sources.

In addressing climate change, it is evident that electricity production from fossil fuels poses several environmental threats. Electricity production from renewable sources takes priority in addressing global climate change and its impact on the environment. Furthermore, the aim is to promote ecological awareness, which is essential in the further development of technologies. Investment in scientific and technological research opens the possibility of addressing global issues and encourages the use of renewable resources. Since not all sources have the same environmental impact, differences are being researched and acceptable solutions sought. For example, research has shown that geothermal energy has the least CO₂ emissions. However, to maintain neutrality compared to other resources, achieving 100% recycling of process water is necessary.

The aim of this work is to illustrate the need for the development of ecological awareness in contemporary society. Regardless of which form of energy source (renewable and/or non-renewable) we exploit, we influence the environment and the future of the planet in some way.

Keywords: *environmental awareness, renewable energy sources, climate change, production, CO₂ emission*

EVALUATING SERBIAN AIR QUALITY INITIATIVES IN A REGIONAL CONTEXT

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Aspirations towards development and modernization of life caused a problem that engulfed the whole world – air pollution. A growing number of recent research indicate the negative influence of air pollution on the environment, economy, human health, and life quality. Consequently, responsible bodies of the European Union and European countries have implemented a series of air quality policies and strategies. This paper includes a review of the World Health Organization air quality guidelines, The Clean Air Package published by the European Commission, and action plans published by the responsible bodies of Western Balkan (Croatia, Serbia, and North Macedonia) and Central Europe countries (Austria and Germany). Based on the collected data, a comparison of action plans and air quality trends was made, mainly with an emphasis on the situation in the Republic of Serbia.

Keywords: *air pollution, environment, human health, life quality*

1. INTRODUCTION

Habits of the modern population caused an exponential decrease in air quality in the last few years, consequently, growing one of the biggest problems facing modern urban communities – air pollution. According to the World Health Organization (WHO), air pollution is associated with around 6.7 million premature deaths annually [1]. Air pollution is causing cancer [2], cardiovascular [3], pulmonary [4], and neurological [5] diseases, thus, disrupting the life quality and reducing global overall life expectancy [6]. Besides the effect on human health, air pollution has significant environmental effects such as acid rains, haze, ground-level ozone, global climate change, wildlife endangerment, eutrophication¹, etc. [7].

To mitigate air pollution, legislative bodies are publishing policies and strategies as guidelines. Overall, better air quality can be achieved by [8]:

- i. Keeping the concentrations of air pollutants at or below maximum permitted levels;
- ii. Reducing the concentrations of pollutants that exceed their maximum permitted levels.

¹ Disequality of aquatic diversity caused by the stimulation of algae blooming under higher concentrations of nutrients.

Air quality monitoring is a requirement for an air quality management system. It gives insight into the intensity of air pollution and its composition and toxicity [8]. Larssen et al. stated that the monitoring system objectives are defining the design and operation of monitoring networks [9]:

- i. Compliance monitoring - supports the air quality directives;
- ii. Air quality surveillance monitoring – describes the air quality in the monitored area, state, or continent;
- iii. Exposure assessment monitoring – defines the air pollution harm to health, vegetation, and materials;
- iv. On-line monitoring – designed to predict high-concentration incidents;
- v. Operational monitoring – designed to observe the air quality around specific sources
- vi. Monitoring programmes to support scientific research.

The fight against air pollution requires a lot of techno-economic efforts which could be a problem for communities with lower life standards and/or level of development. According to the World Bank [10] around 64.5 percent of people in lower-middle-income countries are exposed to higher PM_{2.5} levels (over 35 µg/m³), compared to 4.4 percent in low-income and 0.9 percent in high-income countries. Additionally, Jiang et al. stated that the growth of GDP per capita is positively correlated with emissions per capita [11]. Overall, these statements indicate that developing countries which make up around 85% of the world's population are struggling with intensive air pollution due to aspirations towards development and at the same time not having enough resources or willingness to face this problem.

The Western Balkans consist of Albania, Bosnia and Herzegovina, Croatia, North Macedonia, Montenegro, Kosovo, and Serbia. According to the International Monetary Fund, all mentioned countries except Croatia are developing countries. This paper includes a review of World Health Organization air quality guidelines, The Clean Air Package published by the European Commission, and action plans published by the responsible bodies of Western Balkan (Croatia, Serbia, and North Macedonia) and Central Europe countries (Austria and Germany). Based on the collected data, a comparison of action plans and air quality trends was made often through comparison with legislation and initiatives in the Republic of Serbia.

2. WORLD HEALTH ORGANIZATION AIR QUALITY GUIDELINES

The World Health Organization defined a global target for national, regional, and city communities to improve air quality, consequently, improving the health of their citizens. Generally, those guidelines are a set of recommended limit values for each air pollutant [12]. Table 1 shows the recommended 2021 air quality guidelines set by the World Health Organization.

Table 2. World Health Organization guidelines for 2021

Pollutant	$PM_{2.5}$ [$\mu\text{g}/\text{m}^3$]		PM_{10} [$\mu\text{g}/\text{m}^3$]		O_3 [$\mu\text{g}/\text{m}^3$]		NO_2 [$\mu\text{g}/\text{m}^3$]		SO_2 [$\mu\text{g}/\text{m}^3$]	CO [mg/m^3]
	Annual	Daily	Annual	Daily	Peak season ¹	8-hour	Annual	Daily	Daily	Daily
Guideline	5	15	15	45	60	100	10	25	40	4

To describe the current state of air quality in the Western Balkans, Fig. 1 includes the comparison of annual average concentrations for 2021 for Western Balkan countries with the World Health Organization's guidelines (black limit line).

¹ „Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average concentration [12].“

³ ISO 3166-1 alpha 3 codes

⁴ The 1999 Gothenburg Protocol to abate acidification, eutrophication, and ground-level ozone.

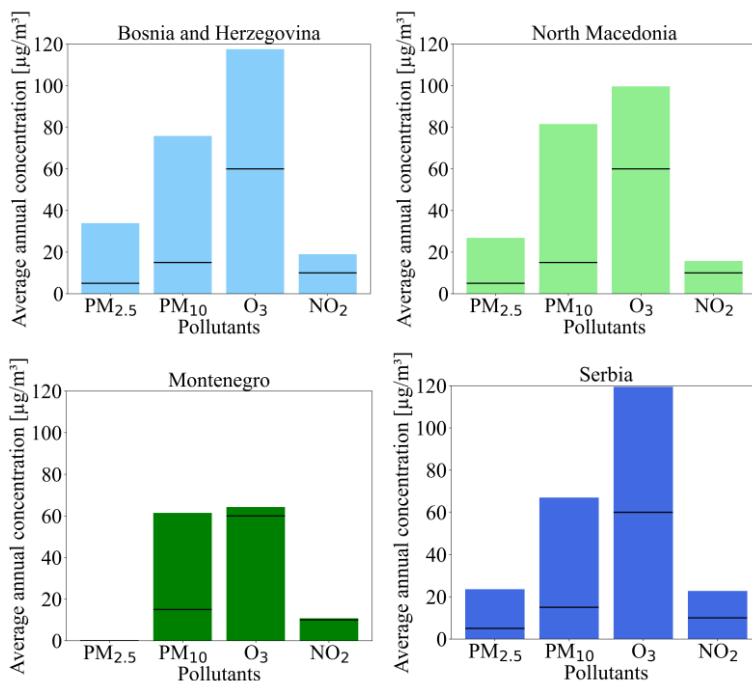


Fig. 8. Average annual concentrations per country of Western Balkan [13]

By comparing average annual concentrations of pollutants for Western Balkan countries, it can be noticed that each country is drastically exceeding WHO-given guidelines indicating the air quality crisis happening in this region.

3. THE CLEAN AIR PACKAGE: IMPROVING EUROPE'S AIR QUALITY

The National Emission Ceilings (NEC) Directive is the main tool for achieving air quality targets. The extended deadline for the NEC Directive is set for 2030, with two important checkpoints: 2020 - setting/updating obligations set under the Gothenburg Protocol¹; and 2025 – setting incidental goals to stay on the pathway towards 2030 obligations. This directive is focused on four original air pollutants (SO₂, NO_x, non-methane VOCs, and NH₃) and two new (PM_{2.5} and CH₄) by proposing obligations for them. Besides the flexibility offered by the NEC Directive, many governments request support via EU source controls. EU source measures should help to achieve the requested reductions (ranging from 57% reduction for VOCs to 72% for NO_x) [13]:

- i. The Ecodesign Directive focused on domestic combustion;
- ii. The Industrial Emissions Directive (IED) strives to develop the Best Available Technologies (BAT) conclusions for main industrial sources, in particular, combustion plants over 50 MW;

- iii. Revision of the Non-Road Mobile Machinery Directive which will cover a wider range of machinery and coordinate the controls with the Euro VI heavy-duty limits.

Important sources of pollution that are not effectively controlled due to the gap in EU source legislation are the thermal capacities between 1 and 50 MW. Thus, the European Commission proposed a Directive on Medium Combustion Plants (MCP) which will provide an effective tool to reduce the emissions of NO_x, SO₂, and PM. It is estimated that this directive will lead to significant emission reductions in most of the member states. Ammonia is another pollutant included in the NEC directive with a requested reduction of 27%. Most of the ammonia is emitted during agricultural activities, and the directive provides a set of measures that are cost-effective even for smaller farms. Additional support is provided to member states by Rural Development Funds. To group the current working strands¹ and to promote activities considering air quality and the environment in the farming community European Commission will establish an agriculture platform as a part of the European Clean Air Forum.

The sulfur emissions from shipping in the EU are ensured by the revised Directive on the Sulphur Content of Liquid Fuels (2012), however, the air quality on land will be still affected by shipping. Shipping should be controlled and developed at the international level considering its global significance. The proposal is that a revised NEC Directive should aim to induce emissions reductions from shipping by allowing them to be offset against the obligations for 2025 and 2030 [13].

Another aspiration of the European Union has been addressed to the non-EU parties. Considering the economic status of the third countries, they are a critical group that has a significant influence on air pollution. The plan is that the European Commission will continue to engage with Eastern Europe, Caucasus and Central Asia (EECCA) states to implement the Gothenburg Protocol, promote the green economy, and provide financial support. Important steps towards better air quality are innovations and research. The EU's research and innovation programme for 2014 to 2020 (Horizon 2020) generally strives for the reduction of health and environmental consequences caused by exceeding air pollution [13].

European Environmental Agency (EEA) published a report considering the status of the NEC Directive in 2022. The report shows that [14]:

- In 2020, 13 countries achieved their 2020-2029 emission reduction commitments for five main pollutants;
- However, 14 countries failed to achieve the set goals for at least one pollutant;
- Ammonia is currently the biggest challenge for the period 2020-2029 with 11 states that need to cut their emissions;
- Emission of sulfur dioxide achieved the highest reduction, with only one state not meeting the commitment;

¹ NEC Directive, the UNECE Ammonia Guidance Document, the increasing focus in the Common Agricultural Policy on environmental protection, and the co-benefits of air pollution control for climate, water, and soil.

- Two member states have already met their commitments for 2030 and beyond;
- Around 60% of member states will need to reduce emissions of ammonia, nitrogen oxides, and fine particulate matter to meet the commitments set for 2030.

Figure 2 shows the status of European Union member states from the aspect of emission reduction commitments. The diagram shows the number of states that met their 2020-2029 commitments, the number of states that need a reduction under 10% to meet their 2020-2029 commitments, the number of states that need the reduction between 10 and 30% to meet their 2020-2029 commitments, and number of states that need the reduction between 30 and 50% to meet their 2020-2029 commitments.



Fig. 9. European Union member states status following the NEC directive

Figure 3 analyses the success of each European Union country from the aspect of meeting the 2030 commitments defined by the NEC Directive. There are a few member states that already met the 2030 commitments (Belgium and Estonia), and countries that are close to achieving their goals set for 2030 (Finland, Greece, and Slovakia).

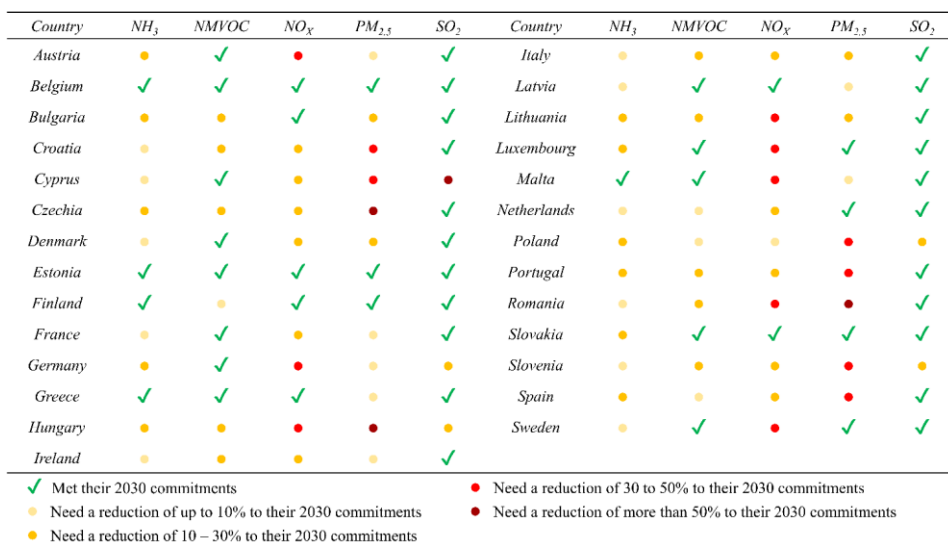


Fig. 10. *Succes of each EU member state from the aspect of meeting the 2030 commitments [14]*

5. RESULTS AND DISCUSSION

By comparing the action plans of Serbia (Belgrade), Croatia (Zagreb), North Macedonia (Skopje), Austria (Vienna), and Germany (Berlin) (Table 2), it is noticeable that they are very similar on paper. However, according to the trends of mean annual PM₁₀ concentrations (Figure 4), Serbia (Belgrade) significantly lags behind Croatia (Zagreb), Austria (Vienna), and Germany (Berlin) in the realization of the plan. North Macedonia (Skopje) has a strong downward pollution trend. Figure 4 indicates that all countries (except North Macedonia) were tentatively in the same starting position (2017 and 2018), Zagreb, Vienna, and Berlin achieved better air quality with a dominant downward pollution trend, while air quality in Belgrade worsened with a stochastic (upward) pollution trend.

Table 3. *A comparative analysis of air quality plans*

(● – measure exists; ● – similar measure exists; ● – measure does not exist)

<i>Measure</i>	<i>Serbia</i>	<i>Western Balkans</i>		<i>Central Europe</i>	
	<i>Belgrade</i> [15]	<i>Zagreb</i> [16]	<i>Skopje</i> [17]	<i>Vienna</i> [18]	<i>Berlin</i> [19]
<i>Urban planning measures</i>					
Pollution-sensitive urban planning	●	●	●	●	●
Street greening	●	●	●	●	●
<i>Transport measures</i>					
Low emission zones	●	●	●	●	●
Promotion of eco-friendly vehicles	●	●	●	●	●

Development of electric vehicle infrastructure	●	●	●	●	●
Clean vehicles in the city enterprises	●	●	●	●	●
Old diesel vehicle retrofiting	●	●	●	●	●
Emission reduction of heavy diesel vehicles	●	●	●	●	●
Traffic stabilization	●	●	●	●	●
Speed limit lowering	●	●	●	●	●
Pollution-sensitive traffic management	●	●	●	●	●
Pollution-sensitive organization of coach traffic	●	●	●	●	●
Promotion of public transport	●	●	●	●	●
Promotion of walking and cycling	●	●	●	●	●
Organization of parking areas	●	●	●	●	●
Promotion of car-sharing	●	●	●	●	●
Promotion of eco-drive		●			
Rehabilitation of damaged roads	●	●	●	●	●
Extension of rail passenger transport lines	●	●	●	●	●
<i>Heating, cooling, and energy production measures</i>					
Increasing the energy efficiency of buildings	●	●	●	●	●
Clean heating energy	●	●	●	●	●
Reduction of small combustion plant emissions	●	●	●	●	●
Installation of mini-combined power plants	●	●	●	●	●
Campaigns for the proper use of wood stoves	●	●	●	●	●
<i>Other measures</i>					
Particle filters for construction machines	●	●	●	●	●
Fugitive dust emissions reduction	●	●	●	●	●
Emission reduction of industry	●	●	●	●	●
Air quality monitoring system modernization	●	●	●	●	●
Household and traffic emissions cadaster	●	●	●	●	●
Development of pollution maps	●	●	●	●	●

Mobile measuring stations air quality control	●	●	●	●	●
More-frequent street cleaning	●	●	●	●	●
Emission reduction from municipal waste treatment	●	●	●	●	●
Reduction in agricultural emissions	●	●	●	●	●

According to the mathematical interpretations of pollution trendlines (Fig. 4) Table 3 shows the estimated mean annual PM₁₀ concentrations in 2030, and the year of reaching the WHO set limit for each country provided that the pollutant emission reduction trend continues exactly at this observed pace.

Table 4. *Estimated mean annual PM10 concentrations in 2030, and the year of reaching the WHO set limit for each country*

City	Mathematical interpretation of the trendline (X – number of years starting from 2018 as baseline)	Estimated mean annual PM ₁₀ concentration for 2030	Year of reaching the WHO set limit for PM ₁₀
Zagreb	$Y = -1.5648 \cdot X + 20.937$	2.16	2021
Vienna	$Y = -1.0022 \cdot X + 20.322$	8.29	2023
Berlin	$Y = -0.6339 \cdot X + 16.129$	8.52	2019
Belgrade	$Y = 0.6402 \cdot X + 20.967$	28.65 (higher than now)	never
Skopje	$Y = -1.6106 \cdot X + 43.006$	23.67	2035

Out of all the analyzed cities, only Belgrade has a strong growth trend (visible also in Fig. 4). This indicates that, without any significant change, the air quality in Belgrade will worsen over time, and that Belgrade will never reach the WHO set limit for PM₁₀ concentrations.

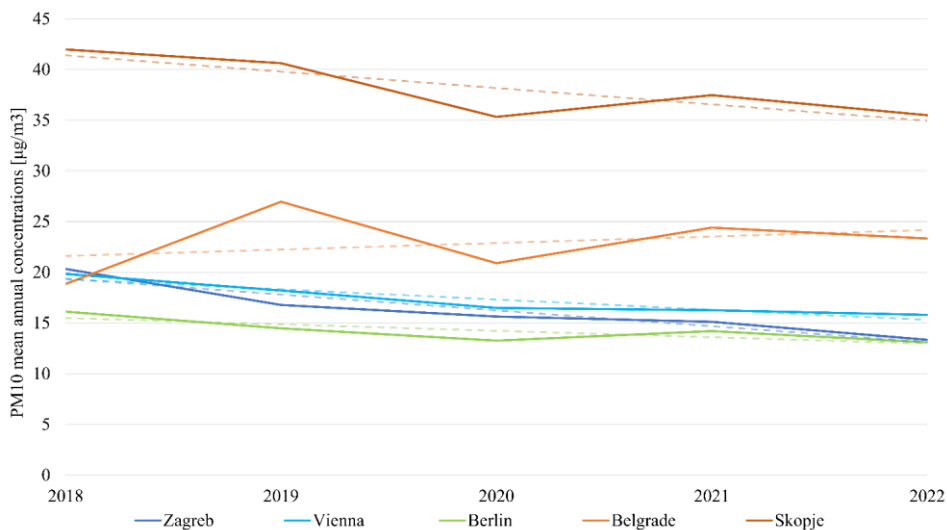


Fig. 11. Mean annual PM_{10} concentrations for Zagreb, Belgrade, and Vienna

According to the analysis of the implementation of the air quality plan for the city of Belgrade [15]: i) the cargo and delivery vehicles ban was not implemented because this measure, according to the government, is not a necessary ii) The pollution forecasting system was established but without the possibility to determine for what location the predictions were made; iii) electric and natural gas-powered buses were purchased, but the following infrastructure was built in only one location; iv) the domestic heating sector emission reduction plan has not even entered the starting phase (data collection and feasibility study); v) the instruction for shutting down of boiler plants, connection to the district heating, and transition to less-polluting fuels were introduced in 2023; vi) municipal waste burning inspections were introduced for few locations, but not for the whole territory of the city; vii) industry emission data is still unavailable for public; viii) study on the necessity and possibility of realization for the introduction and expansion of „30 km/h“ zones has not been done; ix) measure considering the reconstruction of bigger thermal plants is not defined clearly, for now only one plant was reconstructed TP „Cerak“ with estimated NO_x reduction of 30%.

6. CONCLUSION

Overall, the current situation in Serbia suggests that the government is not prioritizing the air quality plan. Furthermore, not only are there no visible steps towards effective improvement of air quality, but, as shown in Figure 4, there is not even enough effort to prevent further worsening and deepening of problems related to air quality. The long-lasting trend of the increased concentration of suspended particles has resulted in a pessimistic attitude of citizens and the impression that accumulated problems can no longer be solved. In this sense, any progress is, in the first place, a much-needed sign to citizens that negative trends can be reversed to the benefit of everyone.

In terms of the aforementioned, the air quality plan needs a deep revision that will define goals more clearly, introduce quantitative indicators to monitor the plan realization and determine the sources of funds that will be effectively used to achieve quicker and more efficient measure results.

In the current situation, the Republic of Serbia is in a situation where this type of cooperation between the government and citizens either does not exist or exists only as a form to be fulfilled. The consequence of the current situation is the polarization of attitudes, in which the government more and more often defends its (indefensible) positions, and the citizens feel as if no one is hearing them. So, the part that could/should be implemented, regardless of the legislation, relates to the necessity of joint work with citizens. The understanding and respecting of their positions/views is needed, especially of those who are most committed to problems related to air quality, while at the same time helping and strengthening the awareness of those who are still not sufficiently informed about the importance of air quality for the general welfare of the environment.

7. ACKNOWLEDGMENTS

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POLLUTANT PARTICLES IN AIR ON THE TERRITORY OF KOSOVSKA MITROVICA

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ABSTRACT:

Climate change is the most common change that has been discussed in the wider scientific community over the last decade. The impact of pollutant particles on all areas of the environment is so great that environmental protection is an extremely important global issue. Air is one of the areas of the environment without which there is no life on the planet. Clean air is the basis for the life of humans, animals, and plants on earth. The composition of gases in the atmosphere plays a very important role in influencing the climate. The change in the composition of clean air due to the presence of pollutant particles has a negative effect on the composition of the atmosphere, which has significant consequences, including damage to the Earth's ozone layer and climate change. Air pollution has been linked to various negative effects on human health, including heart attacks, asthma attacks, bronchitis, and other respiratory symptoms. Therefore, it is very important to monitor air quality and know its composition. In this paper, we will show what pollutants are present in the air, focusing on the Kosovska Mitrovica region, how they affect, and how to reduce them with the aim of a healthier environment.

Keywords: *climate change, air pollution, environmental protection*

1. INTRODUCTION

The environment is the space on planet Earth that enables the survival of all living beings. Without a healthy environment, neither humans nor other living beings can survive. The impact of pollutant particles on all areas of the environment is so great that environmental protection is an extremely important global issue. Air is one of the areas of the environment without which there can be no life on our planet. Clean air is the basis for the life of humans, animals and plants on earth. Climate is an important factor influencing air

quality. Climate change is the most common change that has been discussed in the broad scientific community in the last decade.

Climate change poses a fundamental threat to human health. It affects the physical environment and all aspects of both natural and human systems – including social and economic conditions and the functioning of health systems. [1] It is therefore a threat multiplier, undermining and potentially reversing decades of progress in the health sector. In the wake of climate change, more frequent and intense weather and climate events are being observed, including storms, extreme heat, floods, droughts and forest fires. These weather and climate hazards impact health both directly and indirectly, increasing the risk of death, non-communicable diseases, the occurrence and spreading of infectious diseases and health emergencies. All aspects of health are affected by climate change, from clean air, water and soil to food systems and livelihoods. Further delay in addressing climate change will increase health risks, undermine decades of improvement in global health, and run counter to our collective obligations to ensure the human right to health for all.

In general, climate change is expected to worsen air quality in several densely populated regions by altering atmospheric ventilation and rarefaction, precipitation and other decomposition processes, and atmospheric chemistry. Reduced air quality will have a direct impact on human health and affect ecosystems in a way that could also affect human health and climate in a feedback loop. Several studies indicate that climate change is already having an impact on air quality. For example, Fang et al. [2] simulated that from pre-industrial times (1860) to the present (2000), global population-weighted particulate matter (PM_{2.5}) concentrations increased by 5% and near-surface ozone concentrations by 2% due to climate change. According to Silva et al. [3] the change compared to pre-industrial times resulted in up to 111,000 and 21,400 additional premature deaths due to particulate matter and ozone, respectively, as a result of climate change. Over the past two decades, approximately every degree of warming (°F) in the observed data was associated with a 1.2 ppb increase in ozone concentrations. As the climate continues to change, these effects are expected to continue in the future.

Climate and air quality are inextricably linked (Figure 1.). Many sources of “conventional” air pollutants are also sources of CO₂, other greenhouse gases and/or particulates that affect the climate. These air pollutants interact with solar and terrestrial radiation and disrupt the planetary energy balance, leading to climate change. As the climate continues to change, these effects are also predicted for the future. The composition of gases in the atmosphere plays a very important role in influencing the climate. The change in the composition of clean air due to the presence of pollutant particles has a negative impact on the composition of the atmosphere, with significant consequences, including damage to the Earth's ozone layer and climate change. Air pollution has been linked to a number of negative effects on human health, including heart attacks, asthma attacks, bronchitis and other respiratory ailments. It is therefore very important to monitor air quality and know its composition.

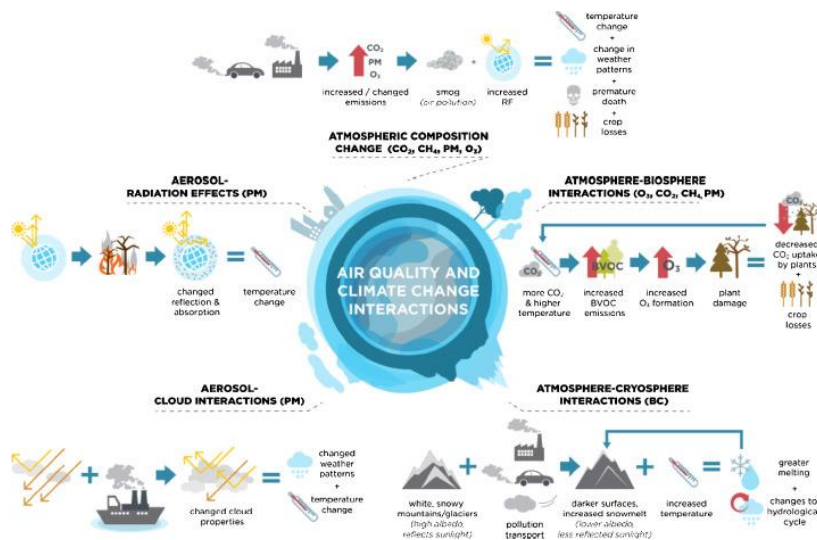


Figure 1. Air quality and climate connections [4]

The U.S. Environmental Protection Agency (EPA) [5] defines air pollution as the presence of contaminants or pollutants in the air that adversely affect human health or welfare or cause other adverse environmental effects. [6] The definition of an air pollutant or air pollution depends on the temporal and spatial context and the effects of a particular situation. [7] Air pollutants affect both human health and ecosystems. It has been reported that in developing countries, the majority of air pollution (approximately 70–80%) is caused by vehicle emissions, particularly from a larger number of older vehicles with low maintenance, poor fuel quality and inadequate road infrastructure [8,9]. The United Nations Environment Programme estimates that indoor and outdoor air pollution is responsible for nearly 5% of the global burden of disease, including excess incidence of asthma and other allergic respiratory diseases and adverse pregnancy outcomes (e.g. stillbirths and low birth weight) [10]. People in developing countries are particularly at risk from air pollution. The effects of air pollution on living systems such as plants, animals and humans as well as other materials are worse. It can impair the biochemical and physiological processes of plants and ultimately lead to yield losses. The pollutants present in the air cause three specific types of damage: they harm human health, they destroy and degrade the environment and ecosystems, and they damage property and cultural monuments. The most important air pollutants are PM particles, ozone (O₃), carbon monoxide (CO), sulphur dioxide (SO₂), nitrogen dioxide (NO₂) and lead (Pb).

2. EXPERIMENTAL

2.1. Study area

Kosovska Mitrovica is located on the southeastern edge of the Dinaric Mountains, in the northern part of the Kosovo region, where the Ibar makes a large bend before flowing into the Ibar Gorge, before which it joins its largest tributary Sitnica on the right. The town is located in the north of the Kosovo basin at 496 metres above sea level. It is surrounded to the east, north and west by the mountains of Mokra Gora and the slopes of Golija and Kopaonik, to the south by the foothills of Čičavica and to the northwest by the foothills of Rogozna. The Ibar River flows through the town, dividing it into its southern and northern parts, Sitnica and the Ibar Ljušta tributary, the mouth of which is located in the town itself. From the city to the north of the town, through which the Ibar flows to Kraljevo, where it flows into the Western Morava.

2.2. Analysis

The analysis of the concentrations of sulfur dioxide, soot and nitrogen dioxide was carried out at two measuring points in the area of the district of Kosovska Mitrovica. The air samples are taken with modern PRO-EKOS AT 801 x 2 devices.

The sulfur dioxide values are determined using the spectrophotometric pararosaniline method and the soot values using the reflectometric method (photoelectric reflectometer). The nitrogen dioxide values are determined using the spectrophotometric method with N(1-naphthyl)ethylenediamine.

The results of the analysis of systematic monitoring of the level of air pollution on the territory of Kosovska Mitrovica District were compared with the regulations on limit values, methods of immission measurement, criteria for determining measurement points and the Regulation on the conditions for monitoring and requirements for air quality ("Official Gazette of RS", No. 11/10, 75/10, 63/13).

3. RESULTS AND DISCUSSION

The results of the measurement of pollutants in the air are shown in the Table 1. Measurements were made at two measuring points: Measuring point 1 "Zavod" Kosovska Mitrovica and Measuring point 2 "Elementary school" Zvečan.

Table 1. Pollutants in the territory of Kosovska Mitrovica during the month of March

Measuring point 1	SO ₂ µg/m ³	Soot µg/m ³	NO ₂ µg/m ³
Average monthly value	9.86	7.77	9.43
Minimum value	1.32	0	0.07
Maximum value	25.97	14.48	21.84

Measuring point 2	SO ₂ µg/m ³	Soot µg/m ³	NO ₂ µg/m ³
Average monthly value	6.30	5.88	4.25
Minimum value	0.00	0	0.28
Maximum value	24.32	30.40	10.80

The measurement of air pollution from sediment in the urban environment was carried out at eight measuring points in March. The measured values of total sediments below the MDV (450 mg/m²/day) at all measuring points are listed in Table 2.

Table 2. Precipitable substances in the territory of Kosovska Mitrovica during the month of March

	pH	Ep*	SO ₄ **	Cl**	Ca**	NO ₂ **	NO ₃ **	NH ₃ **
Average monthly value	6.81	44	1.74	8.97	15.86	0.42	48.17	0.37
Minimum value	6.07	34	1.07	3.93	9.45	0.24	34.86	0.19
Maximum value	7.97	54	2.68	12.93	20.43	0.78	59.46	0.80
*µS/cm ** mg/m ² /day								

The measured values correspond to the expected results for this area, the quality of the air and its level of pollution.

3. CONCLUSION

The fast pace of human life brought with it many advantages as well as many disadvantages. The daily need of people to get to work on time, but also to get home faster to their families, has caused the daily use of cars, which are among the biggest air polluters. In almost all cities in Serbia and Europe, traffic is allowed in confined spaces. Modern construction tends to be high and beautiful buildings with little greenery and many parking lots due to the excessive number of cars. All this leads to an excessive concentration of exhaust fumes that pollute the air in populated areas.

Various measures must be taken to reduce the concentration of pollutants in the air:

- Renewal of heating systems and use of natural gas as a source of thermal energy;
- Introduction of traffic-calmed zones in the immediate urban area and expansion of pedestrian zones and cycle paths;
- Increasing the number of filters in industrial chimneys;
- Increasing green spaces and planting;

- Educating the population to raise awareness of the need to reduce air pollution.

One of the principles of environmental protection is: the polluter pays. The air is available to people completely free of charge, so the question arises: Is it necessary for humans to pay for the air, and would they then pollute the air less and care more about preserving the environment? It is our duty to preserve our environment, our surroundings and the air we breathe, because we have not inherited this planet from our ancestors, but borrowed it from our descendants.

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STATE AND PERSPECTIVES OF SUSTAINABLE FISHERY DEVELOPMENT IN THE REPUBLIC OF SERBIA

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ABSTRACT:

The strategies of the European Green Deal, titled "From Farm to Fork," are focused on establishing fair, healthy, sustainable and environmentally friendly food supply chains. The European Union represents a significant market for the placement of Serbian agricultural products. To continue this trend, it is necessary to improve the development of organic agricultural production through the implementation of measures which will enhance animal welfare, ensure the supply of organic seeds, reduce the carbon footprint of the agricultural sector, and minimize the use of plastic, water, and energy. Fishery in Serbia, as a branch of agriculture, has seen a significant decline in recent years and this is even more obvious when compared to its real potential. The causes include the lack of state support for producers, pollution, the disappearance of spawning grounds and natural habitats. The Serbian market is supplied with fish from domestic production – aquaculture, open water fishing, but it is most frequently filled with imported fish. Aquaculture in Serbia is mainly focused on the production of trout and carp. Serbia utilizes only 10% of its capacity for fish production. The greatest potential for expanding fish farms can be located in the territory of Vojvodina, where infertile land could be turned into a sustainable resource. State support in the form of grants for establishing new and reconstructing existing fish farms, as well as equipment procurement, would significantly contribute to improving the development of sustainable fishery in Serbia. The paper analyzes the current state of fishery and the prospects for the development of sustainable fishery in Serbia in line with the European Green Deal. In addition, the possibilities for improving fishery in protected areas are considered.

Keywords: *development, sustainable fishery, Republic of Serbia*

1. INTRODUCTION

The strategy of the European Green Deal, named "From Farm to Fork," is aimed at establishing a fair, healthy, sustainable, and environmentally friendly food market chain. Serbia possesses favorable natural and economic resources for the development of domestic fisheries. The most important resources are the large land areas in the

Autonomous Province of Vojvodina as well as water resources with all watercourses. However, the fisheries sector lags behind the natural possibilities and needs. Fisheries in Serbia include aquaculture (cultivation of aquatic systems under controlled conditions) and open water fisheries.

Fish farming in aquaculture is predominantly conducted in carp and trout farms, and it is from these sources that the Serbian market is supplied, along with the additional import of certain quantities of fish. Carp farms are mainly located in Vojvodina while trout farms are in mountainous regions, providing optimal conditions for the cultivation of cold-water fish. Fish produced in aquaculture are mainly intended for consumption, with smaller quantities for restocking and very little for aquarium needs.

2. PRODUCTION OF WARM-WATER FISH SPECIES

The production of warm-water fish species is mostly carried out in traditional carp ponds, while a small percentage of production occurs in cage systems and Recirculating Aquaculture Systems (RAS) [1]. According to official data from the Republic Statistical Office, the area of carp ponds in operation varied from 2003 to 2022. The extent of carp pond exploitation ranged from 4045 ha (in 2004) to a maximum recorded 8940 ha (in 2010) [2]. The dominant form of production of carp species is semi-intensive, which involves meeting protein needs from natural food developed within the pond itself, with increases promoted through certain agronomic measures (drying facilities in the winter period, substrate processing, and fertilization). Energy needs in semi-intensive systems are met by using grain-based carbohydrate feeds. Recently, there has been a shift toward meeting energy needs using complete pelleted feeds, which intensifies production [3]. In Serbia, carp is mainly farmed in polyculture with bighead and silver carp, grass carp, and predators such as catfish, pike-perch, and pike [1]. The production of table fish in Serbian carp ponds (Figure 1) varied from 2003 to 2022, with the highest output in 2010 at 7322 tons and the lowest in 2003 with 1218 tons of fish produced [4].

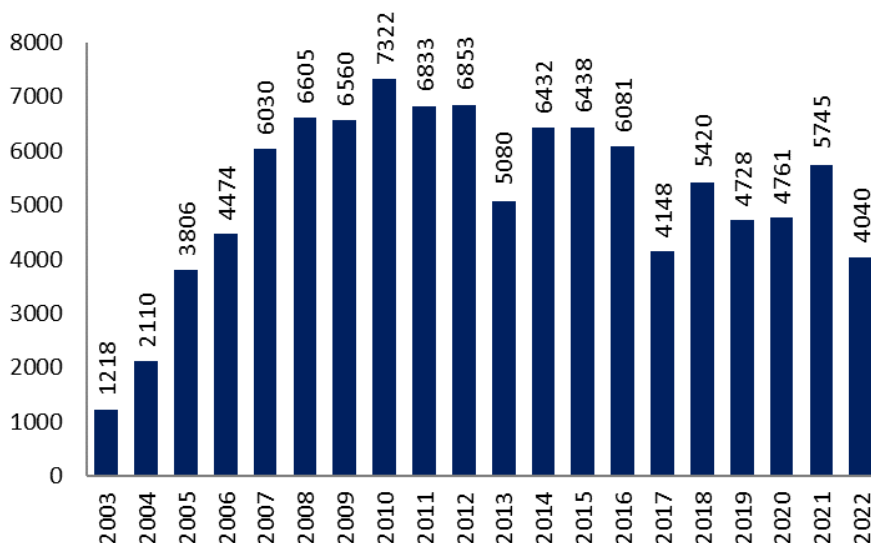


Chart 1. Production of table fish in carp ponds in Serbia from 2003 to 2022
(created by authors in line with [4])

3. PRODUCTION OF COLD-WATER FISH SPECIES

The production of cold-water fish species takes place in trout farms, cage systems, and RAS. The majority of the production is represented in traditional flow-through trout farms [1]. The total operational area of trout farms varied from 2003 to 2022 and according to data from the Republic Statistical Office, it was smallest in 2011, amounting to 33,255 m², while it was the largest in 2018, amounting to 81,411 m² [2]. Trout farms mainly cultivate rainbow trout, while other species are sporadically present. In Serbia, trout farms produce about 25 kg/m³ of water, which is a small amount considering that an intensive production system is applied [1]. Such low production is conditioned by not using all the capacities of the sources and rivers from which the farms are water-supplied. Installing systems for enriching water with oxygen could provide more stable and extensive production. From 2018 to 2022, a growth trend in production on trout farms was observed (Chart 2), with production amounting to up to 2079 tons (in 2019), which is significant compared to the production in 2003, which was only 391 tons [5].

The average yield of fish produced in aquaculture varies and depends on the technology used, the quality of young fish — genetic material, the type and quality of food, the presence of diseases, and piscivorous bird species. In the year 2020, fish production in aquaculture exceeded the quantity of fish harvested from natural sources [6]. Production

can be increased by choosing high-quality pelleted food rich in carbohydrates, as well as additional measures such as water aeration and cultivation in cage systems [7].

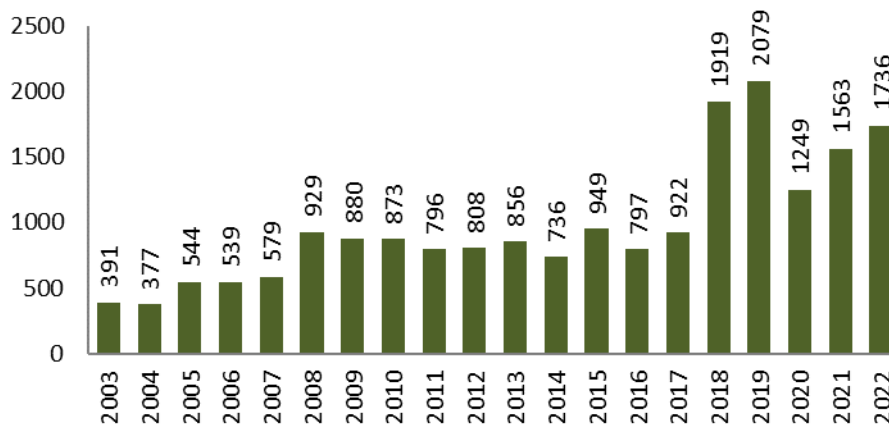


Chart 2. Quantity of table fish in trout ponds in Serbia from 2003 to 2022
(created by authors in line with [5])

4. PRODUCTION OF FISH IN OPEN WATERS

Open water fishing can be divided into commercial - economic and recreational. Commercial fishing in open waters is carried out by fishermen with small capacity and scant equipment. The number of commercial fishermen is on a declining trend, and according to data from the Republic Statistical Office, the number of full-time fishermen in 2022 amounted to 348 [8]. A much more significant portion of the catch from open waters is realized by recreational anglers. Economically significant fish species found in open waters include sturgeon, carp, catfish, pike-perch, pike, bream, silver bream, bighead carp, white carp, etc. [1]. In 2021, a total of 2 353 tons of fish were harvested from open waters, including both commercial and recreational fishing [9]. The reduction in the fish stock in rivers is a consequence of habitat alteration caused by the construction of dams, embankments, deteriorated water quality, the presence of various diseases and parasites, as well as human activities and other animals.

5. ORGANIC AGRICULTURAL PRODUCTION

As a result of increasing environmental pollution and urbanization, there has been a disruption of non-renewable resources. In an effort to protect these resources, agriculture has begun to shift towards organic production, which is based on respecting ecological principles. In terms of fisheries, the market in Serbia is mainly supplied with fish from its own production — aquaculture, open water catches, and imports, which is the most common case [10]. There is almost no organic production. According to data from the

Ministry of Agriculture, Forestry, and Water Management, Directorate for National Reference Laboratories, only in 2017 was one agricultural farm registered for organic fishery production [1]. The practical non-existence of organic fishery production is a result of both producers and consumers not being familiar with the benefits of organic production.

6. FISH CONSUMPTION IN THE DIET

Fish consumption in the diet in Serbia is significantly below the European and global average, and fish farming in artificial ponds is well below objective possibilities and needs. Such low fish consumption in Serbia is due to consumer habits: consumers use domestic animals' meat more than fish in their diet [11]. In addition to consumer habits, the price of fish and the purchasing power of consumers also play a significant role. Fish consumption and fish product consumption per household member in our country averages between 5 and 6 kg [1]. In the market, more than 50% of the fish is in fresh condition, and less than one-quarter is found as frozen fish, with an equal proportion processed technologically as canned or smoked fish. The following types of freshwater fish are available in the market: carp, trout, gray and white bighead carp, grass carp, catfish, pike-perch, and crucian carp [12].

7. PROBLEMS IN FISHERIES

In the Republic of Serbia, there are numerous problems in fisheries. A large area of fish ponds (about 4500 ha) has become neglected due to being taken out of production as a result of a lack of financial resources [1]. This lack of funds is reflected first in the cost of water usage fees, the provision of energy for aeration, and then in the high price of feed. In open waters, uncontrolled fishing is present, leading to a reduction in fish populations. The construction of dams on river courses leads to the disruption of migratory paths and loss of habitats. Pollution issues are also present and pose a significant problem. The presence of various viral diseases such as koi herpes virus in carp ponds and infectious pancreatic necrosis in trout ponds significantly impacts the reduction of production. Moreover, one of the problems in fisheries is the lack of labor for physical and handling tasks in the ponds. Unfair competition from imported fish, which often has inferior quality compared to that produced in Serbia, also does not have a stimulating effect. Climate changes that have intensified in recent years can lead to a lack of water in trout ponds as well as increased water temperatures in carp ponds during the summer period, thereby leading to significant changes in the diet and physiological state of the fish.

From an ecological perspective, it is observed that freshwater ecosystems and the fisheries they support are increasingly threatened by human activities. For these systems to function according to the principles of sustainable development, they need to be based on nine key principles:

1. Support for healthy and productive ecosystems based on the best available science, including the laws of physics and chemistry applied in ecology;
2. Population dynamics are regulated by reproduction, mortality, and growth;

3. The quantity and quality of habitat are prerequisites for fish productivity;
4. Connectivity among habitats is essential for the movement of fish and their resources;
5. Freshwater species and their habitats are closely connected with surrounding watersheds;
6. Biodiversity can enhance the resilience and productivity of ecosystems;
7. Global processes affect local populations;
8. Anthropogenic stressors have cumulative effects;
9. Evolutionary processes can be important [13].

Ecosystems are complex with many intertwined components, and ignoring connections and processes significantly reduces the likelihood of successful management. These principles must be taken into account when identifying management options and developing policies aimed at protecting productive freshwater ecosystems and sustainable fisheries.

Fishing is one of the most widespread activities by which people gather natural resources, but its ecological footprint is not adequately understood and has never been directly quantified. The ecological footprint of fisheries is much larger than the ecological footprints of other forms of food production, even though fisheries provide only 1.2% of the global food production for humans, which is approximately 34 calories per capita per day [14].

8. PERSPECTIVES OF DEVELOPMENT

The perspective of aquaculture development in the Republic of Serbia primarily involves increasing production per unit area as well as expanding the areas under fish ponds. Increasing production in carp ponds can be achieved by intensifying production using high-quality extruded feeds, selection, pond reconstruction, introducing automatic feeders and aerators, and better prevention. To have a positive effect on the development of fisheries, it is necessary to simplify the procedures for establishing new ponds and to reduce the overall production costs. This primarily refers to reducing water charges and offering stimulating prices for electricity, which is extensively used for water supply to the ponds as well as aeration. Introducing stricter controls on fish imports and having the state provide stimulating measures in the form of financial support at the national level would be of great importance. Currently, there is an ongoing competition for granting non-repayable funds for establishing new and reconstructing existing ponds in the Autonomous Province of Vojvodina [15]. This competition aims to improve the use of non-arable agricultural land to enhance fisheries in the territory of the AP Vojvodina. Supporting the professional development of experts engaged in fish farming would have positive effects on fisheries in Serbia.

9. CONCLUSION

Serbia has significant resources when it comes to fisheries. Unfortunately, these resources have not been significantly exploited. For their more extensive use, and thus creating

conditions for the sustainability of fisheries, it is necessary for the state to adopt certain measures primarily focused on structural support and regulation of the market in fisheries. These activities should not only encourage the opening of new ponds but also the development of the processing industry — a chance to employ the local population. It is of utmost importance to reduce poaching to the minimum. The increasing exploitation of fish resources must also be decreased. For further strengthening sustainable fisheries in Serbia, it is important to align existing legislation with the standards of the European Union in this area.

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MANAGING AND POSSIBLE IMPROVEMENT OF ENERGY EFFICIENCY OF SPORTS BUILDINGS; CASE STUDY SERBIA

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ABSTRACT:

The majority of sports buildings in Serbia were constructed between 1960 and 1980, a period when energy efficiency was not a top priority. Even if energy efficiency was considered, the technology and materials used during that time have become outdated in terms of efficiency. These buildings primarily rely on traditional, fossil fuel-based energy sources. With increasingly strict regulations on energy efficiency, it is crucial for these facilities to undergo renovation and subsequent maintenance to reduce energy consumption.

Sports buildings are naturally well-suited for the integration of Renewable Energy Sources (RES), given their spacious open areas and outdoor surfaces. However, this paper investigates the implementation of passive solar technologies in these manmade structures as a means of achieving energy savings. The case studies involve sport center built in Belgrade during the 1980s. Various passive measures, as zenithal lighting, are applied to the building structure, along with the measures resulting benefits in terms of reducing total annual energy consumption for space heating and improving indoor environmental comfort. Gained conditions were simulated using the software package Integrated Environmental Solutions Virtual Environment (IES VE 2016).

Finally, bearing in mind the need to raise awareness about the sustainable aspect of all structures, including such facilities, among management, basic recommendations in maintenance and decision-making will be given as a foundation for future steps in understanding such an important context.

Keywords: *sports buildings, energy efficiency, passive strategies for improvement, management*

1. INTRODUCTION

Energy consumption is closely related to the required conditions of indoor comfort, which should be suitable for sports activities, services, and other activities. Small halls can be ventilated only naturally if their surface area is less than 1000 m²; otherwise, they

should be equipped with mechanical ventilation. Cross-ventilation yields very favorable results. Mechanical ventilation is necessary to supply a space with a certain amount of fresh air and to remove unpleasant odors and moisture. Main ventilation systems should be equipped with heat recovery systems.

Sport facilities are complex; besides zoning and different comfort conditions for different parts of the facility, there are other requirements concerning comfort that should be met or paid attention to. Built-in ventilation systems should provide approximately 128 m³/min of ventilation air in the sports arena, playground, with special attention to the airspeed, which should not exceed 0.1 m/s near the ground to avoid disrupting the game on the field.

[1]

2. CASE STUDY

Building model of the Sport Center Vozdovac in Belgrade, that is analyzed in the paper was created in the Integrated Environmental Solution software package, Virtual Environment IES VE 2016. (Fig.1.)

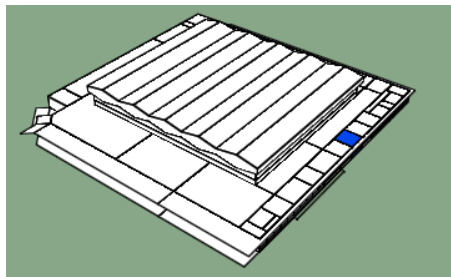


Fig. 1. Model of Sports Center "Voždovac" IES VE 2016

Construction details are collected based on the original project documentation and detailed work records. Internal comfort parameters have been adopted from local and international practices and foreign regulations in the absence of data in local ordinances for this type of facility.

The operating profile of the facility can be divided into occupancy profile of users, operation profile of electrical equipment and lighting, heating and ventilation operation profile, as well as hot water usage profile. The usage profile of artificial lighting is linked to user occupancy. [2]

The most unfavorable situation is considered when it comes to technical systems - hall is in operation until late evening hours (from 08:00-24:00 for recreational users). Sports events also take place on weekends, meaning energy is consumed in locker rooms and wardrobe areas. The rest of the building operates from 07:00 to 14:00 for the building, which are the working hours of the administration and support staff during the workweek, with negligible exceptions. These data were taken into account during the modeling of the existing state of the facilities and the creation of simulations for different groups of buildings. Due to different occupancy modes and equipment content, it would be necessary to simulate comfort conditions for significantly different spaces: an office in the north, locker rooms in the basement, the main hall, and a small hall in the south. However this paper shows data only for the main sport hall.

Due to the extensive work and simulation of comfort conditions in terms of thermal, visual, and hygienic comfort, conditions are simulated only for a universal sports hall and the rest of the facility - which represents office space. It is necessary to divide the facility into two zones; the sports hall and the administrative part - caused by completely different operating modes, structural characteristics, and comfort conditions, as well as activities taking place in these spaces.

It should be mentioned that in the existing state of the facilities loads from people who stay in certain spaces and emit heat, then loads from lighting and electrical equipment are given. Based on the given values of installed equipment, the software package calculates the gains together with the achieved solar gains for a specific area, in this case, Belgrade. [1]

2. PASSIVE MEASURES IMPROVEMENT

The position of the central part of the facility gives us the opportunity to enhance the daylighting comfort only from the roof. During sunny days, the intensity of daylight in the universal hall is satisfactory. If it's cloudy, the intensity of daylight is improved by zenithal lighting, for which simulations have been performed. After simulating the conditions in the hall for roof openings of 2 x 45 m, 3 x 45 m, and 4 x 45 m, it turned out that the most optimal solution for the size of zenithal lighting on the roof of the hall is 2 x 45 m. Double glazing filled with argon and with a low-emissivity coating has been installed (according to the EE RS Regulation $U=1.27 \text{ W/m}^2\text{K}$, $U_{\text{glass only}}=1.14 \text{ W/m}^2\text{K}$, $g=0.5$, according to EnerPHit/EnerPHit+ $U=1.0 \text{ W/m}^2\text{K}$, $U_{\text{glass only}}=0.79 \text{ W/m}^2\text{K}$, $g=0.3$). The achieved results in energy consumption and comfort index for the universal hall, by implementing measures of introducing zenithal lighting according to the Energy efficiency Regulation in Serbia, [3] having in mind that the facility is in Serbia and according to EnerPHit/EnerPHit+ certification [4], are shown in Table 1.

Table 1. Simulation results with improvement of building with zenithal light

<i>Results</i>	<i>RS Regulation</i>	<i>RS Regulation + zenithal light</i>	<i>EnerPHit/EnerPHit+</i>	<i>EnerPHit/EnerPHit+ + zenithal light</i>
$Q_{H,nd} [\text{kWh/m}^2]$	847,9	858,1	810,5	820,4
Energy grade $Q_{H,nd,rel}$	E	E	D	D
Energy saving [%]	17,0	16,0	20,7	19,7
Comfort index од 6-8	22,6	22,8	23,7	23,4

The results have shown that energy savings for heating, as well as improvements in comfort (slightly improved for scenario RS EE Regulation + zenithal lighting), cannot be achieved by the construction of a zenithal window as prescribed by the EE RS Regulation (Figure 2) or according to the parameters prescribed by the EnerPHit/EnerPHit+ certification (Figure 3).

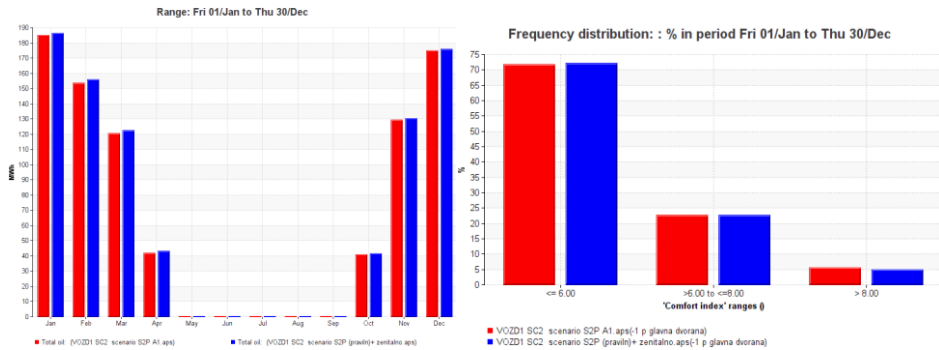


Figure 2. Comparative analysis of simulation results for energy consumption (top) and comfort index (bottom) for zenithal lighting, improvement according to the RS Regulation

The results of dynamic simulations for scenario C2P+ zenithal lighting with measures regulated by the EnerPHit/EnerPHit+ certification are shown in Figure 3.

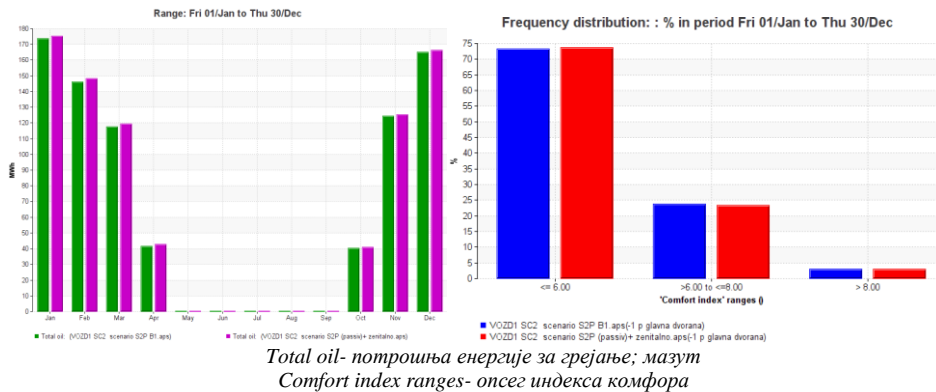


Figure 3. Comparative analysis of comfort index and heating energy consumption for scenario -zenithal light during occupancy in the hall improvement by EnerPHit/EnerPHit+ (passive)

Conditions were simulated following the application of special enhancements, passive systems defined due to the specificity of the base solutions and shapes. In the SC2 model, natural lighting in the universal hall on cloudy days is improved by zenithal lighting. The image depicts the illumination of the hall after the implementation of enhancements in scenario + zenithal lighting (Figure 4).

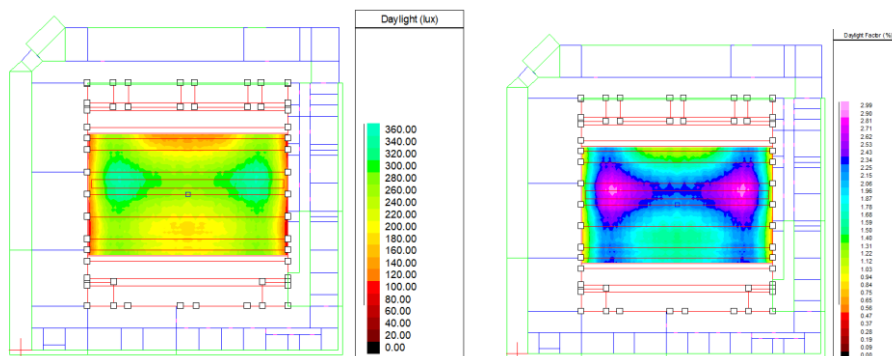


Figure 4. Natural lighting in the universal hall after the implementation of scenario + zenithal lighting, shown in lux (left) and DF % (right)

By installing zenithal lighting, favorable lighting conditions for recreational sports activities can be achieved in the hall. The average illumination of the hall is 249.01 lux, which is very favorable. Professional sports activities primarily occur during the late afternoon and evening hours when artificial lighting is primarily used.

3. MANAGING ENERGY EFFICIENCY

Sports facilities have specific demand patterns and operational requirements, resulting in significant energy consumption. The issue of the sustainability and efficiency of facilities requires clever and practical solutions. In order to create environmentally and socially resilient cities, it is essential to support sports facilities that are efficient and sustainable [5].

Managing energy efficiency in sports facilities is crucial for reducing operational costs, minimizing environmental impact, and promoting sustainability. Over the past ten years, literature developed business models to accomplish the objective of sustainable development in business strategies in order to lessen negative external consequences and generate new beneficial effects for society and the environment [6]. These strategies collectively help reduce energy consumption, lower operating costs, and promote sustainability in sports facilities. Improving insulation and window design, integrating renewable energy sources, optimizing lighting, heating, and cooling systems, and implementing smart building technology are just a few of the various strategies used in the effort to fight against energy inefficiency in buildings. In numerous cases, implementing these techniques into action might end in a 50% decrease in energy consumption [7].

At the other hand, authors highlight the beneficial effects of good governance in promoting sustainability and drawing capital, which in turn drives the growth of environmentally friendly sports facilities. Encouragement of green FDI, the implementation of environmentally friendly taxes, the promotion of sustainability in corporate management, and the use of trade agreements to facilitate the trade of green energy utilities are some of

the suggested policy measures to support the deployment of green energy in sports and public facilities [8].

3. CONCLUSION

Characteristics of existing sports facilities relevant to energy renovation have been identified, and reference models have been defined on which defined individual and package measures have been applied to achieve energy optimization for the climate conditions of Belgrade. Guidelines and recommendations have been provided for achieving optimization of energy performance in the processes of energy renovation of these facilities. A specific methodology has been created as a recommendation for energy-saving in universal sports halls, resulting in expected scientific contributions to research. After selecting reference models for investigating the performance of objects for the application of various individual and package measures, numerical simulations were conducted via the IES VE simulation platform. Energy optimization measures were tested on individual elements of the building envelope as a whole, only in the administration part, and only in the central part of the universal hall. The specificity in the structure and design of sports buildings has led to the application of special enhancements, such as passive strategies, increasing openings, and natural ventilation of space, after which conditions of thermal, visual, and hygienic comfort were simulated. Dynamic simulations were conducted individually with the application of special measures and in combination with three defined basic scenarios.

Although the energy class in European countries is determined based on the required annual primary energy, in Serbia, as mentioned several times, it is determined by the relative value of the annual final energy consumption for heating [%], representing the percentage ratio of the specific annual heating demand $Q_{H,nd}$ [kWh/m²a] and the maximum allowable $Q_{H,nd,max}$ [kWh/m²a] for a certain category of buildings. For the applied passive measure, constructing zenithal lighting on the roof of the building, excluding the consideration of structural aspects, a significant improvement in visual comfort within the building has been achieved. Energy savings due to the additional solar gain of 3% have slightly improved the comfort index, particularly in terms of thermal comfort. It must be mentioned that proper management within the building is very significant in all aspects, especially when it comes to energy savings and all issues related to energy efficiency.

Acknowledgement

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EKOLOGIJA I ODRŽIVI EKONOMSKI RAZVOJ U REPUBLICI SRPSKOJ

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SAŽETAK:

Ekološka kriza u današnje vreme obeležava „kulminaciju“ krize modernog industrijskog društva i njegovog načina mišljenja. Danas, ona posebno limitira dostignute granice određenog tipa razvoja i modernizacije ukupnog društva na pretpostavci iskorištavanja prirodnih resursa. U prvom delu rada fokus će biti na analizi izvora finansiranja životne sredine u pojedinim svetskim zemljama, a u drugom njegovom delu fokusira se regulacija ovog problema u Republici Srpskoj. Republika Srpska je definisala određena zakonska rešenja u tom pogledu ali je praksa pokazala da je neophodna dorada tih rešenja. Zbog toga je fokus ovog rada na određenim aspektima unapređenja rešenja koja se tiču izvora i načina finansiranja zaštite životne sredine u Republici Srpskoj kao entiteta u okviru Bosne i Hercegovine.

Ključneriječi: životna sredina, ekološka kriza, finansiranje

ECOLOGY AND SUSTAINABLE ECONOMIC DEVELOPMENT IN THE REPUBLIC OF SRPSKA

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ABSTRACT:

The ecological crisis today marks the "culmination" of the crisis of modern industrial society and its way of thinking. Today, it especially limits the reached limits of a certain type of development and modernization of the entire society on the assumption of using natural resources. In the first part of the paper, the focus will be on the analysis of sources of environmental financing in certain countries of the world, and in the second part, the focus will be on the regulation of this problem in the Republic of Srpska. Republic of Srpska has defined certain legal solutions in this regard, but practice has shown that it is necessary to refine those solutions. That is why the focus of this work is on certain aspects of improving the solutions concerning the sources and methods of financing environmental protection in the Republic of Srpska as an entity within Bosnia and Herzegovina.

Keywords: *environment, ecological crisis, financing*

UVOD

Ekološka kriza simbolizuje stanje dostignutog stepena organizacije življenja ukupne civilizacije u XXI vijeku. S obzirom na veoma veliku zagađenost životne i radne sredine, kako u bivšoj Jugoslaviji tako i u drugim svetskim zemljama, nedvosmisleno se može konstatovati da danas postoji ekološka kriza. Sve to pokazuje da društvo mora promeniti ponašanje prema radnoj životnoj sredini, ukoliko želi veću dinamiku privrednog razvoja.

Do ekološke krize doveli su sledeći faktori¹:

1. rast stanovništva (demografska eksplozija, problemi hrane, rast gradova itd.);
2. nestašice sirovina i energenata;
3. zagađenje životne sredine;
4. ugrožavanje biološke raznolikosti i

¹ M. Črnjar: „Ekonomika i politika zaštite okoliša“, Ekonomski fakultet Sveučilišta u Rijeci, 2022., str. 22.

5. nerazumna eksploatacija prirodnih resursa.

Ekološki problemi su primećeni još u njihovoj kriznoj fazi i to u onom trenutku kada se uvidelo negativno povratno delovanje ekološkog sistema na društveni sistem. Konkretnije, oni su uočeni onda kada je priroda, zbog vlastite nemogućnosti samoregeneracije i samopročišćavanja od posledica čovjekovog delovanja, povratno se negativno odrazila na floru i faunu odnosno na celokupni život na zemlji.

Budući da su ekološki problemi toliko veliki da ukazuju na neminovnu neophodnost promene savremenog načina života, onda postoji i imperativ ekološke prilagodljivosti čoveka samoj prirodi, kao i potreba izgradnje nove ekološke etike. To znači da nam je danas neophodan veći stepen izgrađivanja ekološke svesti i dogovorene ekološke politike. Prema tome i tržišna ekonomija mora se svesno „ekološki usmeravati“.

Ni u kom slučaju ne treba tržišnu ekonomiju isključivati zbog ekoloških problema, jer ona ima brojne svoje pozitivne elemente. Dakle, moguće je postojanje tržišne ekonomije i ekološki orijentisanog društva. U toj konstelaciji odnosa tržište može u mešovitoj ekonomiji delovati u okvirima *ex ante* datih planskih orijentacija i veličina koje se odnose ne samo na pojedine zemlje nego i na ukupno čovečanstvo. Po našem mišljenju, mešana ekonomija: tržište i ekološka usmjerenost u razvoju je prihvatljiv stav koji danas ima sve više svojih pristalica. Međutim, da bi se sve ovo ostvarilo najrelevantnija dimenzija ove problematike predstavlja obezbeđenje izvora finansiranja životne sredine. Naime, nakon uopštenog fokusiranja izvora finansiranja zaštite životne sredine u pojedinim svetskim zemljama, pokušaćemo istražiti tu problematiku i u Republici Srpskoj.

1. IZVORI FINANSIRANJA ZAŠTITE ŽIVOTNE SREDINE

Politika zaštite životne okoline predstavlja dugoročnu delatnost koja zahteva ogromna finansijska sredstva. Njena uspešnost se temelji na osiguranju dodatnih, stalnih i stabilnih izvora finansiranja. Jedino se na taj način mogu ostvariti ciljevi i mere za zaštitu i unapređenje životne sredine. Svi troškovi finansiranja zaštite životne sredine predstavljaju javne rashode, koji su namenjeni unapređivanju njenog kvaliteta. Još od 70- tih godina XX vijeka javni troškovi zaštite životne sredine bili su podmirivani uglavnom iz državnog budžeta. Međutim, 80-tih godina sve više su se primenjivali ekonomski instrumenti kojima su se osiguravala sredstva za javne izdatke za zaštitu životne

sredine. Tako su ekonomski (ekološki) instrumenti obavljali dve relevantne funkcije:

1. stimulisali su sprečavanje zagađenja životne sredine i
2. postali su stalan izvor finansiranja zaštite životne sredine.

Ti ukupni izdaci ili troškovi zaštite životne sredine veoma su različiti u pojedinim zemljama. Tako, na primer:

1. pojedine zemlje poseduju snažnije izražene probleme zagađenja životne sredine od drugih zbog različite strukture industrijske proizvodnje, kvaliteta životne sredine i sl.;
2. prisutni su različiti standardi kvaliteta životne sredine u pojedinim zemljama i
3. neke zemlje primenjuju napredne tehnologije koje poseduju minimalan negativan uticaj na životnu sredinu.

Isto tako, u nekim zemljama se posebna pažnja pridaje zaštiti voda (Nemačka, Francuska) a u drugim se zemljama veći značaj pridaje zaštiti vazduha (Japan, SAD). Uostalom, to je sasvim i logično zbog različitih geografskih, klimatskih i razvojnih uslova koji su prisutni u tim zemljama. Upravo zbog toga se pri komparaciji visine sredstava za zaštitu životne sredine mora biti u potpunosti oprezan u zaključivanju. To znači da nekada relativno manja izdvajanja iz BDP-a ne moraju značiti da je i nivo zaštite životne sredine u dotičnoj državi nizak, budući da njena zaštita zavisi i od brojnih drugih faktora, a ne jedino od izdvojenih finansijskih sredstava.

Pored troškova za sprečavanje, kontrolu i zaštitu životne sredine, brojne zemlje ulažu i značajan dio sredstava u istraživanje na području ekologije i prirodnih nauka, a sve sa ciljem da bi se što bolje mogle shvatiti ekološke promene na Zemlji, odnosno kako bi se moglo što efikasnije suprotstaviti zagađivanju životne sredine.

Finansiranje zaštite životne sredine može se osigurati iz:

1. proračunskih sredstava države i jedinica samouprave;
2. opštih i posebnih fondova za zaštitu životne okoline;
3. sredstvima privrede i
4. kombinovanih izvora.

Što se tiče razvijenijih zemalja, one su još 70-tih godina XX veka usvojile načelo „zagađivač plaća“, prema kojem je zagađivač obavezan snositi sve troškove sprečavanja, kontrole i otklanjanja štete koju je sam prouzrokovao. Ovo načelo ne sadrži pružanje finansijske pomoći zagađivačima, osim u slučaju kada se uvode

velike novine u politiku zaštite životne sredine, odnosno kada se pojedine grane nalaze u velikim ekonomskim teškoćama, a nastoje uvesti nove, ekološki zdravije tehnologije.

Međutim, ubrzo se primetilo da to načelo nije bilo dovoljno za pokriće troškova zaštite životne sredine pa se uvelo i, drugo po redu načelo, „korisnik plaća“. Primenujući načelo „korisnik plaća“, može se stvoriti autonomni mehanizam za finansiranje zaštite životne sredine, pri čemu zagađivač i korisnik prirodnih dobara osiguravaju sredstva za zaštitu životne sredine koju ugrožavaju.

Budžetska sredstva za zaštitu životne sredine prikupljaju se na temelju zakonskih odredbi, pri čemu se najčešće insistira, zbog kontrole trošenja tih sredstava, na podnošenju javnih izveštaja. Međutim, glavni nedostatak takvog prikupljanja sredstava sastoji se u tome što ona zavise od stanja ili ekonomske snage budžeta i poreskih obveznika.

Ekonomski (tržišni) instrumenti u zaštiti životne sredine, za razliku od naredbodavnih i nadzornih instrumenata koji ne stvaraju prihode i najčešće čine dodatno finansijsko opterećenje lokalnog budžeta, stvaraju dodatne javne prihode uz neznatni vanredni trošak.

Ako se radi o naknadama, kao što su na primer: korisničke naknade za upotrebu vode, naknade za prikupljanje i odlaganje otpada, naknade za upotrebu cesta ili parkirališne takse koje pokrivaju troškove, onda u tom slučaju prikupljeni prihodi pomažu komunalnim službama da održe kvalitet svojih usluga u pogledu životne sredine, a istovremeno omogućavaju puni povrat troškova pod pretpostavkom da se ustanove na dovoljno visokom nivou.

Što se tiče prihoda od poreza i naknada/taksi u zaštiti životne sredine, oni se mogu upotrebljavati za finansiranje državnih programa podrške i sufinansiranja prioritarnih ulaganja u zaštitu životne sredine ili za druge javne potrebe koje nisu vezane za izdatke finansiranja zaštite životne sredine.

Prema tome, sasvim je jasno, da posebno danas u savremenim državama veoma važnu ulogu u zaštiti čovekove sredine imaju porezi i druge fiskalne takse. Zbog njihove namene za koje se uvode i ciljeva koji se njima žele postići, oni se nazivaju ekološkim ili eko porezima. U literaturi i svakodnevnom životu nazivaju se i „zelenim“ porezima, jer su ih najpre počeli zagovarati pripadnici pokreta i političkih stranaka u čijim programima rada je relevantno mesto pripadalo zaštiti prirode. Kada je reč o ovim porezima, treba podvući da se u praksi oporezivanja povlači jasna razlika između ekoloških poreza u užem i u širem smislu. Naime,

ekološki porezi u užem smislu su oni gde se uključuju dažbine koje su uvedene na dobra koja doprinose zagađivanju životne sredine (na primer, fosilna goriva, otpadne materije i sl.), odnosno proizvedena dobra kojih nema dovoljno za potrošnju zbog nivoa njihove zagađenosti (na primer, voda za piće). Prema nekim procenama, danas na Zemlji planeti postoji samo 3% pitke vode, posmatrano u odnosu na njenu ukupnu količinu.

Ekološki porezi u širem smislu podrazumevaju različite ekološke i druge slične dažbine (na primer, registraciona taksa). Naime, postoji mišljenje da bi i takse za nepoštovanje ekoloških standarda i ekoloških propisa trebalo svrstati u poreze u širem smislu, budući da ovaj ekološki instrument može itekako da utiče da se ekološki standardi podignu na viši nivo.

Iako su pojedine zemlje još 70-tih XX veka godina bile osnovale prve fondove za zaštitu životne sredine, ipak je tek 80-tih godina bila uočila korisnost namenskih fondova za zaštitu životne sredine i od tog trenutka bilo je započeto njihovo masovnije osnivanje. Nastanak i razvoj ekoloških fondova povezuje se s razvojem ekonomsko-ekoloških instrumenata politike zaštite životne sredine, pošto se najveći dio prihoda tih fondova obezbeđivao uglavnom od ekoloških taksa, kazni i naknada.

Bez obzira na različitost fondova za zaštitu životne sredine i njihove specifičnosti, njihovi zajednički ciljevi su¹:

1. unapređenje delatnosti i investicija za zaštitu i poboljšanje kvaliteta životne sredine;
2. minimiziranje stvaranja otpadaka;
3. stimulisanje razvoja ekološki povoljne ekonomske strukture;
4. pomaganje istraživačkih i razvojnih projekata i delatnosti;
5. unapređivanje zaštite prirodnih vrednosti i prirodnih staništa;
6. očuvanje biološke različitosti i
7. stimulisanje sticanja ekološkog obrazovanja i sistema praćenja životne sredine.

Fondovi za zaštitu životne sredine naročito su značajni za zemlje u tranziciji. U fazi ekonomskih i političkih promena koje su prisutne u tim zemljama, one menjaju svoj odnos prema privredi, kreću se prema decentralizaciji funkcija države, izgrađujući pri tome nov sistem finansiranja životne sredine. S obzirom da u državnom budžetu uglavnom nema dovoljno sredstava, a i opterećen je raznim troškovima reforme, konstituisanje fondova za zaštitu životne sredine ima za tranzicione zemlje nekoliko značajnih prednosti.

¹ I. Žuvela: "Politika zaštite okoliša u Republici Hrvatskoj", Zbornik, Pula, 2017., str. 7.

Fondovi za zaštitu životne sredine predstavljaju relevantan oblik finansiranja njene zaštite. Oni se javljaju u različitim oblicima, te se mogu razlikovati zbog:

1. različito postavljenih ciljeva;
2. različite organizacione strukture;
3. različitih pravila raspodele sredstava i
4. različite teritorijalne organizacije.

2. FINANSIRANJE ŽIVOTNE SREDINE U REPUBLICI SRPSKOJ

Budući da se i Bosna i Hercegovina, kao i sve druge bivše jugoslovenske republike nalaze još uvek u fazi privredne tranzicije, postoji neophodnost da se razmotre suštinske odredbe Zakona o fondu i finansiranju zaštite životne sredine u Republici Srpskoj, kao jednom od entiteta u okviru BiH.

Fond za zaštitu životne sredine i energetske efikasnost Republike Srpske je osnovan zakonom s ciljem prikupljanja i distribucije finansijskih sredstava za zaštitu životne sredine i unapređenje energetske efikasnosti na području Republike Srpske.

Delatnost Fonda obuhvata poslove u vezi sa prikupljanjem sredstava, kao i finansiranjem pripreme, sprovođenja i razvoja programa, projekata i sličnih aktivnosti u oblasti očuvanja, održivog korištenja, zaštite i unapređivanja životne sredine, te u oblasti energetske efikasnosti i korišćenja obnovljivih izvora energije, a naročito:

- a) stručne i druge poslove u vezi sa pribavljanjem, upravljanjem i korišćenjem sredstava Fonda;
- b) iniciranje, finansiranje, posredovanje i kontrolu realizacije projekata iz delokruga rada Fonda;
- v) posredovanje u vezi sa finansiranjem zaštite životne sredine, energetske efikasnosti i obnovljivih izvora energije iz sredstava međunarodnih organizacija, finansijskih institucija i tijela, kao i stranih pravnih i fizičkih lica;
- g) kontinuirano praćenje programa, projekata i ostalih aktivnosti kroz merljive efekte zaštite životne sredine, količinu uštedene energije i novca, i smanjenje emisije zagađivača;
- d) vođenje odvojenih baza podataka o programima, projektima i sličnim aktivnostima iz područja zaštite životne sredine, energetske efikasnosti i obnovljivih izvora energije, te o potrebnim i raspoloživim finansijskim sredstvima za njihovo ostvarivanje;

đ) podsticanje, uspostavljanje i ostvarivanje saradnje sa međunarodnim i domaćim finansijskim institucijama i drugim pravnim i fizičkim licima radi finansiranja zaštite životne sredine, energetske efikasnosti, kao i obnovljivih izvora energije u skladu sa interesima zaštite životne sredine Republike Srpske.

Prihodi Fonda za finansiranje zaštite životne sredine osiguravaju se iz:

- naknada koju plaćaju zagađivači životne sredine;
- naknada za opterećivanje životne sredine otpadom;
- sredstava ostvarenih po osnovu međunarodnih programa, projekata i drugih aktivnosti u oblasti zaštite životne sredine, energetske efikasnosti i obnovljivih izvora energije;
- naknada za zaštitu životne sredine koju plaćaju vlasnici transportnih sredstava koja koriste naftu ili naftne derivate u skladu sa Zakonom o vodama;
- priloga, donacija, poklona i pomoći;
- iz drugih sredstava u skladu sa zakonom.

Sredstva Fonda za zaštitu životne sredine i energetske efikasnost koristiće se naročito za sledeće namene¹:

- zaštitu, očuvanje i poboljšanje kvaliteta vazduha, vode, zemljišta i šuma, kao i ublažavanje efekata promene klime i zaštitu ozonskog omotača;
- saniranje deponija otpada, podsticanje smanjenja nastanka otpada, ponovnu upotrebu i reciklažu otpada;
- podsticanje na uvođenje tehnoloških procesa koji smanjuju ili potpuno eliminišu negativne uticaje na životnu sredinu;
- zaštitu i očuvanje biodiverziteta i geodiverziteta;
- podsticanje održivog korištenja zaštićenih prirodnih dobara;
- podsticanje čistijeg transporta;
- podsticanje unapređivanja energetske efikasnosti;
- podsticanje realizacije projekata energetske efikasnosti i obnovljivih izvora energije u javnom sektoru;
- podsticanje obrazovnih, istraživačkih, inovatorskih i razvojnih studija, programa i projekata iz oblasti zaštite životne sredine;
- finansiranje programa ekološkog obrazovanja i jačanja javne svesti o pitanjima očuvanja životne sredine i održivog razvoja.

Dosadašnja praksa je potvrdila da se kao najveći problem u pogledu finansiranja zaštite životne sredine nameće nenamensko trošenje sredstava prilikom

¹ Zakon o zaštiti životne sredine Republike Srpske, Banja Luka, 2020.g., str.8.

spvođenja programa i projekata usmerenih na zaštitu životne sredine a što je jednim dobrim delom posledica nedostatka svesti o potrebi zaštite životne sredine.

3. ENERGETSKA EFIKASNOST

Zakonom o energetskej efikasnosti RS uređuje se energetska efikasnost u finalnoj potrošnji, donošenje planova za unapređivanje energetske efikasnosti i njihovo sprovođenje, organizacija poslova na unapređivanju energetske efikasnosti, mjere za poboljšanje energetske efikasnosti i načini finansiranja energetske efikasnosti.

Ovaj zakon odnosi se na energetskej efikasnost u finalnoj potrošnji energije i prilikom pružanja usluga distribucije i snabdijevanja energijom, kao i na energetske karakteristike proizvoda koji koriste energiju.

Energetska efikasnost u sektoru građenja objekata uređuje se u skladu sa propisima za građenje objekata.

Cilj ovog zakona je da se primjenom politike i mjera za poboljšanje energetske efikasnosti u finalnoj potrošnji ostvari održivi energetski razvoj kroz:

- a) smanjenje negativnih uticaja na životnu sredinu,
- b) povećanje sigurnosti snabdijevanja energijom,
- v) zadovoljenje energetskej potreba svih potrošača,
- g) smanjenje emisije gasova koji izazivaju efekat staklene bašte (engl. Greenhouse Gases – GHG),
- d) podsticanje odgovornog ponašanja prema energiji,
- đ) smanjenje eksploatacije fosilnih goriva,
- e) racionalizaciju potrošnje energije,
- ž) povećanje konkurentnosti domaće privrede,
- z) eliminisanje energetskej siromaštva i
- i) ispunjavanje obaveza iz međunarodnih ugovora, sporazuma i konvencija.

Energetska usluga u smislu ovog zakona obuhvata aktivnosti i radnje koje dovode do mjerljivog ili procjenljivog poboljšanja energetske efikasnosti zgrada i drugih objekata, tehničkih sistema i proizvodnih procesa, odnosno ušteta energije koje se mogu izraziti u novcu primjenom energetskej efikasne tehnologije, odnosno postupaka kojima se postižu ušteta energije.

Energetskej uslugu pruža privredno društvo za energetske usluge (engl. Energy Service Company – ESCO) ili drugo pravno lice (u daljem tekstu: davalac energetskej usluge) na osnovu ugovora o energetskej usluzi.

Energetska usluga može obuhvatiti energetske pregled, projektovanje, građenje, rekonstrukciju, energetske sanacije, održavanje, savjetovanje ili upravljanje i nadzor nad korišćenjem energije.

Za obavljanje poslova energetske usluge, projektovanja, građenja i rekonstrukcije zgrada, davalac energetske usluge mora ispunjavati uslove u skladu sa propisima za građenje objekata.

Davaoci energetske usluge samostalno nude i pružaju energetske usluge po konkurentskim cijenama.

Ponuda energetske usluge obavezno sadrži podatke o davaocu energetske usluge, mjere za poboljšanje energetske efikasnosti, cijene, mehanizme finansiranja, model ugovora i druge informacije.

Naručilac i davalac energetske usluge zaključuju ugovor o energetskej usluzi u pisanoj formi koji obavezno sadrži:

- a) podatke o potrošnji energije prije davanja energetske usluge,
- b) podatke o troškovima za energiju prije davanja energetske usluge,
- v) procjenu stanja energetske efikasnosti prije davanja energetske usluge,
- g) mjere za poboljšanje energetske efikasnosti koje će se primjenjivati,
- d) iznos garantovanih ušteda energije ili materijalne koristi,
- đ) način utvrđivanja i verifikovanja ušteda energije i
- e) način plaćanja naknade za pružanje energetske usluge.

Troškove pružanja energetske usluge snosi naručilac energetske usluge ili davalac energetske usluge, u potpunosti ili djelimično, iz vlastitih izvora ili kroz finansiranje treće strane.

Vrijednost investicije za pružanje energetske usluge koju je uložio davalac energetske usluge otplaćuje se od ušteda energije ostvarenih u odnosu na potrošnju energije prije davanja energetske usluge.

ZAKLJUČAK

U današnjim okolnostima, kada su razvoj i zaštita životne sredine suprostavljene, potreba za zaštitu životne sredine predstavlja imperativ svake društvene zajednice pa i našeg društva u celosti. Prema tome, veća dinamika društveno-ekonomskog razvoja zahteva primenu veoma čistih proizvodno-tehnoloških

sistema, koji će moći ako ne u potpunosti sprečiti a onda bar minimizirati zagađenje radne i životne sredine. Naravno, za sve to potrebne su i pozamašne investicije koje *de facto* nedostaju gotovo u svakoj privredno nerazvijenoj zemlji pa i u Republici Srpskoj. Očigledna je potreba za uspostavljanjem efikasne zaštite životne sredine u našoj zemlji zbog prethodno pomenutih problema.

To znači da ekološka pitanja moraju postati predmet odlučivanja svih državnih institucija, preduzeća i ljudi.

Troškovi finansiranja zaštite životne sredine su veoma visoki te je stoga neophodno što pre obezbediti dodatna finansijska sredstva za zaštitu životne sredine. To predstavlja i ključni problem svake zemlje a posebno je izražen u privredno nedovoljno razvijenim zemljama, u kojima je ova problematika posebno danas aktuelna.

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ANALYZING ENERGY RETROFIT AND INDOOR ENVIRONMENT OF THE PUBLIC BUILDING IN SERBIA

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ABSTRACT:

The basic research question is what measures can be taken to improve public buildings in terms of improvement of energy efficiency while maintaining or upgrading optimum values of the comfort for the occupants. The research should provide basic guidelines for measures to improve the use of thermal insulation materials on the building's thermal envelope in the aim of energy saving. The subject of the this paper is the examination of possibilities for optimizing energy performance in the rehabilitation processes of universal sports halls within the sports centres, as well as the suitability of applied measures in accordance with prescribed thermal comfort conditions for this type of facilities. The results can have a practical application because improvement measures aimed at energy optimization of existing sports facilities were investigated and represent a real case study, selected building existing in Belgrade. Most of the buildings of this kind in Serbia were built from 1960 to 1980. Energy sources in these kinds of buildings are traditional, fossil fuel based. Since regulations on energy efficiency are more stringent today, these facilities must be renovated and then well maintained in terms of energy consumption. The case study includes sport centre Vozdovac built in 1976. in Belgrade. Different Passive House measures applied on the building, measures related with reduction of total energy for space heating and conditions of the indoor environment were simulated in software package Integrated Environmental Solutions Virtual Environment.

Keywords: *sports building; energy efficiency; thermal envelope improvement, comfort*

1. INTRODUCTION

Most sports facilities in Serbia, particularly in Belgrade, were built between 1960 and 1980, sharing similar features. These facilities typically consist of a main sports hall and ancillary areas to support regular operations. The main sports hall is versatile, accommodating various indoor team sports such as basketball, volleyball or handball. These centers are compartmentalized for the public, players, management, and technical equipment.

Energy consumption in these structures varies depending on factors like location, size, and building materials used. It includes thermal energy for heating and electrical energy for equipment operation, air conditioning, ventilation, and lighting. Climate conditions play a significant role in energy usage, with average consumption ranging from 260 kWh/m² in Mediterranean climates to 490 kWh/m² in continental climates for large sports buildings. The desired comfort levels for different user groups, including the public and players, as well as the services provided within the center, have a notable impact on energy consumption. Many existing sports buildings fail to meet contemporary environmental standards. Achieving comfort in these facilities requires attention to both spectators and players. This article concentrates on improving the energy efficiency of the Vozdovac sports center's envelope. The main sports hall and the rest of the building, known as administration, are treated as separate thermal zones due to differences in comfort requirements. [1]

2. CASE STUDY

The sports centre Vozdovac is situated in the outskirts of Belgrade, towards the southwest, approximately 5 km away from the city center. The building is positioned on the periphery, bordering a forested area. The layout and the visual representation of both the exterior and interior parts of the building are illustrated in Figure 1.



Fig. 1. Layout and the entrance of Sports Center "Voždovac"

The building under consideration possesses several structural and architectural features that hold significance for the subsequent analysis. It comprises two stories with a total floor area of 6098.86 m², inclusive of the basement. The main sports hall, with a seating capacity of 2000, is positioned at the center, having seats on both sides of the court. The total façade area, including basement amounts to 2635.6 m², with 35.8% of it being glazed. Window opening area is 212.46 m². The structural system is a metal skeleton, complemented by brick walls serving as infill.

Additional crucial details includes information about working hours and the Heating, Ventilation, and Air Conditioning (HVAC) system implemented within the structure and those are taken into consideration while simulating existing and improved conditions [2].

3. METHODOLOGY

The methodological approach consisted of the following steps:

1. Assessment of the existing building model: Initially, the current state of the building was evaluated.
2. Identification of thermal envelope elements requiring refurbishment: Elements were prioritized based on the highest transmission losses, determined by the extent of these losses.
3. Definition of measures for energy improvement: Architectural refurbishment actions were proposed to meet the conditions outlined by EnerPHit/EnerPHit+ regulations (Passive House Certificate for retrofits) [3], resulting in the creation of Scenario 1 and 2. Scenario 1 presents improvement of the thermal envelope of the sports hall only, Scenario 2 presents improvement of the thermal envelope of the rest of the building excluding sport hall. Scenario 1+2 presents improvement of the thermal envelope of the whole building.
4. Analysis of the effects of the applied measures: Parameters such as final energy ($Q_{h,nd}$ [kWh/m²a]) and achieved comfort conditions were evaluated. The effects of each measure were assessed individually and cumulatively.
5. Comparative analysis of Scenario 1 and Scenario 2, as well as Scenario 1+2: The outcomes of the different scenarios were examined in detail to determine their relative effectiveness.

Comfort conditions for the sport hall were evaluated for each proposed scenario. [3]

4. RESULTS

The energy performances of the existing building, as well as the models for Scenario 1, Scenario 2, and Scenario 1+2 after the application of different energy efficiency measures, are simulated using the Integrated Environmental Solutions Virtual Environment 2017 software package, IES VE. The case study model is generated in SketchUp 2016 and then transferred to IES VE 2017, as depicted in Figure 2. The total floor area of the heated space within the sports center is 6,098.85 m², and the overall heated volume of the building is measured at 35,529.56 m³. [1]

4.1. Thermal comfort

The position of the hall within the facility is shown in Figure 2. The hall area is 2395.4 m², the volume of the space is 21747.5 m³, the surface area of the exterior wall is 884.1 m², and the opening area is 460.4 m².

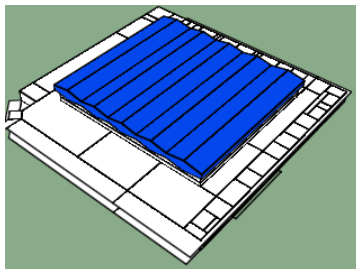


Figure 2. Position of the universal sports hall within the facility

After improvement of the thermal envelope by Scenario 1 the universal sports hall reaches its maximum temperature on July 11th at 17:30, reaching 31.1°C. During 41% of the total occupancy hours of the hall, the air temperature is higher than 16°C, which is set as the lower limit in simulating conditions during the heating period. This is considered highly unfavorable for sports activities. The lowest temperature of 2°C is reached on December 25th (Figure 3).

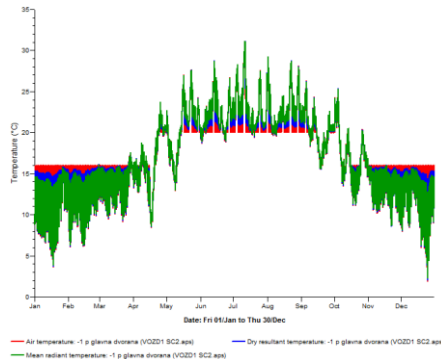


Figure 3. Air temperature in the universal sports hall of the model over the course of a year based on the Apache module, VistaPro, IES VE

The comfort index during the winter period ranges from 3-4% (from uncomfortably cold to pleasantly cool), while in the summer period, it ranges from 7-9% (from pleasant to moderately warm). During 73.2% of the time spent in the hall, the comfort index is less than 6, indicating conditions ranging from uncomfortably cold to cool. About 21.4% of the total hours are considered comfortable in the hall, while only 8% of the time is moderately warm during the summer period (Figure 3). The comfort index is higher than 8 during 5.4% of the total hours spent in the space. [1]

4.2. Comparative analysis of Scenario 1, Scenario 2 and Scenario 1+2

When it comes to Scenario 2, improvement of the rest of the building (excluding sports hall) and Scenario 1+2 energy consumption is analyzed. The comparative analysis of Scenario 1, Scenario 2, and the combined Scenario 1+2 concerning energy consumption and comfort level is presented in Table 5 and Figure 12. When Scenario 1 is integrated with Scenario 2, encompassing the entire building refurbishment, a 64.9 % energy saving is attained. The building is elevated from an E to a C energy level, consistent with the outcome of Scenario 1.

Table 5. Comparison of results of energy consumption for Scenario 1, 2 and 1+2

Results of the simulations	Existing	Scenario 1	Scenario 2	Scenario 1+2
Q _{hnd} [MWh]	1,021.7	494.3	810.5	358.5
Energy level Q _{h, nd, rel}	E	C	E	C

Energy saving after package of measures [%]		51.6 %	20.7%	64.9%
Office- Comfort index, when occupied 6-8	21.4 %	15.5 %	-	15.5% (hall)
Main sport hall- Comfort index, 6-8	13.4 %	-	21.6%	24.6% (hall)

The comparative analysis of energy consumption, results shown in Table 5 of the Scenario 1, 2 and 1+2 are presented in Figure 12 .

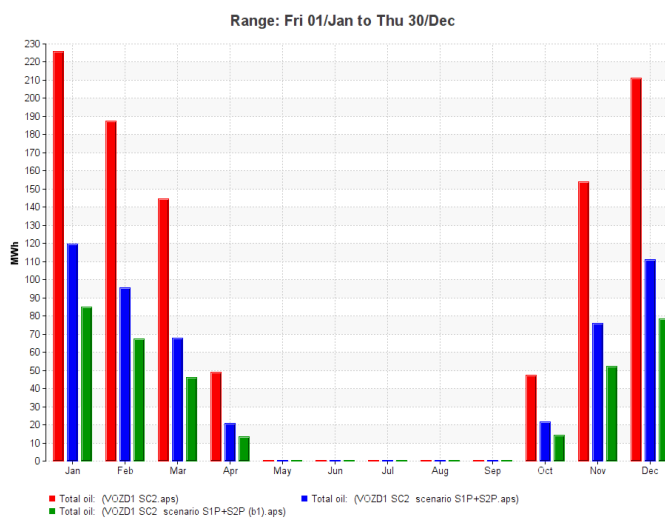


Figure 12. Energy consumption for Sports center Vozdovac for Scenarios 1, 2 and 1+2

5.CONCLUSION

The implementation of specific refurbishment measures, focusing on enhancing the thermal performance of both transparent and non-transparent components of the thermal envelope, significantly reduces energy consumption for space heating.

In Scenario 1, which involves improving the building excluding the main sports hall, overall office space comfort is enhanced by 15.8 %. However, there is a decrease in the percentage of comfortable hours in the office during the occupancy period. The estimated energy savings for space heating amount to 51.6 %.

In Scenario 2, where the thermal envelope of the main sports hall is improved, there is a 20.7 % reduction in energy consumption for heating. Number of hours with positive comfort index is increased from 13.4 % to 21.6 % out of total occupancy, attributed to the presence of two groups of occupants with different comfort requirements – spectators and players engaging in physically demanding activities.

By combining both scenarios (1 and 2), a notable energy savings of 64.9 % for space heating is projected. The research concludes that, if the goal is to improve the energy class, implementing Scenario 1 alone yields the same effect as the implementation of Scenario 1+2 with similar comfort index but significant energy saving.

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VIŠEKRITERIJUMSKI PRISTUP OBNOVI NAPUŠTENIH PODRUČJA: IZBOR METODA REMEDIJACIJE

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SAŽETAK:

Regeneracija područja koja više nisu aktivna, a koja su opterećena prethodnim korišćenjem predstavlja važan segment rezilijentnosti gradova na globalne izazove 21. veka. Tragovi prošlih aktivnosti ovih područja danas se jasno vide kroz zaostavštinu zapuštenih objekata i drugih infrastrukturnih postrojenja, koje često prati prisustvo zagađivača u tlu. Iz tog razloga se kao jedan od primarnih preduslova obnove i ponovne upotrebe napuštenih područja izdvaja sprovođenje remedijacije zemljišta. U zavisnosti od tipa zagađivača i njegove koncentracije u tlu, vrši se izbor optimalne metode remedijacije. U procesu izbora odgovarajuće metode potrebno je uzeti u obzir uticaj metode na okruženje, kompleksnost sprovođenja postupka, troškove, stepen efikasnosti i potrebno vreme za uklanjanje zagađivača. Rad istražuje višekriterijumski pristup u fazi obnove napuštenih područja koja se odnosi na izbor metoda remedijacije. Primenom metoda Analitičkog Hijerarhijskog Procesu (AHP), razmatrajući različite aspekte izbora metoda sanacije, rad ima za cilj da sprovede rangiranje bioloških, fizičko-hemijskih i termičkih metoda remedijacije tla i ukaže na najznačajnije metode u uklanjanju zagađivača.

Ključne reči: višekriterijumski pristup, AHP metod, remedijacija tla, napuštena područja

1. UVOD

Savremena graditeljska praksa mahom je usmerena ka zauzimanju slobodnih površina za izgradnju objekata. Ovakav pristup uz proces urbanizacije vodi širenju gradova ka perifernim slobodnim područjima. Usled neracionalnog korišćenja zemljišta i činjenice da je slobodnih površina sve manje na raspolaganju [1], nameće se potreba za strateškim upravljanjem i restrukturiranjem nedovoljno iskorišćenih i potpuno napuštenih područja, među kojima su i braunfildi. Ova područja predstavljaju degradiraju urbano okruženje u vizualnom, ekonomskom, socijalnom i ekološkom pogledu. Njihovo postojanje često uslovljava smanjenje ekonomske vrednosti nekretnina susednih područja, smanjenje bezbednosti usled povećanja stepena kriminala, iseljavanje okolnog stanovništva i gubitak

identiteta samog dela grada [2]. Ukoliko se osvrnemo na neke od prethodnih namena ovih prostora, neminovno je da pojavu braunfilda prati i određeni stepen zagađenja životne sredine, čime direkto utiču na narušavanje zdravlja, i umanjuju kvalitet života ljudi u gradu [3]. Negativan ekološki uticaj ovih područja, ogleda se prvenstveno u zagađenju zemljišta.

Kontaminacija zemljišta uzrokovana je nekontrolisanim ispuštanjem čvrstih i tečnih zagađujućih materija, usled prethodnog načina korišćenja, i njihovog mešanja sa materijama koje su prirodno prisutne u zemljištu [4]. Kada je reč o bivšim poljoprivrednim dobrima, zemljište ovih područja je zagađeno različitom vrstom pesticida i otrova koje dospevaju i do nivoa podzemnih voda. Deponije narušavaju okolno zemljište prisustvom toksičnih materija iz otpada. Kao vodeći zagađivači životne sredine izdvajaju se napušteni industrijski kompleksi i postrojenja. Usled zastarelih tehnologija proizvodnje i lošeg postupanja sa štetnim materijama, na područjima bivših industrija izražen je visok nivo kontaminacije tla, pri čemu su najopasniji otpadi i hemikalije iz hemijske i naftne industrije, metalurgije i industrije boja i lakova. Istraživanja su pokazala da je sadržaj teških metala u tlu u okolini ovih postrojenja i do 10.000 puta veći od prirodnog [5]. Na ovim lokacijama nailazimo na stare infrastrukturne instalacije, podzemne i nadzemne rezervoare, skladišta goriva, transformatorske stanice i ostalu industrijsku opremu.

Dekontaminacija zagađenog zemljišta neizostavan je korak u procesu regeneracije napuštenih područja. U cilju potpunog uklanjanja ili smanjenja zagađenja na nivo koji neće predstavljati pretnju po životnu sredinu i ljude, neophodno je primeniti neke od metoda dekontaminacije, koje su označene kao tehnologije remedijacije zemljišta. Danas geotehnika nudi mnoge tehnologije remedijacije koje su prema prirodi podeljene na termičke, fizičko-hemijske i biološke metode [6]. Izbor tehnologije remedijacije zavisi od prirode zagađenja zemljišta, cene, složenosti postupka, vremena potrebnog za dekontaminaciju, efikasnosti metode, i uticaja koji postupak ima na životnu sredinu [7].

U procesu odlučivanja koja tehnika sanacije je najoptimalnija, višekriterijumski pristup može biti pogodan alat podrške. Rad se bavi problemom izbora odgovarajuće tehnike remedijacije zemljišta korišćenjem metode Analitičkog Hijerarhijskog Procesu (AHP). Uzimajući u obzir aspekte uticaja na životnu sredinu, troškova, složenosti postupaka, stepena efikasnosti i potrebnog vremena, istraživanje ima za cilj da rangira 18 tehnika remedijacije kako bi se izdvojile najoptimalnije procedure za sanaciju tla napuštenih područja. S obzirom na raznovrsnost prethodnog načina korišćenja napuštenih područja, za potrebe ovog rada uzet je primer područja čija ne prethodna namena bila industrijska proizvodnja.

2. PREGLED METODA REMEDIJACIJE ZEMMLJIŠTA

Remedijacija zemljišta predstavlja skup različitih metoda i tehnika kojima se zagađeno zemljište tretira u cilju potpunog uklanjanja zagađenja ili njegovog svođenja na stepen koji neće predstavljati pretnju po životnu sredinu i ljude [4,5]. Kontaminacija zemljišta se utvrđuje odgovarajućim hemijskim analizama uzoraka tla i fizičkim merenjima. Kao osnovni zagađivači zemljišta ističu se teški metali, aromatični ugljovodonici, policiklični aromatični ugljovodonici i pesticidi. Sve metode remedijacije zemljišta mogu se klasifikovati na osnovu kriterijuma vezanog za mesto njihovog sprovođenja kao in-situ metode i ex-situ metode [6,8]. In-situ metode obuhvataju tehnologije kojima se zagađujuće materije iz zemljišta uklanjaju na licu mesta, bez ili sa iskopavanjem zemljišta,

a ex-situ metode obuhvataju tehnologije kod kojih se zemljište iskopava i transportuje do mesta namenjenog za uklanjanje zagađujućih materija. Prema karakteru metode remedijacije zemljišta svrstavaju se u fizičko-hemijske, termičke i biološke metode [6]. Uredni prikaz svih vrsta metoda remedijacije dat je Tabelom 1.

Tabela 1. Pregled najčešće primenjenih metoda remedijacije zemljišta [8-10]

	In-situ metode	Ex-situ metode
Fizičko - hemijske metode	Elektrokinetička rem. (F ₄) Ispiranje zemljišta (F ₃) Ekstrakcija parom (F ₆) Solidifikacija (F ₅)	Redukcija/oksidacija (F ₂) Hemijska ekstrakcija (F ₁) Ispiranje zemljišta (F ₃) Ekstrakcija parom (F ₆) Solidifikacija (F ₅)
Termičke metode	Vitrifikacija (T ₆) Napredna termička ekstrakcija parom (T ₂)	Vitrifikacija (T ₆) Pirroliza (T ₃) Spaljivanje (T ₄) Dekontaminacija gasom (T ₅) Termička desorpcija (T ₁)
Biološke metode	Landfarming (B ₅) Bioventilacija (B ₃) Bioremedijacija (B ₂) Fitoremedijacija (B ₁)	Biošipovi (B ₄) Landfarming (B ₅) Bioreaktor za mulj (B ₆)

Fizičko-hemijske metode remedijacije koriste fizičke i hemijske zakone da transformišu toksična jedinjenja u netoksična. Ove tehnologije u izvesnoj meri stvaraju nusproizvode koji štetno utiču na životnu sredinu. U procesu regeneracije napuštenih područja primenjuju se hemijska ekstrakcija, hemijska oksidacija, ispiranje zemljišta, elektrokinetička sanacija, očvršćavanje i stabilizacija, kao i ekstrakcija parom. Hemijska ekstrakcija i hemijska oksidacija predstavljaju metode koje dodavanjem organskih jedinjenja i oksidanata hemijskim reakcijama efikasno uklanjaju toksične materije iz zemljišta. Slična metoda je ispiranje tla, koje se zasniva na dodavanju vode u zemljište. Elektrokinetička remedijacija je metoda kojom se kontaminacija uklanja električnom energijom. Iako pokazuje uspešne rezultate, njegova dugotrajna primena menja pH vrednost i povećava kiselost zemljišta [9]. Solidifikacija i stabilizacija predstavljaju procese koji imobilizuju kontaminaciju dodavanjem odgovarajućeg minerala ili cementa, pri čemu se zagađenje ne uklanja potpuno [10]. Najštetniji metod sanacije je ekstrakcija parom, jer vakuumski pritisak koji se koristi često može povećati nivo podzemnih voda.

Termičke metode remedijacije smatraju se najefikasnijim metodama kratkotrajnog tretmana i koriste postupke termičkog zagrevanja, sagorevanja i topljenja. Zbog svog karaktera predstavljaju i metode koje u velikoj meri zagađuju životnu sredinu nusproizvodima termičkih procesa. Najčešće se koriste: termička desorpcija, termička ekstrakcija parom, pirroliza, sagorevanje, dekontaminacija gasa i vitrifikacija. Termička desorpcija je proces korišćenja toplote u cilju povećanja nestabilnosti zagađujućih materija i njihovog uklanjanja. Sa druge strane, termička ekstrakcija parom predstavlja poboljšani

fizički metod ekstrakcije parom. Pošto ove metode ne uključuju sagorevanje, smatraju se najpogodnijim termičkim metodama u pogledu uticaja na životnu sredinu. Koristeći pirolizu i sagorevanje, složena jedinjenja se razlažu na jednostavnija ili se toplotom potpuno uništavaju. Međutim, kao štetni nusproizvod javlja se dim i isparenja koji zagađuju vazduh. Najštetnije metode termičke sanacije su dekontaminacija gasom i vitrifikacija. Dekontaminacija gasom se zasniva na ubrizgavanju vrelog gasa u iskopano tlo, dok se vitrifikacija zasniva na upotrebi toplote za topljenje zagađivača.

Biološke metode remedijacije zemljišta zasnivaju se na sprovođenju prirodnih bioloških procesa unutar strukture zemljišta, uz podršku biljaka, kiseonika i mikroorganizama. Kao rezultat njihove primene, zagađivači se transformišu u supstance smanjene ili potpuno uništene toksičnosti. U procesu regeneracije napuštenih područja najviše se koriste fitoremedijacija, bioremedijacija, bioventilacija, bio-šipovi, bioreaktor za mulj i „landfarming“ tehnika. Primena bioremedijacije i fitoremedijacije nema štetnih uticaja na životnu sredinu. Metoda fitoremedijacije koristi biljke, gljive i alge kao sredstva za upijanje i uklanjanje zagađenja. S druge strane, bioremedijacija se definiše kao proces kojim se mikroorganizmi stimulišu da razgrađuju organske zagađivače u zemljištu do nivoa bezbednog za životnu sredinu [8]. Proces bioventilacije zasniva se na uvođenju vazduha u zemljište kako bi se ubrzala aktivnost mikroorganizama. Primena bio-šipova zasniva se na mešanju iskopane zemlje sa zemljom dobrog kvaliteta. Landfarming metod predstavlja mešanje iskopanog zemljišta poljoprivrednim aktivnostima. Implementacija bioreaktora je slična obradi zemljišta, ali se odvija u strogo kontrolisanim uslovima u zatvorenoj komori, gde se zemljište meša sa vodom do odvajanja peska i mulja [11].

3. VIŠEKRITERIJUMSKO ODLUČIVANJE (MCDM)

Višekriterijumsko odlučivanje (MCDM) je jedan od glavnih problema donošenja odluka koji ima za cilj da odredi najbolju alternativu uzimajući u obzir više od jednog kriterijuma u procesu selekcije. MCDM ima mnogo alata i metoda koje se mogu primeniti u različitim oblastima od finansija do inženjerskog dizajna. Ne postoji odluka na koju se može računati bez upućivanja na proces donošenja odluka. Donošenje odluka, kao složen proces, je program za rešavanje problema koji ima za cilj da odredi poželjan rezultat s obzirom na različite aspekte. Ovaj proces može biti racionalan ili iracionalan, a sa druge strane, može koristiti implicitne ili eksplicitne pretpostavke na koje utiče više faktora kao što su fiziološki, biološki, kulturni, društveni, itd. Svi ovi aspekti zajedno sa autoritetom i nivoom rizika mogu uticati na nivo složenosti procesa donošenja odluka.

Danas se složeni problemi donošenja odluka mogu rešiti korišćenjem matematičkih jednačina, mnogostrukih statistika, matematike, ekonomskih teorija i kompjuterskih uređaja koji pomažu da se automatski izračunaju i procene rešenja problema donošenja odluka. Praktično, MCDM se koristi da se bavi strukturiranjem, donošenjem odluka i koracima planiranja kada domen poseduje višestruke kriterijume za postizanje optimalnog rešenja zasnovanog na preferencijama onih koji odlučuju.

Postoji nekoliko tipova MCDM metoda koje su razvili ili poboljšali različiti autori tokom poslednjih decenija. Glavne razlike između ovih metoda odnose se na nivo složenosti algoritama, metode ponderisanja kriterijuma, način predstavljanja kriterijuma za procenu preferencija, neizvesnu mogućnost podataka i konačno, tip agregacije podataka. Pored toga, svi različiti tipovi MCDM poseduju specifične i različite prednosti i nedostatke

za koje se očekuje da budu objašnjene posebno na osnovu metoda. Na primer, Analitički hijerarhijski proces (AHP) koji je primenjen u ovom radu je jednostavan za korišćenje i suočava se sa problemima zbog međuzavisnosti između kriterijuma i alternativa. Postoje različiti načini tumačenja rešavanja MCDM problema. Proces se može smatrati izborom najbolje (najpoželjnije) alternative iz skupa alternativa. To se takođe može objasniti kao grupisanje alternativa (u višestruke skupove preferencija) i zatim odabiranje malog skupa od njih. U matematičkom obliku, MCDM problem je definisan kao:

$$A = \{A_i \mid i = 1, \dots, m\} \quad (1)$$

gde je A poseban i konačan skup alternativa, a m predstavlja njihov broj.

$$C = \{C_j \mid j = 1, \dots, n\} \quad (2)$$

gde je C skup određenih kriterijuma koji se koriste za procenu A , a n je njihov broj.

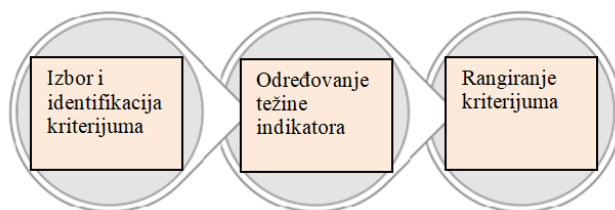
$$W = \{w_j \mid j = 1, \dots, n\} \quad (3)$$

gde je W skup normalizovanih težina koje se dodeljuju svakom kriterijumu na osnovu njihove važnosti. Matematički oblik skupova o kome se govori je jednostavan način da se definiše MCDM problem, a dobijene informacije se obično organizuju kao matricni oblik.

Tabela 2. Matrica višekriterijumskog odlučivanja

MCDM matrica	C_1	C_2	...	C_n
A_1	a_{11}	a_{12}	...	a_{1n}
A_2	a_{21}	a_{22}	...	a_{2n}
...	a_{ij}	...
A_m	a_{m1}	a_{m2}	...	a_{mn}

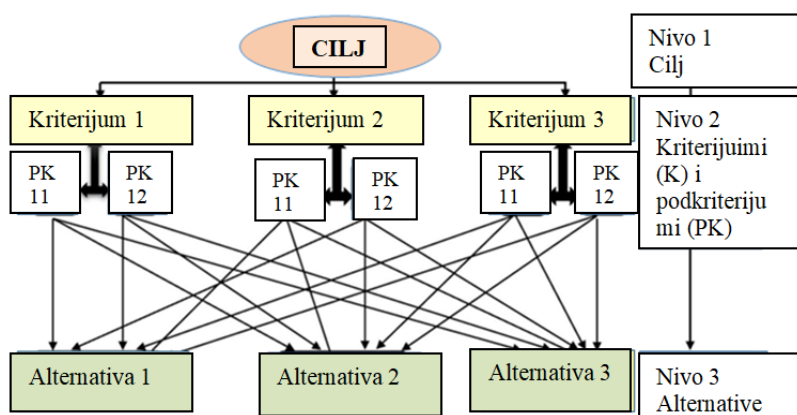
Matrica A i vektor težina $W = \{w_1, w_2, \dots, w_n\}$ su osnovni ulazi za MCDM probleme. U stvari, MCDM ocenjuje alternative i uređuje ih ih od najboljih prema najgorim. Glavni koraci svih MCDM problema prikazani su na Slici 1.



Slika 1. Koraci u MCDM metodu (Izvor: autori)

3.1. Analitički hijerarhijski proces (AHP)

Analitički hijerarhijski proces (AHP) je metod koji se primenjuje kao podrška kod donošenja odluka i zasniva se na formiranju hijerarhije problema. U originalnoj proceduri se vrši vrednovanje (upoređivanje) kriterijuma po nivoima hijerarhije dok se u konačnoj sintezi ne utvrde težine svih kriterijuma (alternativa) na najnižem nivou u odnosu na kriterijume na najvišem nivou [12,13]. U opštem slučaju hijerarhija sadrži cilj, kriterijume i alternative kao na Slici 2.



Slika 1. Hijerarhijska struktura AHP metoda (Izvor: autori)

Donosilac odluka upoređuje kriterijume (podkriterijume) u datom nivou hijerarhije međusobno, svaki sa svakim, u odnosu na sve (nadređene) indikatore u višem nivou hijerarhije. Sa Slike 2 to znači da se prvo u parovima upoređuju svi kriterijumi u odnosu na cilj, a zatim sve alternative u parovima posebno za svaki kriterijum. Svako poređenje se vrši davanjem numerčkih ocena prema Satijevoj skali [14] (Tabela 2).

Tabela 2. Satijeva skala [14]

Numerička ocena	Opis
1	Jednake važnosti
3	Slaba dominacija
5	Jaka dominacija
7	Demonstrirana dominacija
9	Apsolutna dominacija
2,4,6,8	Međuvrednosti

Ocene poređenja parova kriterijuma (podkriterijuma) na datom nivou hijerarhije unose se u matricu poređenja koja je recipročna, odnosno elementi iz gornjeg trougla su simetrično recipročni elementima iz donjeg trougla, dok su elementi na glavnoj dijagonali jednaki 1. Potrebno je izračunati indeks konzistentnosti CI i stepen konzistencije CR za matricu poređenja $P = (p_{ij})_{n \times n}$ sa $CI = \frac{\lambda_{max} - n}{n - 1}$, $CR = \frac{CI}{RI}$, gde λ_{max} je maksimalna sopstvena vrednost, i RI je prihvaćeni slučajni indeks matrice P [12,13]. Vrednost $CR \leq 0.10$ podrazumeva da prihvatamo procenjene elemente matrice, dok u suprotnom moramo otkloniti razloge za nepoželjno visoke ocene i ponavljati poređenje u parovima sve dok stepen konzistentnosti ne dođe u poželjne granice.

4. REZULTATI

U Tabeli 3 dat je prikaz konačnih rezultata rangiranja metoda remedijacije zemljišta napuštenih područja koja su prethodno imala industrijsku namenu. Evaluacija metoda remedijacije sprovedena je od strane eksepata s višegodišnjim iskustvom u naučnoistraživačkom radu i praksi iz oblasti geotehnike.

Rezultati pokazuju da je uzimajući u obzir sve analizirane aspekte najoptimalnije primeniti metode napredne termičke ekstrakcije parom (T_2), fitoremedijaciju (B_1), i spaljivanje (T_4). Tabela pokazuje da prednost imaju termičke metode remedijacije, pri čemu su u top 10 rangiranih tehnika prepoznate piroliza (T_3) i dekontaminacija gasom (T_5). Pored fitoremedijacije, od bioloških metoda najbolje su rangirani metode bioventilacija (B_3) i bioremedijacija (B_2). Najbolje rangirane fizičko-hemijske metode su elektrokinetička remedijacija (F_4) i ispiranje zemljišta vodom (F_3).

Tabela 3. Finalno rangiranje metoda remedijacije zemljišta

Metodi remedijacije	Konačne težine
T2 - Napredna termička ekstrakcija parom	0.1135
B1 - Fitoremedijacija	0.1047
T4 - Spaljivanje	0.0979
T3 - Piroliza	0.0749
T5 - Dekontaminacija gasom	0.0739
B3 - Bioventilacija	0.0710
F4 - Elektrokinetička rem.	0.0668
B2 - Bioremedijacija	0.0614
T1 - Termička desorpcija	0.0579
F3 - Ispiranje zemljišta	0.0385
B6 - Bioreaktor za mulj	0.0367
F5 - Solidifikacija	0.0363
B5 - Landfarming	0.0338
F1 - Hemijska ekstrakcija	0.0334

F2 - Redukcija/oksidacija	0.0334
T6 - Vitifikacija	0.0315
B4 - Biošipovi	0.0177
F6 - Ekstrakcija parom	0.0166

5. ZAKLJUČAK

U okviru težnji ka dostizanju održivog razvoja, posebna pažnja posvećuje se regeneraciji napuštenih područja, i stvaranju mogućnosti njihovog ponovnog korišćenja. Imajući u vidu ekološku opterećenost ovih lokacija, u cilju njihove obnove sanacija se nameće kao osnovni preduslov. Opterećenje površinskih slojeva zemljišta velikim količinama otpadnih materija, koje se ne mogu razgraditi procesima samopročišćavanja, dovodi do narušavanja njegovog kvaliteta, sa negativnim posledicama po životnu sredinu i zdravlje ljudi. Zbog toga je važno pristupiti sprovođenju postupaka kojima se kvalitet zemljišta inicirano i ubrzano obnavlja, a koji su označeni kao remedijacione tehnologije.

U ovom radu, primenom višekriterijumske analize i metoda Analitičkog Hijerarhijskog Procesu (AHP) sprovedeno je rangiranje metoda remedijacije zemljišta na primeru područja koje je prethodno imalo industrijsku aktivnost. Radom je obuhvaćeno 18 fizičko-hemijskih, termičkih i bioloških metoda remedijacije zemljišta. Evaluacija metoda sprovedena je uzimajući u obzir aspekte cene, složenosti postupka remedijacije, vremena potrebnog za sprovođenje postupka, uticaja koji postupak ima na životnu sredinu i vrste zagađivača. Dobijeni rezultati ukazuju da je neoptimalnije primeniti termičku ekstrakciju vodenom parkom i fitoremedijaciju.

Primenjena metodologija može se praktično koristiti u procesima donošenja odluka u različitim aspektima životne sredine zaštite. S obzirom da je u ovom istraživanju rangiranje metoda remedijacije izvršeno na primeru napuštenih industrijskih područja, buduća istraživanja će u obzir uzeti i druge prethodne namene prostora - vojna zemljišta, poljoprivredna zemljišta itd.

Zahvalnica: Ovo istraživanje je podržalo Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, prema Ugovoru o istraživačkom radu Građevinsko-arhitektonskog fakulteta i Elektronskog fakulteta Univerziteta u Nišu u 2024. godini, reg. brojevi: 451-03-65/2024-03/200095 i 451-03-65/2024-03/200102.

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MULTI-CRITERIA DECISION-MAKING APPROACH FOR REGENERATION OF ABANDONED AREAS: SELECTION OF REMEDIATION TECHNIQUES

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ABSTRACT:

Regeneration of areas that are no longer active and burdened by previous use represents an essential segment of cities' resilience to the global challenges of the 21st century. Traces of the past activities of these areas are visible through the legacy of neglected buildings and other infrastructural facilities, often accompanied by the presence of pollutants in the soil. Thus, implementing soil remediation is one of the primary prerequisites for restoring and reusing abandoned areas. The optimal remediation technique is selected depending on the type of pollutant and its concentration in the soil. In choosing the appropriate technique, it is necessary to consider the impact of the method on the environment, the complexity of the procedure, the costs, the degree of efficiency and the time required to remove pollutants. The paper examines a multi-criteria decision-making approach in the restoration phase of abandoned areas related to the choice of remediation techniques. By applying the Analytical Hierarchical Process (AHP) method and considering various aspects of the choice of remediation techniques, the paper aims to rank biological, physical-chemical and thermal soil remediation methods and indicate the most significant ones in pollutant removal.

Keywords: multi-criteria decision-making approach, AHP method, soil remediation, abandoned areas

ZNAČAJ I ULOGA PLANINARSTVA ZA ZAŠTITU PLANINSKE PRIRODE

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ABSTRAKT:

U radu su analizirani pozitivni i negativni uticaju planinarskih aktivnosti na planinsku prirodu, kao i mjere i aktivnosti koje sprovode planinarske asocijacije, na različitim nivoima, da bi se negativni uticaji sveli na prihvatljivu mjeru a pozitivni dodatno unaprijedili. UIAA i EUMA u saradnji sa regionalnim i nacionalnim planinarskim asocijacijama i sličnim organizacijama daju sve veći doprinos zaštiti planinske prirode i održivom razvoju u ovim područjima.

Planine predstavljaju najvrednije i najatraktivniji prostore na nacionalnom i globalnom nivou, ali istovremeno i krhke ekosisteme veoma osjetljive na različite ljudske aktivnosti. Planinarske aktivnosti u javnosti su uglavnom pozitivno percipirane, a planinari važe za ljubitelje i zaštitnike prirode koji svojim djelovanjem doprinose promociji planina i njihovoj turističkoj valorizaciji. Trendovi povratka prirodi i promocija zdravih stilova života doveli su do pritiska velikog broja posjetilaca, najčešće u zaštićenim planinskim područjima, što dovodi do probijanja praga prihvatnog kapaciteta. U takvoj situaciji kumulativni uticaj naizgled malih negativnih učinaka dugoročno stvara velike probleme. Zaštićenim područjima je potreban menadžment svjestan aktuelnih i potencijalnih problema, te sposoban da nađe odgovarajuća rješenja. Održiva rješenja podrazumijevaju integralni pristup, koordinaciju i saradnju između različitih stejkholdera na različitim nivoima od lokalnog preko nacionalnog do globalnog.

Ključne riječi: Planinarstvo, planinarske asocijacije, zaštita planinske prirode, održivi razvoj

UVOD

Planine su najljepši i najatraktivniji prostori na našoj planeti. One savremenom urbanom čovjeku pružaju mogućnost za bijeg iz stresne i nehumane svakodnevice u jedan ljepši i uzbudljiviji svijet. Razvoj saobraćaja, savremena oprema, povećanje prihoda i fonda slobodnog vremena kod najvećeg broja ljudi, pojava novih sportova te promocija zdravih stilova života približili su ove, nekada udaljene i nedostižne krajeve, i učinili ih dostupnim mnogo širem krugu posjetilaca. Kao rezultat toga planinski turizam je danas postao lokomotiva razvoja u mnogim područjima, dok je po globalnoj popularnosti na drugom mjestu odmah iza primorskog turizma. Pretjerana komercijalizacija „prodaje“ planine sve većem broju ljudi, od kojih mnogi inače ne bi smatrali planine poželjnom destinacijom za putovanja, privlačeći pojedince koji se ne odnose odgovorno prema planinama i njihovoj ekološkoj dobrobiti. Masovni planinski turizam proizvodi negativne uticaje na krhku planinsku prirodu, naročito ako destinacija nema razvijenu infrastrukturu i ukoliko se posjetiocima na destinaciji ne upravlja, vrlo lako se može pretvoriti u svoju suprotnost. Veliki broj posjetilaca stvara pritisak na ova područja i izaziva probleme kao što su erozija

planinskih staza, gaženje i uništavanje vegetacijskog pokrivača, uznemiravanje divljih životinja i sl., svemu tome treba dodati otpad koji posjetioci ostavljaju za sobom.

Posjete veličanstvenim predjelima radi uživanja, bilo da se radi o penjanju, planinarenju, pješačenju ili bilo kojoj drugoj aktivnosti, prava su privilegija. Međutim, odgovornost današnjih generacija je da se ta privilegija očuva za buduće generacije. Zato se sve češće postavlja pitanje: Kako zaštititi planinske prostore od negativnih uticaja velikog broja posjetilaca, a istovremeno omogućiti svima koji to žele da posjete ova područja?

Odgovor na ovo pitanje zahtijeva koordinisane napore svih zainteresovanih subjekata, prije svega države, lokalne zajednice, turističke privrede, planinarskih organizacija i organizacija koje se bave zaštitom životne sredine. Specifična i veoma značajna uloga ovdje svakako pripada planinarima i planinarskim organizacijama. Planinarstvo kao organizovana sportska djelatnost sastavni je dio fizičke kulture i sastoji se od čitavog spektra različitih sportskih disciplina, od rekreativnih, preko takmičarskih do ekstremnih, koje se odvijaju na planinskim prostorima.

Planinari se smatraju osviješćenim posjetiocima planina koji se tokom svojih aktivnosti pridržavaju planinarske etike i bontona. Planinarske organizacije se staraju o izgradnji i održavanju planinarske infrastrukture koja je ujedno i turistička. Iz planinarskih organizacija dolaze planinski vodiči i spasioci bez kojih je nemoguće razvijati kvalitetnu ponudu planinskog turizma. Razvoj i unapređenje ekološke svijesti takođe su jedan o prioritarnih ciljeva planinarskih organizacija na lokalnom, regionalnom i globalnom nivou, a planinari predstavljaju pionire zaštite planinske prirode. U proteklom periodu brojne planinarske organizacije i asocijacije izdale su različite smjernice i preduzele brojne aktivnosti da bi se smanjili negativni ekološki uticaji planinarskih aktivnosti.

1. ISTORIJSKI RAZVOJ PLANINARSTVA, PLANINSKOG TURIZMA I POKRETA ZA OČUVANJE PLANINA

Planinarstvo i planinski turizam u približno isto vrijeme stupaju na istorijsku scenu, uporedo se razvijaju, međusobno prepliću i vremenom sve više dobijaju na popularnosti. Veze planinarstva i turizma počele su još od pojave tzv. „Grand tour“¹ putovanja (Bulatović, 2018). Dugo vremena prije toga sve drevne civilizacije su na visoke planine gledale kao na nešto čega se treba bojati i što treba izbjegavati. Planine su bila i ostale sveta mjesta za sve velike religije, a planinski vrhovi prebivalište bogova. Lokalno stanovništvo se kretalo na ovim područjima do granica koje su zahtijevali ekonomski razlozi (lov, napasanje stada, korišćenje šuma, kopanje ruda...), i samo rijetki su se usuđivali da se približe mjestima gdje “borave” bogovi. Uprkos praznovjerju i strahovima

¹ Grand Tour (veliko putovanje) je tradicionalni naziv za putovanje koji su od 17. do 19. vijeka preduzimali mladi pripadnici više klase iz zemalja Sjeverne ili Zapadne Evrope u nastojanju da se upoznaju sa civilizacijskim i kulturnim dostignućima drugih dijelova evropskog kontinenta, prije svega Italije. Proći Grand Tour se smatralo esencijalnim za dobijanje statusa pripadnika društvene elite. Grand Tours su stvorila potrebu za turističkim vodičima, objektima za smještaj i ishranu putnika pa se zbog toga smatraju se važnom institucijom u razvoju modernog turizma.

mnogi visoki prevoji u Alpima i Himalajima savladani su dosta rano prije svega iz ekonomskih i vojnih razloga, dok su vrhovi i dalje čekali na posjetioce.

U doba humanizma i reneanse javljaju se prvi umjetnici kojima su planine postale inspiracija. Jean-Jacques Rousseau je u XVIII vijeku svoju filozofiju utemeljio na povratku prirodi i upravo se ta filozofija smatra izvorom ideje o planinarstvu. U doba romantizma javili su se stavovi da su divlji planiski predjeli nešto čemu treba težiti radi ličnog prosvjetljenja. To je dovelo do toga da su gospoda iz više klase prihvatila planinarenje kao oblik plemenite intelektualne i duhovne aktivnosti. Krajem XVIII i početkom XIX vijeka mnogi avanturisti i istraživači uputili su se iz Zapadne Evrope u Alpe radi osvajanja njihovih tada još neosvojenih vrhova. Profesor prirodnih nauka iz Ženeve Horace Bénédict de Saussure je 1786.godine organizovao veliku ekspediciju na Mont Blanc, sa 18 vodiča i nosača. Ekspedicija je bila uspješna, a najviši vrh u Alpima osvojen je 8.avgusta. Na vrh su se popeli Jacques Balmat i Michel Paccard. Ovaj datum se smatra početkom planinarstva, koje će se u narednim decenijama preplitati sa brojnim naučno-istraživačkim poduhvatima. Prvi planinarski klub “Alpine Club”, osnovan je 1857.godine u Londonu, a njihove će aktivnosti u narednim decenijama biti usmjerne na osvajanje vrhova u Alpima. U to vrijeme engleske aristokratija sve više putuje širom Evrope radi obrazovanja, rekreacije i upoznavanja s kulturom drugih naroda, što je stvorilo potrebu za organizovanjem masovnih turističkih putovanja. Prvo takvo putovanje željeznicom organizovao Thomas Kuk 1841.godine, što predstavlja uvod u masovni turizam.

Iako se Alpine Club u svojim ranim danima nije formalno bavio zaštitom planinske prirode, njegovi članovi su se prema planinama odnosili sa dubokim poštovanjem i odgovornošću, pa se mogu smatrati začetnicima planinarske etike. U isto vrijeme u SAD-u strastveni istraživač i planinar John Muir promovisao je u svojim djelima značaj divljine za ljudski duh i tijelo: “Svako treba ljepotu kao i hljeb, mjesta za igru i molitvu gdje priroda može liječiti i razveseliti i dati snagu tijelu i duši podjednako” (John Muir, 1869). Muir je, među prvima, skrenuo pažnju na važnost zaštite i očuvanja prirode za buduće generacije i zaslužan je za stvaranje sistema nacionalnih parkova u SAD-u.

Kao jedan od osnivača Sierra Club-a¹, Muir je obrazovao Amerikance o važnosti zaštite prirode, nadahnjujući generacije zagovornika divljine. Hiljade umornih, nervoznih i civilizovanih ljudi počinje uviđati da je odlazak u planinu odlazak kući, da je divljina nužnost, te da su planinski parkovi i rezervati korisni ne samo kao izvori drveta i vode za navodnjavanje, već i kao izvori života. Sve više ljudi je pokazivalo želju za boravak i rekreaciju na planinama, pa su tako širom otvorena vrata za komercijalizaciju planinskih prostora i omasovljenje planinskog turizma. Taj trend se nastavio do današnjih dana.

¹Sierra Club je američka organizacija koja pronoviše očuvanje prirode. Njegovo sjedište je u Oaklandu, [Kalifornija](#). Klub je 1892. osnovala grupa Kalifornijaca koji su željeli sponzorirati izlete u divljinu u "planinskim predjelima pacifičke obale". [John Muir](#) bio je njegov prvi predsjednik (1892 – 1914.) i vrlo je brzo uključio klub u političku akciju za dalje očuvanje prirode.

Danas najveći broj ljudi bez obzira na društveni, kulturni i ekonomski status ima jednostavan pristup planinama. Ljudima više nijesu potrebna veća znanja o planinama da bi boravili i uživali u njima, jer im se od strane organizatora putovanja nude različiti turistički paketi. Tako je povećana tražnja za planinskim prostorima istovremeno donijela smanjenje svijesti među posjetiocima o njihovim negativnim uticajima i nezainteresovanost da se isti smanje. Pred kraj XX vijeka pritisak na planinske prostore već je bio daleko od ideala koji je promovisao John Muir sa svojim kolegama nepuni vijek ranije. Od svojih početaka do današnjih dana planinarstvo i turizam su zajedno rasli i izrasli u fenomene savremenog društva, koji zaokupljaju pažnju stručne i naučne javnosti. Dok su planinarstvo i planinski turizam rasli u poslednjih sto godina, planinski glečeri su se zbog klimatskih promjena rapidno smanjivali izazivajući negativne posledice po biljni i životinjski svijet i lokalne zajednice.

Planinski turizam se posljednjih decenija širom svijeta brzo razvijao i rastao po obimu i raznolikosti svojih oblika, uzrokujući značajne ekonomske, društvene i ekološke promjene (Moss i Godde, 2000, Price, 1992). Tako je na primjer, turizam u Alpima 2002. godine predstavljao između 7% i 10% godišnjih prihoda od turista širom svijeta, što je činjenica koja je otkrivena u okviru Međunarodne godine planina i Međunarodne godine ekoturizma. Planinska područja trenutno su druge najposjećenije turističke destinacije u svijetu i čine 15-20% svjetskog turizma, što predstavlja između 70 i 90 milijardi dolara godišnje (Mohd Taher i sar., 2015). Planine već odavno nijesu rezervisane samo za bogove, predstavnike više klase i akademske zajednice, dok se planinski sportovi promovišu kao ključ za srećniji i jednostavniji život širokih masa. Glavne međunarodne destinacije planinskog turizma su i dalje u Evropi gdje se posebno ističu Italija, Francuska, Švajcarska, Austrija i Njemačka. Međutim, na turističkoj mapi su prisusutna i brojna područja koja su u prošlosti bila zaboravljena kod donošenje političkih ili ekonomskih odluka (Messerli i Ives, 1997). U nekima od njih poput Anda živi veliki procenat najsiromašnije populacije. Cole i Landres (1996) navode da je u Sjedinjenim Državama ukupna rekreacija u divljini porasla 10 puta u posljednjih 40 godina. Cordell i saradnici (1995) su utvrdili da su najbrže rastuće rekreativne aktivnosti povezane sa korišćenjem staza i mnoga prirodna područja pružaju mogućnosti za rekreaciju na otvorenom uz staze. Međutim, većina rekreativnih aktivnosti na otvorenom može negativno uticati na prirodno okruženje, pa je sve veća popularnost rekreacije na otvorenom neizbježno rezultirala većim i raširenijim ekološkim uticajima na prirodne ekosisteme (Sun i Walsh, 1998, Wilson i Seney, 1994).

2. ODRŽIVI PLANINSKI RAZVOJ

Održivi planinski razvoj je predmet poglavlja 13 Agende 21 UN, u kojem se navodi da su planine važan izvor vode, energije, biološke raznolikosti, ključnih resursa, kao što su minerali, šumski proizvodi i poljoprivredni proizvodi, te rekreacije. Planinski predjeli predstavljaju glavne ekosisteme koji su ključni za opstanak globalnog ekosistema, ali se

brzo mijenjaju. Mnoga globalna planinska područja doživljavaju brzu degradaciju. Više od deset posto svjetskog stanovništva direktno zavisi od planinskih resursa, dok mnogo veći procenat crpi planinske resurse, posebno vodu.

Kako bi se povećale svijest o važnosti održivog razvoja planina i očuvanja i održivog korišćenja planinskih ekosistema Ujedinjene nacije su 2002.godinu proglasile Međunarodnom godinom planina, dok su dvadeset godina kasnije 2022. godinu proglasile Međunarodnom godinom održivog razvoja planina, pozivajući države članice, organizacije Ujedinjenih nacija, druge međunarodne organizacije, uključujući civilno društvo, privatni sektor i akademsku zajednicu da daju svoj doprinos. Među organizacijama koje mogu dati nezaobilazan doprinos održivom razvoj planina svakako su planinarske organizacije na svim nivoima. Održivost planina čvrsto je skopčana sa održivošću samog planinarstva koje uključuje sva tri aspekta održivosti (ekonomiski, društveni i ekološki).

Održivost planina se ne smije ograničiti na zaštitu prirodne baštine, već takođe mora težiti održivom socio-ekonomskom razvoju zajednice. Elementi održivog razvoja planinarstva prikazani su na slici 1.

Slika1. Održivi razvoj planinarstva



Izvor: *Autor*

Planine pokrivaju 22 % kopnene mase i dom su za 13 posto svjetske populacije (FAO, 2015) i sa njima se mora upravljati na održiv način. Osnovu održivog razvoja planina čine njihovi ljudski i prirodni potencijali. One su bogate resursima kao što su rude, šume, vode, ljekovito bilje i poljoprivredni proizvodi. Pored toga, spektakularni pejzaži i očuvana divlja ljepota mnogih planina, te bogato kulturmo-istorijsko nasleđe ključna su prednost za razvoj planinskog turizma.

2.1. Planinarstvo i planinski turizam u funkciji održivog razvoja planina

Razvoj planinskog turizma na određenoj destinaciji u neposrednoj je vezi sa planinarstvom i stanjem planinske prirode. Planinarstvo daje višestruki doprinos razvoju turizma, kako na strani ponude tako i na strani turističke tražnje. Planinari su na svojim putovanjima u ulozi turista, ali na destinacijama gdje žive važna su podrška turističkoj privredi. Oni predano rade na razvoju, izgradnji i održavanju planinarske infrastrukture, koju čini sistem planinskih staza, različite vrste vježbališta, planinarske kuće i domovi i dr. Planinarska infrastruktura u isto vrijeme je i turistička, jer je bez nje praktično nemoguće razvijati turizam povezan sa outdoor aktivnostima. Solidna planinarska infrastruktura neophodan je uslov da bi se oslobodili i valorizovali turistički potencijali u planinskim područjima, te da bi se proširila klasična turistička ponuda. Ljudski resursi sa

kojima raspoložu planinarske organizacije, zbog specijalnih znanja i vještina, takođe su neophodni za razvoj turističke privrede. Iz redova planinarskih organizacija regrutuju se markacionisti, planinski vodiči, vodiči za kanjoning i gorski spasioci koji su potrebni turizmu (Bulatović, 2018).

Za planinare se može reći da su uglavnom ekološki osviješćeni, da su poštovaoci prirode i njeni čuvari. Kao najbolji poznavaoци udaljenih i nepristupačnih planinskih područja i dokazani ljubitelji i zaštitnici divljine oni svojim djelovanjem mogu biti dobar primjer svim ostalim posjetiocima kako se treba vladati u divljini. Planinski vodiči podučavaju posjetioce o planinskim ekosistemima, kulturi i tradiciji lokalnog stanovništva. Edukacijom posjetilaca povećava se njihova svijest, znanje, razumijevanje i uvažavanje prirodnog i kulturnog okruženja destinacije. Na taj način pojačava se turistički doživljaj i satisfakcija posjetilaca.

2.2. Negativni uticaji planinarstva i turizma na planinsku prirodu

Kao i svaka druga aktivnost u prirodi tako i planinarstvo ima svoje negativne ekološke uticaje. Iako su planine simboli snage i veličine u suštini se radi o veoma krhkim ekosistemima koji su osjetljivi na uticaje ljudskih aktivnosti vezanih za planinarenje i turizam. Ukoliko ove aktivnosti nijesu brižljivo planirane, ograničene i organizovane na odgovarajući način, iste mogu imati ozbiljan negativan uticaj na ekosisteme, kao i na zajednice koje naseljavaju planinske regije. Planinska etika i propisane smjernice lako se gube i zaboravljaju u jurnjavi za novcem s jedne, i primamljivo upakovanim avanturama sa druge strane. U planinama se nudi sve više komfora za sve više novca što neizostavno vodi devastaciji i iscrpljivanju resursa. Hammitt i saradnici (2015) ističu da aktivnosti na otvorenom imaju različite uticaje na različite aspekte životne sredine, kao što su tlo, kvalitet vode i životinjski svijet.

Najvažnije negativne uticaje planinarskih aktivnosti na životnu sredinu čine:

- **Erozija tla.** Velika frekvencija ljudi na planinskim stazama može dovesti do erozije tla, posebno u krhkim planinskim ekosistemima. To može rezultirati gubitkom vegetacije i narušavanjem prirodnih staništa.
- **Oštećenje vegetacije.** Nastaje gaženjem vegetacije od strane penjača, posebno u osjetljivim okruženjima na velikim visinama gdje biljke rastu sporo i podložnije uništavanju. Gaženje predstavlja direktno mehaničko djelovanje i uništava brojne biljne vrste. Može dugoročno negativno da utiče na cjelokupno stanište.
- **Zagađenje vode.** Posjetioци planina mogu kontaminirati izvore vode, utičući na život u vodi i nizvodne zajednice.
- **Uznemiravanje divljih životinja.** Planinarske aktivnosti mogu poremetiti divlje životinje u tom području, uzrokujući stres, raseljavanje i narušavanje prirodnog ponašanja. Naročito mogu biti pogođene ptice gnijezdarice i druge osjetljive vrste.
- **Stvaranje otpada.** Posjetioци planina stvaraju otpad u obliku omota za hranu, boca za vodu, opreme za kampovanje i ljudskog otpada. Nepravilno odlaganje

ovog otpada može zagaditi izvore vode i naštetiti lokalnim divljim životinjama, te narušiti izgled krajolika.

- **Klimatske promjene.** Emisije ugljenika iz saobraćaja, krčenje šuma za razvoj infrastrukture i stvaranje otpada na planinama može doprinijeti klimatskim promjenama.

Da bi se ublažili ovi negativni uticaji, važno je da posjetioci praktikuju principe Leave No Trace, minimiziraju svoj ekološki otisak, poštuju lokalne običaje i propise i podržavaju napore za očuvanje u oblastima koje posećuju. Ideja je ostaviti [divljinu](#) nepromijenjenu ljudskim prisustvom. Održive prakse planinarenja, kao što je korišćenje biorazgradivih proizvoda, odlaganje cjelokupnog otpada i boravak na određenim stazama, mogu pomoći u smanjenju uticaja planinarskih aktivnosti na planinsku prirodu.

3. PLANINARSKJE ORGANIZACIJE I ZAŠTITA PLANINA

Sve planinarske organizacije na lokanom, regionalnom i globalnom nivou među prioritarnim cjevima imaju zaštitu planinske prirode, razvoj ekološke svijesti, te podsticanje ekološkog djelovanja. Da bi se negativni uticaji planinarstva sveli na prihvatljivu mjeru a pozitivni dodatno unaprijedili planinarske organizacije u saradnji sa regionalnim i nacionalnim asocijacijama i sličnim organizacijama daju sve veći doprinos zaštiti planinske prirode i održivom razvoju u planinskim područjima.

3.1. Međunarodna penjačka i planinarska federacija - UIAA

UIAA je osnovana 1932. godine, okuplja 94 članice iz 62 zemlje. UIAA oduvijek je vodila brigu o zaštiti planinskog okruženja (suprotstavljanje planovima izgradnje žičara i željeznica u Alpima, problem posjtilaca koji ostavljaju otpad u planinama, zagađenja od turističkih letova i korićenja helikoptera za pristup udaljenim područjima). Komisija za zaštitu planina UIAA, osnovana 1969. godine, jedan je od vodećih autoriteta u pogledu pitanja održivosti u planinskim regijama. UIAA vjeruje da svi koji imaju udjela u dobrobiti planinskog okruženja trebaju zajednički raditi na podizanju svijesti o krhkoj prirodi planinskih ekosistema, kao i na podsticanju odgovornog i održivog ponašanja i praksi. UIAA je potpisnik “Sports for Climate Action Initiative” Okvirne konvencije Ujedinjenih nacija o klimatskim promjenama (UNFCCC), potpisane u januaru 2020., kao i “Glasgow Declaration on Climate Action in Tourism” u novembru 2022.

Aktivnosti UIAA se fokusiraju na:

- Promovisanje održivog razvoja planinskih regija i nagrađivanje inovativnih inicijativa u avanturističkom turizmu i očuvanju planina.
- Podizanje svijesti o pitanjima životne sredine i dalje obrazovanje o očuvanju planina i o drživoj praksi.
- Podršku konkretnim akcijama koje preduzimaju nacionalne federacije koje imaju za cilj očuvanje planinske sredine u njenom prirodnom stanju.

- Podsticanje usvajanja i poštovanja svih međunarodnih deklaracija, uključujući sopstvene etičke smernice UIAA, u cilju očuvanja planinskih ekosistema i kultura.
- Povezivanje sa međunarodnim organizacijama i pružanje pomoći, nacionalnim federacijama.

UIAA Komisija za zaštitu i pristup planinama razvila je projekte kao što su:

- Godišnja nagrada za zaštitu planina (Mountain protected award)
- Serija Respect the Mountains
- Aktivnosti oko 11. decembra Međunaodnog dana planina.

3.2. Evropska planinarska asocijacija - EUMA

Evropska planinarska asocijacija EUMA je krovna organizacija 33 evropska planinarska udruženja iz različitih zemalja sa približno 3.2 miliona članova. EUMA nastoji planinarstvo uvrsti u prioritete Evropske unije kao važan faktor kvaliteta života i da bude prepoznata kao partner u dijalogu za planinarenje od strane institucija Evropske unije. U okviru svoje misije i ciljeva EUMA se zalaže za:

- Slobodan i odgovoran pristup planinama: planine ne „pripadaju” nikome. One treba da budu stanište i okruženje za živa bića, dijeljene u harmoniji i uz međusobno poštovanje. Osnovno pravo ljudskih bića je da uživaju u ovoj životnoj sredini, bez uništavanja ili narušavanja krhke ekološke ravnoteže.
- Posvećenost zaštiti planinske sredine.
- Zajednički duh evropske zajednice: planinarenje pobjeđuje granice i predrasude.

EUMA promovise:

- Odgovorno planinarenje (zaštita prirode i sigurnost u planinama) koje balansira interese planinara sa zahtjevima razumnog korišćenja.
- Održivi razvoj planinskih regiona i njihovih životnih oblika.
- Planinarenje kao temeljni doprinos koheziji u Evropi jačajući zajednički duh evropske zajednice.

4. UNAPREĐENJE UPRAVLJANJA PLANINARSKIM AKTIVNOSTIMA U EVROPI

Evropska planinarska asocijacija EUMA posvećena je odgovornom upravljanju planinarskim aktivnostima na nivou Evrope. U saradnji sa svojim članicama, nacionalnim i regionalnim organizacijama, ulažu se naponi za unapređenje postojeće prakse, vrši se razmjena iskustava sa ciljem uspostavljanja jedinstvenih standarda. U sklopu tih napora EUMA je realizovala, tokom 2021 i 2022.godine, projekat Unapređenje dobrog upravljanja penjanjem i alpinizmom u Evropi. Glavni cilj ovog projekta sufinansiranog od strane Erasmus + projekta EU je promocija i podrška pješačenju, planinarenju i penjanju

i njihovim objektima i infrastrukturi na nivou Evropske unije. Projekat su realizovale tri radne grupe po tematskim cjelinama planinarski domovi, planinske staze i penjalista na prirodnim stijenama. Dakle, radi se o ključnim segmentima planinarske infrastrukture koji predstavljaju bazu za razvoj planinskog turizma.

U poslednjih 150 godina u Evropi je izgrađeno je više od dvije hiljade planinarskih domova. Oni se nalaze u planinskim područjima na svim nadmorskim visinama između 100 m (Trst) i 4500 m (Monte Rosa) nadmorske visine. Planinarski domovi i skloništa nalaze se različitim planinskim i stjenovitim predjelima, uglavnom na ekstremnim lokacijama i samim tim raspolazu sa različitom infrastrukturom. Kada je u pitanju vrsta područja, od 778 analiziranih objekata njih 24% smješteno je u nacionalnim parkovima, 49% u nekoj drugoj vrsti zaštićenog područja, dok se 27% nalazi van zaštićenih područja. Oprema objekata zavisi od lokacije, pružaju različite vrste usluga, neki imaju stalno osoblje, u nekima se treba najaviti, dok postoje i oni bez nadzora. U okviru projekta, putem anketnog upitnika, od nacionalnih asocijacija, prikupljeni su podaci o ovim objektima prema njihovoj lokaciji, funkciji, vlasništvu i njihovim ekološkim standardima i odgovarajućim uslovima rada. Tokom projekta prikupljeni su podaci od 15 nacionalnih asocijacija, a analiza je pokazala značajne razlike među ovim objektima. Istraživanje je pokazalo da od 1017 planinarskih domova i skloništa 21% ima izvorsku vodu, 56% ima bistijerne ili bunare, 16% je priključeno na javnu vodovodnu mrežu, dok 7% nema riješeno pitanje vodosnabdijevanja.

Upravljanje otpadnim vodama analizirano je za 956 objekata i pokazalo je da se kod 52% objekata vrši mahanički i biološki tretman, 8% je priključeno na kanalizacionu mrežu, za 3% nije specificiran tretman, dok 8% objekata nema tretman otpadnih voda. Tretman otpadnih voda je prikazan u tabeli 1.

Tabela 1. Tretman otpadnih voda u evropskim planinarskim domovima

Analyzed data for 956 huts/shelters:		Analysis per Association			
Type	%	Mechanical + biological treatment	Public Grid	Unspecified	None
mech. + bio treatment	52				
none	37				
public grid connection	8				
Other	3				

Analyzed data for 956 huts/shelters:		Analysis per Association			
Type	%	Mechanical + biological treatment	Public Grid	Unspecified	None
mech. + bio treatment	52				
none	37				
public grid connection	8				
Other	3				

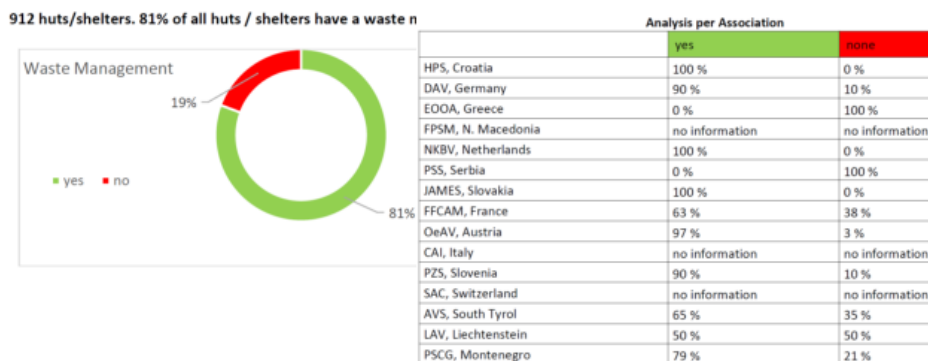
Wastewater Treatment
 • Mechanical + biological treatment (52%)
 • Public Grid (8%)
 • Unspecified (3%)
 • None (37%)

HPS, Croatia	0 %	0 %	2 %	98 %
DAV, Germany	65 %	26 %	0 %	10 %
EOOA, Greece	0 %	0 %	0 %	100 %
FPSM, N. Macedonia	0 %	0 %	0 %	100 %
NKBV, Netherlands	100 %	0 %	0 %	0 %
PSS, Serbia	0 %	0 %	0 %	100 %
JAMES, Slovakia	100 %	0 %	0 %	0 %
FFCAM, France	74 %	0 %	0 %	26 %
OeAV, Austria	71 %	12 %	16 %	1 %
CAI, Italy	no information	no information	no information	no information
PZS, Slovenia	88 %	0 %	0 %	12 %
SAC, Switzerland	no information	no information	no information	no information
AVS, South Tyrol	65 %	0 %	0 %	35 %
LAV, Liechtenstein	100 %	0 %	0 %	0 %
PSCG, Montenegro	0 %	0 %	0 %	100 %

Izvor: EUMA, 2023.

Kada je u pitanju snabdijevanje električnom energijom analizirano je 1008 objekata, 36% je priključeno na električnu mrežu, 39% se snabdijeva iz obnovljivih izvora, 15% je opremljeno agregatima, dok 11% nema riješeno pitanje snabdijevanja. Pored četiri osnovne kategorije snabdijevanja u praksi su često prisutne njihove kombinacije. Analiza upravljanja otpadom obuhvatila je 912 objekata, od čega 81% ima waste management system, što je prikazano u tabeli 2. Sanitarna infrastruktura je analizirana kod 996 planinarskih domova/skloništa, od čega 91% raspolaže toaletima. Podaci o domovima i skloništima predstavljeni su na web karti mapunto <https://mapunto.org>. Ovo omogućava korisnicima da na jednostavan način odaberu svoje destinacije širom Evrope. Potrebno je da se baza dopuni novim podacima od asocijacija koje ih nijesu dostavile. Krajnji cilj koji se želi postići je uspostavljanja minimalnih standarda zaštite životne sredine za planinarske domove širom Evrope, u pogledu snabdijevanja pitkom vodom, odlaganja otpada, tretmana otpadnih voda i sl. Nadalje, prikupljeni podaci će biti od koristi planinarskim organizacijama radi dokumentovanja budućih izazova prilikom zahtjeva nacionalnim i lokalnim vlastima za podršku.

Tabela 2. Upravljanje otpadom



Izvor: EUMA, 2023.

Važni objekti planinske infrastrukture su planinske staze. Uređene planinske staze doprinose boljem upravljanju posjetiocima, smanjenju negativnih uticaja i zaštiti biljnog i životinjskog svijeta. EUMA je izdala uputstvo za odgovorno korišćenje planinskih staza. Istraživanje je pokazalo da na nivou Evrope postoji 1.5 mil. km planinskih staza koje se značajno razlikuju od zemlje do zemlje. Zajedničke karakteristike su da su staze organizovane u nacionalne mreže i da su obilježene znakovima i putokazima. Većina staza se može koristiti besplatno, bez posebnog znanja i ne zahtijevaju posebnu obuku ili opremu. Što se tiče načina obilježavanja, održavanja, upravljanja i sl. tu je situacija veoma različita. Podaci o stepenu težine ili kvalitetu planinarskih staza takođe nijesu ujednačeni. To dovodi do zabune kod planinara i pješaka prilikom korišćenja staza. Takođe, postoje različiti propisi o tome ko smije obilježavati staze, kako ih održavati i ko je odgovoran za štete prilikom korišćenja.

Kada su u pitanju evropska penjališta na prirodnoj stijeni tu je situacija još konfuзнija. Cilj projekta je bio istražiti situaciju u Evropi, dati definicije i različite uticaje koje penjanje može imati na životnu sredinu, sastaviti listu problema i rješenja te ponuditi smjernice i modele za uspješno upravljanje ovim područjima. S povećanjem broja penjača, sve većem broju područja je potreban neki oblik upravljanja, čak i ako to nije bio slučaj u prošlosti. Oni se mogu osloniti na postojeće modele iz oblasti koje su se već uspješno pozabavile ovim problemom. Protok ideja, modela i znanja i povećana saradnja mogu dovesti do stvaranja evropskih standarda za opremanje smjerova u stijenama, i obezbijediti sigurnije i udobnije iskustvo za sve učesnike. Određeni propisi i ograničenja su neophodni kako bi se uspješno upravljalo brojem penjača, očuvalo i održavalo područja i zaštitila prirodna staništa, te izbjegli sukobi s lokalnim stanovništvom.

ZAKLJUČAK

Planine predstavljaju prirodnu, kulturno-istorijsku i ekonomsku baštinu čovječanstva koju posjećuje sve veći broj ljudi. Planine odavno nijesu rezervisane samo za planinare, naučnike i istraživače već su postale dostupne najširem krugu korisnika. Održivi razvoj planina podrazumijeva integralni pristup, koordinaciju i saradnju između različitih stejkholdera na različitim nivoima od lokalnog preko nacionalnog do globalnog. Jedino se na taj mogu obezbijediti pozitivni društveno-ekonomski efekte i pravedna raspodjele koristi među glavnim akterima, a negativni ekološki uticaji na planinsku prirodu mog se svesti na minimum. Pretjerana komercijalizacija i masovni planinski turizam proizvode negativne uticaje na krhku planinsku prirodu, naročito ako destinacija nema razvijenu infrastrukturu i ukoliko se posjetiocima na destinaciji ne upravlja. Veliki broj posjetilaca stvara pritisak na ova područja i izaziva probleme kao što su erozija planinskih staza, uništavanje vegetacijskog pokrivača, uznemiravanje divljih životinja, ostavljanje otpada i sl. Situaciju dodatno komplikuje nedostatak ekološke svijesti i motivacije za ekološko djelovanje kod velikog broja posjetilaca.

Zaštita planinske prirode, širenje ekološke svijesti i podsticanje ekološkog djelovanja spadaju u prioritetne ciljeve planinarskih organizacija. Shodno tome, planinari su kao dokazani ljubitelji prirode i ekološki osviješćeni turisti svjesni negativnih ljudskih uticaja na planinsku prirodu i predano rade na njegovom smanjenju. Poseban doprinos održivom razvoju planinskog turizma daju planinarske organizacije i asocijacije na svim nivoima. One su zadužene za razvoj i unapređenje planinarske infrastrukture bez koje nema turističkog razvoja. vObilježavanjem i održavanjem planinskih staza, kao i opremanjem penjalista smanjuju se negativni uticaji njihovih korisnika na krhke planinske ekosisteme. Planinarski domovi zahtijevaju opskrbu pijaćom vodom, otpadne vode se moraju tretirati, dok se komunalnim otpadom takođe mora upravljati. Pitanja koja zahtijevaju dugoročne odgovore su i snabdijevanje električnom energijom iz održivih izvora i njena racionalna potrošnja, te odabir ekološki prihvatljivih opcija transporta. Ključni akteri za promociju ekoturizma i edukaciju posjetilaca u planinskim područjima su planinski vodiči, koji takođe dolaze iz planinarskih organizacija.

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THE IMPORTANCE AND ROLE OF MOUNTAINEERING FOR THE PROTECTION OF MOUNTAIN NATURE

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APSTRAKT:

The paper analyzes the positive and negative impact of mountaineering activities on mountain nature, as well as the measures and activities carried out by mountaineering associations at different levels, in order to reduce the negative impacts to an acceptable level and further improve the positive ones. UIAA and EUMA, in cooperation with regional and national mountaineering associations and similar organizations, make an increasing contribution to the protection of mountain nature and sustainable development in these areas. Mountains represent the most valuable and attractive spaces at the national and global level, but at the same time they are fragile ecosystems very sensitive to various human activities. Mountaineering activities are generally perceived positively by the public, and mountaineers are considered nature lovers and protectors, who contribute to the promotion of mountains and their tourism valorization through their activities. The trends of returning to nature and the promotion of healthy lifestyles have led to the pressure of a large number of visitors, most often in protected mountain areas, which leads to breaking the carrying capacity. In such a situation, the cumulative impact of seemingly small negative effects creates big problems in the long run. Protected areas need management aware of current and potential problems, and capable of finding appropriate solutions. Sustainable solutions imply an integral approach, coordination and cooperation between different stakeholders from local to national and global levels.

Keywords: *Mountaineering, Mountaineering associations, Protection of mountain nature, Sustainable development*

CITY LOGISTICS STRATEGIES

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ABSTRACT: *The life and survival of people in cities would be unthinkable without satisfying the basic needs that are conditioned by the daily logistics operations. Efficient distribution of goods is one of the basic imperatives affecting the sustainability of cities. In addition, a large concentration of people in cities requires and imposes the disposal of waste and other recycling materials. City logistics is the concept of integrating existing resources to solve problems caused by the constant rise in population and number of vehicles in urban areas. Logistics activities also represent a threat to the processes that is inexorably harder to maintain. Emissions, particulates, noise, destruction of vegetation, poor utilization of energy, resources and transport capacity, traffic accidents, general degradation of quality of life are just some of the negative impacts. Sustainable distribution of goods is a priority in many cities, for this reason many of the proposed measures would have a significant impact on the balance between a large population whose needs must be met and the negative impact of the processes that occur as a result of meeting the basic needs of the population. The paper will be presented to study the impact of the means of transportation involved in the distribution of goods, the flow of traffic, as well as their impact on the environment during the unloading of goods in retail stores.*

Keywords: *City logistics, Environment, Capacity lane*

1. INTRODUCTION

The high concentration of people in cities and rich content of economic and social activities are constantly increasing, what shows us complexity of satisfying all needs. We are all living in a time when cities and their quality depends on the supply and variety of the assortment of goods in retail stores. However, in order to achieve a high level of diversity of product range, or selection of goods, both basic to life, and those that give and raise the level of quality of life in cities, and that can be purchased only in the cities, there must be a well-organized logistics supply of retail goods, which, goods creates a direct relationship with the customer, or placed at the disposal of the city's population. Logistics is very important for the functioning of cities, and has an important impact on the quality of life, mobility of the population and the sustainability of cities.

Efficient distribution of goods is essential for life and the survival of people in cities. The main characteristic of the distribution of goods in cities is reflected in the fact that the delivery of goods small scale is quite frequent or common. Spatial distribution transport

distance of goods in road transport is such that the largest number of transport tasks up to 5 km, and even 51% of the total volume of transported goods is realized at 10 km. [1]

In addition, as the distribution of goods in cities raises the level of competitiveness of urban areas, it has a positive effect on employment growth, which is directly related to the distribution of goods, performance of the transport of goods, and indirectly on retail stores and etc. However, in addition to the above distribution of goods in urban areas has negative characteristics to the traffic and the environment. Due to the high frequency, or frequency in the distribution of goods, delivery vehicles have a huge impact on the capacity of roads, especially during the unloading of goods in retail stores, as during the unloading of goods, delivery vehicles are generally parked on city roads. In addition, cause the emission of harmful gases, soot particles, creating a lot of noise, both on landing, and during movement. They have a negative impact on the environment in cities.

The aim of sustainable urban environment and the effective implementation of the distribution of goods in cities. City logistics should be subject to planning and policy of the city, because the logistics activities, also represent a threat to the processes that are inexorably harder to maintain. City logistics needs to find a balance between effective distribution of goods or satisfying basic needs of residents in the cities, and the impact of same on the efficient distribution of goods, as well as the influences that affect the environment.

This paper will be presented to survey the impact of transport equipment, which participate in the distribution of goods, both in traffic and on their impact on the environment, during the unloading of goods in the retail store, in a certain period of time.

2. THE CONCEPT OF SUSTAINBLE DEVELOPMENT

Logistics activities have recently been focused exclusively on reducing the cost of the flow of goods in the supply chain, as well as improving the quality of logistics services, primarily to reduce delivery times, increased flexibility of delivery, reliability of delivery, readiness to deliver supplies correctness etc.

The concept of sustainable development has emerged as a result of large-scale climate change, global warming, the emergence of greenhouse gases and etc. These negative changes create or have a major impact on them and their formation and transport of goods and passengers. The high concentration of people in urban areas, leading to a great need, both for their own movement, travel by car or public transport, and for meeting the basic needs for food, drink and the like. City authorities have mainly focused on solving problems traditionally associated with public transport, the use of passenger cars, other forms of passenger transport, while the transport and delivery of goods largely ignored. These vehicles have a major negative impact on both the climate change and on the scope and structure of traffic.

The concept of sustainable development refers primarily to meet current needs without compromising the ability to satisfy the needs of future generations. To make the concept of sustainable development was defined by the applicable term triple bottom line, which emphasizes that economic, social and environmental reasons are equally important in decision making. [2]

This term is known as the triple P (People, Profit, Planet), which means that the logistic activities that are planned, controlled and carried out during the flow of material goods

equally focused, or both are important factors, in addition to the cost factor that occur during the running of goods and factors of meeting the needs of people, and a factor of environmental stredine.

2.1. City logistics impact on sustainable development

The supply of people with basic necessities, as well as those associated, in terms of the diversity of the assortment of goods in cities, causing a series of negative and unsustainable activities. The functioning of these negative activity, or the formation of non-viable activity refers primarily to the population, the profit which is realized during implementation of various orders and their impact on the planet, as the impact on the environment.

The negative impact on the population, which is made by vans refers primarily to the effects of exhaust gases, which adversely affect the health of people and can cause a variety of diseases. In addition to the presence of exhaust gases and noise, generated by these vehicles, as well as various vibrations that create discomfort among the population. The presence of commercial vehicles in the total volume of traffic, also has a negative impact on the population, because it increases the risk of traffic accidents. Violation of the quality of life of residents, in terms of loss of green areas, and the loss of attractiveness of the area for transport and logistics infrastructure development.

When one looks at the impact of city logistics at a profit, or economic viability, there are two sides. One page refers primarily to profit from the flow of material goods. However, goods which are located in retail stores must be competitive in the market, both quality and price. Great impact on the price of goods that are located in retail outlets, has primarily transport. When it comes to transport, and in particular the delivery of goods in retail stores, the main characteristic of these transport tasks, is that very frequently, and frequent delivery of goods in retail stores. In addition, the vans that carry out freight delivery, or servicing goods retail stores, their cargo space is generally under-utilized, which by volume, which, according to the loading permitted weight of the vehicle. This creates a waste of resources, and thus additional costs that affect profit. In addition, these vehicles to transport completed its task must participate in traffic, and thus create added congestion and reduce accessibility in cities because of its dynamic driving characteristics of the vehicle, causing an additional impact on profit. On that basis, brings into question the reliability and accuracy of delivery, which is directly related to quality of service, which also has a direct impact on profit alone.

The impact of the delivery of transport, in addition to the impact on the population and economic viability, or profit, has an impact on the environment. The negative impact is mainly reflected due to emissions of greenhouse gases, which cause these vehicles. When it comes to emission urban transport is among the causes of climate change. Also, it is important to note that these vehicles are currently using fuels that are fossil or non-renewable natural resources, which according to this criterion could be considered as unsustainable development. In addition, the maintenance of these vehicles includes the replacement of tires, motor oil and other materials whose disposal has a direct impact on the environment, and whose influence it one of the unsustainable are twofold.

3. DELIVERY OF GOODS OBSERVED RETAIL STORE

Delivery of goods retail stores is one of the logistics of everyday activities that make life a lot of people in the cities richer, and provide a greater choice of various item, how the basics of life, and those accompanying. The importance of this activity, ie city logistics, is given only when the required items or goods are not made available to customers in the retail store. Only then is questioned how the city logistics functions in various cities, in circumstances takes place, what factors influence its development and delivery of goods retail stores. However, their city logistics operation, and striving to meet customer needs, creating negative consequences, affecting not to those users whose needs are relentlessly striving to meet.

Considered one retail store in a period of seven days. Based on the counting of deliveries per day observed deliveries given in Figure 1. In terms of deliveries, each delivery is realized in an average time period of 20 minutes. Very important to note that the retail store has only one server for receipt of goods, which means that if you are in the same time interval the appearance of two or three vehicles, unloading will be done only for one vehicle, while the rest one or two cars are waiting to unload. Also, it is very important to note that while the goods are unloaded from the vehicle or vehicles while waiting to unload goods retailer, these vehicles are stationed or parked on the carriageway. Lane where the vehicles are stationed during unloading or while waiting at the unloading has two lanes in one direction. It means that the capacity of the carriageway is reduced by 50 [%] in the time interval when it is unloaded, or waiting for the delivery vehicle to the unloading of the goods. However, when it comes to capacity, the vehicles in addition to this part of the street network, the real problem overall street network.

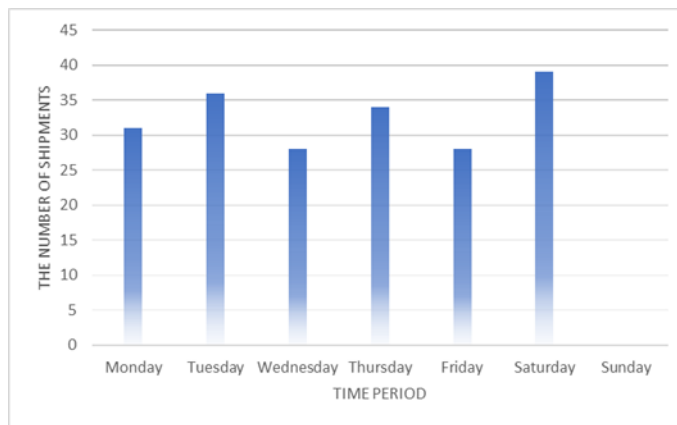


Fig. 1. The number of shipments of goods observed retailer

During the research, observed retail store receives goods or delivery till 2 p.m. every day. Also, it was noted during the study that the maximum number of delivery vehicles that occurs on unloading at the same time interval is three vans, and a delivery vehicle is unloaded, and two vans waiting to unload, which means that on carriageway are three parked vehicles.

3.1. The impact of commercial vehicles on the environment

Delivery vehicles used for carrying out these activities, belong to a heterogeneous fleet, or in structure, can be classified as light trucks. Light-duty vehicles have characteristics which give them this type of transport tasks, because they have good maneuverability, and in contrast to heavy goods vehicles much easier to find a place to stop and parking while unloading goods in a retail store. However, it is very important to note the basic difference between them, but this is primarily related to capacity, as well as the relationship between the weight of goods transported and power of vehicles that transport goods. So in terms of environment, the occupation of space, the capacity of roads and air pollution, light trucks don't have advantages compared to heavy-duty vehicles. The main reason is that the use of light-duty vehicles generates a higher number of deliveries, which is the feature of the delivery transport or distribution of goods. This promotes higher frequency of the vehicle in carrying out its transport assignments.

When it comes to light commercial vehicles used in the distribution of retail goods, we can not avoid the impact on the environment. Vehicles used for delivering goods to retailer observed are mostly older than 15 years. Refurbishing of fleet used for delivery of goods in cities, is slower from refurbishing of fleet used in long-distance transport of goods. The main reason for this is that distribution of goods mainly deals with smaller companies, that in order to reduce the cost competitiveness use older vehicles.

Based of study [3], light trucks emit gases, and these are primarily CO, and carbon monoxide, volatile hydrocarbons NMVOC, nitrogen oxide NO_x, particulate matter PM, nitrous oxide N₂O, ammonia NH₃, as well as other substances which have a detrimental effect on the environment and the inhabitants. Of course, these are vehicles with a drive unit with internal combustion engine, which is fueled with diesel fuel. Based on the research [3], Table 1 shows the contamination of the light-duty vehicles which is emitted while discharging the goods to the retailer. It was the winter period when unloading of goods to the retailer was observed. It is assumed that the main reason of the work of the vehicle during unloading was heating the cab driver, and ensuring pleasant working conditions.

Table 1. Emissions from a delivery vehicle [G/KG FUEL]

Exhaust gases of a vehicle	[g/kg fuel]
CO	11
NMVOC	1.75
NO_x	15
PM	2.8
N₂O	0.069

Exhaust gases of a vehicle	[g/kg fuel]
NH3	0.014
In total	30.633

Based on this we can conclude that a delivery vehicle produces 30,633 g / kg fuel emissions during a delivery of goods to retailer. This is the average value, which is based on our research [3]. Various standards and regulations prescribe limits for exhaust emissions of motor vehicles, or in the Republic of Serbia has no regulations that limit the vehicles can be used for purposes of city logistics and transport tasks to perform in cities.

Based on the research, by using regression analysis for the observed retail store, a model of pollution by exhaust gases from commercial vehicles could be made, where the number of deliveries during the day is independent variable and the dependent variable is impact of commercial vehicles on the environment based on exhaust emissions of these vehicles. Data is the linear equation (1) that represents the relationship between these two variables.

$$y = 30,633 \cdot x \quad (1)$$

Based on regression analysis, we can conclude that if increase the number of deliveries of goods to retailer, it will increase pollution produced by delivery vehicles, and their emissions of gases. That will negatively affect both the population and the environment, as well as quality of life.

3.1. The impact of commercial vehicles on the road capacity

When delivering goods to retailer, both for unloading, vans use traffic lane for parking, both for unload, so also for waiting to unload. Carriageway consists of two traffic lanes for vehicles moving in that direction. So that during the performance of discharging the goods, or the mode of delivery vehicles to the unloading, the flow of traffic uses only one traffic lane, wherein the lane capacity is reduced by 50 [%]. Very important to note is that retail facility is receiving deliveries by commercial vehicles till 2 p.m. So vans, when carrying out its transport assignments or during unloading or waiting for unloading, they park in a traffic lane in the morning peak hour.

Retail has one server for receipt of goods, where the average time of delivery 20 minutes. In one hour of receipt of the goods server can serve a maximum of three vans. Based on research, there was a maximum of three vans in one time interval. However, the capacity of the carriageway, in that time interval, is reduced to a single lane for a time period of 1 h. In this situation the third delivery vehicle will wait 40 minutes to unload, and will spend 20 minutes for unloading. It means that the vehicle will be placed 1 h on that lane.

With regard to the capacity of the lanes, the lanes on the maximum capacity is 3000 [PA / h / direction], on the basis of a HCM-2000. With taken into consideration all constraints, the maximum capacity of a traffic lane in 1500 [PA / h / line]. This is about the maximum capacity, which means that on this road does not appear such a large number of vehicles,

because it occurs more than 1500 [PA / h / direction] in a situation when the delivery vehicle is unloading the goods, or waiting to unload, transport could not take place. However, in the future, considering that the degree of motorization increases, special care must be taken and given to these situations.

Featured depending on the model between the number of deliveries, and time spent on lane. Based on regression analysis, a model where the independent variables are deliveries of goods to retailer, a dependent variable is the time a vehicle spends on the basis of the time of unloading on the carriageway. Delivery truck waiting to unload is not taken into account, because if a delivery van is waiting for unloading it means that the other vehicle which had come before it, is unloading. The main reason for this observation is because the vehicle that is being unloaded and the vehicle waiting to unload, are parked in the same lane. So to have the same impact on capacity, regardless, whether they are in the lane of one or more of parked vans. Data is the linear equation (2) that represents the relationship between these two variables.

$$y = 20 \cdot x \quad (2)$$

Based on this model, it can be concluded that the higher number of deliveries means the greater number of time occupancy of lane, which in this case is represented in minutes. The higher occupancy of lane, expressed in minutes, on the other side brings less capacity lane.

4. CONCLUSION

Based on the research it can be concluded that it is very difficult to find a balance between meeting the basic needs of the population, and their quality of life, in terms of environmental protection, reduction of noise, vibration and the like. Reducing the travel time is the need of residents in cities. It is reflected in the accessibility and capacity of roads. Based on research and mathematical models, it can be concluded that the higher number of deliveries, will increase the level of pollution caused by vans carrying out its transport tasks. On the roads and at the intersections, and the entire street network in the city. Vans must use the road network for completing their delivery tasks. The main measures for the sustainability of city logistics, that is, finding a balance between two already mentioned components that affect their interests poor on the other, are:

- Higher commitment to city logistics to solve its problems and optimize the entire process, with the aim of maximizing the effectiveness and efficiency, taking into account optimizing costs, and meet the needs of residents and the environment as a factor that needs attention in the planning and implementation of the current burdens;
- Avoiding peak period for the implementation of transport tasks by delivery vehicles in cities, which would be the result of previous traffic counts and determined traffic volumes during the day, and based on that, determine the time periods during the day when the delivery transport should be realized in the cities;
- Do not overwrite city logistics transport policy from other cities because every city has a different traffic volume, traffic structure, as well as the different supply

and demand, but policy planning city logistics in the particular case, with the input data of observed city;

- Greater involvement of the city, in terms of paying attention to the overall traffic planning, as well as the adoption of the strategy by the city for city logistics, its planning, implementation, sustainability, with regard to the adoption of the law on the restriction of the number of delivery of a particular part of the city in a week, and in view of the limitations of conditions to be met by vans to establish regular distribution of goods in the city;
- The tendency of greater utilization of space of delivery vehicles, realization of distribution of goods by using vehicles with higher capacity, which in the existing state of impact on reducing frequency of deliveries to retailer would significantly have an impact on the reduction of environmental pollution by emissions;
- Using a delivery vehicle for the realization of the distribution of goods in cities, whose age does not exceed one year, and whose emissions corresponds strictest emission standards, with the aim of crossing vans with fuel to electricity.

In the future, great attention must be paid to city logistics, work on its optimization, weigh no spillage of resources, but their savings as well as the planning of city logistics, making development plans for a specific time period.

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EDUCATION, ONLINE EDUCATION – ELEARNING

PEDAGOŠKA EFEKTIVNOST – KLJUČ KVALITETNOG OBRAZOVANJA

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SAŽETAK:

Pedagoška efektivnost predstavlja pojam koji je nastao iz potrebe definisanja značenja kvalitetnog obrazovanja danas. Iako se neretko koristi naizmenično sa pojmom pedagoške efikasnosti, od velikog je značaja ukazati na distinkciju ovih pojmova. U radu se analizira i određuje sam pojam pedagoške efektivnosti i istorijski razvoj ovog koncepta kroz faze. S obzirom da se pedagoška efektivnost posmatra kao širi pojam, ona praktično predstavlja uniju tri uža pojma. Prvi je sistemska efektivnost koja zavisi od politike i šireg socijalnog i društvenog konteksta jednog okruženja. Drugi je efektivnost škole koju čine vodeći organizacioni i kontekstualni indikatori koji direktno utiču na nastavu i učenje. Dok je u okviru trećeg pojma efektivna nastava okarakterisana brojnim faktorima u čijem fokusu se nalazi nastavnik. U zaključku se naglašava značaj osiguranja i poboljšanja kvaliteta obrazovanja u zemljama u razvoju i daju se predlozi za istraživanja trenutnog stanja koja bi predstavljala osnovu za unapređenje pedagoške efektivnosti kao sržne komponentne kvalitetnog obrazovanja.

Ključne riječi: *pedagoška efektivnost, sistemska efektivnost, efektivnost škole, efektivnost nastave, kvalitet obrazovanja.*

1. UVOD

Istraživanje kvaliteta obrazovanja predstavlja fokus interesovanja i izazov za gotovo sve istraživače kojima su pedagoške nauke i obrazovanje profesionalno opredeljenje. Nastojeći da se sadržajnije definiše šta sve čini „kvalitetno obrazovanje“ proizašao je pojam pedagoške efektivnosti (educational effectiveness) (Jovanović, 2017). Značaj istraživanja pedagoške efektivnosti vidimo u kvalitetu odgovora na sledeća pitanja: Šta čini kvalitetnu školu? I kako do kvalitetnog obrazovanja za sve? Danas kada zajednice preuzimaju odgovornost za obrazovanje svog stanovništva neophodno je da razmotriti kako zadovoljiti potrebe pojedinca a istovremeno osigurati da cela generacija napreduje. Istraživanja na ovu temu ukazuju nam da međunarodna perspektiva jeste od vitalnog značaja za razvoj pedagoške efektivnosti u svakoj zemlji ali ujedno da se dobijeni rezultati ne mogu primenjivati u raznorodnim kontekstima. U tom smislu veoma je važno kako

teorijski tako i empirijski ispitati ovaj koncept u okviru svakog pojedinačnog obrazovnog sistema imajući u vidu već do sada istražene segmente.

2. ISTORIJSKI RAZVOJ PEDAGOŠKE EFEKTIVNOSTI

U razvoju pedagoške efektivnosti analizom dostupne literature (Creemers, Kyriakides & Sammons, 2010; Reynolds, 2010; Teddlie, 2010; Teddlie & Reynolds, 2000; Townsend, 2007; Reynolds et al., 2011) razlikujemo pet faza. Prva faza odnosi se na korene razvoja koncepta pedagoške efektivnosti i na istraživanja Kolemara i saradnika (Coleman et al., 1966) i Dženksa i saradnika (Jencks et al., 1972) koji su zaključili da škole imaju neznatan uticaj na učeničke ishode u poređenju sa efektima sopstvenih sposobnosti i njihovim socijalnim okruženje. U ovoj fazi verovalo se da škole ne prave razliku i da obrazovanje ne može da bude kompenzacija za uticaj društvene sredine. Druga faza u istorijskom razvoju pedagoške efektivnosti prema Reynoldsu i saradnicima (Reynolds et al., 2011) počinje sredinom osamdesetih godina 20.veka i definisana je korišćenjem višestepene metodologije (Goldstein, 2003) čiji rezultati prikazuju naučna svojstva pedagoške efektivnosti u oblastima kao što su veličina i dugoročnost efekata škole, diferencijalni efekti škole u odnosu na učenike različitih karakteristika, vremenska stabilnost školskih efekata i konzistentnost školskih efekata na oblast drugačijih ishoda (Jovanović, 2017). Početkom devedesetih godina dvadesetog veka nastupa treća faza u istraživanju pedagoške efektivnosti u kojoj je osnovna karakterista istraživanja ovog fenomena razlog zbog kojeg određena škola produkuje određeni efekat. U ovoj fazi ispituju se determinante pedagoške efektivnosti u različitim kontekstima koje su rezultirale listom faktora pre svega efektivnih nastavnika. Sledeća, četvrta faza obuhvata period od sredine devedesetih godina dvadesetog veka pa do prve decenije dvadeset prvog veka i u okviru nje su se istraživanja prevashodno odnosila na kompleksnost i složenost koncepta pedagoške efektivnosti (Jovanović, 2017). U okviru ove faze razvijaju se teorijska osnova ove oblasti kao i prvi modeli pedagoške efektivnosti (Creemers, 1994; Scheerens, 1993; Stringfield & Slavin, 1992) sa ciljem da pruže odgovor na pitanje kako i zašto su određene ispitane determinante povezane sa ishodima učenika. U ovom periodu vidljiva je internacionalizacija ove oblasti i otvorenost za učenje iz povezanih istraživanja u različitim zemljama kao i umrežavanje istraživača pedagoške efektivnosti sa praktičarima koji se bave unapređenjem rada škola. Peta i poslednja faza, koja traje i razvija se i danas, počela je krajem prve decenije 21.veka. U ovom periodu istraživači vide pedagošku efektivnost kao dinamičan set odnosa sa različitim interakcijama u okviru obrazovnog sistema sa postizanjem varijabilnih ishoda (Creemers & Kyriakides, 2008). U ovom periodu akcenat je na novim statističkim analizama i strukturalnom modelovanju koje karakteriše uspostavljanje direktne i indirektno veze između obrazovnih faktora i ishoda kod učenika (Jovanović, 2017). Paralelno sa svim navedenim fazama tekao je i međunarodni trend primene obrazovnih sistema zasnovanih na dokazima sa dobrim rezultatima, gde se potencira da kreatori obrazovnih politika i praktičari implementiraju efektivnu praksu. Možemo da zaključimo da su rane faze istorijskog razvoja pedagoške efektivnosti svakako postavile određene temelje koji su bili ključni za teorijski i praktični rast ovog koncepta na globalnom nivou. U svetu danas postoje organizacije, konferencije i naučni časopisi čije područje rada je isključivo pedagoška efektivnost. To su: Međunarodna organizacija za razvoj i efektivnost škole (International Congress for School Effectiveness and

Improvement (ICSEI)) u Evropi; Društvo za istraživanja pedagoške efektivnosti (Society for Research on Educational Effectiveness (SREE)) u Sjedinjenim Američkim Državama koje je održalo i prvu konferenciju na ovu temu; Časopis o pedagoškoj efektivnosti (Journal of Educational Effectiveness), Efektivno obrazovanje (Effective Education) i drugi. Ono što za sada čini se otežava rast i razvoj pedagoške efektivnosti jeste nedostatak kvalitativnih podataka koji bi ilustrovali ono što kvantitativni rezultati pokazuju (Reynolds et al., 2014) te bi u budućnosti studije ove oblasti trebale da se zamene upitnicima, intervjuima i standardizovanim merenjima kvalitativnih podataka. Relativno kratka istorija izučavanja pedagoške efektivnosti, nedostatak kumulativnog rada kao i brojne perspektive uticaja na ovaj pojam učinile su da do danas nemamo njegovo jasno ograničeno značenje.

3. POJAM PEDAGOŠKE EFEKTIVNOSTI

Analizom literature nailazimo na (empirijski proverljive) pretpostavke o obimu i složenosti pojma pedagoške efektivnosti (Jovanović, 2017). Pre svega se složenost odnosi na vrlo često susretanu naizmeničnu upotrebu pojmova efikasnost i efektivnost. Najprostije rečeno efikasnost je odrađivanje stvari na pravi način, a efektivnost znači raditi prave stvari (Jovanović, 2017 prema Drucker, 2006). Na primer, određena osoba je efikasna i to znači da ona radi stvari na pravi način, ali to ne znači i da je efektivna u isto vreme i da radi prave stvari. Ili obrnuto rečeno, neko može da bude efektivan i da radi prave stvari ali to ne podrazumeva da ih u isto vreme radi i na pravi način (ibidem, 2017). Suština je da je za efektivnost bitan rezultat do kojeg je neko došao dok je kod efikasnosti važan način ili postupak dolaska do uspeha. U tom smislu je opredeljenje korišćenja termina pedagoška efektivnost opravdano jer se u obrazovnim sistemima vrednuju ishodi učenika a ne sam postupka dolaska do istih. Teorijsko utemeljenje ovakvog stanovišta pronalazimo kod autora Lohkida i Hanušeka (Lockheed & Hanushek, 1994) prema kojima efikasnost predstavlja odnos ulaza i izlaza u odnosu na ponuđene resurse, a efektivnost ne podrazumeva nužno efikasnost i odnosi se na uticaj na postignuća.

Druga „tačka spoticanja“ upotrebe pojma pedagoške efektivnosti je sama njena definicija, odnosno značenje. Najšire rečeno ovaj pojam se odnosi na ispitivanje efektivnosti jednog obrazovnog sistema. Dok uže, ono predstavlja određivanje kvaliteta određenog sistema na njegovim različitim nivoima: nacionalnom, okružnom, lokalnom, studiji slučaja pojedinačnih škola, razreda ili odeljenja unutar jedne škole, a može da se odnosi i na ispitivanje nastavnika i njihove uspešnosti u postizanju postavljenih ishoda. Pored samog definisanja pedagoške efektivnosti, čini se važnim da ukažemo na distinkciju, ali i međusobnu povezanost i neizostavnu upućenost ovog koncepta sa pojmovima efektivnost škole i efektivnosti nastavnika. U tom smislu smatramo da pedagoška efektivnost predstavlja širi pojam koji se sastoji od unije tri uža diferencirana pojma: sistemska efektivnost, efektivnost škole i efektivnost nastavnika, i shodno tome ćemo ih pojedinačno i analizirati.

3.1. Sistemska efektivnost

Sistemska efektivnost je najširi pojam iz unije užih pojmova pedagoške efektivnosti. Ona zavisi od politike, šireg socijalnog i društvenog konteksta jednog okruženja. Dvadeset prvi

vek uneo je nove imperitive u obrazovnu praksu, a zabrinutost za pristup i kvalitet obrazovanja čini se da raste na godišnjem nivou (Care et al., 2018). Iako se obrazovanje procenjuje kao glavni mehanizam obezbeđivanja znanja, kompetencija i veština potrebnih današnjem društvu, pružanje samog obrazovnog procesa najčešće zaostaje za potrebama tržišta. Postoji sve veća neophodnost da učenici izađu iz obrazovnih sistema sa kompetencijama koje prevazilaze akumulaciju znanja koja je bila visoko cenjena u dvadesetom veku (Care et al., 2018). Da bi se sve ovo ostvarilo neophodno je konstatno preispitivanje kvaliteta i svrishodnosti obrazovnih ciljeva i ishoda, njihovo redefinisavanje, kao i integrisan pristup nastavnim planovima i programima, nastavnoj praksi i ocenjivanju. Razvijene zemlje imaju timove koji se bave razvojem efektivnosti a sumiranjem dostupnih izvora možemo da zaključimo da systemska pedagoška efektivnost podrazumeva sledeće komponente: (1) standarde – uspešan sistem u skladu sa politikom i kontekstom potreba društva jasno definiše očekivanja; (2) procene – uspešan sistem se fokusira na rezultate, merenja i izveštaje o uspehu; (3) odgovornost – uspešni sistemi se zasnivaju na „posledicama“ za kreatora politika, nastavnike i učenike s obzirom na učinak koji postignu; (4) profesionalni razvoj nastavnika – obavezan je kontinuiran rast i razvoj svakog zaposlenog u obrazovnom sistemu; (5) školsku autonomiju – uspešni sistemi daju pojedinačnim školama slobodu delovanja i resurse za takvo delovanje; (6) učešće roditelja – podržavaju proces učenja, utiču na škole i donose odluke o obrazovanju svoje dece; (7) spremnost dece za učenje - uspešni sistemi obezbeđuju kvalitetno predškolsko obrazovanje i imaju podršku u prevazilaženju barijera u učenju uzrokovanih siromaštvom, zanemarivanjem, nasiljem ili narušenim zdravljem kod učenika; (8) tehnologiju – svi uspešni sistemi obezbeđuju tehnologiju kako bi se proširio pristup znanju i povećala produktivnost; (9) bezbednost i disciplina - uspešni sistemi obezbeđuju bezbedno i brižno okruženje za učenike (<https://www.businessroundtable.org>). Kada je systemska efektivnost obezbeđena, hijerarhijski sledi efektivnost pojedinačnih škola.

3.2. Efektivnost škole

Efektivna škola je u interesu kako onih koji školu organizuju i vode, rade u njoj tako i roditelja čija deca je pohađaju, pa i samih učenika. Stoga je definisanje efektivne škole od izuzetne važnosti. Sagledavajući iz šire perspektivne pedagošku efektivnost može se primetiti da je oko ovog pojma fokusiran najveći broj istraživanja sa najvećim brojem varijabli. Uzimajući u obzir navedene činjenice očekivali bi da je definicija efektivne škole jasna i određena. Do danas brojni istraživači ove oblasti nisu uspeli da dođu do jedinstvenog stava šta čini efektivnu školu. Razlog za to je, prema Jovanoviću (Jovanović, 2017), pre svega taj što je pojam *efektivnost škole* sagledavan iz različitih perspektiva: sa ulazno-izlaznog stanovišta (Cheng, 1996; Lockheed & Hanushek, 1988), iz školske perspektive gde je napredak učenika izvan očekivanja (Sammons, Hillman, & Martimore, 1995), razvoja postignuća učenika (Willms, 1992) i iz perspektive prema kojoj fokus ne treba da bude samo na učeničkom postignuću (Sammons, Mortimore, & Thomas, 1996). Kroz kratku istoriju postojanja pedagoške efektivnosti istraživači su nudili različite modele efektivnosti škole od kojih ćemo navesti samo neke. Veber (Weber, 1971) smatra da efektivne škole čine tri osnovne karakteristike: čvrsto liderstvo, dobra atmosfera i visoka očekivanja. Edmonds (Edmonds, 1982) nudi petofaktorski model efektivnosti škole koji čine: čvrsto liderstvo, visoka očekivanja od učenika, bezbedno i uredno

okruženje za učenje, sticanje osnovnih veština i učestale procene učeničkih postignuća. Značajan doprinos ovoj oblasti dao je i Lorens Lezot sa saradnicima. Oni su identifikovali sedam korelata efektivnih (delotvornih) škola koji su neophodni za visoka postignuća učenika. To su: jasna misija škole, bezbedno i uređeno okruženje, klima visokih očekivanja, učestalo praćenje napretka učenika, mogućnost za učenje i preokupacija aktivnostima, instrukciono liderstvo i pozitivni odnosi na relaciji škola-porodica učenika (Lezotte, 1991). 1995.godine Sabs (Subbs, 1995) determinante efektivnih škola definiše kroz pojmove postizanja visokih i jednakih nivoa učenja učenika. Nedostaci ovakvih istraživanja jesu upravo navedene paradigme odnosno perspektive u okviru kojih se efektivnost škole istraživala.

Iako možemo da primetimo sličnosti u utvrđenim korelatima što ukazuje na određenu ujednačenost i stabilnost u različitim zemljama i vremenskim periodima, malo je onih studija gde su istraživači povezivali različite pristupe. U tom smislu su autori Tedli i Reynolds (Teddlie & Reynolds, 2000) mapirali utvrđene karakteristike prema devet procesnih područja: (1) proces efektivnog liderstva – podrazumeva postojanost i svrsishodnost, odabir i zamenu osoblja, uključivanje drugih u proces, stalno personalno praćenje i praksu instrukcionog liderstva; (2) proces efektivne nastave – podrazumeva zajedničku svrhu, kolegijalnost i saradnju nastavnika i konzistentnost prakse; (3) razvijanje i održavanje fokusa na učenju sa akcentom na akademske procese i razvijanje tima za školsko učenje; (4) kreiranje pozitivne školske klime koju čine zajednička vizija, uredno okruženje i pozitivna podrška; (5) kreiranje visokih i svima odgovarajućih očekivanja za učenike i zaposlene; (6) naglašavanje odgovornosti i prava; (7) praćenje napretka na svim nivoima (individualni nivo, razred, škola); (8) razvijanje veština zaposlenih kroz kontinuirani profesionalni razvoja; i (9) uključivanje roditelja na produktivan i prikladan način. Osim ove analize značajno je spomenuti i istraživanje autorke Teodorović (Teodorović, 2009) koja je analizirala korelate efektivne škole u okviru brojnih istraživanja urađenih na osnovu tri paradigme: ulazno-izlaznog stanovišta, efektivnosti škole i efektivnosti nastave. Njeni rezultati pokazuju da na efektivnost škole utiču (1) karakteristike učenika – obrazovanje roditelja, radni status roditelja, ekonomski status porodice, kulturna svojina porodice, struktura porodice i komunikacija u samoj porodici, godine i pol učenika i uključenost roditelja u školske obaveze, (2) ulazno-izlazni faktori u školi – pol nastavnika, njihova plata, iskustvo i nivo obrazovanja i infrastruktura škole (3) karakteristike škole – efektivno liderstvo, uredno i sigurno okruženje, visoka očekivanja od učenika, često procenjivanje napretka učenika, razvijanje veština zaposlenih, saradnja i podrška roditelja (4) proces efektivne nastave – jasna izlaganja i zahtevi prema učenicima, fleksibilnost, entuzijazam nastavnika, didaktičke sposobnosti nastavnika i njihova priprema za čas, ocenjivanje domaćih zadataka i vreme za izradu zadataka, menadžemnt u učionici, odnosi nastavnika i učenika.

Analizom literature možemo da zaključimo da se definisanje efektivnosti škole svodi na traganje za determinantama uspešnosti učenika što dovodi do čitave liste karakteristika efektivne škole. Kako se broj ovih determinanti povećava ili razlikuje u odnosu na ispitivani kontekst tako se i definicija efektivnosti škole menja. Iako kroz godine istraživanja sada imamo zajedničke karakteristike efektivne škole, svako novo istraživanje donese neku novu determinantu što je usko povezano sa obrazovnim kontekstom i brzim promenama u društvu.

3.3. Efektivna nastava

Efektivna nastava je kao i efektivna škola predmet interesovanja stručnjaka iz različitih oblasti pedagoških, socioloških, psiholoških pa i andragoških disciplina ali i tema promišljanja i debata onih koji se bave politikom obrazovanja. Iako postoje različiti pristupi ovoj oblasti, najdominantniji je onaj u kom se efektivna nastava objašnjava karakteristikama njenog ključnog faktora, *nastavnika* (Jovanović, 2017). Da bi se utvrdila koliko je nastavnik efektivan najpre je potrebno definisati kriterijume efektivnosti koji su varijabilni u odnosu na društvo, politiku jedne zemlje i globalna kretanja. Analizom istraživanja ovog tipa (Marsh, 2001; Moreno, 2009; Schaefer et al., 2003; Radmacher & Martin, 2001) možemo da formiramo listu zajedničkih karakteristika efektivnih nastavnika: pripremljenost i jasnoća izlaganja, kreativnost i zainteresovanost, entuzijazam i humor, ekstrovertnost, prisnost i brižnost, pravičnost, podsticanje samoinicijativnog učenja, fleksibilnost... Najopštije rečeno efektivnu nastavu karakterišu sistematičnost u radu, stimulacija učenika i brižnost nastavnika (Jovanović, 2017, prema McKaechie & Kulik, 1975; Cohen, 1981; Marsh, 1982). Možemo konstatovati da efektivna nastava uključuje veliki broj karakteristika ličnosti samog nastavnika, poznavanje predmeta sa didaktičkim sposobnostima i njegovu refleksivnu praksu. Ipak za procenu efektivnosti nastavnika smatramo da treba pored perspektive nastavnika u obzir uzeti i perspektivu učenika kao i perspektivu aktivnosti koje se sprovode u okviru nastave (Kyriacou, 2009). Problemi u nastavi nastaju kada nastavnici za posao, za koji su verovali da dobro poznaju, bili sposobni i efektivni, odjednom gube na efektivnosti usled uslova u kojima rade a koji se menjaju do neprepoznatljivosti (Esteve, 2000). Ovo se dešava zbog velikih tehničkih, tehnoloških, društvenih i moralnih promena u jednom okruženju gde nastavnici odjednom postaju kao glumci na sceni koja se iznenada promenila, a oni ostaju zatečeni u neprilagođenim kostimima uz neminovnu potrebu da nastave predstavu i uspešno je privedu kraju. Javnost, a često i stručnjaci u oblasti obrazovanja veruju da su nastavnici ti koji su jedini neposredno odgovorni za efektivnost nastave, ishode koje ostvaruju učenici i za trenutne propuste u nastavi (Esteve, 2000). Kako bi nastava bila efektivna, a nastavnici ne bi izgledali kao glumci u neadekvatnim kostimima na novoj sceni, primorani na improvizaciju, neophodno je da njihovo inicijalno obrazovanje i profesionalni razvoj kontinuirano prate promene u društvu, savremene trendove potreba i obrazovne ishode.

4. ZAKLJUČAK

Možemo da zaključimo da pedagoška efektivnost predstavlja ključni pojam koji je nastao usled potrebe za preciznijim definisanjem kvalitetnog obrazovanja. Nju čini širok spektar faktora u školama i obrazovnim sistemima kao što su: nastavni plan i program, obrazovno okruženje, nastavnika, formalna i neformalna organizacija škole, liderstvo i drugi. S obzirom da podizanje nivoa kvaliteta obrazovanja predstavlja prioritetni društveni status na globalnom nivou (Marić Jurišin & Malčić, 2022) jasno je da pedagoška efektivnost sa unijom užih pojmova opisanih u ovom radu čine prioritetne oblasti razvoja čitavih obrazovnih sistema.

Iz ovog teorijskog pregleda postaje jasno da je efektivnost kauzalni koncept (Jovanović, 2017) i da se istraživanja ovog koncepta danas ne mogu oslanjati samo na merenje obrazovnih efekata već i na pripisivanje efekata antecedentnim uslovima obrazovanja. Takođe da bi se efektivnost izmerila neophodno je merenja prilagoditi karakteristikama obrazovnog konteksta (karakteristike školskog okruženja, škole kao organizacije i razredne prakse) i uzrasta učenika koji se ispituju.

Kako bi se načinile strategije razvoja ove oblasti u određenom obrazovnom kontekstu i osigurao ali i poboljšao kvalitet obrazovanja, neophodno je uzeti sve navedeno u obzir i uraditi monitoring trenutnog stanja, kao i sveobuhvatno istraživanje sa analizom sistemske efektivnosti, efektivnosti škole, nastave i nastavnika. Ono što je važno za dovijanje istinski održivog rešenja sukcesivnog razvoja pedagoške efektivnosti jeste da pored međunarodnih iskustava u obzir moramo uzeti ekonomsko, društveno i prirodno vlastito okruženje (Elkington, 1994) jer samo tako će ishodi biti dugotrajno kvalitetniji i održiviji.

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EDUCATIONAL EFFECTIVENESS – THE KEY OF QUALITY EDUCATION

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ABSTRACT:

Educational effectiveness is a concept that has emerged from the need to define the meaning of quality education today. Although it is often used interchangeably with the concept of educational efficiency, it is of great importance to emphasize the distinction between these terms. This paper analyzes and determines the concept of educational effectiveness and the historical development of this concept through phases. Considering educational effectiveness as a broader concept, it practically represents the union of three narrower concepts. The first is systemic effectiveness, dependent on the policies and broader social and societal context of an environment. The second is school effectiveness, consisting of leading organizational and contextual indicators that directly influence teaching and learning. Within the third concept, effective teaching is characterized by numerous factors, with a focus on the teacher. In conclusion, the significance of ensuring and improving the quality of education in developing countries is emphasized, along with suggestions for research on the current state, forming the basis for enhancing educational effectiveness as a core component of quality education.

Keywords: *educational effectiveness, systemic effectiveness, school effectiveness, teaching effectiveness, quality of education.*

DIGITALNA PISMENOST OSOBA SA INTELEKTUALNOM OMETENOŠĆU

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SAŽETAK:

Tehnologija i tehnološka dostignuća su od početka dvadesetprvog veka uznapredovala u svim oblastima. Kada su u pitanju osobe sa intelektualnom ometenošću (IO), i osobe ove populacije sve više koriste različite vidove tehnologije. Cilj ovog rada bio je izvršiti pregled dostupne literature koja se bavila digitalnom pismenošću osoba sa IO, a koja se odnosi na stepen digitalne pismenosti ovih osoba, neophodne predveštine za ovladavanjem digitalnom pismenošću od strane osoba sa IO, kao i izvršiti prikaz intervencija sprovedenih u cilju povećanja digitalne pismenosti osoba sa IO. Dostupna literatura prikupljena je putem pretraživača Google Scholar, Scopus, Web of Science i ProQuest. Na osnovu rezultata pregleda literature, možemo zaključiti da je neophodno povećati kompetencije osoba sa IO u domenima digitalne pismenosti. Osim samih osoba sa IO, neophodno je i raditi na povećanju veština digitalne pismenosti i samih defektologa, kao i na povećanju kapaciteta škola za obrazovanje i vaspitanje osoba sa IO u vidu nabavke različitih tehnoloških uređaja. Neophodno je da se od najranijeg uzrasta radi na povećanju neophodnih predveština za ovladavanje digitalnom pismenošću od strane osoba sa IO, odnosno na usvojenosti sposobnosti čitanja, pisanja i razumevanja pročitano. Iako su se intervencije sprovedene u cilju povećanja veština digitalne pismenosti osoba sa IO prikazane u ovom radu pokazale efikasnim, od velikog je značaja da te intervencije budu uz primenu naučno-dokazanih intervencija.

Ključne riječi: *Digitalna pismenost, intelektualna ometenost, predveštine, intervencije.*

1. UVOD

Tehnologija i tehnološka dostignuća su od početka dvadesetprvog veka uznapredovala u svim oblastima (Kraus et al., 2019). Ta tehnološka dostignuća mogu da omoguće da se ljudi osete povezanim sa drugim ljudima, kao i da dovede do povećanja bliskosti među ljudima i posledično poboljša njihove socijalne odnose (Vidojković et al., 2023), kao i da dovede do povećanja veština koje su neophodne ljudima za povećanje samostalnosti i veće mogućnosti zaposlenja (Arsić et al., 2022).

Kada su u pitanju osobe sa intelektualnom ometenošću (IO), i osobe ove populacije sve više koriste različite vidove tehnologije (Gell et al., 2015). Podaci istraživanja pokazuju da osobe sa IO koriste tehnologiju u velikoj meri, gde 97% osoba sa IO koristi mobilni telefon, 93% računar, a 61% tablet (Begara Iglesias et al., 2019), što je slična prevalencija kao i u populaciji osoba tipične populacije.

Kada je u pitanju korišćenje društvenih mreža od strane osoba sa IO, ove osobe društvene mreže najčešće koriste u svrhe socijalnog umrežavanja (Glencross et al., 2021), a rezultati prethodnih istraživanja pokazuju da osobe ove populacije imaju teškoće u korišćenju istih usled deficita u domenima komunikacije, razumevanja i korišćenja jezičkih izraza koji se koriste u digitalnom prostoru i uopšteno deficita u domenima digitalne pismenosti (Caton & Chapman, 2016).

Najistaknutiji rizik za osobe sa IO u digitalnom prostoru je emocionalni distres, koji preživljava skoro četvrtina ove populacije (Glencross et al., 2021), a do njega dolazi usled viktimizacije u digitalnom prostoru. Istraživanja pokazuju da je čak 73.9% osoba sa razvojnim poremećajima i IO imalo iskustva sa viktimizacijom u digitalnom prostoru, što posledično dovodi do povećanja prisustva anksioznosti kod ove populacije (Holfeld et al., 2019; Sallafranque-St-Louis & Normand, 2017).

Rizik za viktimizaciju u onlajn prostoru je manji, ukoliko osobe sa IO imaju u dovoljnoj meri razvijene veštine digitalne pismenosti (Good & Fang, 2015; Phillips & Anderson, 2020). Digitalna pismenost podrazumeva posedovanje veština neophodnih za svakodnevni život i komunikaciju u društvu u kojem se komunikacija i pristup informacija odvija putem digitalnih platformi, kao što su internet, mobilni telefoni ili društvene mreže (Reddy et al., 2020).

Cilj ovog rada bio je izvršiti pregled dostupne literature koja se bavila digitalnom pismošću osoba sa IO, a koja se odnosi na stepen digitalne pismenosti ovih osoba, neophodne predveštine za ovladavanjem digitalnom pismošću od strane osoba sa IO, kao i izvršiti prikaz intervencija sprovedenih u cilju povećanja digitalne pismenosti osoba sa IO.

2. METODOLOGIJA

Dostupna literatura prikupljena je putem pretraživača *Google Scholar*, *Scopus*, *Web of Science* i *ProQuest*. Za pretragu korišćene su ključne reči intelektualna ometenost (eng. *intellectual disability*), digitalna pismenost (eng. *digital literacy*), predveštine (eng. *prerequisite skills*), intervencije (eng. *interventions*). Ključne reči su međusobno kombinovane na srpskom i engleskom jeziku.

U pregledni deo rada uključivani su oni radovi koji su preglednog i istraživačkog karaktera, koji su u uzorku imali osobe sa IO i drugim razvojnim poremećajima koji uključuju prisustvo IO, a koji su objavljeni u poslednjih deset godina (2013-2023).

3. PREGLED ISTRAŽIVANJA

3.1. Digitalna pismenost osoba sa intelektualnom ometenošću

U jednoj metaanalizi (Khanlou et al., 2021) koja je obuhvatila 29 radova koji se odnose na digitalnu pismenost osoba sa IO utvrđeno je da je neophodno poboljšati njihove veštine digitalne pismenosti, a da za to najviše treba da budu zaduženi nastavnici i defektolozi u školskom okruženju. Osim toga, roditelji treba da potpomognu razvijenost ovih veština u kućnim uslovima.

Kao jedne od najučestalijih barijera za razvijenost digitalne pismenosti osoba sa IO ističu se nedovoljna razvijenost veština korišćenja različitih tehnoloških uređaja od strane defektologa koji rade sa osobama sa IO, kao i njihovih roditelja, zatim nedovoljna zastupljenost određenih tehnoloških uređaja u školama u kojima se obrazuju deca sa IO, nedostatak vremena defektologa i nastavnog osoblja koje radi sa ovom populacijom za rad na razvijanju veština digitalne pismenosti u školskom okruženju, kao i nedovoljno samospouzdanje defektologa za podučavanje takvih veština (Masenya, 2021).

Osim barijera koje se tiču nastavnog osoblja, kao i školske infrastrukture za podučavanje ovih veština, postoje i barijere koje se odnose na same osobe sa IO (Arsić et al., 2022). Osobe sa IO često imaju ograničene sposobnosti čitanja, pisanja i razumevanja pročitano, a ove tri veštine se ističu kao neophodne predveštine za ovladavanje veštinama digitalne pismenosti.

3.2. Razvijanje predveština neophodnih za povećanje digitalne pismenosti osoba sa intelektualnom ometenošću

Već je istaknuto kako su neophodne predveštine za ovladavanje digitalnom pismenošću od strane osoba sa IO usvojenost sposobnosti čitanja, pisanja i razumevanja pročitano.

Kada je u pitanju veština čitanja, istraživanje koje je imalo za cilj proučavanje efekata kompjuterskog programa za podsticanje veština čitanja od strane osoba sa IO je sprovedeno od strane Bejlja i saradnika (Bayley et al., 2017). Autori su osmislili kompjuterski program pod nazivom *Abrakadabra*, a u cilju podsticanja tačnosti čitanja, fluentnosti i razumevanja pročitano, a na uzorku koji se sastojao od dece sa poremećajima iz spektra autizma (PSA) i IO. U uzorku je bilo 20 dece uzrasta između pet i 11 godina, a oni su dobijali individualizovane instrukcije u svom domu, a u trajanju od 13 nedelja, sa učestalošću od dva puta nedeljno. Rezultati istraživanja ukazuju na statistički značajno povećanje tačnosti čitanja, kao i razumevanja pročitano od strane osoba sa PSA i IO.

Još jedno istraživanje sprovedeno u cilju povećanja veština čitanja je osmišljeno tako što su ispitanici podučavani globalnom čitanju (Mandak et al., 2019). Uzorak se takođe sastojao od ispitanika koji su dijagnostikovani sa PSA. Softver pomoću kojeg su

ispitanici podučavani veštinama čitanja se sastojao od osam reči kojima su bili podučavani. U početnoj fazi, ispitanici bi trebalo da selektuju određenu reč i povežu je sa korespondirajućom fotografijom, a na osnovu glasovnog outputa. Svi ispitanici iz uzorka su uspešno usvojili globalno čitanje reči kojima su podučavani pomoću softvera.

Kada je u pitanju predveština neophodna za usvajanje digitalne pismenosti koja se odnosi na usvajanje sposobnosti pisanja, grupa autora (Evmenova et al., 2016) sprovela je istraživanje u cilju ispitivanja efekata kompjuterskog programa usmerenog na povećanje kompetentnosti 10 ispitanika dijagnostikovanih sa IO, ADHD ili PSA u tom domenu. Program je omogućavao ispitanicima samovođeno uvežbavanje veštine pisanja eseja. Efekti upotrebe programa su procenjivani merenjem povećanja broja reči i rečenica relevantnih za temu. Rezultati istraživanja su pokazali da je intervencija bila efikasna, jer je kod svih ispitanika došlo do povećanja kvaliteta pisanja eseja, ali i kvantiteta napisanog. Socijalna validnost, odnosno vrednovanje intervencije i zadovoljstvo programom je bila procenjivana u vidu intervjuisanja ispitanika, a rezultati su pokazali da su svi ispitanici bili veoma zadovoljni intervencijom, kao i da im se osmišljeni kompjuterski program dopao.

Cilj istraživanja koje su sproveli Asaro-Saddler i saradnici (Asaro-Saddler et al., 2015) odnosio se na utvrđivanje specifičnosti koje otežavaju usvajanje veštine pisanja, kao i kako korišćenje tehnologije doprinosi prevazilaženju ovih teškoća. U pilot istraživanju uzorak su činili srednjoškolci sa PSA koji su koristili First Author® softver kako bi unapredili veštinu pisanja. Rezultati istraživanja pokazali su da je došlo do poboljšanja u kvalitativnom i kvantitativnom aspektu pisanih radova kada su učenici podučavani uz upotrebu First Author® softvera. Takođe, date su preporuke za nastavnike i stručnjake koji rade u neposrednom radu sa decom (Asaro-Saddler et al., 2015).

Kada je u pitanju neophodna predveština za usvajanje digitalne pismenosti osoba sa razvojnim teškoćama, a koja se odnosi na razumevanje pročitano, u istraživanju Omara i Bidina (Omar & Bidin, 2015) sprovedenom sa ciljem utvrđivanja načina na koji multimedijalni elementi (tekst i slika) pomažu u razumevanju pročitano kod dece sa PSA, rezultati su pokazali da ovaj način može unaprediti razumevanje pročitano kod deca sa PSA.

U jednom istraživanju (Reutebuch et al., 2015) autori su sproveli istraživanje u cilju poboljšanja sposobnosti razumevanja pročitano, a na uzorku koji se sastojao od tri srednjoškolca sa PSA. Svaki učenik sa PSA bio je uparen sa učenicom tipične populacije kako bi ovladavali i primenjivali strategije čitanja na informativnim tekstovima dva do tri puta nedeljno. Podaci o razumevanju na dnevnom nivou prikupljeni su posmatranjem radi uočavanja prisustva problema u ponašanju i socijalnih interakcija tokom primene intervencije. Učenici su pospešili razumevanje pročitano i češće stupali u socijalne interakcije, dok se učestalost problematičnog ponašanja smanjila.

3.3. Intervencije za povećanje digitalne pismenosti osoba sa intelektualnom ometenošću

Istraživanje Cihaka i saradnika (Cihak et al., 2015) je imalo za cilj ispitivanje efikasnosti programa za podučavanje veština digitalne pismenosti osoba sa IO koje su srednjoškolskog uzrasta. Autori su osmislili kurikulum koji je obuhvatao podučavanje veština slanja i čitanja e-mailova, korišćenja vebajtova za pretragu poslova i prijavljivanje na isti, pristupanje onlajn prostoru za čuvanje fotografija i dokumenata. Svi

ispitanici su nakon pohađanja obuke u potpunosti ovladali podučavanim veštinama, a rezultati obuke su se održali i nakon protoka vremena. Autori ističu kako su obuke ovog tipa od velikog značaja za osobe sa IO, jer omogućavaju veću socijalnu participaciju u digitalnom svetu.

U istraživanju Mekmahona i saradnika (McMahon et al., 2016) sprovedenom u cilju povećanja veština digitalne pismenosti, ispitanici su bili studenti fakulteta, a koji imaju IO ili PSA. U uzorku je bilo tri ispitanika sa IO i jedan ispitanik sa visokofunkcionalnim PSA. Autori su koristili uređaje virtuelne realnosti kako bi ispitanike naučili razumevanju i primeni reči koje se odnose na neophodne veštine digitalne pismenosti. Prikupljeni su podaci o sposobnostima ispitanika da definišu i napišu tri seta reči. Nakon sprovođenja intervencije, svi ispitanici su uspešno definisali i imenovali navedene pojmove koji su obuhvaćeni obukom, a autori u zaključnim razmatranjima ističu kako bi uređaji virtuelne realnosti mogli uspešno da se primenjuju za podučavanje osoba sa IO i PSA poznavanju bilo kakvih pojmova relevantnih za njihovo školovanje, jer bi na taj način mogla da se podstakne njihova edukacija.

Cilj istraživanju koje su sproveli Mek Mahon i saradnici (McMahon et al., 2015) bio je da se ispituju efekti podsticanja veština snalaženja u prostoru, odnosno navigacije u prostoru pomoću uređaja virtualne stvarnosti u poređenju sa Google mapama i kartonskim mapama kao pomoćnim sredstvima za navigaciju osoba sa IO. Ispitanici u ovom istraživanju bili su tri studenta sa IO i jedan student sa PSA. Procenjena je sposobnost donošenja odluke kod ispitanika kako bi se prevozili do nepoznatih lokacija u gradu pomoću navedenih uređaja. Rezultati ovog istraživanja su pokazali da su studenti imali više uspeha u pronalaženju lokacije koristeći virtuelnu stvarnost u poređenju sa Google mapama i kartonskom mapom, što je doprinelo smanjenju velikog broja barijera.

Cilj istraživanja koje su sproveli Rivera i saradnici (Rivera et al., 2017) bio je da utvrde efikasnost primene multikomponentne intervencije multimedijalnog deljenja priča (MDP) putem iPad-a u svrhu povećanja digitalne pismenosti troje učenika osnovne škole sa IO. Deljene priče, isporučene putem iPada, obuhvatale su fotografije, tekst i videozapise. Kako bi se procenio napredak učenika, izvršena su merenja pre i posle primene intervencije. Rezultati su pokazali da su sva tri učenika ovladala korišćenjem digitalnim uređajima, unapredila svoj vokabular i generalizovala svoje znanje. Osim toga, sa porastom korišćenja iPad uređaja, defektolozi pronalaze sve više načina da ih iskoriste u podsticanju akademskih sposobnosti kod svojih učenika sa IO (Rivera et al., 2017).

3. DISKUSIJA SA ZAKLJUČKOM

Na osnovu rezultata pregleda literature, možemo zaključiti da je neophodno povećati kompetencije osoba sa IO u domenima digitalne pismenosti. Osim samih defektologa, i roditelji osoba sa IO ili razvojnim poremećajima se mogu podučiti kako da podučavaju svoju decu putem onlajn tehnologija (Arsić et al., 2023), u različitim domenima sposobnosti, pa i u povećanju digitalne pismenosti svoje dece. Takođe, lični pratioci dece sa IO takođe mogu da sprovedu intervencije u cilju povećanja digitalne pismenosti (Gajić et al., 2021). Međutim, od velikog je značaja da te intervencije budu uz primenu naučno-dokazanih intervencija (Arsić et al., 2021), kako bi bile efikasne.

Osim samih osoba sa IO, neophodno je i raditi na povećanju veština digitalne pismenosti i samih defektologa, kao i na povećanju kapaciteta škola za obrazovanje i vaspitanje osoba sa IO za razvijanjem ovih veština u vidu nabavke različitih tehnoloških uređaja koji bi omogućili podsticanje razvoja veština digitalne pismenosti osoba sa IO. Bitno je raditi na obučavanju nastavnog osoblja, jer istraživanja pokazuju da osobe sa IO efikasnije usvajaju veštine ukoliko podsticaj koji dobijaju dolazi od strane čoveka, nasuprot samog tehnološkog uređaja (Coleman et al., 2015). Međutim, ukoliko osobe sa IO doživljavaju tehnološke uređaje kao visoko motivišućim predmetima, sama nagrada im može biti i korišćenje uređaja (Constantin et al., 2017).

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DIGITAL LITERACY OF PEOPLE WITH INTELLECTUAL DISABILITY

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ABSTRACT:

Technology and technological achievements have advanced in all areas since the beginning of the twenty-first century. When it comes to people with intellectual disabilities (ID), people of this population are increasingly using different types of technology. The aim of this paper was to review the available literature that examined the level of digital literacy of people with ID, the necessary prerequisite skills for mastering digital literacy by people with ID, as well as to present the interventions implemented in order to increase of digital literacy of this population. The available literature was collected through Google Scholar, Scopus, Web of Science and ProQuest search engines. Based on the results of the literature review, we can conclude that it is necessary to increase the competences of people with ID in the domains of digital literacy. In addition to the people with ID, it is also necessary to increase the digital literacy skills of the special education teachers themselves, as well as increasing the capacity of schools for the education of people with ID in the form of purchasing various technological devices. From the earliest age, it is necessary to work on increasing the necessary prerequisite skills for mastering digital literacy by people with ID that is, on acquiring the ability to read, write and reading comprehension. Although the interventions implemented in order to increase the digital literacy skills of people with ID presented in this paper have proven to be effective, it is of great importance that these interventions are accompanied by the application of scientifically proven interventions.

Keywords: *Digital literacy, intellectual disability, prerequisite skills, interventions.*

LABORATORY ACTIVITIES TO INTRODUCE THE QUALITATIVE ANALYSIS OF BIOMOLECULES IN THE COMMON FOOD STUFF – AN EXAMPLE OF INQUIRY-BASED TEACHING IN THE CHEMISTRY CLASSROOM

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ABSTRACT:

The inquiry-based teaching methodologies have important place in the laboratory school practice and science education. Inquire-based learning combines the hands-on activities with student-centred discussion, and, in the same time, promotes the students engagement, collaboration and self-confidence, as well as their critical thinking and problem-solving abilities. Herein we present practical examples of inquiry-based activities for the qualitative determination of the presence of carbohydrates, starch, proteins and vitamin C in common food stuff. The developed activities were realized with the third and fourth grade students from the vocational school (The first technical school, Kragujevac, Serbia). The students were requested to perform the qualitative tests for the determination of starch (Iodine test), reducing sugars (Fehling test), proteins (Biuret test) and vitamin C (Iodine test), prior to the realization of final task where they needed to choose adequate methods and solve real-life conceptually based problems using acquired knowledge and skills. Confirmatory and structured inquiry teaching were applied and the students were equipped with experimental procedures. The applied methodology has been used to reinforce students' existing knowledge and connections with real-life concepts.

Keywords: *inquiry-based teaching; biomolecules; chemistry*

1. INTRODUCTION

Inquire-based teaching is a method where educators guide students through the learning process by posing questions, encouraging exploration, and fostering critical thinking. It promotes active engagement and deeper understanding of the subject matter. The inquiry-based teaching methodologies have important place in the laboratory school practice and science education [1]. They combine the hands-on activities with student-centered discussion, and, in the same time, promote the students engagement, collaboration and self-confidence [2], as well as their critical thinking and problem-solving abilities. There are five inquiry-based teaching methods, namely simulation, field study, project, demonstration of discrepant events and experiment [3]. Experiment takes central place in doing investigation in chemistry classroom. The experiment offers controlled environment

for experimentation, discovery, and the validation of scientific theories. By combining laboratory activities and research, more abiding feature is created in which teaching and learning become an active cooperative process. The framework created in this way includes active students' engagements in the learning scientific concepts with the focus on observations, experience, adoption of problem-based learning process, permanent development of skills and autonomy through experience [4]. The methodology employed for learning chemistry in Serbian education is based on the traditional teaching method and the little attention has been placed on the activities that will engage students in the experimental design process. Taking all above in consideration, herein we present the results of the application of inquire-based activities for the learning concepts from the biochemistry (determination of the presence of carbohydrates, starch, proteins and vitamin C in common foodstuff) on the students' personal reflections and attitudes towards this learning model.

2. SAMPLE AND METHODOLOGY

Herein we present practical examples of inquiry-based activities for the qualitative determination of the presence of carbohydrates, starch, proteins and vitamin C in common food stuff. The developed activities were realized with the third and fourth grade students from the vocational school (The first technical school, Kragujevac, Serbia, N=85, girls 63, boys 22). The students were working in small groups (4 students in one group). The activities were realized at the laboratories of Faculty of Science (Department of chemistry, University of Kragujevac), under supervisory of professors and PhD students whose have rich experience in the implementation of different kinds of active learning methodologies in the chemistry classroom. At the first workshop, the students were requested to perform the qualitative tests for the determination of starch (Iodine test), reducing sugars (Fehling test), proteins (Biuret test) and vitamin C (Iodine test), prior to the realization of final workshop where the given tasks required from students to choose adequate methods and solve real-life conceptually based problems using acquired knowledge and skills. Confirmatory and structured inquiry teaching were applied and the students were equipped with experimental procedures. The applied methodology has been used to reinforce students' existing knowledge and connections with real-life concepts. After the activities were realized, the survey related to the students' personal reflections and attitudes toward inquire-based activity application in learning chemistry contests was given to the students.

3. RESULTS AND DISCUSSIONS

In a confirmatory inquiry activity the teacher provides research questions and procedure, and students are asked to confirm a previously taught relationships. From the other side, in structured inquiry, the research questions and procedure are also provided but students don't know the expected outcomes of the given problems [5]. In this research, we have offered students to learn the concepts from the biochemistry (presence of different biomolecules in common food stuff) at different levels of inquiry – namely combination of confirmatory and structured inquiry, as indicated in Table 1. It is important to

emphasize that, in all levels, students analyzed data to find solutions for research questions but the levels of inquiry differs in the quantity of information provided by teachers.

Table 1. Levels of inquiry applied in our study.

Inquire level	What Teachers Provides	Examples in our study
Confirmatory	Question Method Solution	After learning about biomolecule examples and their presence in everyday life, students practice the chemical tests for the detection of the presence of the selected examples (reducing sugars, ascorbic acid, proteins and starch). Data analysis: Qualitative evidence of a reactions for each class of biomolecules (recorded color changes of the reagents used in the chemical tests).
Structured	Question Method	To the students, previously equipped with procedure for determination of biomolecules in the food samples, the problems related to the real-life concepts and presence of biomolecules in common food stuff are given to solve. Data analysis: Distinguishing between qualitative chemical tests necessary for the determination of presence of reducing sugars, vitamin C, starch and proteins in food samples (Coca Cola classic, Coca Cola zero, natural juice, flour, and milk).

At the initial workshops, students learn how to perform qualitative tests for the determination of biomolecules (Iodine test for starch, Fehling test for reducing sugars, Biuret test for proteins, Iodine test for vitamin C). The students previously were equipped with the knowledge about using chemical laboratory glass and equipment and safety rules in laboratory work. During activities, students followed given experimental procedures and observed changes of the colors in the performed chemical tests. After completing the experimental work, students wrote a procedure, turning to the important practical aspects of the experiments. Even at the first workshop, students get benefits from the activities reflected in achievement of starting point for development of their own experiments and enjoying of performing experiments in groups. Confirmatory activities are helpful in reinforcing challenging chemical concepts, as well as in creating better students' focus on a specific laboratory tests. After the first workshop was realized, at the second workshop, the following chemical problems were given to the students:

Problem 1. There are test tubes with samples of the natural orange juice and flavored orange juice. By using appropriate reaction find out which sample is containing natural juice.

Problem 2. There are test tubes with Coca-Cola Classic and Coca-Cola zero. By using appropriate chemical reaction find out which sample contains Coca-Cola Classic.

Problem 3. At your working place you will find the samples of flour and milk. Using appropriate reagents, confirm the presence of:

- a) sugar b) protein c) starch in appropriate food sample.

For instance, to solve problem 1, students needed to know that natural orange juice contains vitamin C and then to apply reaction for its identification in the sample. Problem 2 required from students to apply Fehling reaction for the qualitative identification of reducing sugar in classic Coca Cola sample, since the Coca Cola zero doesn't contain sugars. In order to solve the problem 3, it was necessary for students to recognize that flour sample contains starch and to apply iodine test for its identification; that milk sample contains proteins and to apply Biuret test to identify them, as well as reducing sugar lactose and to apply Fehling reaction for its identification. The presented problems required from the students to propose an experimental procedure in order to solve them and, in the same time, to combine practical knowledge with theoretical knowledge about biomolecules and their presence in common food stuff. Students were working in small groups and in order to solve the problems, they had to work together, communicate and discuss possible solutions. According to the teachers' personal opinions and observations established during realization of workshops, some negative and positive experiences are summarized in Table 2.

Table 2. Positive and negative experiences during realization of workshops according to the teachers' opinions

Positive experiences	Negative experiences
Students expressed interest during working on the given topics. Most of them were motivated to accomplish given tasks and achieve good results.	In several cases, lack of the necessary content knowledge.
Students experienced skilled and successful accomplishment of the practical part.	Some students preferred more to work independently.
Matured, environmental-conscious approach on the students' part.	Some students felt pressured during realization of activities (fear from unsuccessful accomplishment of the tasks).
Better connections with real-life concepts.	

After all groups finished activities, the following survey list was administrated to the students (Table 3). Table 3 also indicates the students' responses on given statements.

Table 3. Survey – Students’ attitudes and personal reflections towards inquire-based teaching implementation in chemistry classroom

Statement	Fully agree (%)	Agree (%)	Disagree (%)	Fully disagree (%)	Agreement with the statement (%) N=85
I’ve enjoyed doing laboratory activities.	20	64.7	8.2	7.1	84.7
These activities helped me to understand chemistry contents in everyday life-concepts.	35.3	47.1	16.5	1.1	82.4
I’ve enjoyed doing activities in a group.	56.5	43.5	0.0	0.0	100
I felt pressured to do activities.	0.0	10.6	34.1	55.3	10.6
I would like to have more teaching and learning activities based on inquiry	29.4	57.6	13.0	0.0	87

The students’ answers enabled us to find out whether students considered inquiry-based teaching important in their motivation to study chemical contents and how important for them was group work in the performance of activities. From the results obtained in our study, it can be concluded that the introduction of inquiry-based teaching into the chemistry classroom led to a significantly better acquisition of chemistry concepts related to biochemistry, and produced positive students’ attitudes towards chemistry and laboratory activities.

4. CONCLUSION

When it comes to suggestions for chemistry teaching, the varied teaching models and approaches available for inquiry-based teaching could be included in schools as a suitable classroom practice. Herein we described the examples of inquiry-based activities for the qualitative determination of the presence of carbohydrates, starch, proteins and vitamin C in common foodstuff that were applied in the work with the students from a vocational school in order to follow their personal reflections and attitudes toward inquire-based activity application in learning chemistry contests. The influence of applied activities on the reinforcement of students' existing knowledge and connections with real-life concepts was also studied. According to the obtained results, it can be concluded that introduction of inquiry-based teaching into chemistry classroom led to a significantly better acquisition of chemistry concepts related to biochemistry, and produced positive students' attitudes towards chemistry and laboratory activities.

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OUTSIDE-OF-THE-BOX STEM TEACHING FOR PRIMARY SCHOOL CHILDREN IN SERBIA ON TOPIC DIVERSITY OF NATURE - WATER

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ABSTRACT:

It is well known that STEM education and its early implementation has great benefits for the development of thinking and reasoning skills in younger children, and that early and appropriate experiences can influence and foster interest in STEM. Also, advantages of STEM education are reflected in interdisciplinarity and connection to real life experiences [1,2]. In this study we conducted (2nd grade students, N=29, Primary school “Moma Stanojlovic”, Kragujevac, Serbia) some hands-on activities that mimicked certain real-life scenarios in order to evaluate their impact on student motivation, perception and acquired knowledge. Faculty staff took the role of “STEM ambassadors” and with the help of teacher the experiments involving water cycle in nature, surface tension, capillary force, reflection, reaction medium and heat capacity were conducted through various game-like hands-on activities and demonstrations. The concept of inquiry-based teaching was used, and children were encouraged to ask questions, make suggestions and draw conclusions. Due to the young age of participants, the appropriate data were collected by the teacher through the interview. The results have shown that children gained more lasting knowledge and were highly collaborative and motivated to participate in all activities. It was noticed that the practical nature of proposed activities gave children the feeling of participating in a game or a free activity, so they were more engaged in their learning process, and it was perceived that hands-on activities better match the energy levels of children of that age and the need for a diversity of sensory stimuli.

Keywords: STEM, Chemistry, Primary school education

INTRODUCTION

The basic principle of science relies on foundational concepts of exploring, questioning, speculating and learning about the world through observation, listening, and recording. Children are by their nature full of wonder, curious and are constantly investigating the world that surrounds them in pursuit of new experiences and knowledge in order to better fathom and understand their environment. The educational concept that can nurture these innate characteristics of children and intertwine them with science and knowledge seeking culture can help children to develop skills that have become imperative in the technologically oriented 21st century.

STEM (science, technology, engineering, and mathematics) education which is conducted through the lens of inquiry-based learning approach could be an efficient way of introducing young children to problem-solving interdisciplinary teaching method which is focused more on applying knowledge rather than remembering knowledge [1-5]. This type of learning strategy is favoring student-centered learning environment through the examination of real-life phenomena where students' creativity, problem-solving skills, critical thinking, self-directed learning and communicational skills are nurtured [6]. Also, positive aspect of STEM education is that it is interdisciplinary in its nature and can make connections between school and community and in that way creating a broad mix of skills and interdisciplinary knowledge in students [7]. Cultivating STEM skills in the early years can help building metacognitive skills and foster positive learning dispositions in their future school years.

The majority of STEM education activities are hands-on activities where the student is in the central position, often in co-constructed learning environments where emphasis is on collaborative or partnership working. This helps children cultivate responsibility, independence, self-confidence, resilience and social flexibility which is especially important in younger students. In order to successfully implement STEM education, teacher should adjust the theme to the children's interests and needs through observing and listening to children in their everyday activities. Following children's interests is crucial in building motivation to embark on a scientific exploration.

Gamification, incorporation of game elements in learning environment, has become an increasingly popular motivational and productivity tool in education [8]. Another advantage of STEM education is in its ability to set the problem-solving ambience into competing, experimenting, hypothesizing, making predictions and wondering setting and enable the student sense that are participating in a game or competition rather than learning.

In this research we designed a series of STEM-based activities within the subject *The World Around Us* on topic diversity of nature – water. Faculty staff took the role of “STEM ambassadors” and with the help of teacher the experiments involving water cycle in nature, surface tension, capillary force, reflection, reaction medium and heat capacity were conducted through various game-like hands-on activities and demonstrations, all in order to evaluate their impact on student motivation, perception and acquired knowledge. Also, this research should provide better insight into sustainability of proposed activities

and possibility of their permanent incorporation in teachers' curriculum and STEM education becoming a standard practice in evolving education curriculums.

General background and sampling

The research was conducted during the year 2023. Students included in the research (sample N=29) were 2nd grade (age 8-9) primary school students (both female and male) from Primary school "Moma Stanojlovic", Kragujevac, Serbia. The students were selected by random cluster sampling method i.e. all were from the same class.

Instrument and procedures

The activities designed for this study are within a subject *The World Around Us* on topic diversity of nature – water. Activities were held with the help of a teacher in a various forms: game-like hands-on activities and demonstrations. The experiments covered the following topics: water cycle in nature, surface tension, capillary force, reflection, reaction medium and heat capacity. All activities were prepared on the principles of STEM education requirements in a regular classroom setting. Experiments were created to meet the needs of a standard classroom, so all required materials, equipment and compounds were cheap and available in regular shops.

Children had the opportunity to get familiar with the topic *water cycle in nature* by experiment *Claud in the jar*. The experiment was first demonstrated by the teacher, and then the children, divided into small groups, were asked to repeat it. The topic *surface tension* was done through two game-like activities both set as competitions between two previously formed groups. In the first activity, a small glass of water was filled to maximum, and then teams were asked to alternately insert small nails to the glass. The team which first spilled the water loses. In the second activity, the teams were competing in whose fish travels further. Foam-paper fish-like cutout with V-shaped flipper is placed in the bowl filled with water. Q-tip is dipped in dishwashing soap and the area behind V-shaped flipper is touched. By breaking the surface tension, paper fish moves forward. The *capillary forces* were examined by hands-on activities by inserting young leaves of lettuce into the food coloring concentrated solution and *heat capacity* by examining which objects heat up quicker; empty or filled with water. The experiments based on *reflection* were conducted by creating a rainbow and drawing an arrow which inverts by placing it behind the glass filled with water. The children also addressed the property of water as a solvent and reaction medium.

To evaluate the outcome of the study two interviews were conducted. The first interview was conducted by the teacher on students. Due to the young age of participants, the data were collected by the teacher through the semi-structured interview which is flexible and open-ended in its nature. This type of interview is selected as an exploratory tool where students' answers could guide interviewer to future research questions that can help gain better insight into the outcomes of research and develop a more robust

knowledge base for future research. The questions were grouped in three clusters: (a) motivation, readiness and attitude; (b) personal experience; (c) obtained knowledge.

The second interview was conducted by the researchers with a teacher to examine: (1) usefulness and sustainability of proposed activities and possibility of their permanent incorporation in teachers' curriculum; (2) their accordance with the curriculum and whether they had a positive impact on learning process compared to the standard teaching plan; (3) possible difficulties of implementation of the proposed activities.

Results and discussion

The first part of the study is the implementation of prepared activities on the subject Water. Carefully designed experiments, which are in accordance with the curriculum, abilities and age of students, were conducted as described in the previous section.

During or after each activity, instead of presenting the answer and revealing the explanation of the observed activity, teacher was prompting the conversation with a range of proposed scenarios and questions for students in order to help them to uncover and construct meaning from their explorations. Also, questions were designed to prompt children to think about what they already know, what they expect might happen during activities and encourage children to try different ideas.

The data analysis of the first interview, conducted by the teacher on the students, revealed that the children were highly motivated and eager to participate in all activities, especially in those which included competition between the groups. All children were included in all activities and tasks were distributed among the members of the group by mutual agreement or sometimes by teacher. In the interview the students indicated that there were some problems in mutual communication, collaboration and work within some groups. It has been shown that in children this young, suitable division into groups represents one of the most important factors for students' positive personal experiences in group work. Therefore, teachers could be advised to pay more attention to this part when preparing for group activities. Generally, most of the children had a feeling that they had participated in a play and not to be involved in the learning process. The children who are known to be more introvert and shy showed more confidence and were more eager to participate than in regular classroom activities. After the activities all children expressed increased interest in the natural phenomena that surround them and showed intrinsic motivation in exploring them. Short quiz questions have shown that children obtained more lasting knowledge on a subject.

The data analysis in the second interview, conducted by the researchers with a teacher, have shown the applicability of proposed activities and its beneficial outcomes on students and obtained knowledge. The teacher pointed out as a possible downfold of these activities the time consumption and some problems with keeping the discipline and focus during some activities.

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INTEGRATIVNI MODEL LIDERSKIH PRAKSI U ŠKOLSKOM OKRUŽENJU

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SAŽETAK:

Empirijska istraživanja jasno ukazuju na to da liderstvo predstavlja jednu od ključnih determinanti funkcionisanja škola. Shodno tome, istraživači su zainteresovani za pitanje koja leaderska ponašanja su potrebna u školskom okruženju. Cilj ovog rada je analiziranje efektivnih leaderskih praksi koje mogu da realizuje pojedinci na različitim položajima u školskoj organizaciji. Prikazan je model leaderskih praksi koji je integralan iz dva razloga. Prvo, prakse su izdvojene iz različitih modela obrazovnog liderstva, kao što su pedagoško i transformaciono liderstvo. Drugo, ovaj model uključuje spektar aktivnosti koje su karakteristične ne samo za liderstvo već i za menadžment u obrazovanju. Dodatni kvalitet predstavljenog modela leaderskih praksi jeste njegova opštost i relevantnost za različite nastavne i školske ishode. Izdvajanje efektivnih leaderskih praksi pruža važne implikacije za praktičare i kreatore programa profesionalnog razvoja školskih lidera. U zaključku rada diskutuje se o preporukama za buduća istraživanja.

Ključne riječi: *liderstvo u obrazovanju, leaderske prakse, modeli liderstva, škola*

1. UVOD

Liderstvo je jedan od ključnih unutarškolskih faktora akademskog postignuća učenika [1]. U literaturi je opisano više modela liderstva u obrazovanju koji su fokusirani na različite aspekte rada škole. Pored pedagoškog liderstva, koje je u funkciji kvaliteta nastave i učenja, transformaciono liderstvo je drugi istaknuti model liderstva u školskom okruženju [2]. Transformaciono liderstvo je usresređeno na stvaranje uslova koji podstiču profesionalni razvoj i učenje nastavnika. Generalni zaključak dosadašnjih istraživanja je da je pogrešno svoditi efektivno školsko rukovođenje na pedagoško-instruktivni rad budući da organizacioni procesi u školi imaju važnu ulogu [3].

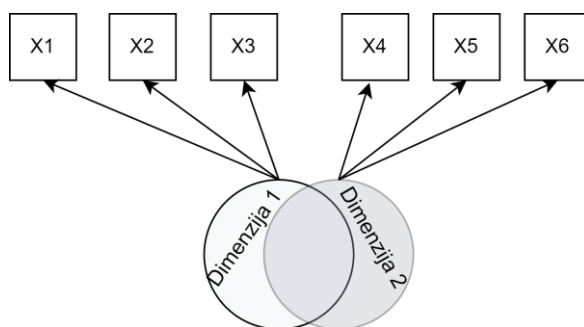
Međutim, u poslednje vreme naučnici postavljaju pitanje koja je najcelishodnija jedinica analize liderstva [4]. Preciznije rečeno, ukazuje se na to da istraživanja apstraktnih modela liderstva ne mogu da pruže konkretne praktične implikacije. Različiti konceptualni i empirijski problemi u vezi s modelima obrazovnog liderstva su motivisali istraživače da se fokusiraju na temu efektivnih leaderskih praksi.

2. PROBLEMI U VEZI S MODELIMA OBRAZOVNOG LIDERSTVA

Iako su istraživanja modela obrazovnog liderstva brojna, njih karakterišu evidentni konceptualni i empirijski problemi. Prvo, nominalno isti modeli obrazovnog liderstva su na različite načine definisani i mereni. Na primer, transformaciono liderstvo u obrazovanju je mereno sa više instrumenata koji su zasnovani na različitim teorijskim polazištima [5]. Na taj način otežano je poređenje dobijenih rezultata istraživanja. Drugo, ista liderska ponašanja smatraju se sastavnim delom različitih modela liderstva. Konačno, liderske prakse koje se smatraju delom istog modela mogu imati različite efekte. Na primer, Robinsanova i saradnici [6] su ustanovili da podsticanje profesionalnog razvoja nastavnika, u poređenju sa stvaranjem uređenog i bezbednog okruženja u školi, ima značajno veći uticaj na postignuće učenika.

Istraživanja modela obrazovnog liderstva imaju i dva empirijska ograničenja. Prvo, učestalo uvođenje novih liderskih modela suprotno je naučnom principu parsimonije. Kada dva naučna konstrukta imaju veoma slične relacije sa drugim relevantnim varijablama, jedan od konstrukata postaje suvišan [7]. U takvim situacijama treba pažljivo razmotriti da li je reč o nepotrebnom preimenovanju konstrukta koji već postoji u literaturi [8]. Na ovaj problem ukazuju saznanja o značajnom preklapanju između autentičnog i transformacionog liderstva, dva modela koji se u literaturi obično tretiraju kao samostalne koncepcije [9].

Drugo, instrumente za procenu obrazovnog liderstva karakteriše nedovoljna diskriminativna validnost (slika 1). Zbog visokih korelacija između ispitivanih dimenzija modela liderstva, istraživači po pravilu koriste sumativne skorove na upitnicima ili model liderstva tretiraju kao konstrukt višeg reda. Međutim, korišćenje sumativnih skorova sprečava ispitivanje efekata i prediktora individualnih dimenzija liderskog modela [10]. Imajući u vidu pomenute teškoće, istraživači su počeli da se bave praksama lidera u obrazovanju. Liderske prakse predstavljaju obrasce aktivnosti pojedinca ili grupe, koje doprinose ostvarivanju pozitivnih ishoda [11].



Slika 1. Preklapanje dimenzija modela obrazovnog liderstva: hipotetički prikaz

3. EFEKTIVNE LIDERSKE PRAKSE U ŠKOLSKOM OKRUŽENJU

Litvud i saradnici [12] navode da je nedvosmisleno dokazano da se svi uspešni lideri u obrazovanju oslanjaju na isti, relativno mali, spektar uspešnih liderskih praksi. Efektivne prakse su izdvojene na osnovu njihove povezanosti sa akademskim postignućem učenika. U ovom radu biće prikazane kategorije efektivnih liderskih praksi (tabela 1) koje su predstavili Tan i saradnici [13].

Tabela 1. Efektivne prakse liderstva u školi

Kategorija	Liderske prakse
Pedagoški menadžment	Unapređivanje nastave i učenja
	Formulisanje zajedničke vizije
Unapređivanje kapaciteta nastavnika	Podsticanje profesionalnog razvoja
	Oснаživanje nastavnika
	Motivisanje nastavnika
Organizacione odgovornosti	Upravljanje organizacionim resursima
	Redizajniranje škole
Uključivanje spoljašnjih aktera	Uključivanje porodice i zajednice
	Upravljanje spoljašnjim pritiscima i odnosima

Ovaj model objedinjava prakse koje su deo različitih modela obrazovnog liderstva. Na primer, unapređivanje nastave i učenja je ključni prioritet pedagoškog liderstva, dok osnaživanje i motivisanje nastavnika spada u domen transformacionog liderskog ponašanja. Drugi važan aspekt ovog modela je integrisanje ponašanja koja su karakteristična kako za liderstvo tako i za menadžment. Meta-analički nalazi [14] potvrđuju važnost liderskih i menadžerskih aktivnosti direktora škole u podsticanju akademskog uspeha učenika. Drugim rečima, usresređenost na pedagoško liderstvo u užem smislu nije dovoljno za unapređivanje nastavne prakse i postignuća učenika. Iako nisu ustanovili značajnu povezanost upravljanja organizacionim resursima i redizajniranja škole sa postignućem učenika, Tan i saradnici [13] ukazuju da postoji mogućnost da su efekti ovih liderskih praksi vremenski odloženi.

Davanje odgovora na pitanje šta na svakodnevnom nivou uspešni obrazovni lideri rade ima direktne praktične implikacije. Na osnovu istraživačkih rezultata mogu se formulirati konkretne preporuke na koje aktivnosti treba da obrate pažnju direktori škola, njihovi pomoćnici i drugi lideri. S obzirom na ograničeno vreme koje rukovodioci obrazovnih ustanova imaju na raspolaganju, ove smernice mogu biti veoma korisne. S druge strane, izdvajanje efektivnih liderskih praksi predstavlja osnovu za planiranje aktivnosti profesionalnog razvoja lidera u školama i njihovo validno procenjivanje [11].

Predstavljene liderske prakse su usmerene na unapređivanje brojnih karakteristika škole koje mogu da utiču akademsko postignuće učenika. Međutim, treba imati u vidu da je uloga konteksta krucijalna u primeni efektivnih liderskih praksi. Liderstvo se događa u specifičnom društvenom i vremenskom kontekstu [15], te identična liderska ponašanja mogu biti različito opažena u različitim okolnostima. Na primer, uključivanje u donošenje

odluka iskusnih nastavnika može biti shvaćeno kao izraz ličnog uvažavanja. S druge strane, istovetno ponašanje direktora škole neiskusni nastavnici mogu shvatiti kao dodeljivanje uloge za koju nisu spremni. Uvažanje mladih nastavnika direktor škole može pokazati na drugačije načine, kao što je, na primer, traženje povratnih informacija o svojoj odluci.

3. ZAKLJUČAK

Iako i dalje dominiraju studije efekata pojedinačnih modela obrazovnog liderstva, istraživači sve češće ukazuju na to da je smislenije staviti akcenat na specifična liderska ponašanja [11], [16]. Dalji napredak teorije i prakse liderstva u obrazovanju podrazumeva diferenciranje praksi na specifična ponašanja i njihovo validno i pouzdano merenje. Drugo važno istraživačko pitanje tiče se ispitivanja varijabli posredstvom kojih izdvojene prakse utiču na nastavne ishode. Konačno, treće zanimljivo pitanje odnosi se na empirijsko testiranje ulogu ličnih karakteristika i kontekstualnih faktora u ispoljavanju poželjnih liderskih praksi.

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AN INTEGRATED MODEL OF LEADERSHIP PRACTICES IN SCHOOL SETTINGS

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ABSTRACT:

It is clear from empirical research that school leadership is one of the crucial determinants of school functioning. Consequently, researchers are interested in the question of what leadership behaviors are needed in the school environment. This paper aims to examine effective leadership practices that individuals in different roles in the school organization can perform. A presented model of leadership practices is integral for two reasons. First, practices are derived from different models of educational leadership, such as instructional and transformational leadership. Second, this model includes a range of activities that are characteristic not only of leadership but also of educational management. An additional quality of the presented model of leadership practices is its generality and relevance for different types of instructional and school outcomes. Identifying effective leadership practices has important implications for practitioners and creators of professional development programs for school leaders. In the conclusion of the paper, recommendations for future research are discussed.

Keywords: *educational leadership, leadership practices, leadership models, school*

IZUČAVANJE ANATOMIJE LJUDSKOG TELA KROZ PRIZMU VIRTUELNE STVARNOSTI (VR)

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SAŽETAK:

Iako su sistemi koji se oslanjaju na robotiku i veštačku inteligenciju uveliko prisutni u različitim sferama privrede, primena čak i mnogo manje komplikovanih virtuelnih aplikacija u obrazovanju, posebno u zemljama u razvoju, tek je na svojim skromnim počecima. Biologija kao interdisciplinarna nauka u sebe uključuje različite oblasti, u okviru kojih se izučavaju raznovrsni aspekti građe, funkcije i uticaja živih sistema. Jedan od sadržaja koji se izučava u okviru biologije je anatomska građa ljudskog tela. S obzirom na činjenicu da su ovi sadržaji složeni, te da se (izuzimajući medicinske fakultete) delovi tela uglavnom ne mogu direktno posmatrati na prepariranim organima, učenici i studenti neretko imaju poteškoće u savladavanju ovih sadržaja. Napretkom tehnologije, resursi poput virtuelnih 3D modela i virtuelnih laboratorija postaju sve dostupniji, a njihov potencijal za primenu u obrazovanju i nauci je veliki. Vizualizacija u nastavi biologije je jako važna, a virtuelno okruženje zasnovano na VR tehnologiji upravo to i omogućuje. Aplikacije koje nude ikustvo učenja anatomije ljudskog tela su raznovrsne, a neke od njih su: My Anatomy (VR), Human Body, Anatomy Learning – 3D Anatomy, i mnoge druge koje se mogu besplatno preuzeti sa Android Play prodavnice. U ovom radu prikazane su mogućnosti virtuelne aplikacije Human Body. Virtuelne aplikacije su raznovrsne i veoma dostupne, te ne postoje prepreke za njihovo masovnije korišćenje u nastavi. Time bi se podstakli i istraživači da detaljnije ispituju efekte upotrebe virtuelnih aplikacija u obrazovanju učenika i studenata.

Ključne reči: nastava biologije, anatomija ljudskog tela, android 3D aplikacije, virtuelna stvarnost.

1. UVOD

Savremeni način komunikacije, razmene informacija i uopšte života u eri digitalnih tehnologija pred školu postavlja nove zahteve, koje treba na adekvatan način realizovati, kako bi se učenicima pružilo odgovarajuće obrazovanje. Od nastavnika i njegovog pristupa radu očekuje se da od učenika stvori samostalnu i aktivnu ličnost koja će logično razmišljati, postavljati pitanja, istraživati i proveravati podatke, analizirati primere, izvoditi zaključke i primenjivati znanja.

Navedeni ciljevi, iako ambiciozni, mogu se postići promenom dosadašnjeg pristupa tradicionalnog učenja i primenom inovativnih modela rada. Jedan od njih je svakako

korišćenje virtuelnih aplikacija u nastavi. Široka upotreba hardvera za aplikacije koje nude doživljaj virtuelne stvarnosti (VR) omogućila je korišćenje VR kao obrazovnog alata. Virtuelna stvarnost ima potencijal da vrlo „realistično“ prikaže različite biološke entitete, od onih mikroskopskih do makro nivoa. Takođe, VR omogućuje učenicima da rukuju različitim virtuelnim alatima kao u pravoj laboratoriji, čime se postiže efekat praktičnog rada koji je bio prilično zapostavljen u tradicionalnoj nastavi (Coan, Goehle, & Youker, 2020).

Danas postoji veliki broj alata za kreiranje aplikacija virtuelnih laboratorija, ali je mali broj onih koji su jednostavni za korišćenje i koji bi omogućili nastavnicima da kreiraju visokokvalitetne VR modele prema svojim potrebama (potrebama konkretne škole/odjeljenja), a još je manje onih koji bi te modele integrisali u laboratoriju ili konkretnu lekciju (Borrel & Fourches, 2017). S druge strane postoji veliki broj gotovih VR aplikacija koje se uspešno mogu koristiti u nastavi biologije, a koje se besplatno mogu preuzeti s Android Google Play prodavnice.

Iako je bilo nekih studija koje ispituju upotrebu VR alata u biološkom obrazovanju, i to najviše iz oblasti biohemije i molekularne biologije (Garcia-Bonete, Jensen, & Katona, 2019; Garzon, Magrini, & Galembeck, 2017; Johnston et al., 2018; Mikropoulos, Katsikis, Nikolou, & Tsakalis, 2003), još uvek postoji mnogo otvorenih pitanja u ovoj oblasti koje tek treba istražiti. U ovom radu prezentovane su mogućnosti VR platformi u izučavanju bioloških sadržaja (građa ljudskog tela) na primeru aplikacije *Human Body*. U skladu s tim, cilj ovog rada je da motiviše učenike i nastavnike da više primenjuju aplikacije ovog tipa u nastavnoj praksi, ali i istraživače da ispituju uticaj primene ovih aplikacija na postignuće učenika i nastani proces u celini.

2. UPOTREBA VR APLIKACIJA U NASTAVI

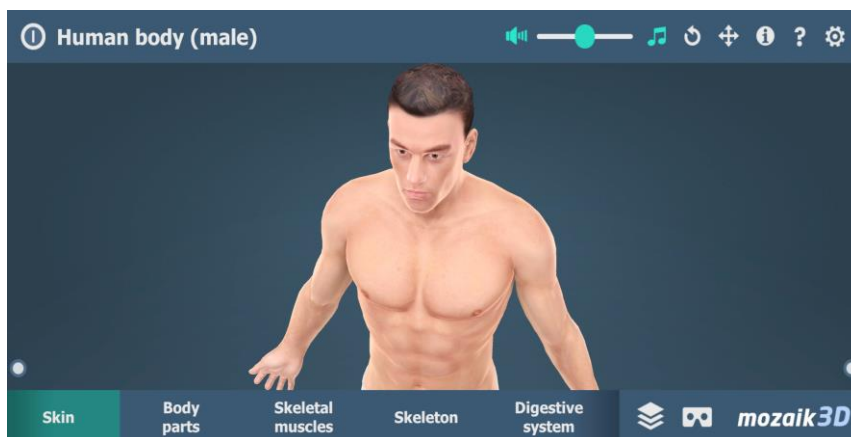
Informaciono-komunikacione tehnologije su već odavno osnova na kojoj se zasnivaju promene u nastavnom procesu u pogledu modernizacije nastave. Biologija kao nauka čija znanja se koriste u medicini, veterini, poljoprivredi i drugim naukama, uključuje oblasti na polju anatomije, fiziologije, citologije, molekularne biologije, genetike... S obzirom na to da su procesi koji se dešavaju na nivou ćelija, molekula ili fiziološki procesi unutar tela nevidljivi, često apstraktni i veoma složeni, predavač bi morao da bude vrlo vešt kako bi takve procese mogao približiti i objasniti učenicima (Lazarević i sar., 2018). Međutim, zahvaljujući brojnim aplikacijama koje se zasnivaju na modelu virtuelne stvarnosti, ove procese je moguće učenicima mnogo bolje predstaviti, pa je ovakav vid nastave itekako poželjan pri obradi složenih sadržaja.

Nastavna tema u okviru biologije koja je posebno pogodna za ovu vrstu nastave je Antropologija, a broj virtuelnih aplikacija koje prikazuju anatomiju ljudskog tela je veliki. Neke od aplikacija koje nude ikustvo učenja anatomije ljudskog tela putem VR tehnologije su: *My Anatomy (VR)*, *Human Body*, *Anatomy Learning – 3D Anatomy...* Tokom korišćenja ovih aplikacija, učenik stiče utisak da se nalazi u pravoj laboratoriji u kojoj su mu na dohvat ruke svi organi ljudskog tela koje želi da proučava.

2.1. Prikaz aplikacije *Human Body* kao virtuelnog sredstva u nastavi

Aplikacija *Human Body* omogućuje iskustvo proučavanja anatomije ljudskog tela kombinujući dva modela: 1) trodimenzionalne slike ljudskog tela koje se mogu rotirati komandama na displeju digitalnog uređaja i 2) doživljaj prave virtuelne laboratorije, gde uz pomoć VR naočara učenik stiče iskustvo proučavanja građe ljudskog tela kao da se nalazi u pravoj laboratoriji.

Pokretanjem aplikacije na displeju se pojavljuje spoljašnji izgled čoveka. Na traci iznad prikazanog tela su raspoređene komande za zvuk, navigaciju i rotiranje tela, zatim „taster“ za informacije o organu koji se trenutno prikazuje i opcije koje omogućuju pomoć i podešavanja same aplikacije. Na traci na dnu displeja nalaze se nazivi pojedinačnih sistema organa, gde kada se učenik opredeli za jedan od njih, on mu se automatski prikazuje. Takođe, na ovoj navigacionoj traci se nalazi opcija za proučavanje tela uz pomoć VR naočara (Slika 1).



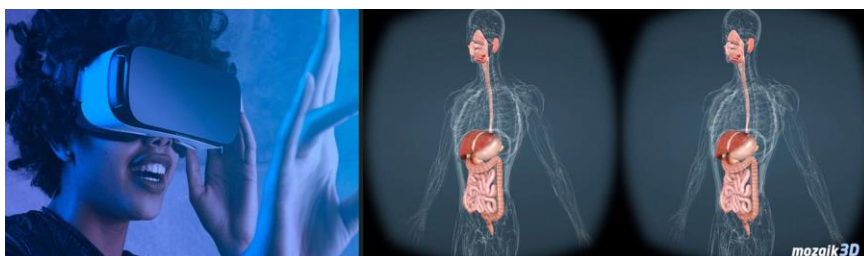
Slika 1. Virtuelno okruženje koje se prikazuje pri pokretanju aplikacije *Human Body*

Ukoliko korisnik (učenik) želi da istražuje neki sistem organa, potrebno je da se opredeli za njega odabirom opcije za dati sistem sa kontrolne trake koja se nalazi u donjem delu displeja. Tada aplikacija prikazuje realističnu 3D animaciju datog sistema organa. Učenik može, uz pomoć navigacionih tastera ili jednostavnim prevlačenjem prsta preko displeja da okreće telo (dati sistem organa) u radijusu od 360° po sve tri ose koordinatnog sistema, tako da se telo može posmatrati s trbušne strane, s leđne strane, s bočnih strana, iz ptičje ili žablje perspektive. Takođe, svaki deo tela se može zumirati kako bi se detaljnije videla struktura određenog dela. Pored toga, ukoliko učenik aktivira tu opciju, na displeju se mogu pojaviti nazivi pojedinih delova tela (kostiju, mišića ili nekih drugih organa). Aktivacijom opcije „info“, na displeju se prikazuje tekst boks koji nudi osnovne informacije o datom sistemu organa. Još jedna interesantna opcija koju nudi ova aplikacija je ta da je telo predstavljeno u slojevima (spolja je koža, ispod kože su mišići i skelet, a u unutrašnjosti različiti organi. Učenik može da „skida“ jedan po jedan sloj i otkriva šta se nalazi ispod njega (Slika 2).



Slika 2. Telo je predstavljeno slojevito, a različiti sistemi organa se mogu proučavati pojedinačno

Za bolje iskustvo i realističniji doživljaj može se aktivirati opcija koja omogućava posmatranje građe pojedinih delova tela uz pomoć VR naočara, što daje utisak da se nalazite u virtualnoj laboratoriji neposredno ispred tela koje se prikazuje (Slika 3). Pri ovom modu korišćenja, takođe je moguće kretati se kroz različite slojeve i delove tela uz pomoć virtuelnih komandi koje se pojavljuju na displeju pri odgovarajućem pokretu glave. Okretanjem glave na određenu stranu moguće je promeniti sistem organa koji se posmatra i aktivirati opciju koja prikazuje nazive pojedinih delova tela.



Slika 3. Potpuni doživljaj virtualne laboratorije se postiže tek korišćenjem VR naočara

3. ZAKLJUČAK

Efikasnost obrazovanja značajno zavisi od kvaliteta nastavnog procesa. Savremena škola zahteva da u nastavi budu zastupljeni modeli nastave kojima se postiže veći stepen aktivnosti i saradnje učenika, a jedan od njih je i korišćenje novih virtuelnih tehnologija. Budući da su sadržaji iz anatomije i fiziologije ljudskog tela široko zastupljeni tokom osnovnoškolskog i srednješkolskog obrazovanja, ali i na fakultetima koji se u okviru pojedinih predmeta bave proučavanjem strukture i funkcija ljudskog tela, primena aplikacija na modelu VR tehnologije mogla bi značajno da unapredi kvalitet nastave.

Pojedini autori koji su se bavili istraživanjem efekata primene VR aplikacija, utvrdili su značajno poboljšanje učeničkog postignuća kod učenika koji su koristili ove aplikacije u nastavi (Lathvesen & Belova, 2021; Makri, Vlachopoulos i Martina, 2021). Analizirajući date nalaze, može se tvrditi da je VR iskustvo učenja bilo višeg kvaliteta u poređenju sa drugim resursima za učenje. Lathvesen i Belova (2021), su takođe utvrdili da je na dobitke u učenju uticalo veće interesovanje učenika za korišćeni tehnološki medij. Takav nalaz navodi i na zaključak da učenicima ove tehnologije nisu strane i često se s njima bolje snalaze od nastavnika, što još jednom potvrđuje pretpostavku da bi uvođenje ovih modela u nastavu doprinelo motivaciji i većoj aktivnosti učenika, a samim tim i poboljšanju učeničkog postignuća.

S druge strane, za uspešnu primenu VR aplikacija u nastavi, neophodan je sveobuhvatan pristup obuci i tehničkoj podršci za nastavnike, posebno za one nastavnike koji ne poseduju odgovarajuće digitalne kompetencije (Christopoulos & Sprangers, 2021).

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USPEŠNOST VEŠTAČKE INTELIGENCIJE CHATBOT U REŠAVANJU ZADATAKA IZ OPŠTE HEMIJE

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SAŽETAK:

Besplatna dostupnost veštačke inteligencije Chatbot i njena sve veća primena u svim oblastima života je izazvala veliko interesovanje i diskusiju među istraživačima u oblasti obrazovanja. Cilj rada jeste identifikovanje uspešnosti veštačke inteligencije u rešavanju zadataka iz hemije. Primenjen je chatbot ChatGPT za rešavanje zadataka iz opšte hemije za prvi razred gimnazije. Uspeh veštačke inteligencije u rešavanju zadataka iznosio je 68,75% što je iznad prosečnog postignuća učenika (48,9%). Dodatna objašnjenja koja je pružio Chatbot su vrlo korisna za učenike. Međutim, evidentno je da za sada ChatGPT nema potrebno znanje iz hemije za pouzdano rešavanje zadataka i davanje preciznih objašnjenja i da je strah od gubitka posla nastavnika neopravdan.

Ključne riječi: veštačka inteligencija, Chatbots, hemija, srednjoškolski učenici

1. UVOD

Razvoj i dostupnost besplatnih alata koji uključuju veštačku inteligenciju su svojim nedavnim pojavljivanjem izazvali veliko interesovanje i primenu u svim sferama života. Veštačka inteligencija generiše odgovore kombinovanjem postojećih znanja na osnovu ogromne količine podataka kojima raspolaže. Analizirajući jezički model ulaznog pitanja, Chatbot identifikuje ključne pojmove, određuje kontekst i preuzima relevantne informacije iz svoje baze [1]. Pojava veštačke inteligencije podstiče strah pojedinaca da će biti zamenjeni jer se menja potreba za njihovim kvalifikacijama na radnom mestu [2]. Tri najpoznatija alata zasnovana na veštačkoj inteligenciji su ChatGPT (OpenAI, San Francisco, CA), Bing (Microsoft Corporation, Redmond, WA) i Bard (Google, Mountain View, CA).

2. PRIMENA VEŠTAČKE INTELIGENCIJE U OBRAZOVANJU

Veštačka inteligencija ima sve više primena u obrazovanju, od administrativnih poslova i menadžmenta do nastave [3]. Početne reakcije nastavnika na primenu veštačke inteligencije u nastavnom procesu su zabrinutost za akademski integritet, mogućnost plagijata i smanjena odgovornost učenika za sopstveno učenje [4]. Ipak, veštačka inteligencija je mnogo šire od jednostavnog alata za učenje i mogu je koristiti i nastavnici

i učenici u različite svrhe. Veštačka inteligencija doprinosi povećanju resursa dostupnih kako učenicima, tako i nastavnicima [5].

Dao i saradnici [6] su ukazali na veliki potencijal jezičkih sistema zasnovanih na veštačkoj inteligenciji, koji se ogleda u pružanju pomoći u učenju i podučavanju, posebno u pružanju brzih povratnih informacija i personalizovanih iskustava učenja. Veštačka inteligencija može pružiti pomoć u učenju kroz odgovaranje na pitanja, objašnjavanje pojmova i pružanje smernica za učenje. Veštačka inteligencija se može uspešno primeniti u nastavnom procesu ako se učenicima postavi zadatak da na osnovu svog znanja procene tačnost odgovora koji je dala veštačka inteligencija i identifikuju problematične tvrdnje. Nastavnici mogu koristiti veštačku inteligenciju za prilagođavanje nastavnih sadržaja, pronalaženje novih ideja i primera koji mogu biti korisni u nastavnom procesu. Takođe, ovi sistemi se mogu koristiti za generisanje pitanja i materijala za vežbanje i procenu znanja. Pored toga, veštačka inteligencija ima veliku primenu u istraživačkom i laboratorijskom radu jer može da pruži pomoć prilikom pisanja laboratorijskih izveštaja, rezimea, projekata, istraživačkih zadataka [6].

Istraživanja sprovedena na polju hemijskog obrazovanja pokazala su da objašnjenja alata zasnovanih na veštačkoj inteligenciji imaju manjkavosti i da su slični objašnjenjima i greškama koje imaju i učenici [1]. Pouzdanost odgovora na pitanja iz hemije nije dovoljna jer su pokazali da na testovima ostvaruju niže postignuće u odnosu na prosečno postignuće učenika [6, 7]. Uprkos velikom potencijalu veštačke inteligencije u oblasti hemijskog obrazovanja, evidentno je da imaju ograničenja u zameni ljudske inteligencije [6].

3. METODOLOGIJA

Kako veštačka inteligencija napreduje, njen potencijal i izazovi u obrazovanju postaju sve očigledniji. Međutim, da bi se veštačka inteligencija primenjivala u obrazovanju, neophodne su sveobuhvatne procene njene sposobnosti posebno kada se primenjuje na maternjem jeziku (koji nije engleski) uz primenu specifičnosti naučnog jezika, kao što je hemijski jezik, koji uključuje korišćenje hemijske simbolike i terminologije. Stoga, cilj rada je ispitivanje efikasnosti aplikacije ChatGPT za rešavanje zadataka iz hemije za prvi razred gimnazije na srpskom jeziku.

U istraživanju je primenjen test znanja koji je sadržao 16 pitanja zatvorenog i otvorenog tipa i računskih zadataka. Pitanjima je obuhvaćeno gradivo opšte hemije predviđeno Planom i programom nastave i učenja za gimnaziju. Intervju sa ChatGPT-3.5 održan je u decembru 2023. godine. Nakon dobijanja odgovora na postavljeno pitanje, postavljana su potpitanja kako bi se bolje stekao uvid u sigurnost datih odgovora.

4. REZULTATI ISTRAŽIVANJA

ChatGPT je odgovarao na 16 pitanja iz 7 nastavnih tema: vrste supstance; struktura atoma; hemijska veza; disperzni sistemi; hemijske reakcije; kiseline, baze i soli; oksidoredukционе reakcije. Tačan odgovor je iz prvog pokušaja dobijen na 11 zadataka. Ukupan skor ChatGPT je 68,75%. Najmanje poznavanje gradiva je pokazao iz oblasti hemijske veze i struktura atoma, i to u zadacima višestrukog izbora koji su uključivali analizu hemijskih formula i elektronske konfiguracije atoma i primenu znanja.

U daljem tekstu dati su odlomci intervju sa GPT, odnosno primeri pitanja i dobijeni odgovori. Na pitanja koja se odnose na poznavanje činjenica i ne zahtevaju upotrebu simbola i hemijskih formula odgovori su bili potpuno tačni uz tačna ili delimično tačna objašnjenja.

Primer 1.

Pitanje: Atomski broj određen je brojem:

a) elektrona, b) protona, c) neutrona, d) nukleona.

ChatGPT: Atomski broj određen je brojem: b) protona.

Pitanje: Zašto?

ChatGPT: Atomski broj, označen simbolom Z, predstavlja broj protona u jezgri atoma. Svaki element ima svoj jedinstveni atomski broj koji određuje njegovu hemijsku identitet. Stoga je atomski broj određen brojem protona u jezgri atoma. Elektroni, neutroni i nukleoni takođe su važni za strukturu atoma, ali ne određuju atomski broj.

Primer 2.

Pitanje: Šta su izotopi?

ChatGPT: Izotopi su atomi istog hemijskog elementa koji imaju isti broj protona, ali različit broj neutrona u jezgri. To znači da imaju isti atomski broj, ali različit maseni broj. Različiti izotopi istog elementa ponašaju se hemijski slično jer imaju isti broj elektrona i, stoga, iste hemijske osobine. Međutim, razlikuje se po masi i svojstvima povezanim s tom masom.

Na primer, vodonik ima tri izotopa: protijum, deuterijum i tricijum. Svi imaju jedan proton, ali različit broj neutrona, što rezultira različitim masenim brojevima. Izotopi se često označavaju pomoću oznake koja sadrži atomski broj i maseni broj, na primer, 1H (za protijum), 2H (za deuterijum) i 3H (za tricijum).

Zadaci koji su uključivali hemijsku simboliku su imali manji procenat tačnih odgovora. Na neka pitanja tačan odgovor je dobijen nakon više pokušaja.

Primer 3.

Pitanje: U kom od navedenih nizova se nalaze formule onih jedinjenja koja imaju samo jonski tip veze?

a) CCl_4 , FeCl_3 , MgO , NH_3

b) FeCl_2 , AlCl_3 , Na_2O , HBr

c) MgO , MgCl_2 , CCl_4 , CaO

d) FeCl_3 , Na_2O , CaO , HCl

e) AlCl_3 , BaCl_2 , FeCl_3 , K_2S

ChatGPT: Jednačenja koja sadrže samo jonski tip veze su obično ona gde se javljaju metalni i nepolarni elementi. Jonska veza se obično formira između metala i nemetala.

Pogledajmo nizove:

a) CCl_4 (molekularna veza), FeCl_3 (jonska veza), MgO (jonska veza), NH_3 (molekularna veza)

- b) FeCl₂ (jonska veza), AlCl₃ (jonska veza), Na₂O (molekularna veza), HBr (molekularna veza)
c) MgO (jonska veza), MgCl₂ (jonska veza), CCl₄ (molekularna veza), CaO (jonska veza),
e) AlCl₃ (jonska veza), BaCl₂ (jonska veza), FeCl₃ (jonska veza), K₂S (jonska veza)
Izgleda da su jonske veze prisutne u opcijama b) i d). Međutim, tačan odgovor je:
b) FeCl₂, AlCl₃, Na₂O, HBr

Pitanje: Kakva je veza između atoma vodonika i broma?

ChatGPT: Veza između atoma vodonika (H) i broma (Br) u molekulu vodonik-bromida (HBr) je kovalentna veza. Kovalentna veza se formira deljenjem elektrona između atoma kako bi se postigla stabilna elektronska konfiguracija. U ovom slučaju, atom vodonika deli svoj jedini elektron sa atomom broma.

U molekulu HBr, vodonik donira svoj jedini elektron bromu, stvarajući kovalentnu vezu. Oba atoma dele elektrone kako bi postigli konfiguraciju najbližnju hemijskoj konfiguraciji, koja je veoma stabilna.

Važno je napomenuti da, iako se veza između vodonika i broma u HBr smatra kovalentnom, vodonik-bromid je jak elektrolit kada se rastvori u vodi, jer se molekuli disociraju u jone H⁺ i Br⁻.

Nakon ovog odgovora ponovljeno je prethodno pitanje i iz ovog drugog pokušaja je dobijeno tačno rešenje.

ChatGPT je tačno rešio računске zadatke koji su se odnosili na primenu hemijskih formula i na stehiometrijska izračunavanja, čak i kada su uključivali složene jezičke konstrukcije.

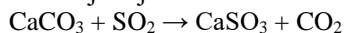
Primer 4.

Pitanje: Kisele kiše koje sve više ugrožavaju biljni i životinjski svet na Zemlji potiču najvećim delom od SO₂ i NO₂. Jedan od postupaka za uklanjanje SO₂ iz gasova iz industrijskih dimnjaka sastoji se u njihovom prevođenju preko ovlaženog krečnjaka pri čemu dolazi do sledeće hemijske reakcije: CaCO₃ + SO₂ → CaSO₃ + CO₂. Kolika je zapremina SO₂ (na normalnim uslovima) koja je uklonjena iz dima ako je nastalo 0,5 mol ugljenik(IV)-oksida?

- a) 22,4 dm³ b) 11,2 dm³ c) 50 dm³ d) 2,24 dm³

ChatGPT: Da biste odredili zapreminu SO₂ koja je uklonjena iz dima, moramo koristiti koeficijente izbalansirane hemijske jednačine kako bismo uspostavili odnos između broja molova reaktanata i produkata.

Iz hemijske jednačine:



Vidimo da koeficijent ispred SO₂ iznosi 1. Dakle, za svaki mol CO₂ koji nastaje, jedan mol SO₂ je uklonjen.

Ako je nastalo 0,5 molova CO₂, to znači da je 0,5 molova SO₂ uklonjeno.

Kako bismo pronašli zapreminu SO₂ (u dm³) na normalnim uslovima, možemo koristiti molarni volumen gasa pri standardnim uslovima (STP) koji iznosi 22,4 dm³/mol.

Zapremina SO₂ = Broj molova SO₂ x Molarni volumen na STP

Zapremina SO₂ = 0,5 molova SO₂ x 22,4 dm³/mol

Zapremina SO₂ = 11,2 dm³

Dakle, tačan odgovor je:

b) 11,2 dm³

5. DISKUSIJA

Istraživanje je sprovedeno s ciljem da se pruži uvid u efikasnost veštačke inteligencije u odgovaranju na pitanja iz hemije na srpskom jeziku. Kroz intervju koji je obuhvatio 16 pitanja ustanovljeno je da veštačka inteligencija (ChatGPT-3.5) poseduje izuzetne sposobnosti tumačenja hemijskih problema, ali da odgovori još uvek nisu dovoljno pouzdani. Takođe, uočavaju se problemi jezičke prirode i nepravilnog korišćenja hemijske terminologije. Na primer, kovalentna veza je nazvana molekularna veza, umesto zapremina koristi se pojam volumen, ili čak nudi nejasna objašnjenja, npr. izjava: „Oba atoma dele elektrone kako bi postigli konfiguraciju najbližnju hemijskoj konfiguraciji, koja je veoma stabilna.“ Ovu pojavu je trebalo objasniti činjenicom da udruživanjem svojih valentnih elektrona oba atoma postižu elektronsku konfiguraciju najbližeg plemenitog gasa, koja je stabilna. Veštačka inteligencija takođe ne koristi odgovarajuće nivoe reprezentacije hemijskih pojava. Prema tripletnom modelu [8], za tumačenje i objašnjavanje čestične strukture supstance koristi se submikroskopski nivo, a za opis fizičkih i hemijskih svojstava supstanci ili njihove primene primenjuje se makroskopski nivo. U navedenim zadacima u testu znanja veštačka inteligencija nije pravila razliku između ova dva nivoa reprezentacije. To se uočava u dopunskom odgovoru u primeru 3: „U molekulu HBr, vodonik donira svoj jedini elektron bromu, stvarajući kovalentnu vezu.“ Pogrešno su korišćeni termini „vodonik“ i „brom“ (makroskopski nivo) umesto „atom vodonika“ i „atom broma“ (submikroskopski nivo), jer se za objašnjenje građenja kovalentne veze koriste atomski i molekulski modeli sa prikazom čestica (atoma, elektrona, elektronskih parova).

Slični zaključci o nepouzdanosti veštačke inteligencije u hemiji dobijeni su i u inostranim istraživanjima. Studija koju je sproveo Clark [7] je pokazala da, iako veštačka inteligencija nudi dobro strukturisane odgovore, ona pravi proceduralne greške i izostavlja relevantne informacije. Aplikacije na bazi veštačke inteligencije imaju ograničenja u odgovaranju na pitanja iz oblasti hemije što ukazuje na njihovu nesposobnost da rasuđuju i primenjuju znanja [6]. Takođe, istraživači su potvrdili da postoji sličnost između odgovora koje generiše veštačka inteligencija i odgovora koje daju učenici [1].

Dobijeni rezultati su pokazali da je uspešnost ChatGPT u sprovedenom istraživanju na srpskom jeziku iznosila 68,75%. Ako ove vrednosti uporedimo sa rezultatima ranijih istraživanja [9] u kojima su 265 učenika odgovarali na ista pitanja, a čije je prosečno postignuće iznosilo 48,9%, zapažamo da je ChatGPT imao više uspeha u rešavanju. U istraživanjima Clark [7] i Dao sa saradnicima [6] veštačka inteligencija je imala niže postignuće u odnosu na postignuće učenika.

6. ZAKLJUČAK

Rezultati su pokazali da ChatGPT ima ograničenja u odgovaranju na pitanja u oblasti opšte hemije na srpskom jeziku za učenike gimnazije. Veću uspešnost ChatGPT je pokazao u rešavanju zadataka koja uključuju opšte informacije u odnosu na pitanja koja zahtevaju analizu hemijske simbolike i primenu stečenih znanja. Takođe, ChatGPT je pokazao veliku uspešnost u rešavanju računskih zadataka.

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EFFICACY OF ARTIFICIAL INTELLIGENCE CHATBOT IN SOLVING PROBLEMS IN GENERAL CHEMISTRY

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ABSTRACT:

The free availability of artificial intelligence chatbots and their increasing application in all areas of life has caused great interest and discussion among researchers in the field of education. The aim of this work was to identify the efficacy of artificial intelligence in solving tasks in chemistry. Chatbots ChatGPT was used to solve problems in general chemistry test designed for the first-grade students of high school. Chatbots score in solving problems was 68.75%, which is above the average achievement of students (48.9%). The additional explanations provided by the Chatbot are very useful for students. However, it is evident that for now ChatGPT does not have the necessary knowledge of chemistry content to be reliable in solving problems and providing explanations, so the teachers' fear of losing the job to artificial intelligence is unfounded.

Keywords: *artificial intelligence, chatbot, chemistry, high school students*

ENHANCING STUDENTS` KNOWLEDGE AND SKILLS IN STEM EDUCATION

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ABSTRACT:

The application of STEM (Science, Technology, Engineering, and Mathematics) in teaching is becoming increasingly important due to its positive impact on the acquisition of knowledge and understanding of the teaching content. STEM integrates various disciplines through practical, problem-based activities, resulting in multiple positive effects on educational outcomes. STEM education has been found to increase student interest. Additionally, the integration of STEM disciplines into the education system contributes to the development of 21st-century skills crucial for the future labor market: creativity, innovation, critical thinking, teamwork, problem-solving, as well as the development of digital skills. Empirical data indicate that students readily accept the integration of content from different disciplines in both curricular and extracurricular activities. This paper discusses the characteristics of STEM education and its potential applications. Furthermore, it provides concrete examples of STEM education for elementary school students.

Keywords: *STEM, natural sciences, physics, elementary students*

1. INTRODUCTION

Student demotivation to learn has caused the development of a new educational paradigm, which shifts the focus from the teacher to the student. Thus, the newly developed teaching approaches become student-centered approaches, which mean that the teacher gets the role of facilitator, collaborator and director of student activity, while students take an active role in creating their own knowledge [1]. A particular advantage of these approaches is their inclusiveness. The materials created within the framework of modern approaches have the possibility of adapting to the specifics of the individual, e.g. pace of work, learning style, etc. However, the effectiveness of the teaching approach largely depends on the teacher's preparation and training for the implementation of new approaches, as

well as on the means necessary for the implementation of the given approach. That is why special attention is paid to the empowerment of teachers in the form of concrete examples for the implementation of a modern approach to teaching. Accordingly, the goal of this work is aimed at empowering teachers to apply STEM, as a very complex approach that requires integrates various disciplines through practical, problem-based activities, resulting in multiple positive effects on educational outcomes.

2. STEM TEACHING APPROACH

STEM (Science, Technology, Engineering and Mathematics) education has “potential to improve the quality of education” [2, p.50] because is “identified as a platform for developing important skills and competences” [3, p.369], i.e., “combines scientific inquiry, technology, engineering design, and mathematical analysis into a cohesive learning paradigm” [4, p.112]. Therefore, Vasquez and coworkers define STEM education as “an interdisciplinary approach to teaching and learning that removes traditional barriers among STEM disciplines, and integrates them into real-life relevant learning experiences for students” [5, p.2]. Students will perceive some learning experiences as relevant if the problem (concept) is relevant and close to them. Therefore, problems which will be used into STEM project should be of local or global relevance [3]. Real-life problems require interdisciplinarity, that is, a synergy of four individual subject areas or disciplines [6]. However, apart from the interdisciplinarity within which these disciplines overlap, problem solving requires critical thinking and innovation. Taking into account all of this, STEM education has become vital to equip the next-generation knowledge workers for Industry 4.0 world [7]. How Industry 4.0 and modern jobs are based on the need for 4C (critical thinking, collaboration, communication, and creative thinking) abilities, competencies needed by knowledge workers in the 21st century include learning “how to use knowledge effectively, search for the knowledge needed, generate new knowledge, as well as organize and store knowledge”, and share it to benefit of society [7, p.2]. So, in order to develop STEM skills, which consist of five dimensions: “Ability to abstract (creativity and innovation, critical thinking and conflict resolution), Collaborative and cooperative work (Affective communication, collaboration with others) and professional competence” [8, p.7], it is necessary to train and empower teachers to implement the STEM approach. “Building a strategic approach to integrating STEM concepts requires strong conceptual and foundational understanding of how students learn and apply STEM content” [9, p.3]. If it is known that the capacity of the working memory is limited [10], and the duration of the information in it is short, then it is especially important to raise the internal motivation of the students so that they themselves will additionally study the given teaching material. By identifying with the problem and understanding its importance for everyday life, the students' motivation to study that problem, that is, to search for an appropriate solution, increases. That is why the choice of problem is particularly important in the STEM approach. According to Bybee, “design problems provide an interdisciplinary context to learn science concepts” [11, p.140]. So, the problem should be important to the student, but also foster a holistic understanding of scientific concepts, which is insisted on in the Next Generation Science Standards.

2.1. An example of a problem that can be used in a STEM approach

As mentioned above, the problem should be sufficiently complex and relevant for the students. One example of the problem is the Greenhouse Effect. The greenhouse effect is a global problem, the consequences of which can be seen in the local area as well. Specifically, students can observe that the number of snow days decreases with time, as does the retention of snow on the ground. The reason for this is the increased air temperature, which is caused by the increase in CO₂ concentration. However, this increase in CO₂ concentration became more significant with the industrial revolution, as the development of society was accompanied by an ever-increasing need for energy. As fossil fuels are the main source of energy, the increasing concentration of CO₂ is understandable. During the upper grades of elementary school, students study the problem related to the Greenhouse Effect, but within special subjects. For example, the concept of temperature is studied in Physics classes; in Chemistry classes, the units Air, water and soil pollutants are covered; Protection measures; Determination of air, water and soil pollution and protection measures, while within Biology these areas are: Ecology and the environment; Endangerment, protection and improvement of ecosystems; Global consequences of environmental pollution, etc. However, the networking of this knowledge within the project problem is the basis for the STEM approach. Thus, a specific task for students can be to create a model of a greenhouse using Arduino microcontrollers with appropriate sensors for measuring CO₂, thermometers, and different substrates, i.e. ecosystem simulators (Fig. 1). In this way, it is possible to examine the level of heating of different substrates (sand, earth, water, etc.), as well as to determine the connection between the concentration of CO₂ and the heating of air and soil.

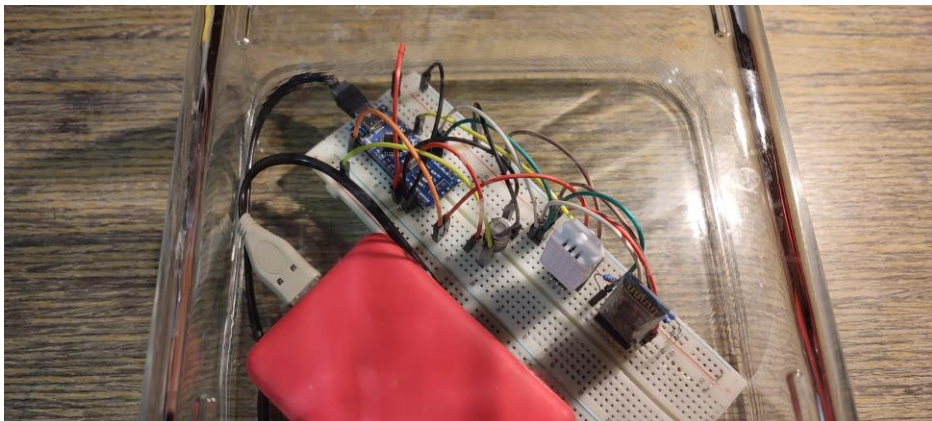


Fig. 1. Experimental setup for measuring the Greenhouse Effect

3. CONCLUSION

Global problems that are becoming more and more intense require a holistic approach. At the same time, “a lack of students' interdisciplinary scientific thinking, innovation, and the ability to solve practical problems” was observed [7, p2]. Therefore, STEM education was introduced as one of the solutions. This interdisciplinary approach links the disciplines “to make the education meaningful, focused, and relevant to learners and prepare globally competitive human capital” [7, p3]. However, it is necessary to systematically empower the teacher to apply new approaches so that its effects are fully realized. Therefore, the goal of this paper was to show the basic characteristics of the STEM approach and show a concrete example of its application.

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KOMPETENCIJE IZ OBLASTI INFORMACIONIH TEHNOLOGIJA KAO OSNOV ZA UNAPREĐENJE USLUGA U TURIZMU: ANALIZA STUDIJSKIH PROGRAMA TURIZMA U REPUBLICI SRBIJI

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SAŽETAK:

Konstantno unapređenje i inoviranje turističkih usluga postalo je neophodno ukoliko se želi zadržati ili poboljšati postojeća pozicija na turističkom tržištu. Informacione tehnologije su među neizostavnim komponentama savremenog turističkog poslovanja, a njihova uloga vremenom postaje sve veća. Upoznatost zaposlenih sa savremenih tehnologijama, njihova spremnost da ih uvode i primenjuju u poslovanju može odrediti budući poslovni uspeh. Sistem formalnog obrazovanja je jedan od načina na koji postojeći i budući zaposleni u turizmu mogu unaprediti svoje tehnološko znanje i veštine. Polazeći od sve značajnije uloge koju imaju u turizmu, kompetencije iz oblasti informacionih tehnologija kao osnov za unapređenje usluga u turizmu predstavljaju predmet istraživanja ovog rada. Cilj je da se kroz analizu akreditovanih studijskih programa turizma koji se realizuju na ustanovama visokog obrazovanja u Republici Srbiji dođe do saznanja o zastupljenosti predmeta iz oblasti informacionih tehnologija.

Ključne riječi: visokoškolske ustanove, visoko obrazovanje, kurikulumi, IT kompetencije, studije turizma

1. UVOD

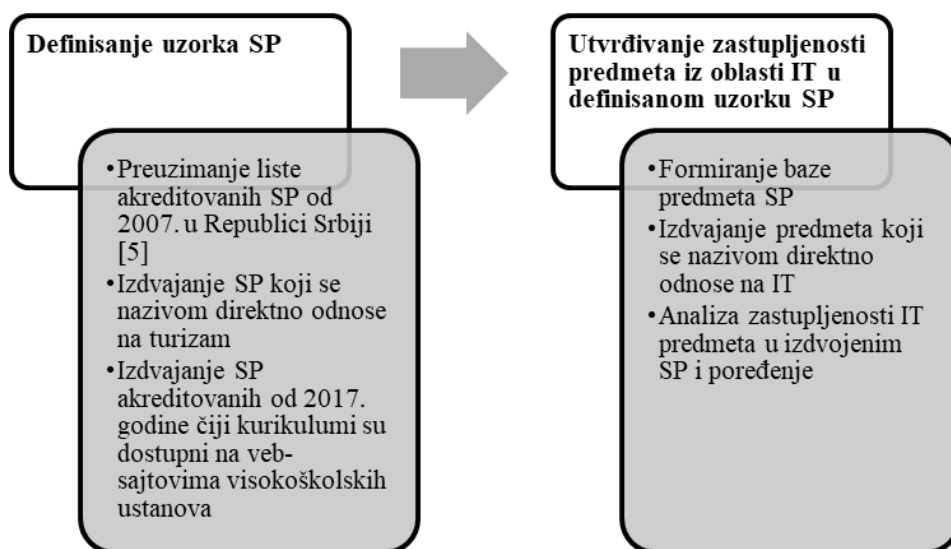
Informacione (i komunikacione) tehnologije u turizmu imaju značaj koji se konstantno povećava, što potvrđuje i sve veće interesovanje istraživača za digitalne tehnologije u turizmu oličeno u broju objavljenih radova. Centralno mesto zauzima „pametni turizam“, ali je povezanost tehnologije, ugostiteljstva i menadžmenta neizostavna stavka u kreiranju budućih istraživačkih pravaca [1]. Među najznačajnijim oblastima istraživanja su „model prihvatanja tehnologije, elektronska prodaja od usta do usta, sadržaj koji generišu korisnici, tehnologije samousluživanja, robotika, pametni turizam, virtuelna stvarnost i poverenje u tehnologiju“ [2].

Razvoj veština iz oblasti informacionih tehnologija stvara osnov za poboljšanje kvaliteta pružanja usluga u turizmu. Postoji veliki interes za digitalnu pismenost, posebno kada je reč o studentima [3]. Analizom studijskih programa turizma u Portugaliji ustanovljeno je da uopšteno posmatrano da na strukovnom nivou postoji veća integracija elemenata kurikulumu povezanih s tehnologijom i da su na nivou osnovnih studija elementi kurikuluma uglavnom uvodni [4].

Predmet ovog rada su kompetencije iz oblasti informacionih tehnologija kao osnov za unapređenje usluga u turizmu. Cilj rada je analizirati akreditovane studijske programe turizma koji se realizuju na ustanovama visokog obrazovanja u Republici Srbiji sa aspekta zastupljenosti nastavnih predmeta iz oblasti informacionih tehnologija.

2. OPIS ISTRAŽIVANJA

Analiza studijskih programa turizma izvršena je početkom marta 2024. godine i sastojala se iz dve glavne faze koje su obuhvatale i podfaze.



Slika 1. Faze analize studijskih programa

3. REZULTATI ISTRAŽIVANJA I DISKUSIJA

Na opisan način identifikovano je 28 studijskih programa turizma. Oni se realizuju na 14 institucija (tabela 1), tj. na 6 univerziteta (42,86%), 6 akademija strukovnih studija (42,86%) i 2 samostalne visoke škole strukovnih studija (14,26%). Većina institucija su državne visokoškolske ustanove (VŠU).

Tabela 1. Visokoškolske ustanove na kojima se realizuju studijski programi turizma

Univerzitet/akademija – Delovi univerziteta/akademije ili samostalne VŠU*
Univerzitet u Beogradu – Geografski fakultet, Beograd
Univerzitet u Novom Sadu – Prirodno-matematički fakultet, Novi Sad
Univerzitet u Kragujevcu – Fakultet za hotelijerstvo i turizam u Vrnjačkoj Banji
Univerzitet u Nišu – Prirodno-matematički fakultet, Niš
Univerzitet „Singidunum“ – Studije pri univerzitetu; Fakultet zdravstvenih i poslovnih studija, Valjevo; Visokoškolska jedinica van sedišta ustanove bez svojstva pravnog lica, Novi Sad; Visokoškolska jedinica van sedišta ustanove bez svojstva pravnog lica, Niš
Univerzitet „Union – Nikola Tesla“ – Fakultet za sport, Beograd
Akademija strukovnih studija Beograd – Odsek Visoka turistička škola, Beograd
Akademija strukovnih studija Južna Srbija – Odsek Visoka poslovna škola Leskovac
Akademija tehničkih strukovnih studija Beograd – Odsek Primenjene inženjerske nauke, Požarevac
Akademija strukovnih studija Zapadna Srbija – Odsek Užice
Toplička akademija strukovnih studija – Odsek za poslovne studije Blace
Akademija strukovnih studija Šumadija – Odsek Aranđelovac
*Visoka poslovna škola strukovnih studija Novi Sad
*Visoka poslovna škola strukovnih studija „Prof. dr Radomir Bojković“ Kruševac

Većina studijskih programa turizma u Republici Srbiji su studije koje se realizuju na državnim visokoškolskim ustanovama (22 studijska programa, tj. 78,57%). Polovina studijskih programa je na osnovnom nivou studija (tabela 2). Preciznije, najveći broj studijskih programa turizma su osnovne strukovne i master akademske studije – po 8 studijskih programa, tj. po 28,57% studijskih programa.

Tabela 2. Struktura studijskih programa turizma

Studije	Broj	Procenat (%)
Osnovne strukovne	8	28.57
Osnovne akademske	6	21.43
Master strukovne	3	10.71
Master akademske	8	28.57
Doktorske akademske	3	10.71

2.1. Osnovne strukovne studije turizma

Svi studijski programi osnovnih strukovnih studija turizma imaju predmete iz oblasti informacionih tehnologija. Takođe, svi navedeni studijski programi imaju obavezne predmete iz oblasti informacionih tehnologija. Za razliku od obaveznih predmeta, izborne predmete ima manje od 40% svih studijskih programa, kao i manje od 30% studijskih programa akreditovanih na državnim visokoškolskim ustanovama. Izborni predmeti su

zastupljeni na svim studijskim programima akreditovanim na privatnim visokoškolskim ustanovama – 1 studijski program.

Tabela 3. Prisutnost predmeta iz oblasti informacionih tehnologija na studijskim programima osnovnih strukovnih studija turizma

		Studijski programi prema svojini nad visokoškolskom ustanovom na kojoj se realizuju					
		Sve (N=8)		Državne (N=7)		Privatne (N=1)	
		Broj	Procenat	Broj	Procenat	Broj	Procenat
IT predmeti	Svi	8	100.00	7	100.00	1	100.00
	Obavezni	8	100.00	7	100.00	1	100.00
	Izborni	3	37.50	2	28.57	1	100.00

Najznačajniji obavezni predmeti iz oblasti informacionih tehnologija na osnovnih strukovnim studijama turizma su predmeti koji se odnose na informatiku, a potom na informaciono-komunikacione tehnologije i informacione sisteme. Elektronsko poslovanje je najprisutniji izborni predmet (tabela 4).

Tabela 4. Predmeti iz oblasti informacionih tehnologija na studijskim programima osnovnih strukovnih studija turizma

	Državne VŠU	Privatne VŠU
Obavezni predmeti	<ul style="list-style-type: none"> • Informacioni sistemi u turizmu • Informatika • Internet i elektronsko poslovanje • Odnosi s javnošću i digitalne komunikacije • Osnove informaciono-komunikacionih tehnologija • Osnove poslovne informatike • Osnovi informatike • Primena informacionih tehnologija / Informaciono komunikacione tehnologije • Primena računara • Smart sistemi menadžmenta 	<ul style="list-style-type: none"> • Informacioni sistemi • Poslovna informatika
Izborni predmeti	<ul style="list-style-type: none"> • Elektronsko poslovanje • Elektronsko poslovanje 	<ul style="list-style-type: none"> • Elektronsko poslovanje • Komunikacione tehnologije

2.2. Osnovne akademske studije turizma

Svi studijski programi osnovnih akademskih studija turizma imaju predmete iz oblasti informacionih tehnologija (tabela 5). Takođe, svi navedeni studijski programi imaju obavezne predmete iz oblasti informacionih tehnologija. Za razliku od obaveznih predmeta, izborne predmete ima polovina svih studijskih programa, dve trećine studijskih programa akreditovanih na privatnim i trećina studijskih programa akreditovanih na državnim visokoškolskim ustanovama.

Tabela 5. Prisutnost predmeta iz oblasti informacionih tehnologija na studijskim programima osnovnih akademskih studija turizma

		Studijski programi prema svojini nad visokoškolskom ustanovom na kojoj se realizuju					
		Sve (N=6)		Državne (N=3)		Privatne (N=3)	
		Broj	Procenat (%)	Broj	Procenat (%)	Broj	Procenat (%)
IT predmeti	Svi	6	100.00	3	100.00	3	100.00
	Obavezni	6	100.00	3	100.00	3	100.00
	Izborni	3	50.00	1	33.33	2	66.67

Najznačajniji obavezni predmet iz oblasti informacionih tehnologija na osnovnih akademskim studijama turizma je poslovna informatika, ali važnu ulogu imaju i predmeti iz sfere informacionih sistema. Predmeti koji se odnose na informacione sisteme su najprisutniji izborni predmeti.

Tabela 6. Predmeti iz oblasti informacionih tehnologija na studijski programima osnovnih akademskih studija turizma

	Državne visokoškolske ustanove	Privatne visokoškolske ustanove
Obavezni predmeti	<ul style="list-style-type: none"> • Informacione tehnologije u turizmu • Osnove GIS-a • Poslovna informatika • Praktikum iz softverskih alata 	<ul style="list-style-type: none"> • Informacioni sistemi u turizmu i hotelijerstvu • Poslovna informatika • Poslovna informatika

	Državne visokoškolske ustanove	Privatne visokoškolske ustanove
Izborni predmeti	<ul style="list-style-type: none"> • Informacione i komunikacione tehnologije u hotelijerstvu i turizmu • Kvantitativna softverska analiza u hotelijerstvu i turizmu • Poslovni informacioni sistemi • Razvoj informacionih sistema 	<ul style="list-style-type: none"> • Digitalni marketing • Informacioni sistemi u turizmu i hotelijerstvu • Internet kao poslovno okruženje • Klauz tehnologije • Odlučivanje i poslovna inteligencija

2.3. Master strukovne studije turizma

Dve trećine studijskih programa master strukovnih studija turizma imaju predmete iz oblasti informacionih tehnologija (tabela 7). Takođe, isti udeo studijskih programi imaju izborne predmete iz oblasti informacionih tehnologija. Za razliku od izbornih predmeta, obavezne predmete ima trećina svih studijskih programa. Važno je napomenuti da su svi studijski programi master strukovnih studija turizma akreditovani na državnim visokoškolskim ustanovama.

Tabela 7. Prisutnost predmeta iz oblasti informacionih tehnologija na studijskim programima master strukovnih studija turizma

		Svi/državni studijski programi (N=3)	
		Broj	Procenat (%)
IT predmeti	Svi	2	66.67
	Obavezni	1	33.33
	Izborni	2	66.67

Najznačajniji obavezni predmet iz oblasti informacionih tehnologija na master strukovnim studijama turizma je digitalni marketing. Predmeti u vezi komuniciranja (uključujući i marketing) imaju važnu poziciju među izbornim predmetima (tabela 8).

Tabela 8. Predmeti iz oblasti informacionih tehnologija na studijski programima master strukovnih studija turizma

	Državne visokoškolske ustanove
Obavezni predmeti	<ul style="list-style-type: none"> • Digitalni marketing • Digitalni marketing

Državne visokoškolske ustanove	
Izborni predmeti	<ul style="list-style-type: none">• Digitalni marketing• Poslovna inteligencija• Primena digitalnih alata u poslovnom komuniciranju

2.4. Master akademske studije turizma

Polovina studijskih programa master akademskih studija turizma imaju predmete iz oblasti informacionih tehnologija, kao i zasebno posmatrano predmete izbornog tipa (tabela 9). Ista je situacija i sa studijskim programima na državnim i privatnim visokoškolskim ustanovama. Za razliku od izbornih predmeta, obavezne predmete ima četvrtina svih studijskih programa i trećina studijskih programa akreditovanih na državnim visokoškolskim ustanovama, dok ih na studijskim programima koji se realizuju na privatnim visokoškolskim ustanovama nema.

Tabela 9. Prisutnost predmeta iz oblasti informacionih tehnologija na studijskim programima master akademskih studija turizma

		Studijski programi prema svojini nad visokoškolskom ustanovom na kojoj se realizuju					
		Sve (N=8)		Državne (N=6)		Privatne (N=2)	
		Broj	Procenat (%)	Broj	Procenat (%)	Broj	Procenat (%)
IT predmeti	Svi	4	50.00	3	50.00	1	50.00
	Obavezni	2	25.00	2	33.33	0	0.00
	Izborni	4	50.00	3	50.00	1	50.00

Najznačajniji obavezni predmeti iz oblasti informacionih tehnologija na master akademskim studijama turizma su upravo predmeti koji svojim nazivom ukazuju na informacione tehnologije (tabela 10).

Tabela 10. Predmeti iz oblasti informacionih tehnologija na studijskim programima master akademskih studija turizma

	Državne VŠU	Privatne VŠU
Obavezni predmeti	<ul style="list-style-type: none"> • Geografske informacione tehnologije u lovnom turizmu • Informacione tehnologije u turizmu 	-
Izborni predmeti	<ul style="list-style-type: none"> • Analiza geoprostornih podataka u GIS-u • Elektronsko poslovanje u turizmu • Informacione tehnologije i sistemi u kulturnom turizmu 	<ul style="list-style-type: none"> • Inteligentni aplikativni softver u turizmu

2.4. Doktorske akademske studije turizma

Dve trećine studijskih programa doktorskih akademskih studija turizma imaju predmete iz oblasti informacionih tehnologija i svi predmeti su izborni – nema obaveznih (tabela 11). Polovina studijskih programa akreditovanih na državnim i svi studijski programi na privatnim visokoškolskim ustanovama (1 studijski program) imaju (izborne) predmete iz navedene oblasti.

Tabela 11. Prisutnost predmeta iz oblasti informacionih tehnologija na studijskim programima doktorskih akademskih studija turizma

		Studijski programi prema svojini nad visokoškolskom ustanovom na kojoj se realizuju					
		Sve (N=3)		Državne (N=2)		Privatne (N=1)	
		Broj	Procenat (%)	Broj	Procenat (%)	Broj	Procenat (%)
IT predmeti	Svi	2	66.67	1	50.00	1	100.00
	Obavezni	0	0.00	0	0.00	0	0.00
	Izborni	2	66.67	1	50.00	1	100.00

Najznačajniji obavezni predmeti iz oblasti informacionih tehnologija na doktorskim akademskim studijama turizma se odnose na informacione sisteme (tabela 12).

Tabela 12. Predmeti iz oblasti informacionih tehnologija na studijskim programima doktorskih akademskih studija turizma

	Državne VŠU	Privatne VŠU
Izborni predmeti	<ul style="list-style-type: none"> • Menadžment turističkim resursima putem GIS-a • Inteligentni informacioni sistemi 	<ul style="list-style-type: none"> • Internet i globalne turističke regije

4. ZAKLJUČAK

Najveći prosek predmeta iz oblasti informacionih tehnologija imaju studijski programi na osnovnim akademskim studijama. Ista je situacija i kod studijskih programa na državnim visokoškolskim ustanovama. Na studijskim programima privatnih visokoškolskih ustanova, najveći prosek imaju osnovne strukovne studije. Najmanji prosek, u svim slučajevima, imaju master akademske studije.

Najveći prosek obaveznih predmeta iz oblasti informacionih tehnologija imaju studijski programi na osnovnim strukovnim studijama. Navedeno važi kako za studijske programe na državnim, tako i na privatnim visokoškolskim ustanovama. Najmanji prosek imaju doktorske akademske studije, sa napomenom da su izjednačene sa master akademskim studijama u slučaju studijskih programa na privatnim visokoškolskim ustanovama.

Najveći prosek izbornih predmeta iz oblasti informacionih tehnologija uzimajući u razmatranje sve studijske programe na državnim visokoškolskim ustanovama imaju osnovne akademske studije. Osnovne strukovne studije imaju najveći prosek na studijskim programima privatnih visokoškolskih ustanova. Najmanji prosek imaju osnovne strukovne studije (svi državni) i master strukovne studije (svi privatni).

Najveći prosek procentualnog učešća obaveznih predmeta u ukupnom broju predmeta je na osnovnim strukovnim studijama, osim u slučaju studijskih programa na privatnim visokoškolskim ustanovama gde su na prvom mestu osnovne akademske studije. Sa druge

strane, najveći prosek procentualnog učešća izbornih predmeta u ukupnom broju predmeta imaju doktorske akademske studije, pri čemu u slučaju studijskih programa na privatnim visokoškolskim ustanovama dele tu poziciju sa master akademskim studijama.

Zaključuje se da su prema broju predmeta iz oblasti informacionih tehnologija, kao i procentualnom učešću obaveznih predmeta, najbolje pozicionirani studijski programi osnovnih studija, a prema procentualnom učešću izbornih predmeta viši nivoi studija. IT kompetencije su veoma važne za unapređenje usluga u turizmu. U cilju osnaživanja i očuvanja svoje konkurentske pozicije na svetskom turističkom tržištu, u Republici Srbiji je potrebno osavremeniti kurikulume studijskih programa turizma jačanjem pozicije IT kao predmetnih, ali i međupredmetnih kompetencija.

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COMPETENCES IN THE FIELD OF INFORMATION TECHNOLOGIES AS A BASIS FOR IMPROVING TOURISM SERVICES: ANALYSIS OF TOURISM STUDY PROGRAMS IN THE REPUBLIC OF SERBIA

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ABSTRACT:

Constant improvement and innovation of tourist services has become necessary if one wants to maintain or improve the existing position on the tourism market. Information technologies are among the indispensable components of modern tourism business, and their role is becoming greater over time. Employees' acquaintance with modern technologies, their willingness to introduce and apply them in business can determine future business success. The formal education system is one of the ways in which existing and future employees in tourism can improve their technological knowledge and skills. Based on the increasingly significant role they play in tourism, competences in the field of information technologies as a basis for improving services in tourism are the subject of this paper. The aim is to analyse the accredited study programs of tourism that are implemented at institutions of higher education in the Republic of Serbia from the aspect of the representation of subjects in the field of information technology.

Keywords: *higher education institutions, higher education, curriculum, IT competences, tourism studies*

PROBLEMS AND SOLUTIONS TO INCREASE THE EFFICIENCY OF ENGINEERING GRAPHIC COURSE

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ABSTRACT:

There has been a great market demand for the engineers with advanced levels of knowledge in the field of CAD technologies. The first course at the Faculty of Technical Sciences in Čačak, where CAD technologies are studied, is Engineering Graphics. The students enrolling these studies have different prior knowledge in this field. Therefore, the Engineering Graphics course is adapted to the intermediate level of knowledge. In order to overcome this gap between market demands and acquired knowledge of CAD technologies, the possibilities of teaching improvements have been explored, so that future engineers acquire the advanced level of knowledge required at the market. A survey was organized for students and this paper analyses the results. The survey provides information of the difficulties experienced and perceived when learning CAD technologies. The survey results also provide basis for recommendation for developing learning materials and approaches.

Keywords: Computer graphics, education, CAD technology, SolidWorks

1. INTRODUCTION

The rapid development of computers and information technologies has contributed to the modern approach to making technical drawings. The classic approach to modelling parts involves presenting a three-dimensional (3D) model using its orthogonal (2D) layouts, while the modern approach involves creating three-dimensional (3D) models on the basis of which classic two-dimensional (2D) technical drawings can be created using a computer. New teaching aids are now used in classes, primarily computers, which makes computer drawing a standard procedure for making technical drawings. CAD software packages have gained a central role in education as well as in industry in the last twenty years. Also, CAD is used not only for traditional documentation purposes but to evaluate design alternatives. Parametric solid models capture design geometry, but they also serve as digital prototypes used in downstream analysis, prototyping, and manufacturing applications as well as for marketing and sales [1].

In the Engineering Graphics course at The Faculty of Technical Sciences in Čačak, students acquire basic knowledge of the graphic representation of three-dimensional

objects in plane and space using a computer. At first, only plane drawings could be drawn with the help of a computer, and later, due to the need for a more visual representation of the model, the possibilities for spatial representation were developed. Computer aided technologies provide the aids for design, analysis, manufacture, and assembly of products and for design, planning, scheduling, controlling, and operations of production systems [2]. Various software packages are used to display the model in space, in its full form and in all three dimensions. Between them, SolidWorks was chosen due to its most appropriate features for teaching Engineering Graphics course.

With the development of new technologies, the demands of the market are growing as well, so it is necessary to produce engineers who can respond to these needs. The improvement of the Engineering Graphics course is conditioned by several parameters. The biggest challenge is overcoming the heterogeneous structure of students who come with different prior knowledge. The students are mostly from secondary schools and encounter more difficulties in learning CAD programs due to little or no previous experience in engineering graphics. For this reason, research was conducted to determine whether it was possible to improve the course so that all students could achieve a satisfactory outcome.

Before the conducting questionnaire, a review of the literature was carried out in order to determine whether there are similar problems faced by other teachers and proposed solutions as well. Following are some of the representative papers.

2. RELATED WORK

In [3] the authors investigate the factors associated with the difficulties faced by students in the section drawing component of the Engineering Graphics and Design course. Questionnaires, classroom observations and focus interviews were used to collect data. 40 students participated in the research. The results of the study showed that students have a poor Engineering Graphics and Design (EGD) background; experience difficulties in understanding cross-sectional drawings; misunderstanding of the principle of section drawing; lack of knowledge about 2D/3D section drawing as well as poor pedagogical practice. Also, spatial visualization was one of the difficulties faced by students. The researcher's recommendation is to pay more attention to exercises for working with lines and spatial visualization during classes, using Piaget's perception theory of images. These topics should strengthen the specific subject didactics of technological subjects in order to prepare efficient and quality engineers [3].

Authors in [4] state that the critical shortage of engineers in South Africa is linked directly to the schooling systems' inability to develop fundamental skills required in engineering courses, such as spatial visualization ability. This study aimed to explore first year EGD Pre-Service Teachers' (PSTs) spatial visualization skills and the factors that enables or constrains their spatial visualization skills. Their finding brings to the fore the potential role of indigenous art (painting and bead work) in enabling the development of spatial visualization skills and ability among students studying EDG [4].

The work in [5] discuss the current state of engineering graphical communication in Engineering Education, as part of a research aimed at improving teaching and learning of technical drawing (TD) for BS courses in Engineering. The paper presents the results of a survey carried out with students enrolled in the first two years of the BS in Engineering at three Italian university locations. Based on analyses of the results the authors conclude that students show interest in 3D CAD modelling topics such as part or assembly construction and also, in more traditional subjects like sketching and dimensioning. Study reveals that student are aware of the different outcomes related to it and that even if there is a clear interest in the most modern topics like 3D and 2D CAD, more traditional and fundamental topics such as sketching and dimensioning must not be neglected [5].

The paper in [6] aims to evaluate educators' and students' preferences for either computer-aided design (CAD) or traditional hand drafting in working drawings coursework. A questionnaire was conducted in the architecture department of a governmental male university in Saudi Arabia. The results show that in achieving the working drawing characteristics of accuracy, neatness, pen assignment adjustments, material presentation, ease of modification, etc., educators' and students' preferences CAD method compared to the hand drafting method. However, the respondents confirmed the negative impact of CAD copy commands from previous projects on the understanding of working drawings and their preference to use the hand drafting drawing method for drawing notes on site visits. The authors conclude that working drawings coursework should combine the CAD and hand drafting methods to utilize the advantages of both in order to improve the course learning outcome [6].

In their work [7], authors identify that the main problem in teaching the subject "Descriptive Geometry and Engineering Graphics" in Uzbekistan is the development of students' spatial imagination. Due to their high school background, the graphic competencies and spatial perceptions of first-year students entering higher education vary. The lack of development of students' spatial imagination in the teaching of "Drawing Geometry and Engineering Graphics" creates various problems in the transfer of knowledge in the subject. One of the solutions, according to authors is usage of modern multimedia computer technologies and computer graphics [7].

Studies have shown [8] that graphic and practical work affect mental activity in different ways. In the process of performing diverse graphic tasks, potential abilities of students can be revealed. Accordingly, it is necessary to compare the content of graphic and practical exercises included in the educational process, enrich them with such exercises as reading drawings with views, drawing from an image, drawing a missing line or filling in views. Students should develop the spatial imagination through training excursions. However, important recent developments have focused on the development of students' dynamic spatial imagination. Accordingly, the visual activity of students should be based on tasks characteristic of the composition of creative activity necessary for modern production, such as the excitability of students' spatial imagination, the development of logical and figurative thinking [8].

3. SURVEY DESIGN AND METHODOLOGY

A questionnaire has been developed to propose online to students of the first and second year of vocational studies at The Faculty of Technical Sciences in Cacak, University of Kragujevac. The questionnaire consisted of ten questions. The first two questions were gender and age relative. Another two questions were related to higher school, course and the software package used for engineering graphics, if any. Next question was divided on seven sub-questions that were related to the knowledge level of specified areas that were covered in the course Engineering graphics in the SolidWorks program. The students were asked to evaluate them using the one-to-five Likert Type scale. In the next question students have to choose one of the four statements that best describe their current readiness to work in SolidWorks software. In addition, there were one open question to collect the students' opinion about the course in general. Questionnaire is given in Table 1.

Table 1. Questionnaire Improvement of teaching in the Engineering graphics course

Questionnaire: Improvement of teaching in the Engineering graphics course					
1. Mark gender.					
2. How old are you?					
3. Name of the high school.					
4. Did you have a 3D modelling class in high school?					
5. If the answer to the previous question was YES, state the name of the tool in which you studied 3D modelling.					
6. On a scale from 1 - "very poor" to 5 - "very good", evaluate your KNOWLEDGE LEVEL for the specified areas that were worked on in the course Engineering graphics in the SolidWorks program.					
Modelling of prismatic parts	1	2	3	4	5
Modelling of rotational parts	1	2	3	4	5
Inserting threads	1	2	3	4	5
Orthogonal projections	1	2	3	4	5
Dimensioning the drawing	1	2	3	4	5
Showing surface roughness in drawing	1	2	3	4	5
Showing tolerances in drawing	1	2	3	4	5
7. The grade I received in the Engineering Graphics course.					
8. Based on your previous experience with 3D modelling in SolidWorks, choose the statement that best describes your current readiness to work in this program.	I'm not sure I can work independently in SolidWorks (even very simple examples)				
	I can work independently in the SolidWorks with someone's help				
	I can create simple models by myself, but it takes me a lot of time to do it.				
	I can independently create complex models				

9. Do you think it is necessary to improve the Engineering Graphics course with the new areas such as Modelling of Complex Parts and Modelling of Assemblies (currently in demand on the market)?

10. If you have a suggestion on how to improve the Engineering Graphics course, you can write it in the field below.

4. RESULT ANALYSIS

The questionnaire was administered online using JotForm¹ software. Total number of 38 students filled out the questionnaire. The data was electronically downloaded into the table, which eliminated the need for manual entry. The aim of the questionnaire was to find out if there is a relationship between students' prior knowledge in 3D modelling and the current knowledge level. Also, the goal was to find out what is the students' opinion about improvement of Engineering Graphics course with the new areas. The "IBM SPSS Statistic 21" statistical package (evaluation version) was used for data analysis. Cronbach's reliability coefficient is ($\alpha = 0.830$), which indicates a high level of reliability of the used questionnaire. The contribution of individual statements was determined by analyzing the arithmetic mean, standard deviation, corrected total correlation coefficients and Cronbach's alphas after deleting each of the questions at the level of the entire questionnaire.

Out of the total number of respondents, 55.3% had 3D modelling in high school, and 44.7% hadn't. The examination of the relationship between the independent variable "Did you have a 3D modelling class in high school?", which can have the value Yes and No, and other dependent variables was performed using the crosstabulation method. The Pearson Chi-Square test was calculated to check whether the intersection of the selected variables is statistically significant. According to convention, when the value of this parameter is less than 0.05 ($p < 0.05$), it indicates that it is possible that there is a certain relationship between the variables that have been selected. In other words, the intersection of the selected variables passed the test of statistical significance. Given that $p = 0.280$ was obtained, for crosstabulation of variables "Did you have a 3D modelling class in high school?" and "Modelling of prismatic parts", it can be concluded that there is no significant relationship between these variables. Similar results are obtained for variables: "Modelling of rotational parts", "Orthogonal projections", "Showing surface roughness in drawing" and "Showing tolerance in drawing". This could indicate that prior knowledge doesn't have much influence in learning these areas of engineering graphics. However, intersection of independent variable "Did you have a 3D modelling class in high school?" and the variables "Inserting threads" and "Dimensioning a drawing" is statistically

¹ www.jotform.com

significant, since $p=0.011$ and $p=0.003$. This could mean that students who had 3D modelling in prior education show better success in completing tasks.

Considering the results obtained by crosstabulation, in the continuation of the analysis, the methods of descriptive statistics (more precisely, frequency table) are applied. Out of the total number of respondents, 36,8% think that they can work independently in the SolidWorks with someone's help. Same percent state that they can work in the SolidWorks by themselves but it takes them a lot of time to do it. Finally, 26.3% respondents can independently create complex models. It should be noted that there were no respondents who chose first option, i.e. that he/she cannot create simple model in SolidWorks. When these results are crossed with variable "Did you have a 3D modelling class in high school?" Pearson Chi-Square test ($p=0.003$) show that this relationship is statistically significant for the research. It can be seen that students who did not have 3D modelling in high school still considered themselves to have relatively high readiness to create models in SolidWorks.

Finally, according to the analysis, majority of students (57.9%) agree that Engineering Graphics course should be improved in order to meet the need of market demands. Rest of the answers are equally distributed (21.1%) to "No, it should stay at this level" and "I don't know". When used in crosstabulation, it can be seen that $p=0.007$ and that relationship between these two variables are statistically significant. This distribution is expected since those who had 3D modelling in high school seek to upgrade their knowledge.

Table 2 Intersection of the "Did you have a 3D modelling class in high school?" and "Do you think it is necessary to improve the Engineering Graphics course with the new areas such as Modelling of Complex Parts and Modelling of Assemblies (currently in demand on the market)?"

	Do you think it is necessary to improve the Engineering Graphics course with the new areas such as Modelling of Complex Parts and Modelling of Assemblies (currently in demand on the market)?			Total
	Yes, it is necessary to respond to the demands of the market	No, it should stay at this level	I don't know	
Did you have a 3D modelling class in high school?	14	3	0	17
	8	5	8	21
Total	22	8	8	38

Unfortunately, correlation between prior knowledge from high school and obtained grade cannot be measured since most of the respondents have yet to take the test. On the other hand, number of students who passed the test from the previous school year was not enrolled in this school year and thus were not included in the questionnaire.

5. CONCLUSION

The development of science and technology requires responsible, modern and urgent requirements for the young generation in all spheres of human activity to be able to understand the reception and processing of information and master it with the help of graphics. Therefore, one of the most important issues is the study of the effectiveness of the formation of basic graphic knowledge and skills in students. Improving the quality of the educational process is one of the most important tasks in the development of general and professional education. The need for research in this area arose due to the growing demand for improving the knowledge of students, in order to meet the demands of the market.

Analysis of the results from conducted survey show that prior knowledge in 3D modelling has partial influence on current students' knowledge level enrolled in Engineering graphics course. Areas such as Modelling of prismatic parts, Modelling of rotational parts, Showing surface roughness in drawing, etc., are equally successful overcome. On the other hand, success in Inserting threads and Dimensioning a drawing depends on prior knowledge of students. Analysis also reveals students' willingness to upgrade their knowledge level with new areas such as Modelling of Complex Parts and Modelling of Assemblies in order to respond to market demands.

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INTERKULTURALNE KOMPETENCIJE I VANNASTAVNE AKTIVNOSTI UČENIKA OSNOVNE ŠKOLE

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SAŽETAK:

U radu se analiziraju interkulturalne kompetencije učenika kao skup vještina neophodnih za život u XXI vijeku. Rad se temelji na proučavanju teorija interkulturalnosti ali i na analizi sprovedenog empirijskog istraživanja. S obzirom da savremeno doba podrazumijeva saradnju sa pripadnicima različitih kultura, nacija i narodnosti, bilo je neophodno ispitati koje aktivnosti utiču na razvoj istih. Pored formalnog obrazovanja, vannastavne aktivnosti su bitan faktor vaspitanja i razvoja svakog djeteta. Rad se bavi proučavanjem nivoa interkulturalnih kompetencija u odnosu na vrstu vannastavne aktivnosti koju učenici pohađaju. Istraživanje je sprovedeno na 150 učenika završnih razreda u dvije osnovne škole. Vannastavne aktivnosti koje su identifikovane istraživanjem su grupisane u kategorije: muzičke i plesne aktivnosti, kursevi stranih jezika i sport. Instrument konstruisan za potrebe istraživanja je Skala interkulturalnih kompetencija-SIK, čiji rezultati su dovedeni u vezu sa aktivnostima koje učenici pohađaju. Dobijeni rezultati nedvosmivelno ukazuju, da učenici koji pohađaju časove stranih jezika postižu statistički značajno više rezultate na skali interkulturalnih kompetencija, u odnosu na vršnjake koji se bave nekim drugim aktivnostima. Zaključci izvedeni iz dobijenih rezultata mogu da budu od koristi u daljem usmjeravju pedagoške prakse ali i teorijskom razvoju društvenih nauka.

Ključne riječi: *interkulturalne kompetencije, vannastavne aktivnosti, interkulturalno vaspitanje*

1. UVOD

Život u savremenom društvu podrazumijeva maksimalan razvoj kompetencija neophodnih za saradnju sa pojedincima koji su po bilo kom kriterijumu drugačiji od nas. Da bismo djecu adekvatno pripremili za budućnost, važno je da njihove interkulturalne kompetencije razvijemo do maksimuma. S obzirom da na razvoj ličnosti utiču različiti faktori, bilo je potrebno pozabaviti se vannastavnim aktivnostima i njihovom ulogom u razvoju ličnosti djece. Teorijski dio rada je posvećen definisanju osnovnih pojmova i analizi tangentskih istraživanja, dok metodološki dio objašnjava cilj, hipoteze i zadatke

istraživanja. Dobijeni rezultati nisu samo od značaja za trenutnu praksu nego i za buduće usmjerenje vaspitno-obrazovnog procesa.

2. TEORIJSKI PRISTUP PROBLEMU ISTRAŽIVANJA

Za jasnije razumijevanje istraživnog problema neophodno je pozabaviti se definisanjem osnovnih pojmova. S obzirom da se rad bavi interkulturalizmom, na samom početku analizirali smo definicije kulture, interkulturalnog obrazovanja ali i vannastavnih aktivnosti.

Interkulturalno obrazovanje je pojam za čije objašnjenje možemo naći mnogo različitih definicija domaćih i stranih autora. U samom nazivu je jasno da se odnosi na obrazovanje koje je dostupno svima, međutim za bolje razumijevanje potrebna je detaljnija analiza. Cilj obrazovnog procesa bi trebao da bude usmjeren na prevenciju i suzbijanje predrasuda među učenicima ali i razvoj ključnih kompetencija za međusobnu saradnju. Škola kao institucija u saradnji sa roditeljima je zadužena za obrazovanje ali i vaspitanje djeteta, te bi dio njenih obaveza bio stvaranje atmosfere u kojoj bi sve razlike među učenicima bile prihvaćene. Priznavanje jednakosti predstavlja izazov za kompletan vaspitno-obrazovni sistem, s obzirom da postavlja nove zahtjeve za sve njegove učesnike. „Važne utiske i uvjerenja o sebi i svijetu u formalnom obrazovanju djeca stižu upravo u školi gdje dolaze u puno direktniji doticaj s različitim kulturama (primjer toga je kultura romskih nacionalnih manjina) i njihovo kasnije predodređenje i stavovi prema različitosti kultura oblikuje se upravo direktnim utiscima i idejama. Stoga je važno približiti koncepte drugih kultura i podići na nivo opšte prihvaćenosti i privrženosti” (Hercigonja, 2017, str. 105). Ovo govori o bitnosti uloge nastavnika u interkulturalnom vaspitanju i odgovornosti njegove uloge. Biti dobar nastavnik nije sa samo pitanje prezentacije naučnih sadržaja nego kreiranja atmosfere prožete tolerancijom i prihvaćenošću svakog pojedinca.

Da bismo se posvetili interkulturalnom obrazovanju, prvenstveno je potrebno precizno definisati pojam kulture. „Kultura je kao način života pripadnika društva; zbirka ideja i navika koje članovi društva uče, dijele i prenose iz pokoljenja u pokoljenje” (Harambosu, 1980, str. 16). Navedena definicija se odnosi na pravila, sistem vrijednosti, i vjerovanja koja usmjeravaju ponašanje pojedinaca. Poseban segment značajan za naš rad je interkulturalno obrazovanje. Osnovni zadatak interkulturalnog obrazovanja je razviti svijest mladih ljudi o vlastitoj nacionalnoj samobitnosti, ali i toleranciju prema pripadnicima drugih kultura (Spajić-Vrkaš 1993). Cilj ovakvog pristupa je razvoj tolerantnih oblika ponašanja kroz razvoj osjećaja pripadnosti cijelom društvu i čovječanstvu. Da bismo kod učenika razvili toleranciju i razumijevanje drugih kultura prvenstveno je potrebno raditi na usvajanju znanja o vlastitom identitetu. Kroz plan i program osnovne škole usvajaju se određena znanja ali je potrebno obratiti pažnju i na ostale faktore koji imaju uticaj na razvoj djeteta. Šira društvena zajednica, vršnjaci, vannastavne aktivnosti i pojedinci sa kojima dijete dolazi u dodir mimo vaspitno-obrazovne institucije mogu da budu bitan vaspitni faktor. Pored plana i programa koji utiče na razvoj interkulturalnih kompetencija učenika, neophodno je govoriti i o sposobnostima nastavnika. “Važnu ulogu nosi vaspitač koji ima snažan uticaj na

prepoznavanje i iskorištavanje djetetovih potencijala. Već se sama priprema vaspitača počinje razmatrati u svjetlu sistemskih i kontinuiranih promjena, koje trebaju rezultirati njihovom većom profesionalnom odgovornošću za praktične odluke. Stoga se govori o novim ulogama vaspitača koje obuhvataju mijenjanje karaktera, uslova i potreba prakse. Vaspitači se preusmjeravaju na poučavanje kroz procese učenja, prihvatanje i zadovoljavanje individualnih različitosti djece, potreba za saradnjom s kolegama, razvijanje sposobnosti refleksije i samorefleksije prakse te konstruiranje i sukonstruiranje znanja” (Tomašić, 2022, str. 2). Zadatak nastavnika je upravo da prepoznaje različitosti te da ih prezentuje kao prednost, a ne ometajući faktor u komunikaciji. Potrebno je poznavanje individualnosti svakog učenika kao i upoznavanje sa njegovim porodičnim i društvenim okruženjem. “globalizacija je donijela saznanja da moderna društva moraju naučiti saradivati jedni s drugima” (Samovar i sar., 2013, str. 2). Interkulturalne kompetencije su osnova za budući razvoj društva i međusobnu saradnju pojedinaca iz različitih kultura.

2.1. Interkulturalne kompetencije

Da bismo objasnili međuzavisnost vannastavnih aktivnosti koje učenici pohađaju i interkulturalnih kompetencija neophodno je analizirati vještine koje pomenute kompetencije obuhvataju. Interkulturalna kompetencija je “stalno razvijanje razumijevanja odnosa između kultura, u čemu nam može pomoći i proučavanje shvatanja karakterističnih vjerovanja i ponašanja pojedinih društvenih skupina unutar pluralnog društva koje se ističe svojom posebnošću u odnosu na dominantnu kulturu, etničnost, rasu, religiju, tjelesnu i/ili mentalnu sposobnost, polnu i/ili rodnu orijentaciju s ciljem konstruktivnog djelovanja i rješavanja pitanja koja se javljaju među kulturama unutar jednog društva“ (Hrvatić i Piršl, 2007, str. 402). Drugim riječima rečeno, interkulturalne kompetencije prvenstveno podrazumijevaju znanja o drugim kulturama, sposobnost identifikacije i prihvatanja razlika kao i izgrađeno mišljenje u cilju uspješne komunikacije i savladavanja međusobnih sukoba. Interkulturalno obrazovanje se ne odnosi jedino na iskazivanje stavova prema drugačijima nego i njihovo prihvatanje (Tomašić, 2022). Da bismo nastavni proces usmjerili u pravcu razvoja kompletne ličnosti učenika, izuzetno je važna uloga nastavnika. „Pojam kompetencija i kompetentnost učitelja sve su važnije teme u pedagojskoj nauci jer se želi ustanoviti koje sposobnosti, vještine, znanja i vrijednosti trebaju posjedovati učitelji i nastavnici kako bi se unaprijedio proces vaspitanja i obrazovanja” (Sambolić, 2020, str. 3). Uloga nastavnika zahtijeva različite vještine kako bi se vaspitno obrazovni proces organizovao na najvišem nivou. Macháček (2006) kompetencije učitelja dijeli na:

- stručno-predmetne kompetencije (poznavanje gradiva)
- pedagoške kompetencije (oblikovanje procesa učenja i stvaranje pozitivne klime na času);
- organizacijske kompetencije (određivanje dinamike i rasporeda učenja);
- komunikativne kompetencije (interakcija sa učenicima);
- savjetodavne kompetencije (prevazilaženje teškoća i podrška učenicima);
- evaluacijske kompetencije (vrednovanje rezultata nastavnog procesa);
- interkulturalne kompetencije.

Rad nastavnika koji se temelji na interkulturalnim kompetencijama, učenike bi trebalo da podstakne na razumijevanje, kooperativnost i međusobnu pomoć. Tokom interkulturalnog obrazovanja učenici treba da se pripreme na život u demokratskom društvu, da razviju vještine komunikacije i saradnje sa različitim kulturama i narodnostima.

2.2. Vannastavne aktivnosti učenika osnovne škole

Za precizno razumijevanje teme neophodno je napraviti jasnu distinkciju između pojmova vannastavne i vanškolske aktivnosti. Vannastavne aktivnosti se odnose na vaspitno-obrazovni rad sa učenicima koji se organizuje mimo nastave na osnovu učeničkih izbora i želja (Koraj, 1999). Fokus ove definicije je na željama učenika kao osnovnom temelju za realizaciju aktivnosti. Vanškolske aktivnosti se organizuju po sličnim načelima s tim što se realizuju u društvima, klubovima ili insitucijama van škole (Cindrić, 1992). Vannastavna aktivnost učenika je značajan vid djelatnosti i pretpostavka formiranja svestrano razvijene ličnosti. Zato se i u nastavnim planovima i programima osnovnih i srednjih škola ukazuje na ulogu vannastavnih aktivnosti u ostvarenju ciljeva i zadataka vaspitnoobrazovnog rada” (Filipović, 1980, str. 19). Kao što definicija navodi smisao vannastavnih aktivnosti je u svestranom razvijanju ličnosti. Interkulturalno kompetentan nastavnik pomaže učenicima da se naviknu na suživot sa različitim rasama i nacijama (Juričić, 2014). Sve brži razvoj moderne tehnologije čini svijet globalnim selom čime su pojedinci primorani sa savladaju vještine komunikacije sa ljudima širom svijeta. “Tokom susreta s drugim kulturama, kulture su podložne promjeni, što dokazuje da je pojedinac aktivan subjekt te u stalnoj interakciji s drugim kulturama. Zbog susreta između različitih grupa u multikulturalnom društvu dolazi do akulturacije - promjene u vjerovanjima, shvatanjima i običajima kao posljedice susreta između dvije ili više kultura” (Sambolić, 2020, str. 11).

Jedan od razloga zašto smo baš odabrali izučavanje uticaja vannastavnih aktivnosti na razvoj interkulturalnih kompetencija, je u činjenici da postoje brojne prednosti u ovakvom načinu učenja. Učenici usvajaju znanje spontano i kroz igru što je mnogo prilagođenije njihovom razvojnom stepenu. Učenje nije nametnutno pa djeca nemaju osjećaj prisile, što bitno utiče na njihovu motivaciju i spremnost da usvajaju nova znanja. Oblasti iz kojih se mogu definisati vannastavne aktivnosti su: 1. Naučna oblast; 2. Kulturno-umjetnička oblast; 3. Tehnička oblast; 4. Sportska oblast; 5. Društvena oblast. (Feriz, 2020, str. 7). Za potrebe našeg istraživanja aktivnosti su grupisane u kurseve stranih jezika, sport, te muzičke i plesne aktivnosti. Važnost vannastavnih aktivnosti nije samo pitanje svestranog razvoja ličnosti nego i stvar prestiža vaspitno-obrazovne institucije. „U mnogim ozbiljnim zemljama vannastavne aktivnosti učenika su ogledalo škole, prva slika prepoznavanja vrijednosti i dostignuća škole koja o kvalitetu ustanove govori znatno više nego fotografije čeonae fasade školske zgrade i bijeli, uglancani i sterilni školski kabineti“ (Majić, 2016, str. 11). Zadatak škole se ogleda u obezbeđivanju adekvatnih sadržaja mimo redovne nastave koji bi učenicima omogućili napredak u svim komponentama vaspitanja. “Škole sve više temelje svoj rad na načelu jednakosti, a interkulturalno obrazovanje traži dodatno priznavanje i poštovanje kulturoloških razlika između pojedinaca. Škole bi

trebale pokušati kreirati jednake društvene i obrazovne uslove za djecu manjinskih grupa, a jedna od njihovih uloga je i podizanje svijesti o kulturnim razlikama i načinu suprotstavljanja diskriminaciji i razvijanja kulturnog pluralizma” (Sablić, 2011, str. 129).

2.3. Rezultati tangentnih istraživanja

Pojedina istraživanja navode da su najčešće vanškolske aktivnosti učenika sportske aktivnosti (47%), učenje stranog jezika (19%), muzičke aktivnosti (16%), literarne ili dramske aktivnosti (5%), ostale (26%) (Ilišin i sar., 2001).

Rezultati istraživanja Zvonimira Tomca (2019) koje se bavilo uticajem vannastavnih aktivnosti na motorički razvoj “je pokazalo kako u većini varijabli nema značajnih razlika između grupa ispitanika, ali učenici koji nisu uključeni u dodatne vannastavne i vanškolske sportske aktivnosti postižu bolje rezultate u jednoj manipulativnoj vještini (vođenje lopte; $Z=2,68$, $p=0,01$) te dvije grube motoričke vještine (sklekovi; $Z=281$, $p=0,00$; podizanje trupa $Z 2,06$, $p=0,04$ ”) (str. 1).

Pozitivan uticaj dodatnih časova sporta se pokazao u istraživanju Jurak i Kovač (2007), koje je dokazalo da učenici koji su dodatno uključeni u sport postižu bolje rezultate u koordinaciji, snazi trupa, ruku i ramenog pojasa.

Pojedina istraživanja su dokazala da mladi ljudi koji pohađaju vannastavne aktivnosti su manje uključena u korištenje raznih opijata (Darling, 2005; Gottfredson i sur., 2004). Navedeni benefiti su dovoljan razlog za pretpostavku da aktivnosti mimo formalne nastave mogu da utiču na određene segmente razvoja pojedinca, uključujući interkulturalne kompetencije.

“U drugim je situacijama sudjelovanje u vannastavnim aktivnostima pogoršavalo poremećaje u ponašanju. Tako Bronfenbrenner i Morris (1998) objašnjavaju da će adolescenti primijeniti socijalno znanje i vještine stečene unutar jednog društvenog okruženja na druge društvene interakcije u koje su uključeni. Stečena socijalna znanja i vještine razlikovaće se zavisno od društvene interakcije kojoj prisustvuju. Uz to, određene socijalne vještine mogu biti korisne u jednom okruženju, ali mogu biti kontraproduktivne u nekim drugim okruženjima” (Maglić, 2021, str. 60).

3. METODOLOGIJA PEDAGOŠKOG ISTRAŽIVANJA

3.1. Problem i cilj

Sve brži razvoj tehnologije čini svijet globalnim selom, što za posljedicu ima svakodnevnu potrebu za međusobnom komunikacijom ljudi širom svijeta. Da bismo nove generacije pripremili za život u savremenom društvu neophodno je da od rođenja radimo na razvoju interkulturalnih kompetencija. Iako na razvoj ovih vještina utiče porodično vaspitanje i vaspitno-obrazovne institucije, fokus našeg istraživanja je bio na utvrđivanju nivoa interkulturalnih kompetencija u odnosu na vannastavne aktivnosti koje učenici pohađaju. Pitanje razvoje ovih sposobnosti nije samo dobrobit djece drugi nacionalnih pripadnosti, kultura, jezičkih ili etničkih različitosti, nego svih pojedinaca kao budućih

članova društva jednakosti. Iako postoje različita istraživanja na temu interkulturalnosti, pitanje uticaja vannastavnih aktivnosti još uvijek nije dovoljno istraženo.

Cilj istraživanja je bio utvrditi koje vannastavne aktivnosti najviše pohađaju učenici i u kojoj mjeri one utiču na razvoj interkulturalnih kompetencija.

3.2. Hipoteze istraživanja

U istraživanju se pošlo od sledećih hipoteza:

H1: Učenici koji u sklopu vannastavnih aktivnosti pohađaju kurseve stranih jezika postižu više interkulturalne kompetencije od vršnjaka koji pohađaju neke druge aktivnosti

H2: Učenici koji se ne bave ni jednom vrstom vannastavnih aktivnosti postižu statistički značajno niže interkulturalne kompetencije u poređenju sa ostalim učenicima

Uzorak ispitanika

Uzorak ispitanika u sprovedenom istraživanju čini 150 učenikau završnih razreda u dvije osnovne škole. Metodom slučajnog uzorka sveukupan broj ispitanika čini 73 (48,67%) ženskog spola i 77 (51,33%) muškog pola.

4. ANALIZA I INTERPRETACIJA REZULTATA

Na osnovu prikazanih podataka iz *Tabele 1*, zaključuje se da učenici koji pohađaju časove stranih jezika postižu statistički značajno više rezultate na skali interkulturalnih kompetencija, u odnosu na vršnjake koji se bavi nekim drugim aktivnostima.

Najpozitivnije stavove u interkulturalnim kompetencijama imaju učenici koji pohađaju časove stranog jezika, za njima slijede, učenici muzičkih i plesnih aktivnosti te sporta. Dobijeni rezultati potvrđuju prvu postavljenu hipotezu. Ovi rezultati nisu iznenađujući s obzirom da učenici kroz strani jezik usvajaju i znanja o drugim kulturama, čime im one postaju razumljivije. Što više znanja imaju o pripadnicima drugih nacija lakše ostvariti uspješnu komunikaciju.

Tabela 1. Interkulturalne kompetencije u odnosu na vannastavne aktivnosti

Vannastavne aktivnosti	N	M	SD	F	df	Sig.
Časovi jezika	62	93,03	12,60			
Muzičke i plesne aktivnosti	21	87,54	13,80			
Sport	45	82,20	16,12			
Bez aktivnosti	22	82,22	16,20			
Ukupno	150	88,37	14,79	51,72	2	0,00**

Iako je bilo za očekivati da je korisnije da se učenici bave bilo kojom od vannastavnih aktivnosti, nego da vrijeme provode u dokolici, po ovom kriterijumu nije dokazana statistički značajna razlika. Druga hipoteza je opovrgnuta. Upravo ovakvi rezultati idu u prilog činjenici koliko je važno da djecu usmjeravamo u pravcu korisnih aktivnosti za cjelokupan razvoj ličnosti i podjednak napredak svih komponenti vaspitanja.

5. ZAKLJUČAK

Na osnovu svega navedenog jasno je koliko su interkulturalne kompetencije učenika važne za buduće generacije. Sveopšti napredak društva postavlja nove zahtjeve za vaspitno-obrazovni sistem, koji podrazumijevaju razvoj novih kompetencija u čijoj osnovi su vještine komunikacije, tolerancije, prihvatanja različitosti i spremnosti na prihvatanje brzih promjena. Pored teorijskih razmatranja rad je obuhvatio i prikaz rezultata sprovedenog istraživanja, čiji rezultati mogu da unaprijede vaspitno-obrazovnu praksu, ali i da budu ideja vodilja pri razvoju pedagoških kompetencija roditelja. S obzirom da su dobijeni podaci dokaz da je važno na koji način djeca provode slobodno vrijeme, potrebno je da sistemski utičemo na organizovane vidove različitih vrsta aktivnosti koji će podsticati dječiji razvoj. Vannastavne aktivnosti je potrebno usmjeriti u pravcu razvoja različitih kompetencija uključujući i interkulturalne kompetencije. Svi učesnici vaspitno-obrazovnog sistema bi trebali intenzivno da rade na podsticanju učenika za učestvovanje u vannastavnih aktivnostima. Kroz časove istorije, stranog jezika, geografije ali i časove umjetnosti, moguće je zainteresovati učenike za drugačije kulture i približiti im drugačije kulturološke obrasce. Sprovedeno istraživanje pored odgovora na postavljene zadatke, ostavlja prostora za neka slična ispitivanja o drugim mogućim uticajima vannastavnih aktivnosti.

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INTERCULTURAL COMPETENCES AND EXTRA-CURRICULAR ACTIVITIES OF PRIMARY SCHOOL STUDENTS

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ABSTRACT:

The paper analyzes the intercultural competences of students as a set of skills necessary for life in the 21st century. The work is based on the study of theories of interculturality, but also on the analysis of the conducted empirical research. Given that the modern age implies cooperation with members of different cultures, nations and nationalities, it was necessary to examine which activities influence their development. In addition to formal education, extracurricular activities are an important factor in the upbringing and development of every child. The paper deals with the study of the level of intercultural competences in relation to the type of extracurricular activities that students attend. The research was conducted on 150 final grade students in two elementary schools. The

extracurricular activities identified by the research are grouped into the following categories: music and dance activities, foreign language courses and sports. The instrument constructed for research purposes is the Intercultural Competence Scale-ICC. The results of the scale are linked to the activities that the students attend. The obtained results unequivocally indicate that students who attend foreign language classes achieve statistically significantly higher results on the scale of intercultural competence, compared to their peers who engage in other activities. The conclusions derived from the obtained results can be useful for the further direction of pedagogical practice, but also for the theoretical development of social sciences.

Keywords: *intercultural competences, extracurricular activities, intercultural education*

ŠTA UČENICI I STUDENTI (NE)OČEKUJU OD KLASIČNE NASTAVE U UČIONICI, A ŠTA OD ONLINE NASTAVE

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SAŽETAK:

Očekivanja su integralni dio ljudskog života i nalazimo ih u svim ljudskim aktivnosti. Upravo od očekivanja i praćenja njihovog ostvarenja u najvećoj mjeri ovisi i nivo naše uključenosti u te aktivnosti. U ovom radu predstavljeni su rezultati ispitivanja o očekivanjima učenika i studenata u klasičnoj i u online nastavi, kao i o tome šta im se ne sviđa i šta ne očekuju da se dešava. Rezultati su pokazali da kod 591 ispitanika dominira konkretni interes koji je vezan da dobre ocjene, to je ono što ih najviše interesuje i što očekuju, a sa druge strane najviše im se ne sviđa i najmanje očekuju ono što narušava te dobre ocjene.

Ključne riječi: očekivanja, klasična nastava, online nastava

UVOD

Jedna od najčešćih komponenti ljudskog života su „očekivanja“. Teško je pronaći konkretnu situaciju kojoj ne prethodi određeno očekivanje. Svjedno je da li se radi o očekivanom kvalitetu knjige koju uzmemo da čitamo, filma ili utakmice koju odlučimo gledati, mjesta koje odlučimo posjetiti, posla kojim se odlučimo baviti, pa čak i kafe na koju odlučimo izaći. Očekivanja su naprosto sastavni dio naših života. Osim što su sastavni dio našeg života, očekivanja u značajnoj mjeri određuju i naš odnos spram aktivnosti u kojoj se nalazimo. Recimo ukoliko vidimo da se naša očekivanja na ispunjavaju i da kolokvijalno rečeno „to nije to“, automatski dolazi do opadanja koncentracije, gubitka interesa za konkretnu aktivnost, a ukoliko vidimo da se očekivanje u značajnoj mjeri ne ispunjava i procijenimo da neće biti ispunjena, vrlo često dolazi i do odustajanja od date aktivnosti. Te situacije neminovno rezultiraju manjom ili većom dozom razočarenja. Posljedica razočarenja najčešće je trajni gubitak želje da ponovimo slično iskustvo ili da se bavimo datom aktivnošću.

Očekivanja imaju i suprotan pol. Naime, u životu vrlo često nam se dešava nešto i tada nešto i ne očekujemo da se dešava. Međutim, život nas uči da baš ono što ne očekujemo može postati naša realnost. To su situacije koje redovno prati iznenađenje i nelagoda. Po

samoj svojoj prirodi čovjek se trud izbjeći te situacije u kojima se ostvaruje ono što ne očekuje. Naravno, pod velikim uvjetom da to može izbjeći.

Upravo iz tog razloga je izuzetno važno uvrstiti šta djeca (učenici i studenti) očekuju a šta ne očekuju u nastavi, jer očekivanja imamo i u nastavi. Po prirodi stvari učenici imaju određena očekivanja od nastave pa i od nastavnika. Isto važi i za neočekivanja. Samo za razliku od odraslih, učenici i studenti najčešće ne mogu izbjeći te aktivnosti. Umjesto toga javlja se snažno prisutno osjećanje dosade, pa čak i trpljenja.

Da bi se sve to izbjeglo potrebno je da se nastavnici na početku svake godine, pa i svakog pojedinačnog susreta sa učenicima upoznaju sa očekivanjima i neočekivanjima svojih učenika i studenata, ako ništa barem u pogledu nastavnog sadržaja koji je okosnica njihove komunikacije.

Očekivanja od nastave

Očekivanje je jedan od temeljnih pojmova psihologije. Uobičajeno se definiše kao: „hipotetičko stanje organizma, vrsta stava ili seta, koje je izraz iskustvom oblikovanog predviđanja da će se nešto dogoditi; bihevioristi ga shvaćaju kao stanje povećane pripravnosti na reagiranje; u suvremenim kognitivnim teorijama (npr. motivacije) shvaća se kao subjektivno uvjerenje u vezi s ishodom nekog događaja i određuje se fenomenološki, na temelju subjektivnih procjena vjerojatnosti pojedinih ishoda.“ (Petz, B., 2005: 307)

Lahko je uočiti da u svakom očekivanju dominiraju dvije kategorije: procjena vjerovatnoće zacrtanih ciljeva i vrijednost ciljeva te aktivnosti za svakodnevni život pojedinca.

Atkinson smatra kako na očekivanja s jedne strane utjecaj ima potreba za uspjehom: motivacija za uspjeh, procijenjena vjerojatnost uspjeha i poticajna vrijednost mogućeg uspjeha. S druge strane očekivanja oblikuje i potreba za izbjegavanjem neuspjeha putem: motiva za izbjegavanje neuspjeha, procjene vjerojatnosti neuspjeha i negativne poticajne vrijednosti neuspjeha. (prema Beck, R., 2003: 325) Dakle, motivacija, kao polazna tačka svake ljudske aktivnosti, direktno je povezana s (ne)ispunjenjem očekivanja.

Osim važnosti za svakodnevni život, pitanje očekivanja je jedno od pitanja koje su od velike važnosti za nastavu i nastavni proces. Još je Glaser (1994) utvrdio da većina učenika na početku svog školskog puta želi dobro i kvalitetno raditi i učiti. Ono što nije potrebno dokazivati jeste činjenica da se do kraja određenog ciklusa školovanja većina ovih očekivanja izgubi i da učenici i studenti traže najlakše način da zaobiđu „školske obaveze“ i što lakše prođu na ispitima. Brojna kasnija istraživanja su pokazala da njihova želja za učenjem i razvojem, kod većine, tokom vremena slabi ili čak potpuno nestaje. (Vidi više Key, E., 2000; Robinson i Aronica, 2011)

Želja za ličnim razvojem koji je usko vezan za ova startna očekivanja prelazi u drugi plan, a u prvi plan dolazi želja da izbjegavanjem ili što lakšim prolaženjem kroz školske obaveze.

Želja za ličnim razvojem, ako preživi, biva kompenzirana „željom za što boljim školskim i akademskim uspjehom“. Glaser je utvrdio da i gotovo „svi priznaju da nikad nisu kvalitetno radili i ni ne namjeravaju“ (Glaser, 1994; 13) Dokazao je da učenici očigledno ne stavljaju znak jednakosti između učenja za ocjenu i kvalitetnog rada usmjerenog ka izgradnji ličnih kapaciteta, odnosno podizanju ličnih kompetencija.

Na taj način društvo dobija učenike s odličnim ocjena koji ne razumiju neke od osnovnih životnih stvari, kao i diplomante sa raznih fakulteta koji dolaze sa najvećim prosjekom ocjena i nesposobni su uraditi konkretan posao koji se od njih traži u firmi ili ustanovi koja ih zaposli i to u oblasti za koju su se školovali. Tako se ponavlja priča neispunjenih očekivanja i ispunjenih očekivanja, te se društvo počinje vrtiti u začaranom krugu.

Dokazano je da ljudi u takvim situacijama imaju sklonost realistično mijenjati svoje ciljeve, odnosno svoja očekivanja njihovog ostvarenja. Sve to nastaje kao rezultat proživljenog iskustva. (Beck, R., 2003: 325).

U pitanju je vrlo kompleksan problem, ali ono što je sigurno jeste da sastavni dio tog problema odnos očekivanja učenika od nastave i nastavnika, ako i neočekivanja od nastave i nastavnika. Naravno, ovo pitanje ima i drugu dimenziju a to je odnos nastavnikovih očekivanja od učenika i studenata i neočekivanja, ali to je predmet za drugo istraživanje.

Očekivanja učenika od nastave i nastavnika su dodatno dobila na važnosti pojavom online nastave, kada je kompletna nastava dobila potpuno novu dimenziju. Po definiciji „Online učenje/ E-učenje / eObrazovanje / elektronsko učenje (eLearning) - obuhvata široki skup aplikacija i procesa kao što su web-bazirano učenje, kompjuterski podržano učenje, virtuelnu učionicu, te kolaboraciju u nastavnom procesu i učenju koja je podržana elektronskim i digitalnim sredstvima, uključujući i isporuku edukativnih sadržaja putem interneta, lokalnih (intranet/extranet LAN/WAN) računarskih mreža, putem audio i video medija, emitovanje edukativnih sadržaja putem satelita, interaktivne TV, opto-medija i drugih digitalnih i elektronskih sredstava.“ (Halilović, N. 2020: 98) Naravno, pojavu nove dimenzije su pratila i nova očekivanja učenika i studenata.

U ovom radu su prikazani rezultati dva očekivanja, šta učenici očekuju od klasične nastave, a šta od online nastave. Uz to je i istraživano i šta učenici i studenti ne očekuju od klasične i od online nastave.

Metodologija istraživanja i rezultati analize

Cilj ovog istraživanja je da utvrdi očekivanja učenika i studena u pogledu klasične i online nastave.

Istraživačka pitanja su uvrđiti:

1. Šta ispitanici očekuju od klasične nastave
2. Šta ispitanici očekuju od online nastave
3. Šta ispitanici ne očekuju od klasične nastave
4. Šta ispitanici ne očekuju od online nastave

Istraživanje je realizirano u dva navrata, prvo 2012. godine o klasičnoj nastavi drugo 2024. godine o online nastavi.

Istraživanje o očekivanjima učenika od klasične nastave realizirano je u 2012. godini. Anketnim upitnicima putem ispitana su 444 ispitanika (232 ženska i 212 muških) iz 6 srednjih škola u Bosni i Hercegovini. Upitnik se sastoji od 14 zatvorenih pitanja koje su učenici ocjenjivali u skali od 1 do 5 ovisno o stepenu svog očekivanja. 15. pitanje je bilo otvorenog tipa da učenici dopune nešto drugo.

Upitnik je ponovljen 2024. godine radi utvrđivanja očekivanja učenika i studenata u online nastavi 147 ispitanika je popunilo online upitnik (88 ženskih i 59 muških). Rezultati su obrađeni statistički i Microsoft Excelu.

Upitnik je kreiran sondažnim istraživanjem da se utvrdi koja su najčešća njihova očekivanja u nastavi, a nakon toga je po njihovim rezultatima kreiran sljedeći set pitanja:

SVIĐA MI SE/OČEKUJEM

1. Prijatna i opuštena atmosfera na časovima ovog predmeta	8. Korištenje kvizova u nastavi
2. Šala, zabava i duhovitost na času	9. Mogućnost kreiranja samostalnih referata i prezentacija
3. Mir i disciplina za vrijeme časa	10. Otvorene i slobodne razgovore sa nastavnikom
4. Česti grupni radovi	11. Debate i diskusije o određenoj temi
5. Posjete raznim objektima i praktična nastava	12. Dobre i zaslužene ocjene
6. Korištenje priča i anegdota u objašnjavanju lekcije	13. Korištenje pismenih provjera znanja (kontrolnih, testova, pismenih vježbi i sl.
7. Korištenje multimedije (filmova, video-klipova, muzike, prezentacija ...)	14. Kada me profesor motiviše i zainteresira za sadržaje koje učimo
15. Nešto drugo što nije navedeno	

Na isti način je kreiran i set pitanja u pogledu onoga šta im se ne sviđa u nastavi i šta ne očekuju da se dešava:

NE SVIĐA MI SE I NE OČEKUJEM

1. Česta buka i nemir u učionici za vrijeme nastave	8. Kada nastavnik samo čita sa prezentacije, a mi to moramo prepisati
2. Nemogućnost uspostave discipline od strane nastavnika	9. Kada nastavnik koristi neku novu tehnologiju, novi način rada, a vidi se da nije vješt u tome
3. Manjak poštovanja prema nastavniku i predmetu	10. Nisam mogao/la postaviti pitanje za ono što me interesovalo i što mi nije bilo jasno
4. Često diktiranje lekcija bez adekvatnog pojašnjenja	11. Čas je čisto predavanje, profesor nas tretira kao objekat i nimalo nas ne uključuje u tok časa
5. Improvizirano pojašnjavanje lekcija bez dobre pripreme	12. Poklanjanje ocjena
6. Stalno isti dosadni način rada	13. Nenajavljeni kontrolni i testovi
7. Kada učenici rade prezentacije i referate i izlažu to na času	14. Profesor me nije motivisao i nemam želju ni interes da učim na času
15. Nešto drugo što nije navedeno	

Obradom prikupljenih podataka od ukupno 591 ispitanika dobili smo sljedeće rezultate:

Očekivanja od klasične nastave

Rezultati istraživanja obavljenog 2012. godine u 6 srednjih škola u Bosni i Hercegovini pokazuju zorno prikazuju šta su ispitanici navedenog uzorka očekivali od nastave i nastavnika:



(Grafikon 1 – Očekivanja ispitanika od klasične nastave).

Rezultati istraživanja su pokazali da je u vrhu ispitanika ovog uzorka „dobre i zaslužene ocjene“, što ukazuje da je ključni interes njihovog rada vezan da ocjene.

Pored toga, visoko cijene uspješnu motivaciju profesora, mir i disciplinu u nastavi, otvorene i slobodne razgovore s nastavnikom. Sve su to elementi prijatne i ugodne atmosfere, koju očigledno i ispitanici žele u učionici.

Najslabije su ocijenjeni česti grupni radovi, iako je reforma obrazovnog sistema u Bosni i Hercegovini išla upravo ka forsiranju i što češćem korištenju grupnih radova, stiče se dojam da je to aktivnost koja nije omiljena učenicima u klasičnoj nastavi.

Na začelju rang liste se našlo o korištenje kvizova i pisane provjere znanja, te korištenje multimedije. Očigledno je da učenici bolje sami znaju izabrati multimediju, nego što im izabiru profesori i nude na časovima.

Zanimljivo je da su slabo ocijenjene i šala, zabava i duhovitost na času, što bi trebalo biti predmet posebnog istraživanja, jer čovjek po svojoj prirodi voli šalu i zabavu. Sasvim je moguće da u nastavi imamo pojave neprimjerenih šala, neukusnih šala, kao i veliki nesklad u ponašanju nastavnika, jer „čas se šale, a već idući čas daju loše ocjene“ kako primjeti jedan od ispitanika.

Što se tiče dopune upitnika koju omogućava pitanje br. 15, ispitanici su još naveli sljedeće karakteristike koje im se sviđaju i koje očekuju:

- bilo bi mi zadovoljstvo biti na ovakvom času 20 minuta časa, 5 minuta šale i 20 minuta čas,
- blag odnos prema učeniku,
- da profesori budu opušteniji i liberalniji,
- da su dobri prema nama,
- da su profesori tolerantni,
- internatski život,
- kad imamo više časova za sportske aktivnosti,
- kada posebnu pažnju posvetimo određenoj temi,
- kada nastavnik mimo lekcije proširuje znanje učenicima,
- kada nastavnik razgovara o nekoj zanimljivoj temi,
- kada su profesori raspoloženi,
- kada vidi da se dosađujemo pa promijeni način rada,
- korištenje laptopa za vrijeme nastave,
- maksimalno zalaganje nastavnika na času,
- način na koji profesor postupa sa učenicima,
- pouke profesora,
- praktičan rad,
- prijatnost,
- tolerancija profesora,
- veća mogućnost odgovaranja.
- veća sloboda, itd.

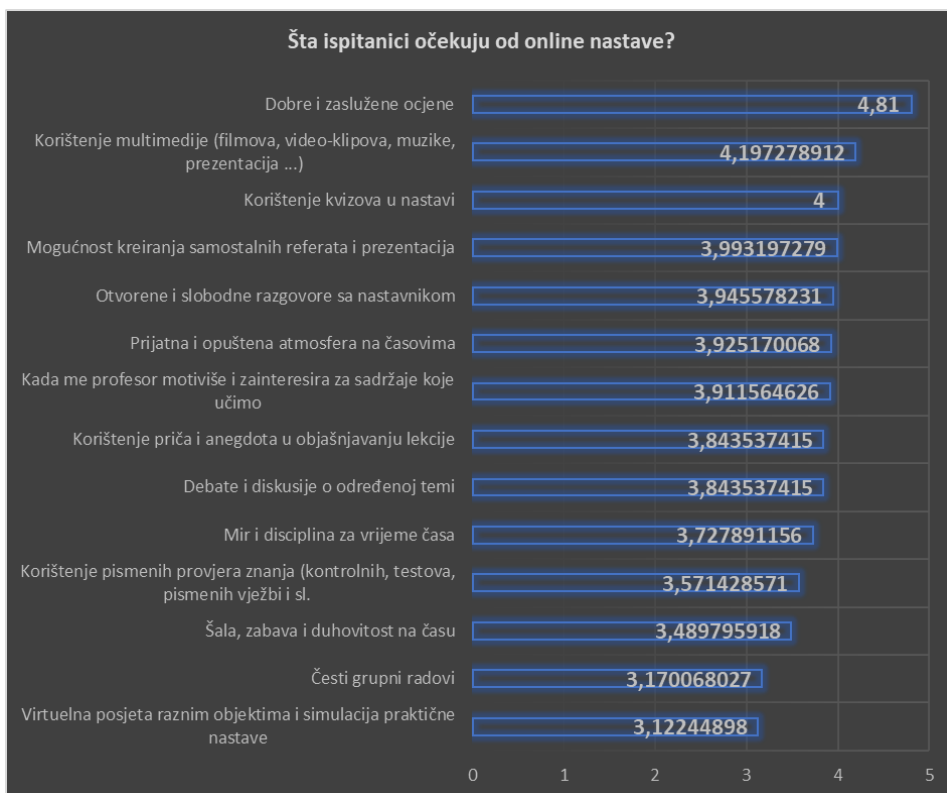
Kao što se može primijetiti, većina dodatnih komentara ispitanika ukazuju na značaj dobrog odnosa nastavnika prema ispitanicima.

Vrlo je zanimljiv i komentar očekivane realizacije časa po modelu 20 minuta predavanja, kratka efektivna pauza od 5 minuta, te ponovo 20 minuta predavanja. Ovaj model je značajan i zbog toga što je u skladu s dječijom pažnjom i njenim ograničenjima.

Očekivanja od online nastave

Budući da je pojava pandemije Covid 19, nametnula online nastavu kao osnovni model izvođenja nastave diljem svijeta, urađeno je ispitivanje da se vidi očekivanje ispitanika od online nastave. Iskorišten je isti model pitanja iz 2012., s tim da su djelimično modificirana.

Korištenjem online upitnika Google Forms dobiveni su sljedeći rezultati:



(Grafikon 2 – Očekivanja ispitanika od online nastave).

Rezultati su potvrdili očekivanje u pogledu dobrih i zasluženih ocjena kao jedno od najbolje ocijenjenih. Ambijent online nastave nije promijenio očekivanja učenika u pogledu ocjena koje se dobijaju, bilo u klasičnoj, bilo u online nastavi.

Druga stavka po značajnosti je korištenje multimedije. U ispitivanju iz 2012. ovo je bilo na samom kraju očekivanja učenika od nastave, a u slučaju online nastave je u samom vrhu. Razlog je lahko shvatiti, jer online nastava ima brojna ograničenja, a multimedija se javlja kao sredstvo način osvježenja te nastave.

Odmah zatim po značajnosti dolazi i korištenje kvizova u nastavi koji ispitanicima daju brzu povratnu informaciju o napretku u učenju.

Ispitanici visoko cijene i mogućnost kreiranja samostalnih referata i prezentacija, jer proces učenja i jeste individualni proces, te tu imamo mogućnost samostalnog ostvarenja učenika.

Na samom začelju ponuđenih nastavnih aktivnosti ocijenjena je virtuelna posjeta raznim objektima i simulacije, što je osnova za posebno istraživanje. Može se pretpostaviti da su upravo ove aktivnosti najslabije primjenjivane u nastavi, da ih najmanje ima u ponudi, ili su one koje se nude na tako niskom nivou kvaliteta da ih učenici izbjegavaju.

Što se tiče dopune upitnika koju omogućava pitanje br. 15, ispitanici su još naveli sljedeće karakteristike koje im se sviđaju i koje očekuju:

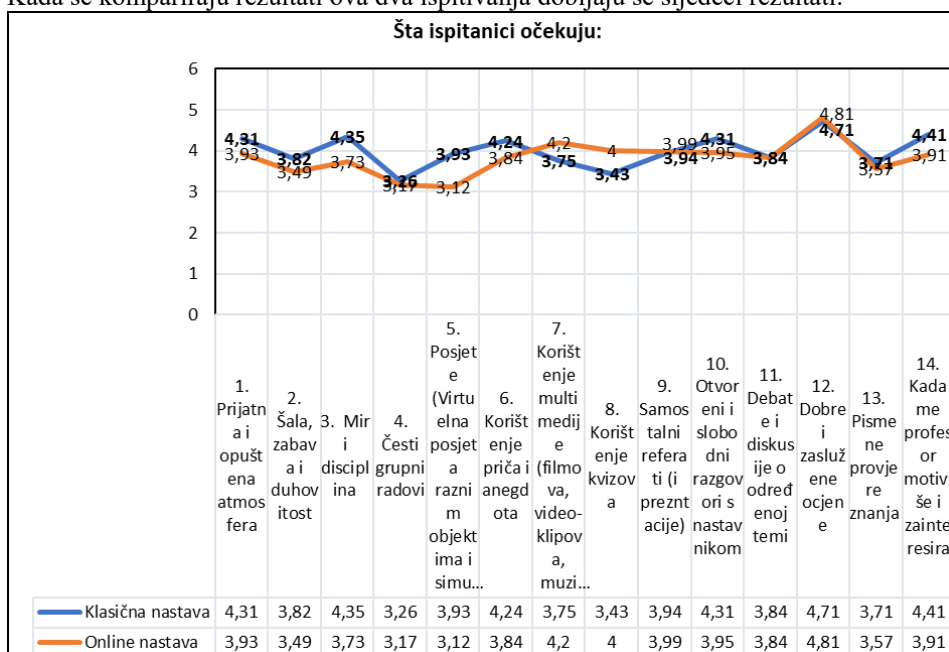
- Aktivnost učenika

- Bolji konekciju
- Da se može jesti na časovima
- Da se približi radu kao nastavi u učionici, ali bez bespotrebnih dolazaka.
- Dinamika učenja i sortiranje učenika po kvaliteti u grupe
- Dogovor za održavanje časova
- Dopada mi se što možemo biti u udobnosti vlastitog doma tokom časova
- Inovativni načini obrade lekcija
- Kada ne učimo cijeli čas nego imamo određeni period za odmor
- Kada profesor detaljno i razumljivo objašnjava sadržaj
- Konkretna struktura časa, dinamika od početka do kraja umjesto listanja jedne monotone prezentacije 45 minuta.
- Korištenje raznovrsnijeg digitalnog materijala.
- Kreativnost
- Loš raspored kontrolnih radova, spontani usmeni odgovori,
- Manje zadaće, i više rada za vrijeme trajanja časa.
- Mogućnost da pitamo i razgovaramo sa profesorom ukoliko nam nešto nije jasno
- Mogućnost usmjeravanja učenika na korisne i edukativne sadržaje, kad već dosta vremena provode u virtuelnom svijetu
- Mogućnost neverbalne komunikacije
- Nastavnik ne može djecu natjerati da prisustvuju online nastavi, nemaš tačan uvid ko je stvarno tu
- Netolerancija za tehničke probleme
- Obzirom da online nastava umije biti jako suhoparna i takoreći dosadna, očekujem od profesora da prilagode predavanja takvom vidu nastave da studenti vrlo rado dolaze na predavanja a ne da izbjegavaju. Da to ne bude samo pukom listanje prezentacija i čitanje istih.
- Online pop quiz
- Online testovi
- Pauze
- Poštivanje vremena
- Praktična nastava
- Prezentacije
- Priče i primjeri iz svakodnevnog života
- Primjena naučenog znanja (praksa)
- Primjeri iz prakse, analiza studije slučaja
- Pristup velikoj količini različitih informacija
- Razgovor o dešavanjima iz života, svakodnevnice
- Redovnost na nastavi

- Sloboda
- Sloboda razgovora i diskusije sa kolegama iz razreda
- Tačnost, informiranost
- Učestvovanje u novom gradivu, nagrada za aktivnost.

Kao što se može uočiti ispitanici visoko cijene kreativnost i posvećenost nastavnika u online nastavi, otvorene razgovore, odnosno svako izbjegavanje suhoparnog listanja prezentacija i čitanje istih, na što se najčešće i u najvećem broju slučajeva svodi online nastava.

Kada se kompariraju rezultati ova dva ispitivanja dobijaju se sljedeći rezultati:



(Grafikon 3 – Komparacija odnosa očekivanja ispitanika od klasične i online nastave).

Rezultati istraživanja pokazuju da se ispitanicima i u klasičnoj nastavi i u online nastavi najviše sviđaju „Dobre i zaslužene ocjene“, što potpuno korespondira na prethodnim istraživanjima ukazanim u teorijskom dijelu, sa druge strane ispitanici i iz klasične i iz online nastave ukazuju da najmanji značaj daju čestim grupnim radovima. Iako je jedno vrijeme korištenje grupnih radova okosnica reforme brojnih sistema obrazovanja, na ovom uzorku (591 ispitanik) utvrđeno grupni radovi nisu omiljeni među ispitanicima i na samom su začelju njihovih utvrđenih očekivanja.

Rezultati istraživanja su pokazali i da ispitanici i u prvom i drugom istraživanju imaju usaglašen stav u pogledu procjenjivanja mjesta i pozicije:

1. Grupnih radova
2. Samostalnih referata i pravljenja prezentacija
3. Debata i diskusija o određenoj temi

4. Dobrih i zasluženih ocjena

5. Pismenih provjera znanja.

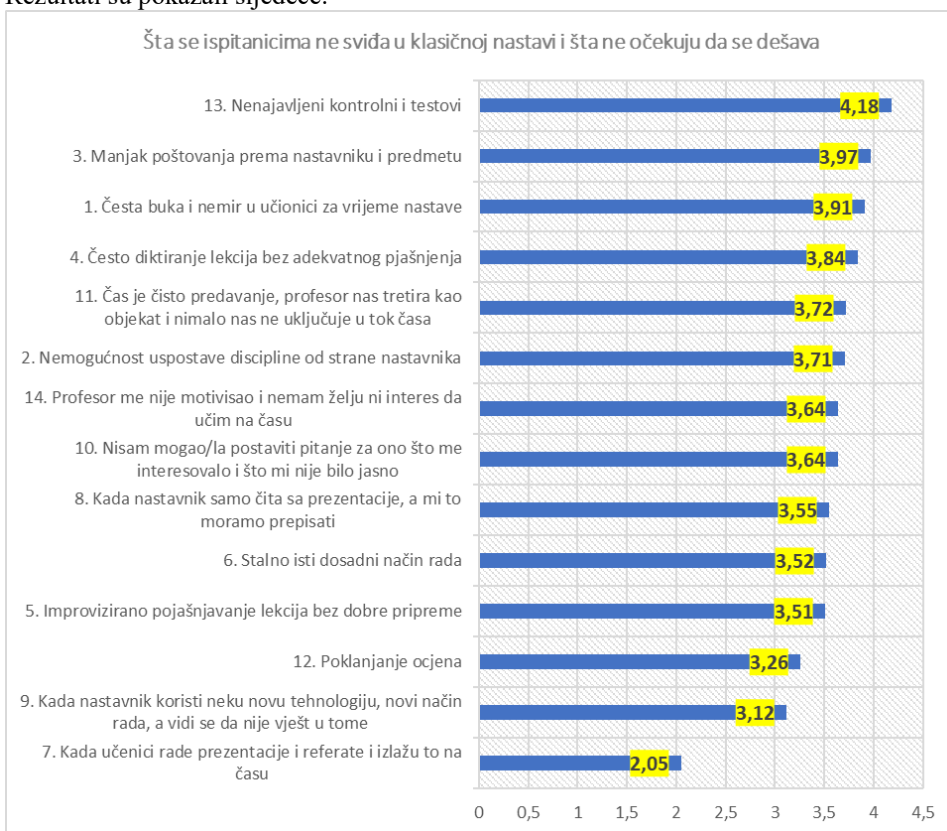
Dakle, 5 od 15 pitanja se približno ili čak i potpuno identično ocjenjuju.

Rezultati istraživanja su utvrdili da ispitanici u prosjeku pozitivnije ocjenjuju aktivnosti iz klasične nego iz online nastave.

Šta se ispitanicima ne sviđa u klasičnoj nastavi i šta ne očekuju da se dešava

Drugi dio upitnika se odnosio na ono što se ispitanicima ne sviđa u klasičnoj nastavi i šta ne očekuju da se dešava.

Rezultati su pokazali sljedeće:



(Grafikon 4 – Šta ispitanici ne očekuju od klasične nastave).

Rezultati i ovog ispitivanja potvrđuju najveći učenički interes za ocjenama. Upravo zato im se i ne sviđaju nenajavljeni kontrolni, ispiti i testovi, jer upravo ta aktivnost im najčešće i najviše narušava dobre ocjene. Iako je ovo mahom zabranjeno, činjenica je da se u praksi uglavnom dešava pojava da se nastavnici ovo koriste.

Rezultati su pokazali da ispitanicima u klasičnoj nastavi smeta i sve ono što im odvlači pažnju i onemogućava praćenje sadržaja i učešće u nastavnim aktivnostima (manjak

poštovanja prema predmetu i nastavniku, galama, buka, nemir, nemogućnost uspostave discipline itd.)

Ispitanici jasno detektuju i ističu da im se ne sviđa formalizirana, rutinska nastava, sa pukim diktiranjem, predavanjem ili čitanjem prezentacija.

Ne sviđa im se ni nemogućnost uspostave komunikacije sa nastavnikom i postavljanja pitanja za ono što im se sviđa.

Rezultati su pokazali da im najmanje smeta kada učenici rade prezentacije i referate i čitaju ih na času, a utvrđeno je i da su osjetljivi na pojave improvizacije časova od strane nastavnika, te poklanjanje ocjena učenicima bez ikakvog kriterija.

Što se tiče dopune upitnika koju omogućava pitanje br. 15, ispitanici su još naveli sljedeće karakteristike koje im se sviđaju i koje očekuju:

- dobacivanje učenika za vrijeme časa,
- nemarnost nastavnika na času,
- kada profesori pitaju bez najave,
- govorenje riječi koje nas vrijeđaju,
- čitanje lekcije iz knjige,
- nastavnik dolazi ljut na čas
- simpatisanje pojedinaca od strane profesora,
- kad nastavnik ispituje na način učenja - sve napamet,
- povišen ton, da galami na nas,
- pravljenje razlike među učenicima,
- ne zna prenijeti znanje na učenike
- nepoštivanje,
- galama,
- osjetljivost profesora i stalno povišen ton (tjelesni) nervoza i drskost, oštrost, velika ozbiljnost, brzo diktiranje.

Kao što se jasno vidi u pitanju su aktivnosti u kojima se jasno vidi da ispitanici prepoznaju nastavnikov loš odnos prema učenicima kao i prema predmetu koji predaje.

Šta se ispitanicima ne sviđa u online nastavi i šta ne očekuju da se dešava

Kada su ista pitanja iz 2012. godine postavljena ispitanicima koji su imali iskustvo online nastave u 2024. godini dobili smo sljedeće rezultate:



(Grafikon 5 – Šta ispitanici ne očekuju od online nastave).

Rezultati pokazuju da ispitanicima najviše smeta manjak poštovanja prema nastavniku i predmetu, što je očigledno redovna pojava u slučaju online nastave. Jako teško je naći ispitanika koji je oduševljen online nastavom. Stiče se dojam da je manjak poštovanja prema online nastavi i većini profesora koji je realiziraju na monoton način osnova u odnosu ispitanika spram ovog vida nastave. Većina ispitanika se sa online nastavom susrela u nuždi i samim tim se cjelokupna nastava i doživljava kao nužna. Nastavnici su mahom nespremni ušli u realizaciju online nastave, što je neminovno izazvalo manjak poštovanja i prema njima i prema takvoj nastavi.

Sljedeća pojava poslije toga je česta buka i nemir u online učionici. Ovdje se mora istaći da u nedisciplinu spada i tišina, odnosno ignorisanje profesora od strane učenika i studenata, što je u stvari i najčešći oblik nediscipline u online učionici.

Nakon toga slijedi velika slabost online nastave a to je nemogućnost da ispitanici pitaju nastavnika za ono što ih zanima. U suštini, online nastava je ponudila daleko više mogućnosti za slanje upita nastavniku (direktno uživo, u chatu, slanjem maila...), nego što ih nudi klasična nastava, ali čini se da te opcije nisu zaživjele i da su ispitanici daleko više naviknuti na licem u lice (f2f) komunikaciju.

Ispitanici su izuzetno osjetljivi i na poklanjanje ocjena, odnosno izostanak adekvatnih kriterija prilikom ocjenjivanja.

Iako je online nastava, u suštini, inovacija, vrlo brzo je zapala u rutinu i neadekvatno izvođenje. Upravo u tome i leži jedan od razloga zašto ispitanici ističu više rutinskih dimenzija online nastave: često diktiranje lekcija bez dodatnog pojašnjenja, stalno isti dosadni način rada, kada je čas čisto predavanje, nastavnik samo čita s prezentacije..., improvizovano pojašnjenje lekcije i sl. Sve ove pojave su prisutne u online nastavi.

Ispitanici su najmanje istakli da im smeta kada nastavnik koristi novu tehnologiju a vidi se da nije vješt u tome jer online korištenje tehnologije je vrlo jednostavno i odmah nakon ostvarene konekcije i počinje čas.

Utvrđeno je da im najmanje smetaju nenajavljena ispitivanja i kontrolni testovi, jer se ta aktivnost najrjeđe dešava u online nastavi.

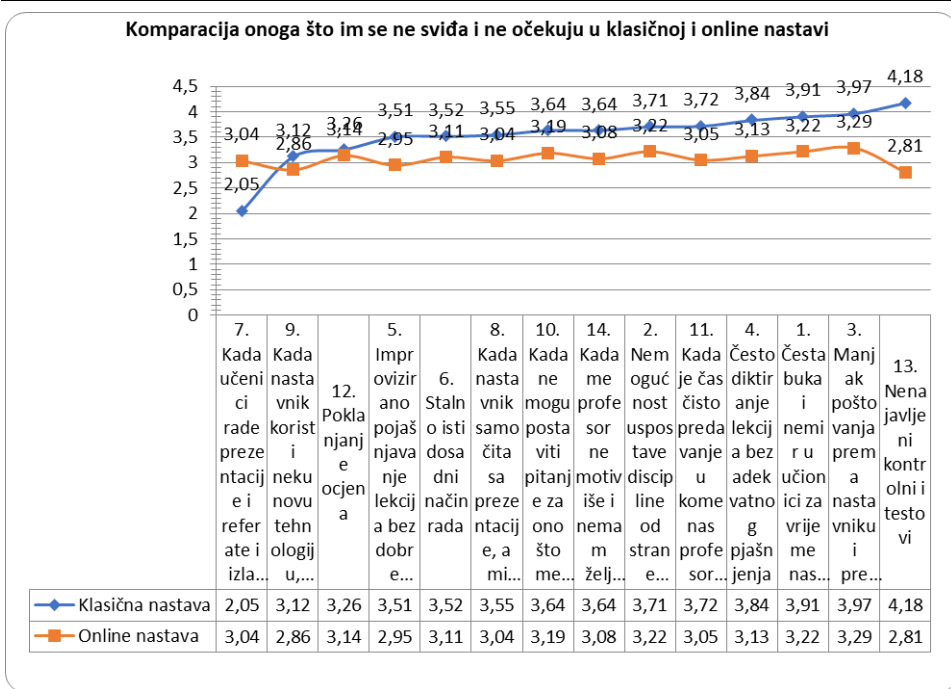
Što se tiče dopune upitnika koju omogućava pitanje br. 15, ispitanici su još naveli sljedeće karakteristike koje im se sviđaju i koje očekuju:

- Apatetič(a)n(a) profesor|ica
- Čitanje lektire
- Da se čas održi samo jer se mora održati
- Izdvajanje pojedinaca
- Jedino što nije direktan kontakt, ali online nastava je i motivacija i uključenost
- Kada nema praktičnog rada na času, pripremanja prezentacije, eseja, studija slučaja, primjera iz prakse, itd.
- Kada profesor ne želi objasniti nejasno gradivo
- Kada profesor od mene traži da znam nešto što nije objasnio
- Kada profesor zahtijeva da upalimo kamere tokom online nastave. Smatram da je nepotrebno jer postoji dosta studenata, učenika koji možda dijele sobu sa bratom/sestrom ili žive u malom stanu, te to nije prijatna situacija da učenik/student ima upaljenu kameru. Ili npr. djevojke koje nose hidžab moraju se takoreći maksuz pokriti, a navodno nam online nastava treba biti olakšanje.
- Kada se ružno ponaša prema nama
- Kontrola učeničkih radova.
- Loš pristup Online nastavi, dosta nelogičnosti.
- Loš raspored časova, manjak discipline na času za koji profesor ne zna da odgovara, manjak tema koje se obrađuju na času a da se mogu primijeniti u stvarnom životu,
- Loša komunikacija
- Loša konekcija
- Manjak motivacije, discipline i zajedničkog rada
- Manje kontrole učenika
- Motivisanje učenika kroz online nastavu , ocjene ne po znanju .
- Nastava uživo je mnogo bolja
- Nespremnost nastavnika i učenika za online nastavu

- Ne sviđa mi se kada učenici samo pokušavaju prekopirati
- Neadekvatno objašnjenje gradiva
- Nedosljednosti
- Nedostatak želje da se dati predmet uopšte relativizira učenicima.
- Nekooperativnost profesora
- Neposredni dijalog
- Neposlušnost na času kao i korištenje mobitela za vrijeme nastave
- Nepoštivanje dogovorenih vremenskih okvira
- Očekivanje od učenika da znamo o nečemu i prije nego što radimo tu nastavnu oblast
- Opušten razgovor
- Pasivnost profesora
- Potencijalni problemi sa internetom ili uređajima onemogućavaju potpuno praćenje časa
- Prezentacija bez objašnjavanja
- Različit odnos prema učenicima
- Slabi rezultati
- Tehnički problemi su dosta česti.
- Učenici pripremaju prezentacije
- Više posvećenosti vanrednim studentima

Rezultati pokazuju mnoštvo iskazanih manjkavosti online nastave i uglavnom su vezana za neadekvatan način rada, lošu komunikaciju s ispitanicima, te tehnički problemi zbog slabe konekcije i sl.

Kada se usporede rezultati onoga što se ispitanicima ne sviđa u klasičnoj i online nastavi dobija se sljedeći grafikoni:



(Grafikon 6 – Komparacija odnosa neočekivanja ispitanika od klasične i online nastave).

Grafikon jasno otkriva izostanak podudarnosti između onoga što im se ne sviđa i šta ne očekuju u klasičnoj i online nastavi. Vidljivo je da ispitanici daju znatno veće ocjene klasinoj nego online nastavi.

Zaključak

Očekivanja prate sve ljudske aktivnosti i u značajnoj mjeri utiču na ukupno ljudsko ponašanje. I učenici u nastavi imaju određenja očekivanja a njihovo ispunjenje ili neispunjenje u značajnoj mjeri se odražava na njihov rad i nastojanja.

Očekivanja učenika i studenata postoje bez obzira da li su nastavnici svjesni ili nesvjesni njihovog postojanja. Osvještenje nastavnika o očekivanjima učenika jedna je od polazišnih tački svake obrazovne reforme i u principu svakog nastavnog časa ili predavanja na univerzitetu.

Ovo istraživanje je imalo za cilj da utvrdi očekivanja učenika i studena u domenu klasične i online nastave. Svaka očekivanja imaju i suprotan pol te se nastojalo utvrditi i šta ispitanici ne očekuju od jedne i druge nastave. U želji za poboljšanjem svog nastavnog rada zadatak svakog nastavnika je da utvrdi šta njegovi učenici ili studenti očekuju ili ne očekuju od njega, njegovog predmeta i načina izvođenja njegove nastave.

Rezultati istraživanja iz 2012. godine i ponovljenog istraživanja iz 2024. godine o uvjetima online nastave ukazuju da ispitanici imaju jasno definisana očekivanja i u pogledu jedne i druge nastave.

Utvrđeno je da ispitanici jasno artikuliraju svoj interes i u slučaju jedne i druge nastave za dobre i zaslužene ocjene, što otkriva suštinu njihovog odnosa i pristupa nastavi i nastavnim predmetima.

Sa druge strane, utvrđeno je i da učenicima najviše smeta ono što ih ometa u postizanju dobrih ocjena, bilo da su u pitanju nenajavljeni ispiti i testovi (u slučaju klasične nastave) ili pak lošeg tretiranja predmeta ili profesora zbog nevještog izvođenja online nastave.

Na isti način je utvrđeno i šta ispitanici najmanje očekuju od klasične i online nastave, a da im se sviđa, a to su česti grupni radovi.

U pogledu onoga što se učenicima najviše ne sviđa i što ne očekuju da se dešava u klasičnoj i online nastavi istaknuto je narušavanje njihovih dobrih ocjena, bilo da se radi o iznenađnim testiranjima i ispitima, ili pak o lošem nastavnom radu.

Pored ponuđenih odgovora, utvrđene su još neke stavke koje se sviđaju ispitanicima a koje su sastavni dio nastave.

Ovo istraživanje je dobar osnov za neka još dublja i konkretnija istraživanja ovog pitanja, kao i za stručne edukacije nastavnog kadra.

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WHAT PUPILS AND STUDENTS (NOT) EXPECT FROM CLASSIC CLASSROOM TEACHING, AND WHAT FROM ONLINE TEACHING

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ABSTRACT:

Expectations are an integral part of human life, and we find them in all human activities. The level of our involvement in these activities largely depends on the expectations and monitoring of their realization. This paper presents the results of a survey on the expectations of students in classical and online classes, as well as what they don't like and what they don't expect to happen. The results showed that 591 respondents are dominated by a specific interest related to getting good grades, that is what they are most interested in and what they expect, and on the other hand, what they dislike the most and least expect is what spoils those good grades.

Keywords: *expectations, classical teaching, online teaching*

STUDENTS SECTION

ZNAČAJ EKOLOŠKOG MENADŽMENTA

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SAŽETAK:

U domenu ekologije, menadžment ima veliki značaj i veliku važnost, nesumnjivo doprinoseći poboljšanju privrednog ambijenta. Društvo koje teži ka uravnoteženom ekonomskom, socijalnom i kulturnom razvoju bez ugrožavanja životne sredine, zahtjeva kreativne i sposobne ljudske resurse. Time je stvorena i potreba za obrazovanjem i stvaranjem kvalitetnog menadžmenta sa tendencijom da se dosadašnje društvo transformiše kao društvo koje uči. Koncept koji podrazumijeva korelaciju privrednog razvoja i životne sredine uz uvažavanje zakonitosti ekoloških sistema bi morao biti glavni fokus budućim menadžerima. U uslovima ograničenih prirodnih resursa, a kroz koncept ekološkog menadžmenta stvara se spona između ekologije i ekonomije, uzevši u obzir da su i ekologija i ekonomija okrenute razvojnim ciljevima čovječanstva. Neosporno je činjenica da zaštita životne sredine i očuvanje prirodnih resursa, postali osnova razvoja mnogih novih tehnologija. Ovakav pristup zahtjeva i novi tip menadžera koji će naći zadovoljavajuće rješenje između ekonomskih, socijalnih i ekoloških zahtjeva.

Ovaj rad ima za cilj da prikaže koliko je bitna uloga menadžmenta, kroz društveno odgovorno poslovanje, koje podrazumijeva da budućim generacijama obezbijedimo kako zdravu ekonomiju tako i zdravu životnu sredinu. Pod dirigentskom palicom menadžera koji ima dovoljno znanja i svijesti, moguće je napraviti harmoniju između svih elemenata koji su sastavni dio poslovanja i zaštititi sredinu u kojoj se posluje.

Ključne riječi: klimatske promjene, ekološki standardi, održivi transport, dekarbonizacija i javni prevoz

1. Uvod

Ako pogledamo današnji život svih ljudi na planeti, vidimo da sa jedne strane, industrijalizacija omogućava poboljšanje životnog standarda velikog broja ljudi na Zemlji ali s druge strane negativno utiče na kvalitet životne sredine i zdravlje čoveka. Akumulirani ekološki problemi svakako čine jedno od ključnih obeležja današnje civilizacije.

Ovi problemi se mogu identifikovati na različitim nivoima: na globalnom nivou govorimo o globalnom zagrevanju atmosfere i smanjivanju ozonskog omotača, na regionalnom o

“kiselim kišama”, zagađenju podzemnih voda, izlivanju ulja i nafte, a na lokalnom o zagađenju vode, vazduha kao i o neadekvatnom odlaganju različitih vrsta otpada.

Nalazimo se u kritičnom trenutku Zemljine istorije, vremenu kada čovječanstvo mora odabrati svoju budućnost. Budući da svet postaje sve povezaniji i lomljiviji, budućnost istodobno predstavlja veliku opasnost i veliko obećanje.

Moramo se povezati kako bismo stvorili održivo globalno društvo utemeljeno na poštovanju prirode, ekološke etike, opštih ljudskih prava, odgovornosti za buduće generacije i kulture mira. Za ostvarenje tog cilja neophodno je da mi, svi ljudi na zemlji, objavimo odgovornost jedni prema drugima, prema široj zajednici života i budućim naraštajima.

Kroz ovaj rad pokušali smo da damo doprinos tome na način što ćemo o pomenutim problemima glasno pričati, ponavljati priču u nadi da bar jednim dijelom utičemo na svijest svih ljudi da je ono što ostavljamo iza sebe, služio kao dokaz ko smo i šta smo bili!?

2. Menadžment i ekologija

Pod menadžmentom treba podrazumijevati naučni i profesionalni proces planiranja, organizovanja, odlučivanja, vođenja i kontrole prirodnih, ljudskih i informacionih resursa radi postizanja uspjeha u poslovanju. Meri Parker Folet (1868-1993), jedna od značajnijih teoretičara u istoriji menadžmenta bila je uvjerenja da čovjek ne može da bude kompletan ako nije član grupe.

Menadžment koji svoja sredstva isključivo usmjerava sa ciljem ekonomskih parametara, je menadžment koji zahtijeva sijek izmjena u svom poslovanju. Te izmjene upravo uvodi ekološki menadžment, koji sem usmjerenja na ekonomske parametre usmjerava se ka zaštiti životne sredine. Na taj način ekonomija i menadžment mogu da sinhronizovano djeluju i da povećanje produktivnosti preduzeća podrazumijeva i očuvanje životne sredine u kojoj preduzeće posluje i aktivno učestvuje kao član šire zajednice.

Termin ekologija je prvi put upotrebio njemački biolog Ernest Hekel 1866. godine, u svom djelu „PRIRODNA ISTORIJA STVARANJA“. Hekel kaže: „Pod ekologijom podrazumijevamo zbir znanja koja se odnose na ekonomiku prirode: izučavanjem sveukupnosti uzajamnog odnosa živog svijeta sa sredinom koja ga okružuje, i to, kako organskom tako i neorganskom, a prije svega prijateljskih i neprijateljskih odnosa sa životinjama i rastinjem sa kojima direktno ili indirektno stupa u kontakt.“

Ekologija je naučna disciplina koja proučava odnose živih bića prema živoj i neživoj prirodi.

Uzimajući u obzir da razvoj savremenog svijeta podrazumijeva transformaciju dosadašnjeg društva u društvo koje uči. Takvo društvo bi kroz ispravne i jasne strategije koje se odnose na održivi razvoj, bilo društvo koje misli na sjutra, odnosno na budućnost.

Pravo sadašnje generacije na iskorišćavanje resursa i na zdravu životnu sredinu ne smije ugroziti isto takvo pravo narednim generacijama.

Svakodnevno smo svjedoci da je u porastu broj ekoloških incidenata koji se dešavaju širom svijeta, bez obzira što je sve većim dijelom u svim segmentima društva primjena visoke tehnologije prisutna. Za svaki ekološki propust višestruko plaća čovječanstvo. Najskuplju cijenu je izražena kroz posledicu zagađenja vode, vazduha ili kroz genetski modifikovanu hranu. Sve više životni prostor u kojem se nalazimo poprima neke druge obrise, koji su crveni alarm za buduće generacije i njihov opstanak u tom istom prostoru.

Za sada još uvijek je implementirano mišljenje u društvu, da zaštita životne sredine podrazumijeva smanjenje profitabilnosti za preduzeće i povećane troškove za potrošače, dok istovremeno profitabilnost podrazumijeva potrošački mentalitet, nepotrebno korišćenje i time uništavanje prirodnih dobara.

Ekonomija i ekologija kao dvije nepomirljive suprotnosti, moraju uspostaviti međusobnu ravnotežu na način što će staviti u centar samoga čovjeka i njegov opstanak a industriju i sve proizvodne kapacitete da budu u službi inteesa prirode i socijalnih dobara. Ekonomski razvoj mora biti usmjeren na povećanje kvaliteta života i očuvanju biloškog diverziteta u lokalnim i globalnim međunarodnim okvirima.

3. Ekološki menadžment

Sami naziv ekološki menadžment ukazuje na povezanost menadžmenta i ekologije u jednu cjelinu i stvaranje jedne nove naučne discipline, čija je primjena u svakodnevnom životu i poslovanju sve više neophodna.

Ekološki menadžment treba da bude sinonim za zaštitu životne sredine i njegova glavna uloga je dobrobit čovječanstva. On treba da obezbjedi ravnotežu između rizika po životnu sredinu i cijene proizvoda ili usluge.

Ekološki menadžment treba da bude jedan sistem upravljanja zaštitom životne sredine, da ima cilj da se u industriji i drugim granama uspostavi sistematizovan pristup koji obezbeđuje da se zaštita životne sredine ugradi u svaku biznis strategiju i praksu.

Postoji više ciljeva ekološkog menadžmenta ali da su dva posebno važna: (Pavlović, 1996)

1. opšti ciljevi vezani za zaštitu životne sredine kao što su održivi razvoj, pravo čovjeka na zdravu životnu sredinu, kvalitet života, opstank ekosistema, itd.

2. konkretniji ciljevi pojedinih subjekata privređivanja vezanih prije svega za samu suštinu tržišnog privređivanja –ostvarenje profita.

Treba istaći da neki od gore navedenih ciljeva su i formalno određeni. Prvi princip Rio deklaracije o životnoj sredini i razvoju iskazuje da „ ljudska bića imaju centralno mjesto u brizi za održivi razvoj. Ona imaju pravo na zdrav i produktivan život u harmoniji sa prirodom.“

Agenda 21, smatra se kao globalni dokument usvojen na Svetskom samitu o životnoj sredini i održivom razvoju (Rio de Ženeiro, 1992), u glavi 30, koja je posvećena jačanju uloge biznisa i industrije, sadrži dva odvojena programa i to:

1. unapređivanje čistije proizvodnje i
2. unapređivanje odgovornosti preduzetništva

Prednost ekološkog menadžmenta za koncipiranje valjane ekološke politike preduzeća leži prije svega u činjenici da preduzeće mora maksimalno da ističe odgovornost u korišćenju svih raspoloživih resursa, a prije svega ljudskog i prirodnog. Neosporna je činjenica da se zahtjevi klijenata moraju uvažavati, ali njihovi zahtjevi više nisu samo ekonomski ili tehnički, već i ekološki. Zabilježen je rast sve viši za ekološkim zahtjevima, što podrazumijeva da će u bliskoj budućnosti postajati sve dominantniji pa se nameće mišljenje da su pomenuti zahtjevi neposredno u funkciji optimizacije kvaliteta života.

4. Klimatske promjene

Klima se mijenjala tokom istorije Zemlje. Ali prirodni uzroci ne mogu objasniti zašto je došlo do brzog zagrijavanja tokom prošlog vijeka. Uzrok leži ipak u aktivnostima koje su izvodili upravo ljudi. To se dešavalo uglavnom zbog velike upotrebe fosilnih goriva – uglja, nafte i gasa – u domaćinstvima, fabrikama i u transportu. Prilikom sagorijevanja fosilnih goriva, najviše dolazi do oslobađanja ugljen – dioksida. To zadržava dodatnu energiju u atmosferi blizu površine Zemlje, što dovodi do zagrijavanja planete.

Od početka industrijske revolucije, kada su ljudi počeli da sagorijevaju velike količine fosilnih goriva, količina ugljen – dioksida porasla je za oko 50%.

Klimatske promjene su uzrok globalnog zagrijavanja, tačnije povećanje prosjeka ukupne temperature naše planete.

Svijet je sada za oko 1,1 stepen Celzijusa topliji nego krajem 19. vijeka.

To se može odraziti na životnu sredinu na sledeće načine:

- češće i intenzivnije ekstremne vremenske nepogode, poput toplotnih talasa i obilnih padavina
- brzo otapanje glečera i ledenog pokrivača što utiče na podizanje nivoa mora
- ogroman porast zagrijavanja arktičkog morskog leda i okeana
- život ljudi se takođe mijenja poput pojave nepogoda kao što su suša, požari, poplave i ostalo
- u 2022. godini, evropski toplotni talasi doveli su do nenormalnog povećanja smrtnih slučajeva

Možemo da zaključimo da podstaknuti vremenskim i klimatskim ekstremima, učestalost katastrofa povezanih sa klimom dramatično je poraslo poslednjih godina. U nekim djelovima svijeta suočavamo se sa klimatskim katastrofama za koje nijesmo spremni i malo je i vjerovatno da ćemo moći u potpunosti da im se prilagodimo.



Slika 1. Klimatske promjene

(internet izvor)



Slika 2. Lice ekologije i industrijalizacije

(internet izvor)

Naučnica Frančeska Guljelmo rekla je da je 2024. počela onako kako se završila 2023-sa visokom temperaturama i velikim ekstremima i da postoji šansa da 2024. postavi novi rekord po pitanju visokih temperatura, kada će one po prvi put preći 1,5% preko nivoa.

Naučnici razmatraju sada rizike koji su do sada bili nezamislivi!

Velike promjene moraju da budu sprovedene od strane vlada i kompanija, ali i pojedinci mogu da daju svoj doprinos:

- koristiti manje energije
- poboljšati kućnu izolaciju i energetska efikasnost
- prelazak sa centralnog grijanja na korišćenje toplotnih pumpi
- korišćenje električnih vozila i javnog transporta

5. Slobodna dobra-Prirodni resursi

Prirodni resursi kao što su: voda, čist vazduh, zemljište svojevrjemenom su tretirani kao „slobodna dobra“, koja se nalaze na raspolaganju besplatno i koja ne zahtijevaju nikakve izdatke.

Možemo reći da su prirodni resursi pojave, procesi ili objekti u prirodi koji utiču konstruktivno ili destruktivno na razvoj živih bića i njihovih aktivnosti. Čovjek može koristiti prirodne resurse kao potencijale za razvoj.

Prirodni resursi se mogu podijeliti na više načina :

- ograničene i neograničene
- obnovljive i neobnovljive
- biotičke i abiotičke

Prirodni resursi su ekonomska interpretacija prirodnog potencijala u smislu iskorišćavanja prirode od strane čovjeka. Prisustvo prirodnih resursa predstavlja mogućnost za njihovu eksploataciju. Prirodni resursi su definisani ljudskom percepcijom, navikama i potrebama, ono što predstavlja resurs u jednoj kulturi ne mora biti percipirano kao potencijal za stvaranje bogastva u drugoj kulturi.

6. Vazduh

Vazduh je smješa gasova od kojih su neki promjenjivog sadržaja. Uglavnom sadrži 78,08% azota, kiseonika 20,95%, argona 0,93% i u vrlo malim količinama kriptona, ksenona, helijuma, neona i drugih. U promjenjivim količinama u vazduhu može biti vodene pare, ozona, ugljen dioksida radona i drugih. Sastav vazduha varira na različitim visinama. Pri većoj visini smanjuje se količina kiseonika, a povećava se sadržaj vodonika.

Vazduh koji se primarno sastoji od dva gasa: kiseonika i azota, je jedina supstanca bez koje ljudi ne mogu da prežive u prosjeku više od tri minute.

Kada pomenemo termin „čist vazduh“, teško je naći jednostavnu definiciju zbog prisustva malih količina sastojaka koji kontaminiraju vazduh.

Ti sastojci zapravo predstavljaju bilo koje materijale van okvira stalnih gasova ili zagađivače koji imaju konotaciju da su proizvod ljudskih aktivnosti, ali obuhvataju i gasove, prašinu i čestice koje generišu prirodni procesi.

Zagađivače vazduha možemo da podijelimo u dvije grupe: prirodni i antropogeni zagađivači.

Prirodni zagađivači potiču iz nevještačkih procesa u prirodi i uključuju štetne emisije Zemlje i živog svijeta na Zemlji. Vulkani i vrela emituju velike količine ugljendioksida. Biljke u fazi raspadanja emituju metan, okeani i bakterije sa tla oslobađaju azot –oksid.

Ljudi i životinje u procesu disanja, hranjenja i varenja emituju vodonik-metan, vodonik – sulfid, nitrogen i ugljendioksid.

Antropogeni zagađivači su neželjni proizvodi ljudskih aktivnosti koji generišu zagađivanje okruženja kroz proces proizvodnje različitih proizvoda, transport putnika i robe, zagrijavanja ili hlađenja stambenih objekata, korišćenje električnih uređaja i slično.

Postoji grupa od šest zagađivača vazduha koji se smatraju štetnim za javno zdravlje, dobrobit i okruženje:

1. SUMPOR DIOKSID (SO₂): Bezbojan i nezapaljiv gas koji može izazvati srčane i disajne probleme, smanjuje vidljivost izaziva štetu kod usjeva i vegetacije i predhodi pojavi kisele kiše.

- Antropogeni izvori SO₂ su topionice, naftne rafinerije, sagorijevanje goriva u dizel motorima, itd..

- Metodi kontrole se odnose na upotrebu opreme za kontrolu zagađenja, upotrebu nisko – sumpornih goriva, itd.

2. UGLJEN MONOKSID (CO): Gas bez boje i mirisa koji umanjuje snadbijevanje vitalnih organa kiseonikom, umanjuje vidljivost i može izazvati vrtoglavicu, nesvjesticu i smrt.

- Nastaje usled nepotpunog sagorijevanja ugljeničnih goriva u automobilima i industrijskim kotlovima.

- Metode kontrole se odnose na upotrebu efikasnih tehnika sagorijevanja, testiranja emisija iz vozila , itd.

3. AZOT (O) : Bezbojan ili plavičasti gas formiran od isparljivih organskih jedinjenja i azotnih oksida koji iritira sluzokožu, izaziva srčane i disajne probleme, šteti biljkama, smanjuje prinos usjeva, itd.

- Antropogeni izvori su rastvarači boje, deponije, sagorijevanje goriva u motornim vozilima, itd.

- Metode kontrole se odnose na kontrole isparenja, upotrebu opreme za kontrolu zagađenja, upotrebu rastvarača sa manjim nivoom isparljivih organskih jedinjenja, itd.

4. AZOT DIOKSID (NO₂):Crvenkasto –braon gas koji izaziva respiratorne iritacije, srčane i disajne probleme, redhodi kiselim kišamaa, itd.

- Nastaje sagorijevanjem goriva u motornim vozilima i industrijskim pogonima.

- Metode kontrole se odnose na upotrebu opreme za kontrolu zagađenja, recirkulaciju izduvnih gasova, itd.

5. ČESTICE U VAZDUHU: Čestice koje su manje od 10 mikrona u prečniku i čestice koje su manje od 25 mikrona u prečniku. Mogu izazvati respiratorne bolesti i uvesti toksične materije duboku u respiratorni sistem, umanjuju vidljivost i mogu izazvati srčane i disajne probleme.

- Antropogeni izvori su : hemijska industrija, čeličane, neasfaltirani putevi i parkinzi, peći na drva, itd.

- Kontrolne mjere odnose se na upotrebu prečistača, filtera, itd.

6. OLOVO (Pb): Težak metal koji je toksičan za nervni sistem, organe i većinu tjelesnih funkcija.

- Antropogeni izvori su proizvođači olovnih baterija, spaljivanje smeća koje sadrži olovo, upotreba goriva sa olovom, itd.

- Kontrolne mjere se odnose na upotrebu opreme za smanjivanje zagađenja u industriji, upotrebu bezolovnog goriva, itd.

7. Održivi transport

Ekološki održiv transport zahtjeva strategiju koja obuhvata sve aspekte transporta koji utiču na okolinu. Biće potrebno mnogo manjih i većih promjena u dugom periodu vremena da se postigne ekološki održiv transportni sistem. U većini gradova javni prevoz nije dovoljno razvijen i nije najboljeg kvaliteta.

Gužve u saobraćaju predstavljaju ugrožavanje životne sredine, a svakako da doprinose i zagađenju vazduha u centrima većih gradova. Starost automobila kod nas kao i u zemljama u regionu je nezadovoljavajuće, kao i mjere kontrole kvaliteta goriva.

Prema podacima iz Eurostata, statističke agencije Evropske unije, više od četvrtine putničkih automobila u Crnoj Gori je starije od 20 godina. Zvaničnih podataka o prosječnoj starosti autobusa još uvijek nema.

Prema istraživanjima Eurostata, u Albaniji je čak 41% vozila starije od 20 godina, na Kosovu je 22,6% a u Bosni i Hercegovini je taj procenat 35.

Poređenja radi, u Njemačkoj je te starosti samo osam odsto vozila.

Što se tiče novijih vozila, proizvedenih u posljednje dvije godine, svega je 0,78% u Albaniji. Prema istim podacima, najviše auta starih do dvije godine je u Luksemburgu(18,4%) , Njemačkoj (15,4%) , Švedskoj (14,5%) , Belgiji i Irskoj (13,1%).

Prema nedavnim istraživanjima je takođe utvrđeno da od država Zapadnog Balkana, najviše automobila na 1.000 stanovnika ima Crna Gora -369.Slijede Srbija sa 344 automobila na 1000 stanovnika , Sjeverna Makedonija 263 , bosna i Hercegovina 262 , Albanija 226 i Kosova 182.

Međugradska transportna infrastruktura (drumska i željeznička) je relativno u lošem stanju i postoji potreba da se izvrši renoviranje same mreže i poboljša uloga željezničkog transporta. Izgradnju novih puteva treba pažljivo planirati i procijeniti sa stanovišta zaštite životne sredine.

Ekološki održiv sistem podrazumijeva sistem koji omogućava smanjenje buke, zagađenje vazduha i vode, koji potiču od drumskog, željezničkog, vodenog i vazdušnog saobraćaja, smanjenje upotrebe privatnih motornih vozila poboljšanjem javnog saobraćaja, efikasno korišćenje resursa uključujući fosilna goriva i zemljišni prostor, povećavajući integraciju transportnih i energetskih sistema, fokusirajući se na transport koji omogućava dostupnost destinacija.

Ekološki poželjno i korisno za zdravlje ljudi treba favorizovati korišćenje električnih automobila, bicikala kao i pješaćenje.

Održivi transport treba da bude transport koji ima prijateljski odnos prema okolini, kao što je javni transport, vožnja bicikla, pješaćenje i prevoz više lica u jednom automobilu.

U narednom periodu potrebno je izvršiti promjene koje moraju biti dobrovoljne i koje će uticati na podizanje svijesti kroz kampanje i poboljšanjem pristupa informacijama o mogućnostima korišćenja transporta koji ne zagađuje ili manje zagađuje okolinu.

Automobili, kamioni, autobusi koji koriste fosilna goriva najveći su zagađivači vazduha. Kompletan saobraćaj emituje više od polovine azotnih oksida u vazduh što ga čini jednim glavnih razloga globalnog zagrijavanja u svijetu. Takođe, uzrok je i mnogih ozbiljnih bolesti.

Zagađivači iz automobila doprinose različitim vrstama zagađenja vazduha. Kada se ugljevodonici i azotni oksidi kombinuju sa sunčevom svjetlošću, oni proizvode ozon. Visoko u atmosferi, ozon nas štiti od sunčevih ultraljubičastih zraka. Kada rupe u ozonskom omotaču onemogućuju da se ozon približi Zemlji, to doprinosi smogu i uzrokuje respiratorne probleme.

Zagađenje vazduha iz automobila, kamiona i autobusa dijeli se na primarno i sekundarno zagađenje. Primarno zagađenje se emituje direktno u atmosferu: sekundarno zagađenje je rezultat hemijskih reakcija između zagađivača u atmosferi.

8. Zelena agenda-Dekarbonizacija

U decembru 2020.godine EU je usvojila Strategiju održive i pametne mobilnosti, kojom se utvrđuju smjernice ka održivim i pametnim rešenjima u transportu, sa ciljem da najmanje 30 miliona vozila sa nultom emisijom štetnih gasova bude u funkciji na evropskim putevima do 2023.godine.

Evropski zeleni dogovor poziva na smanjenje emisije gasova staklene bašte koji proizilaze iz transporta za čak 90%, s ciljem da EU postane klimatski neutralna ekonomija do 2050.godine.

Dekarbonizacija transportnog sektora takođe je jedan od glavnih stubova Zelene agende za Zapadni Balkan koju su podržali lideri zemalja zapadnog Balkana u novembru 2020.godine na samitu organizovanim u Sofijui u okviru Berlinskog procesa.

„Dekarbonizacija“ je relativno nov pojam. U javnom diskursu se ovaj termin pojavio uporedo sa osvješćivanjem javnog mijenja u vezi sa klimatskim promjenama i globalnim zagrijevanjem. Danas predstavlja imperativ, posebno u transportnom i industrijskom sektoru.

Kada govorimo o uskoj specijalizaciji zvanoj „dekarbonizacija motora“, zapravo riječ je o praksi čišćenja kompletnog sistema uz pomoć vodonika koji se proizvodi elektrolizom vode, od usisne grane, preko unutrašnjosti motora do izduva .

Vozilo koje prolazi tretman dekarbonizacije motora praktično se vraća na fabričke vrijednosti po pitanju performansi na planu usisa, sagorijevanja i izduva, što je posebno važno kada su u pitanju vozila sa dizel motorima, koji su veliki zagađivači.

Međutim, dizel motori su poznati po tome da troše manje goriva, pa je posljednjih decenija postajala česta praksa da se prvenstveno oni kupuju i koriste za razne djelatnosti, najčešće u svim vrstama transporta.

Smanjiti zavisnost od fosilnih goriva, postiže dodatno dekarbonizaciju.akcenat je stavljen na vodonik, posebno zeleni vodonik, kao jedno od mogućih goriva koje će postaći dekarbonizaciju različitih sektora.

U zavisnosti od načina proizvodnje, postoji nekoliko vrsta vodonika kao što su sivi, plavi i najvažniji –zeleni vodonik. Sivi vodonik se proizvodi iz fosilnih goriva i njegova proizvodnja emituje emisije ugljen-dioksida, tako da se ne smatra gorivom budućnosti.

Proces proizvodnje plavog vodonika je isti kao i proizvodnja sivog vodonika, ali se u njegovom slučaju, uz korišćenje takozvane tehnologije parnog reformisanja metana, koristi tehnologija zahvatanja, korišćenja i skladištenja ugljenika, pa je proizvodnja toga vodonika povoljnija za životnu sredinu jer se njegovim skladištenjem eliminiše uticaj ugljen-dioksida.

Najbolji potencijal za dugoročnu održivu proizvodnju pokazuje zeleni, koji se proizvodi iz takozvane zelene električne energije, to je energija dobijena iz obnovljivih izvora energije kao što su solarne i vjetroelektrane. Zeleni vodonik se proizvodi tehnologijom elektrolize vode, u kojoj se molekuli dijele na molekule vodonika i kiseonika, uz korišćenje obnovljive električne energije, a tako proizveden vodonik može da se skladišti.

Vodonik će biti važan faktor u dekarbonizaciji transporta i mobilnosti, posebno u segmentima transporta i pomorskog i vazdušnog saobraćaja. Kamioni koji učestvuju u drumskom transportu jedan su od od potencijalnih potrošača vodonika jer je, u poređenju sa električnim vozilima, domet vozila na vodonik znatno veći. Vozila drumskog saobraćaja proizvode 6% od ukupnih emisija, smanjenje emisije u tom segmentu imaće blagotvoran efekat. Do 2050. godine vodonik bi mogao predstavljati 24% energetskeg tržišta .

Proces dekarbonizacije podrazumijeva nabavku ekološki prihvatljivi vid transporta, posebno u javnom sektoru. Dekarbonizacija drumskog saobraćaja, sa učešćem većim od 20 %u globalnim emisijama koje su u vezi sa energijom, izazov je sa kojim se u koštac uhvatila čitava planeta. Vozila na alternativna goriva, koja bi zamijenila upotrebu dizela i benzina, predstavljaju jedan od načina smanjenja emisija, međutim električna vozila su ključna za postizanje nulte emisije.

Za početak, svako električno vozilo koje na našim putevima i ulicama zamijeni vozilosa motorom sa unutrašnjim sagorijevanjem smanjiće koncentraciju izduvnih gasova koji nastaju u procesu sagorijevanja fosilnih goriva tokom same vožnje. Veći broj električnih vozila zahtjeva i brži razvoj infrastrukture za punjenje. Specijalna serija punjača Enel X za gradske sredine napravljena je u sklau sa cirkilarnomekonomijom, što se ogleda u korišćenju obnovljivih izvora energije za napajanje i mogućnosti da se djelovi punjača ponovo koriste.

Istraživanja pokazuju da upotrebom električnih vozila smanjuje se potražnja za naftom za 1.5 miliona barela dnevno. Razvoj elektromobilnosti na kopnu predvodi Kina i Evropa .

U scenariju ekonomske tranzicije se do 2035. očekuje 468 miliona električnih automobila. Da bi došli do neto-nulte emisije bile ostvarene potrebno je da ih bude 612 miliona. Poslednje vozilo sa motorom sa unutrašnjem sagorijevanjem treba da bude prodato 2038. Svetskim putevima se već sad vozi nevjerovatnih 275 miliona dvotočkaša i trotočkaša na električni pogon, kao i 685 hiljada autobusa. Električni automobili su postali predvodnici putovanja u zelenu budućnost, kada je riječ o saobraćaju.

Zanimljivo je da, iako nam se čini da je početak proizvodnje električnih automobila novijeg datuma, zbog izolovanja CO₂ iz naših života –preteča današnjih elektro-vozi nastao još prije 125 godina. Prvi električni automobil je konstruisan krajem 19. vijeka, tačnije 1898. godine, a njegov tvorac je bio otac današnjih popularnih sportskih automobila Ferdinand Porše.



Slika 3. Ekološki automobil
(internet izvor)

9. Javni prevoz

Potreba za gradskim prevozom postojala je od postanka gradova. Da bi se zadovoljile potrebe prevoza putnika, bilo je neophodno angažovati veliki broj autobusa, koji su postali jedni od brojnih zagađivača životne sredine zbog ispuštanja štetnih materija usled sagorijevanja dizel goriva.

Trebalo je stvoriti efektivnu zaštitu životne sredine pomoću tehnoloških i održivih inovacija sa ciljem smanjenja emisija CO₂. Jedna od takvih inovacija u automobilskoj industriji je proizvodnja automobila na električni pogon, koje su napajali litijumski akumulatori. Pravi tehnološko-revolucionarni bum je bila proizvodnja električnih autobusa za javni gradski prevoz građana.

Benefiti korišćenja vozila na električni pogon su čistiji vazduh, manje buke, udobnije putovanje, prijatniji boravak i život u gradu, finansijska korist i tehnološki napredak.

Globalni lider u proizvodnji električnih autobusa je Kina i tamo ih ima preko 400.000. Kineski Šenžen je prvi veliki grad na svijetu čiji autobuski prevoz potpuno čine električni autobusi. Planiraju da sva taksi vozila budu električna. To je grad sa 12 miliona stanovnika i postao je prvi grad na svijetu koji je u ratu zagađenja u jednoj od vodećih industrijskih zemalja svijeta, odnio ekološku pobjedu.



Slika 4. Električni autobus
(internet izvor)

10. Zaključak

Današnja civilizacija razvijana je na paradigmi stalnog materijalnog rasta, samim tim i podsticanje beskrupolozne potrošnje prirodnih resursa. Posledice ovakvog načina razmišljanja i ponašanja su više nego poznate. Čovječanstvo ulazi u treći milenijum sa velikim ekološkim problemima i to na globalnom nivou.

S jedne strane, industrijalizacija omogućava poboljšanje životnog standarda, ali s druge strane negativno utiče na kvalitet životne sredine i na zdravlje čovjeka. U suštini, ekološka kriza je samo nerazdvojni dio velikih događaja jedne civilizacije.

Prije svega, ona je dio duboke krize jednog načina proizvodnje, modela potrošnje i privrednog rasta, uz istovremeno gubljenje osnovnih ljudskih vrijednosti. Takav način života izveo je društvo, kao i samog čovjeka iz ravnoteže sa prirodom. Očuvanje i unapređenje sistema zaštite životne sredine su neminovnost u savremenom svijetu. Smanjenje zagađenja i pritiska na životnu sredinu, postiže se korišćenjem prirodnih resursa od strane privrednih i drugih subjekata, ali na takav način da se obezbijedi njihova raspoloživost za buduće generacije.

Razvoj, bez narušavanja životne sredine, moto je koji je ugrađen u ekološki standard i široko se primjenjuje širom svijeta. Iako, na njega obavezuju mnoge međunarodne i regionalne konvencije i predstavlja uslov za održavanje kontakta sa svijetom, kod nas se još uvijek nedovoljno ne primjenjuje.

Zato ekološki menadžment postaje neraskidiv dio poslovanja svake firme. Pokazatelj o tome kako preduzeće utiče na životnu sredinu, na prirodne resurse, na zagađivanje i slično, utiču na njegovu sudbinu, a nepoštovanje zakonske regulative može da košta i proizvod i firmu gubitka tržišta.

Problemi u ljudskom odnosu prema prirodi proizilaze iz toga što se ta priroda upotrebljava i zloupotrebljava u tu svrhu da čovjek preživi i da zadovolji prirodu svojih potreba, a one

su sve veće i prevazilaze njihovo zadovoljenje. Postoje samo dvije mogućnosti širenja svijesti o problemu vezano za zaštitu životne sredine i njegovom rešenju – pisati i govoriti o tome.

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IMPORTANCE OF ENVIRONMENTAL MANAGEMENT

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ABSTRACT:

In domain of ecology, management plays an important role. Society striving towards balance between economic, social and cultural development without endangering environment, requires creative and capable human resources. Therefore, need has been created for education and creation of quality management with tendency to transform present society as a society that learns. Concept implying correlation of economic development and environment with regard to ecosystems had to be main focus to future managers. In conditions of limited natural resources, and through concept of environmental management, link is created between ecology and economy, regarding that both are turned towards developmental aims of humanity. Indisputable is the fact that protection of environment and natural resources preservation, became basis for development of numerous new technologies. Such approach requires new type of managers in search to find satisfactory solution between economic, social and environmental requests.

This paper is aimed to show the importance of the role of management, through socially responsible business operations, enabling healthy economy as well as healthy environment to future generations. Led by the managers with sufficient knowledge and awareness, it is possible to make harmony of all the elements making integral part of business operations and protect environment in which these businesses are conducted.

Keywords: *climate change, environmental standards, sustainable transport, decarbonization and public transportation*

RESOURCE-BASED ECONOMY AS A POSSIBLE UNIVERSAL SOLUTION FOR ACHIEVING SUSTAINABLE DEVELOPMENT ON A GLOBAL LEVEL

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ABSTRACT:

The paper briefly analyzes the theory of Resource-Based Economy (RBE) and its unique potential for solving the biggest problems of the entire human race (sustainable development, wars, world hunger, boring and monotonous jobs, economic and political crises, destruction of the environment, global warming, disappearance of jobs due to automation, crime, corruption, lack of energy, etc.) through a systems approach and the use of science and technology for the benefit of all humanity. It shows why full sustainable development cannot be achieved in the current monetary system and why delaying the start of the controlled transition to RBE will most likely lead to a cataclysmic outcome either due to wars or climate change. On top of that, it wants to show that the transition to RBE has in some way already started with the collapse of the monetary system, the process scenario of which is developing, but that the majority of the human population is not aware of it. A new paradigm is being presented that covers all spheres of human life. The new system of arriving at decisions using the scientific method instead of the decision making process that is practiced now is also explained. The paper also calls for action and joining the academic and professional community at the global level to contribute to the further development of the RBE theory, its testing and introduction into the "mainstream" in all spheres and levels of human life and work,...

Keywords: *sustainable development, resource based economy, monetary system, socio-economic system, systems approach*

1. INTRODUCTION

The triangle of sustainable development (SD) contains 3 general and interrelated areas that are observed, namely economic, environmental and social. The monetary system (economy based on money) cannot solve all three angles of SD at once, because if one is affected positively through it, the other is affected negatively. The current monetary system prevents sustainable development in all important segments (destruction of the environment, global warming, consumption of resources, increasing hunger in the world, wars, differences in personal income and economic crises, to name only a few, are problems growing in size and increasing in frequency and whose end is not in sight). The

monetary system carries with it a number of elements and products that are an immutable barrier to sustainable development. Some of them are inflation, war, corruption, economic crises, the need for profit, crime, global warming, destruction of the eco system, etc.

The only proposed solution that encompasses all three areas and that can be empirically proven is the so-called Resource-Based Economy (RBE) theory. RBE is something humanity hasn't tried yet that promises to solve many of humanity's big problems on a large scale. It represents a new paradigm of a whole new socio-economic system, the study, testing and further implementation of which requires the involvement of interdisciplinary teams from academic and professional communities, but also the entire human population.

This paper contains an extremely abbreviated description of the RBE theory, Jacques Fresco's life's work through the prism of a student of management, where an attempt is made to add a new perspective and a clearer argument for RBE and against the monetary system.

This paper is an advocate for bringing RBE into the "mainstream" of global human society. The goal is to attract and join the academic and professional community to contribute to the further development of the RBE theory, its testing and introduction into the everyday life of all spheres of society. Due to limited space, this paper cannot describe everything that this topic should, so the reader is invited to independently research more.

2. THE EXISTING PARADIGM OF MONETARY ECONOMY

2.1 Monetary economics is not an exact science!

Monetary economics is not an exact science because it cannot control all its variables in order to perform repeatable experiments, arrive at knowledge that is accurate, precise and convincing, and accurately predict future outcomes of all economic moves, actions and events. Economic processes are complex and depend on many changing and unpredictable factors (pandemics, geo-politics, environmental impacts, the behavior of all participants in the economy, resource availability, wars, energy prices, etc.). Monetary economy is an art and it should be classified with other arts (musical, artistic, literary, etc.), and should be treated as such, that is, we must not lead human society through such an economy as its base. Would you ever get into an airplane that was built with such vague expectations as social affairs are run with the help of a monetary economy, where the engineers disagree on whether or not the airplane will even fly?

Monetary economists do not know how to successfully, painlessly and without risk finance the green transition that we need to fight against global warming and climate change (they are not even sure if we will manage to finance it at all).

2.2 Just some of the many limitations of the monetary economy to think about

It cannot bring about a more correct distribution of resources throughout the planet, regardless of whether we have a system managed through free markets, a planned economy or a mix of them, because we have limitations in the form of borders and individual state opportunities for money production, international trade that is influenced by geo-political relations between countries and limited capacities for trade, individual resources, etc. In addition, it seems impossible to maintain even and fair trade between countries due to the various variables affecting individual systems that are constantly changing. Equality among nations is not possible.

The monetary economy stops the progress of knowledge because it also comes with a price. Thus, millions of people do not have access to adequate education and humanity loses because the equation for progress does not include the lost inputs of millions of human beings who are denied education because of money. Research in science requires money, so even though we have all the physical resources, many researches are stopped due to lack of money or because there is no way to profit from the results of those researches. Contrary to the accepted belief that money is the motive for faster development of humanity, the author claims that the exact opposite is happening. Money is a brakeman against the faster development of humanity.

Inflation is another integral segment of the monetary system, which by its very nature is an opponent of sustainable development, regardless of the level of inflation at any given moment. Namely, all the money earned in one period is a custodian (or holder) of the value of some spent human work, resources and energy, the time of human lives, but it is also a token of damage of a small part of the Earth's eco system (because in the process of earning money it has to damage it in one way or another). As soon as inflation is created, a part of what was stored in money is lost. Even if all the technology that participates in the creation of income would be neutral for the Earth's ecosystem, the fact that inflation has lost human labor is an indelible indicator of the bad influence of the monetary system on the corners of the economy and society from the triangle of sustainable development (this means economic distribution because all people cannot equally successfully protect themselves from inflation, while social inclusiveness also depends on economic equality, etc.).

2.3 Climateflation, fossilflation and greenflation

In short, climateflation is increasingly created due to the need to finance protection, repair and reparations from climate change. It will also affect the increase in food prices due to worse weather conditions, climate instability and increasingly frequent damage from extreme events (floods, hail, rising sea levels, droughts, etc.). Fossilflation is equally created more and more due to our dependence on fossil fuels and their inevitable price increase due to the reduction of their quantity and the taxes that will be higher on their use. Greenflation is the one caused by the need to finance green energy sources and other green technologies as soon as possible (green transition), and is increasing due to the increasing need for faster "greening" of energy and other technologies and production processes.

Economists (including those who work in governments and those who work in central banks) think (but are not sure) that future inflationary pressures from these three new dimensions of influence can be dealt with by monetary and fiscal policies, and have designed several different measures that they believe would be effective and efficient in solving these mentioned problems. There are several problems with this, and we draw attention to some of them here.

One problem is again that they do not have any clear basis on which they can convince us with what certainty (if at all) their measures will be successful. It seems that a large redistribution of wealth from the haves to the have-nots will be required at not only the national level but also internationally (rich and developed countries to poorer and underdeveloped ones). As we have seen throughout history, such redistribution has never been successful. Therefore, there remains an extremely large and non-acceptable risk that they will not succeed and that the product of that failure will be a climatic cataclysm and a nuclear war. Why nuclear? Throughout human history, it has certainly been recorded that in major wars humans have always used the most destructive weapons they had. It is therefore to be expected, that the next big war sooner or later becomes nuclear.

Another big problem is that in the estimations of economists, it is expected that in the fight against these three destructive economic forces, private capital becomes involved to a larger extent. Throughout human history, we can see that private capital has always found ways to avoid investing in unprofitable businesses. It is therefore realistic to expect that it will do it again because it is extremely difficult to make a profit by investing in public goods.

The third problem is the uncertainty whether or not we will discover the necessary green technology in such a short time.

The fourth problem is the uncertainty regarding the existence of the resources (now and in the future) needed to fight these three forces. On a non-expanding planet with finite resources, we cannot waste resources forever.

2.4 Management in companies

Although ESG¹ is being taught in parallel in most business schools today with SD, ESG as a less encompassing concept actually takes priority in business. Managers have the primary task of bringing as much profit as possible to current and future company owners. They therefore evaluate every investment they need to make for the company through a very limited prism in terms of sustainable development. E.g. if the prices of any green

¹ An acronym from Environmental, Social and Governance, that is different from Sustainable Development (SD), which is a more comprehensive term. The main difference is whose interests are taken into account in the operations of the company. That is, ESG should only satisfy the needs of owners and investors in the company for financial success, and not the long-term interest of future generations. ESG has the task of mitigating the risk imposed by SDG for investors and shareholders in companies.

technology rise to unprofitable heights, managers will delay investing in them. At the risk of company loses in the business race with the competition, or having its survival or profitability threatened for any other reason, management almost always chooses financial performance and the survival of the organization at the expense of sustainable development. Managers who do not make such a choice endanger their position and stay in the company, and thus their own existence. Since in the global monetary economy a constant struggle for survival on the market exists for all companies (regardless of the socio-political system management system they come from), we should expect that by thinking about the owners of the company and its future investors, themselves and their families, the management of most companies will make moves which are the opposite of SD, and will constantly look for ways that those unpopular decisions do not reflect negatively on the companies they lead.

2.5 Five Big Forces

The monetary system, according to Ray Dalio, has five big forces that affect the major economic cycle of individual countries, global economies and world order. These forces are:

- the amount of internal debt created and its monetization (credit, debt, market and economic cycles in their entirety)
- the level of internal conflict and growing populism
- conflicts between great powers for supremacy in the world order
- natural phenomena (climate changes, droughts, pandemics, earthquakes, floods, etc.)
- the development of new technologies and their impact on the economy, wars, armies and weapons

In April 2024, when this paper was written, we can notice that all the mentioned forces are working against sustainable development and are creating a very worrying situation. The debts of the leading countries (and especially the USA) are growing to heights where it becomes extremely difficult to service (return) them without problems. The level of internal conflicts is also growing while the differences between the rich and the poor are increasing, the middle class in developed economies is totally disappearing, the number of the rich is decreasing and the number of the poor is increasing, the burden we leave to future generations is increasing and without any tendency to decrease. This all leads to fertile ground for populist leaders and sharper divisions among the population that can lead to internal and international conflicts. At the same time, a new rising power (China) aspires to take over the leadership of the world from the current leader (USA), and the conflict between them seems to be getting closer because of the so-called Thucydides trap. If we add to these three, the climate changes caused by humans, and the uncontrolled development of automation technologies (robotics and artificial intelligence), and the destructive power of the products of the military industry, the time that is coming really looks bleak.

If we exclude purely natural phenomena, everything else is the product of a monetary system which no one controls and whose results are unpredictable. All five forces have a

negative impact on sustainable development. All five forces are connected and extremely bad outcomes and effects from one directly affect the others.

2.6 Automation is inevitable

Automation is the process by which human work is replaced by robotics (in the physical sense) and artificial intelligence (in the cognitive sense). It is slowly entering all branches of the economy, even those for which only a few years ago it was impossible to even think that this could happen to them. Automation is a natural path in the struggle for survival on the market of all business entities and it occurs in all economic management systems. It is difficult to predict how much time humanity has until the automation of production and services reaches such a high level where it begins to visibly disable the functioning of the monetary system as we know it today (think about the fact that people who lose their jobs due to automation will not be able to get money to spend and maintain the monetary system). Machines do not work for money, they are far more productive than people are, and consume very little products and services (except for parts, energy, lubricants and the need for servicing). We therefore see that within our triangle of sustainable development and the monetary system, the inevitable automation acts as a stable barrier for the social and economic parts. It can only have a positive effect in the ecological sphere, but it seems simple to conclude logically that it will prevent a fairer (re)distribution of goods and economic stability.

We can conclude that because of this, the transition to RBE has already begun in this segment, because the very goal of RBE is as much automation as possible. The good thing is that humanity has the technology for even greater automation, but it is not being used because of the barrier created by the monetary system (retained patents and the inability to monetize certain automation potentials). The bad thing is, humanity is not aware that soon it will not be able to create occupations and jobs that will be replaced by machines, in order to keep people employed and maintain the monetary system by people's participation in consumption (without consumption, the monetary system collapses because there is no circulation of money, economic growth, opportunities to settle the obligations of the participants of the global economy and return the debts of the produced FIAT money). It is therefore imperative to start making plans and models for a successful and sustainable transition to a new paradigm where people will no longer work for money or any other medium of exchange to access the necessary life resources and services.

According to several leading central banks and financial institutions and companies, in the next 3-5 years artificial intelligence is predicted to permanently replace 30%-50% of jobs in developed and semi-developed economies. If we add to that the replacement of people in the process of industrial production by robotics, we can easily exceed 60%!

This is extremely high because everything is happening very quickly, so it will be extremely difficult to create new jobs and have a sufficient number of people who will manage to retrain themselves for them. The loss of so many participants in the economy and consumption will also affect those who are not directly displaced.

2.7 In order to achieve sustainable development on a planetary scale, the current monetary economy must stop.

That is, we must stop making products with planned obsolescence and reduced performance, but so that they are all the best we can make at that moment and never fail or get broken. We need to use the best materials and alloys that remember their shape¹, and to change such products with new ones (with previous recycling of old ones) only when we have developed such a better technology that it is worth doing so, taking into account the energy spent, resources and human labor where it is needed. Making long lasting unbrakable products will cause disruptions in the monetary economy because the circulation of money will be reduced. Therefore, the monetary system does not allow economization and resource saving and preservation.

2.8 How does the monetary system break down?

This will manifest itself through ever greater and more frequent economic crises, inflationary disorders, dissatisfaction and unrest among the population as an increasing number of people becomes affected by problems that are the cause of the greatest human misfortunes, wars and devastation due to climate change. As in the analogy with the frog that jumps into hot water and immediately jumps out of it and thus survives (because the change is sudden and the frog notices it), and the case when the frog is in cold water that heats up to the boiling point and thus dies because it never jumps out of it (change is slow and the frog gets used to the heat before it's too late), so it is with people and the collapsing monetary system. Very few notice it before it affects them, and most notice when they begin to feel adversity and misfortune. By the time a critical mass is created to collectively try to get out of the situation, it will probably be too late. Therefore, we must react before it hurts us!

3. WHAT IS RBE?

The theory of RBE was coined by Jacques Fresco through his life's work and presented through the organization Venus Project, which he started with his associate Roxen Meduz in Venus, Florida, USA. RBE is a new socio-economic system in which people do not use money or any other medium of exchange to access products and services. In order to achieve this, science and technology must be used to automate the production of as many products and services as possible. It takes extremely high productivity level to create an abundance of everything and to offer it all equally to all people on the planet without any compensation. In order to achieve abundance, all products, machines and technical devices would be made in such a way that they would never break down. In this way, it would relatively quickly be achieved that everyone has access to those goods, which would be replaced (with recycling) only when the technology had advanced so much that it would be worthwhile (in terms of the resources and energy required for the production of new products and the recycling of old ones) to replace new products.

The theory predicts that planet earth and all its resources should be declared as the comon heritage of all people on the planet, and patents should be freed so that inventions of

¹ Shape memory alloys

science and technology can be used without legal and financial barriers. Since states are seen as artificial divisions between people, RBE theory also calls for erasing all borders between states. RBE is a system that will constantly evolve, so there is no end result that is static. The theory predicts that the more we transit into the RBE the better, greater and more visible its effects will be for humanity. RBE therefore implies the use of science and technology for the benefit of humanity as a whole and establishing an equilibrium with nature. The theory also predicts that all people, even the richest, will live better than under the current monetary system. This is because the monetary system hindered human progress in science and technology (because it did not allow the development of anything that could not be profitably monetized), and it destroyed the conditions for life on the planet (polluted the air, water and land, caused global warming and wars), and caused psychological problems among all strata of the population. In addition, it captured everyone, even the richest in work for money.

Arriving at decisions

A very important segment of RBE is the way of arriving at decisions on how to manage Earth's resources. In the current system, decisions are made by people, while in RBE, we would arrive at decisions with the help of interdisciplinary teams, computers, sensors and the scientific method. E.g. the decision where to build a new automated city would be reached after analyzing the available resources, the shape and quality of the terrain, climate data, the number of people who would live in it, etc., with the help of sensors and data entered into the central computer system of each city, which are later connected into the network with each other. Decisions about what product to make are made by analyzing data entered into a central computer system about what people need.

RBE does not have a government that runs the system, nor does it have an assembly that makes laws (going deeper into RBE laws will not even be needed). In RBE, the scientific method is used to reach decisions, but since everything is a process of transition and change, it should be expected that this way of reaching decisions cannot be achieved overnight on a global level, hence there will be a period of learning, gradual testing and improvement. What's more, even when it is fully achieved, it will be improved as all other knowledge, skills and experiences of people are improved, as well as technologies. RBE is not a democracy, autocracy, technocracy or any other form of socio-political arrangement that humanity has tried so far.

Language

The language we speak is only a tool for communication, therefore any attachment to the languages of the culture we come from is a complete failure in terms of communication. In addition, keeping more than one language that would be used by all people together on the planet is another failure in the form of a loss of time spent on learning foreign languages. Humanity needs to come together to design a new language and a new way of communication based on shared semantic agreement and clear shared references for every bit of what is spoken. We should also reduce abstract terms that would be subject to different interpretations. This would increase the quality of communication and understanding between people, which would lead to a better homogenization of the population.

Value system

The value system that humanity holds will also evolve as we move further into the RBE. What's more, we all need to start learning about the value system to which the RBE theory aspires, in order to create a critical mass with a desire for a controlled transition.

Since we don't have enough space to go into this topic in detail, let's look at just a few examples. The incentive for corruption, criminal activities such as banditry, production and dealing of narcotics, theft, etc., is in money because it is the medium through which people who practice these activities get to other things they need. When, with the help of automation, we provide those people with free access to the resources they really want, the incentive for those bad actions and behavior immediately disappears and we won't need the police or punitive measures to get rid of them. Apart from the fact that there would be no incentives for the production and trafficking of narcotics, the better living conditions of the RBE would drastically reduce the demand for them. The theory describes that the main warehouse of all things necessary for human life would be in the center of our RBE city. Food and consumable personal goods and certain devices for daily use would be delivered there and taken to homes, while some products not for daily use would be returned after use to a central building, just like we return books to libraries. Other products used in common places (e.g. sports fields, parks, lakes, rivers, seas, etc.) could be left there (e.g. balls, golf clubs, rackets, umbrellas, boats, etc.). This creates the problem of joint ownership or nobody's ownership, which we can reduce with adequate education about the values that would be desirable if the system were to be maintained. No matter how much we prepare for a situation in which abundance, rather than scarcity reigns, there will likely be instances where people take home 10 loaves of bread instead of the 1 or 2 they realistically need, or 10 televisions instead of the 1 or 2 they need, especially in the beginning of the transition. They will probably try to sell some of the things they have taken in excess, but when they see that no one wants to buy them, because they have it all for free, or when they see that the bread is free every day and that the surplus bothers them in the house, they will stop taking what they have not required. Some will probably take excess only to throw it away, but we need to start eradicating such a value system by training all ages already, so that it appears in as few cases as possible, insufficient to reduce the positive effects of RBE.

It is evident that a certain number of people would be needed to maintain and improve the city's system. They would join the multidisciplinary teams voluntarily. Again, for such a collaboration, people must prepare themselves with adequate education. For one to have a desire to contribute to humanity, for one to have an interest in solving problems and to enjoy it as one would enjoy any other fun activity, etc., and to do it without having to do it, such a person can only develop gradually.

In order to test the RBE theory, it is necessary to apply a systemic approach and create the first automated-self-sustaining city, preferably a circular one because it is an easier model to copy while creating other similar cities. Interdisciplinary teams would work in this city and test all segments that would later be replicated in the following cities. The first city would serve as a base for testing human behavior in a new system in which there is no money because no one would be paid and everything would be available to them for a modern life free of charge. The test city would make its own food, clothing, transportation,

and everything else people needed, and people would monitor the automated systems and work to service and improve them.

RBE should free people from boring monotonous jobs and give them more time to enjoy life and reach their highest potential, creativity, spirituality and self-fulfillment.

Through his life's work that culminated in a completely provable¹ theory of RBE, Jacques Fresco also came to the conclusion that for sustainable development it would be necessary for all human endeavors and way of life to take place in accordance with the carrying capacity of the planet we live on. Given that many organizations measure how much humanity consumes resources, we have data that we are currently consuming about 1.8 times more than the planet can renew. This leads us to the conclusion that we will have to take care of the size of the human population if we want to return to the path of sustainability, if we fail to technically ensure that the consumption of resources is at a level where they can be renewed. Here, once again, money is seen as a barrier because the recycling of spent resources depends on the potential for the recycling to be done profitably. With this, there is a great danger that not only will we experience a collapse in the current system, but also that the longer we continue on this path and level of consumption, we will endanger the possibility of running the RBE system in the future because it cannot function at its optimum if there are not enough resources.

3.1 Why is RBE a solution for sustainable development?

Our problems of sustainable development are purely technical. We live in a system that was not designed by anyone but slowly developed over the centuries. The monetary system has evolved with certain social developments and technological advances. It was necessary and useful in the previous period of development of human society, but now it is outdated and is the main cause of our biggest problems.

RBE is a new system that attacks the cause of the problem, offering itself as its complete replacement. As a new socio-economic system that has been completely designed from the start, it offers a feasible solution to humanity's biggest problems. Since in the RBE there is no medium for the distribution of services and goods, the only barrier to achieving all the objectives of the SD is the eventual consumption of the Earth's resources.

RBE will change the prevailing global value system because values are shaped by the system and the environment it creates. All misconduct will be greatly reduced because the RBE theory predicts that its effects have an extremely large positive impact on human behavior. Positive changed values will strengthen such a system and all the good that it brings, unlike those values from the monetary system that are directed towards its collapse.

¹The author adheres to the scientific method and its principles that the theory is proven even if the experiment shows that something is not as expected and not only confirms the expected. In the case of the RBE theory, the non-functioning of such a system would be a clear proof of the theory, that is, it would be proven that the RBE does not function as expected despite all the indicators.

3.2 We don't need energy

Due to the cyclical setting for the maintenance of the monetary system, it is constantly necessary to produce products and services, to sell them to someone, to be paid for it so that we can be customers of some products and services, and then those products break down or become artificially obsolete, then demand for new ones would be created, and therefore, the need for our work and the consumption of resources and energy. If we could stop the current economic paradigm by producing products that do not break down and do not need replacement, we would see that we do not need additional energy capacities, to such an extent, for development. Everything in the economy is connected. If we exclude a large number of physical products from this scheme, we will see that we do not need a large number of services and trips because they were generated in connection with the production of physical products, and these are additional energy capacities that have been saved.

3.3 People don't want jobs!

Because we see everything through the economy and the monetary system, we constantly forget that people don't want jobs, especially not boring ones. People want access to things and they need money for that, so they are forced to work for it, often jobs they don't enjoy. Economists worry about how to create jobs instead of working with other experts from other scientific fields on how to get people out of work.

3.4 Behaviorism

A large part of the RBE theory is about behaviorism, a branch of psychology that aims to predict human behavior, and above all, the construction and evolution of a different value system at all levels of the transition to RBE. In addition to his personal work and experience, Jacques Fresco relies heavily on the work of B.F. Skinner and his followers who maintain that our behavior and value system are largely shaped by our environment, experiences and upbringing. In addition, through the decades-long development of the RBE theory, the influence of Robert Sapolski's works on human behavioral biology, free will (or its non-existence) and the influence of the environment on the biology of humans and other animals, is evident.

2.4. War is a sure path to failure in sustainable development

Wars are an inevitable byproduct of the monetary system. With the simplest logic, we should see that from the very beginning of the twenty-first century, wars are an absolutely sure path to failure in sustainable development. The destructive power of conventional weapons is enough to set humanity back tens or hundreds of years, while nuclear weapons are just a way to destroy all life on the planet forever in just 30 minutes. The arming of any nation or war conflict of any intensity is a waste of resources and another additional impediment to sustainable development. Therefore, wars must be avoided at all costs! RBE promises to finally and forever solve the problem of the existence of wars.

2.5. When would RBE not work?

It is obvious that this kind of system can only be sustainable when there are enough resources, because as soon as they run out, the RBE system would start to collapse. Therefore, it is crucial that we preserve the resources that the Earth has. In addition, it seems that it would not be possible to make a successful transition to the RBE if it was not accepted on a global level because any attacks from a part of humanity that is not in it would greatly destabilize it.

2.6 What does working on RBE bring?

Considering that RBE is positive for all humanity and the Earth's ecosystem, the very work on RBE and talk about RBE would bring accelerated rapprochement of nations. As we learn about this system and contribute to its improvement, we also reduce the possibility that the problems arising from the monetary system, its gradual collapse and the pressures on it from global warming and climate change, will cause new war conflicts. Moreover, RBE is probably the best way to extinguish existing conflicts.

If one or more testable self-sustainable cities were to be built through cooperation, they would be meccas for scientific-research, academic and technical communities. In addition to being the first inhabitants of such a city, together with the people and families who participated in its construction, they would also be the first test subjects because the first measurements of the effects of living in a moneyless system would be made on them (their behavior and values). Of course, they might not be the most representative representatives of the human population, so another city(ies) should be built as soon as possible, in which other people would live who were not in favor of RBE from the start, or do not have the same profile.



Figure 1¹. Circular self-sustaining automated city-research center from RBE

The surplus of food and other products created in the first cities would be transferred to other already existing cities, so the effect of RBE could be examined from that side as well.

Working on RBE and learning about it, very quickly leads to the realization that all people are one and that the current state borders are artificial divisions between people. That the monetary system is an extremely outdated way of managing human society and planetary resources. Learning about the behavioral aspect helps in dealing with people.

3. CONCLUSION

Monetary economics is not an exact science, therefore leading human society according to it is extremely wrong. It has too many limitations that hinder the development of the entire human society. Due to the needs of the green transition, climate change caused by global warming and the use of fossil energy sources, three new types of inflation will represent a dangerous addition to the existing inflation problems in the coming decades. Although private capital and the global economy are expected to be the bearers of the transitions that await us, due to the monetary system, management in companies has a different description of their job, which is such that they must put profit, that is, financial sustainability in the first place, against the goals of global sustainable development. Since the automation of production and services with the help of artificial intelligence and robotics is inevitable, and develops practically exponentially, it will have the same effect on the collapse of the monetary system as people are left without jobs. However, many people do not notice these changes, because they come too subtly for the attention of ordinary people. Many do not look for solutions and there lies a great danger. The monetary system, which is outdated and no longer relevant, is holding back the development of human society and technology, it is the cause of practically all global human problems, and it is absolutely irrelevant how it is managed (market economy, planned economy or the mix of those two), global sustainable development is not achievable in it.

It is necessary to try some other system, and the resource-based economy stands as a feasible solution. It is unlike any other way of managing society and Earth's resources that humanity has tried so far. It is a humane multidisciplinary scientific approach to the management of Earth's resources and human society, to achieve equilibrium with nature and a better life for everyone, including the richest, with the help of science and technology. RBE is the best described alternative so far, it is based on the scientific method and can be tested. It coincides with the necessity and inevitability of the current monetary economy coming to a complete halt. Her theory can be empirically tested in controlled conditions even without immediate entry into such a system of all the individual countries of planet Earth. The RBE theory promises to solve most global social problems (wars,

¹Image source:<https://www.TheVenusProject.com>

economic crises, crime, corruption, environmental destruction and global warming, poverty and hunger, etc.), and to free people from working in boring and monotonous jobs to lead a more fulfilled and happier life, learning what really interests us in order to realize our greatest potential on individual and societal level.

All socio-economic systems will always change and so will RBE. We all need to get involved in research on RBE and its promotion, in work on expanding the theory of RBE, its testing and application because it is neither an ideology nor a utopia. RBE is not a perfect system because it has a limit that it can only function if it has enough resources. Still, it's far better than what we have now and what we've tried before. RBE must enter the "mainstream" as soon as possible because all great and radical new ideas need time to be understood and accepted, and time is running out. Dalio's five forces shaping the global state of economy and society, whose effects stem from the monetary economy, are approaching a common culmination by the end of this decade¹. The risk of bad effects of them happening together is extremely high. We must understand RBE and test it as soon as possible to reduce the risk of the collapse of the entire human society. Understanding this new path for humanity is only possible if the RBE theory enters into all parts of global society, from the media, political representatives and educational institutions, to families themselves.

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