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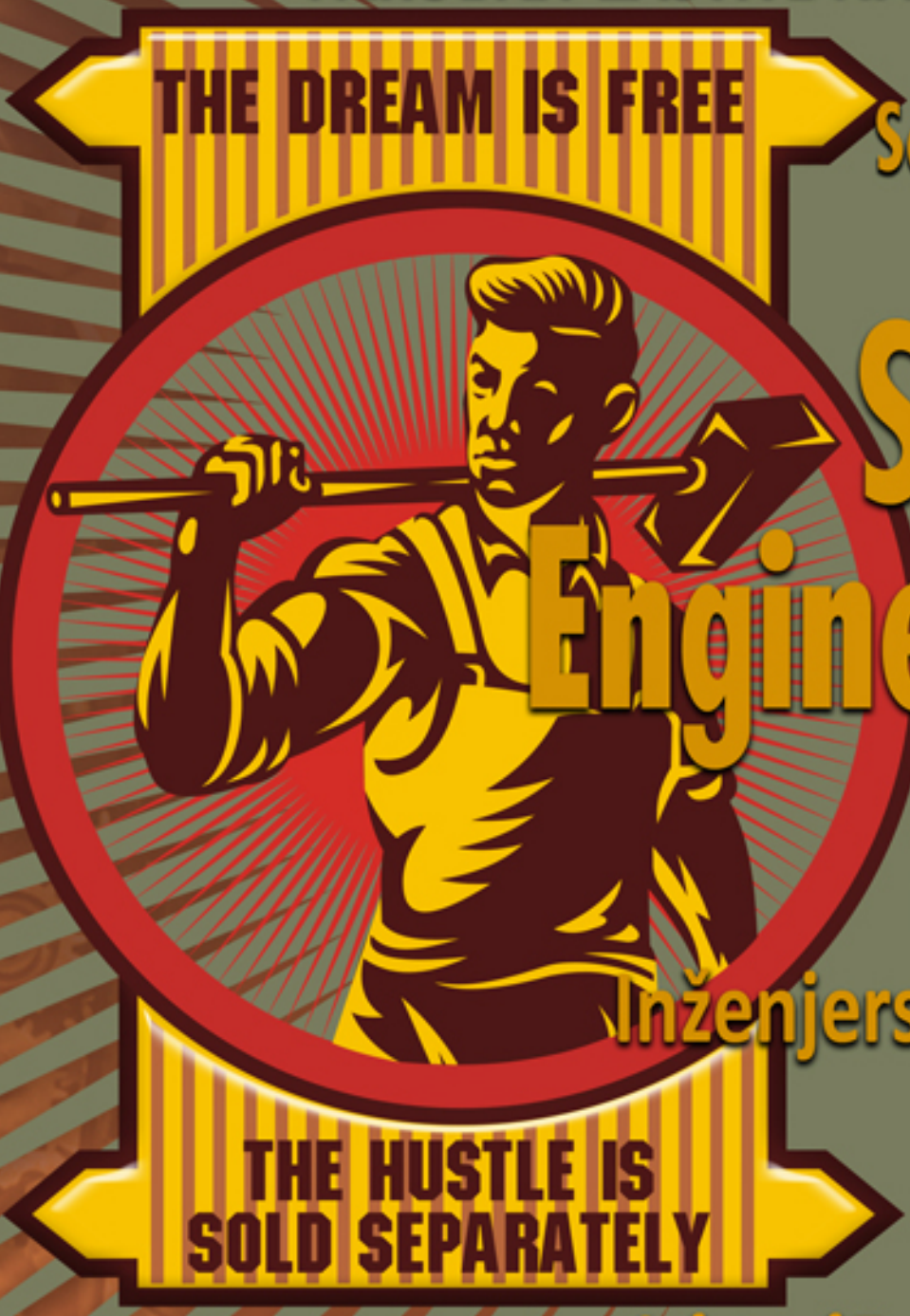

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From Editor's desk

„Najlepša stvar kod učenja je to što ti znanje niko nikada ne može uzeti."
B.B. King

U novom ciklusu akreditacije visokoškolskih ustanova, Fakultet zaštite na radu je akreditovao tri studijska programa osnovnih akademskih studija (Zaštita na radu, Zaštita životne sredine i Zaštita od požara) i pet studijskih programa master akademskih studija (Inženjerstvo zaštite na radu, Inženjerstvo zaštite životne sredine, Inženjerstvo zaštite od požara, Upravljanje vanrednim situacijama i Menadžment zaštite životne sredine). Studijski programi omogućavaju studentima sticanje i usvajanje znanja iz polja tehničko-tehnoloških, prirodnih, društveno-humanističkih i medicinskih nauka, kao i veština i kompetencija koje će im omogućiti da rade na složenim multidisciplinarnim poslovima zaštite radne i životne sredine. Cilj ovog akreditacionog ciklusa jeste približavanje dualnom sistemu obrazovanja, kroz realizaciju dela nastave u malim i srednjim preduzećima (građevinarstvo, hemijska, metaloprerađivačka, prehrambena industrija i dr.), velikim preduzećima (elektroprivreda, telekomunikacije, naftna industrija, saobraćaj, rudarstvo i dr.), inspekcijama, institutima, naučnoistraživačkim ustanovama i dr., čime se studenti praktično osposobljavaju za rešavanje problema u oblasti Inženjerstva zaštite životne sredine i zaštite na radu. Novi broj časopisa *Safety Engineering* ostaje fokusiran na teme inženjerstva zaštite od internacionalnog značaja, sa osvrtom na neke lokalne specifične događaje i primere domaće i inostrane prakse. Publikacijom radova na temu modeliranja udesnih događaja, monitoringa kvaliteta vazduha, energetske efikasnosti i uticaja pandemije virusa Covid19 na zaposlene još jednom se ukazuje na značaj profila budućih inženjera zaštite akademskoj i stručnoj javnosti.

"The beautiful thing about learning is nobody can take it away from you."
B.B. King

In the new cycle of accreditation of higher education institutions, the Faculty of Occupational Safety has accredited three study programmes of Basic Academic Studies (Occupational Safety, Environmental Protection and Fire Protection) and five study programmes of Master Academic Studies (Occupational Safety Engineering, Environmental Protection Engineering, Fire Protection Engineering, Emergency Management and Environmental Management). Study programmes enable students to acquire knowledge in the fields of technical and technological sciences, natural sciences, humanities and social sciences and medical sciences, as well as to gain work skills and develop competencies for their future occupations in the multidisciplinary field of occupational and environmental safety. The goal of this accreditation cycle is to move towards the dual system of education, through organizing trainings in small-and medium-sized enterprises (construction, chemical, metal processing, food industry, etc.), large enterprises (electric power companies, telecommunications, oil industry, transport, mining, etc.), inspections, institutes, research institutions, etc., which will help students learn how to become adept problem solvers in the field of Environmental Engineering and Occupational Safety. The new issue of *Safety Engineering* remains focused on topics of safety engineering of international importance, with a review of local specific events and examples of domestic and foreign practice. The publication of papers on accident modeling, air quality monitoring, energy efficiency and the impact of the Covid19 pandemic on employees once again points to the importance of the profile of future safety engineers to the academic and professional public.

On behalf of the editors
Prof. Dr. Dejan Krstić

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CONCENTRATIONS AND CHEMICAL COMPOSITION OF PM_{10} AND $PM_{2.5}$ IN THE TOWN LIBRARY IN BOR, SERBIA

Abstract: *This paper presents the PM_{10} and $PM_{2.5}$ concentrations and results of chemical analyses of PM samples collected at the public library in Bor town, Serbia. Two sampling campaigns were carried out during six consecutive working days in June 2015 and in March 2016. The results show that PM_{10} and $PM_{2.5}$ concentrations in the library were strongly connected with the respective PM concentrations in ambient air. So, most PM particles in the library originate from the outdoor air. High $PM_{2.5}/PM_{10}$ ratios in both indoor and outdoor environments indicate the considerable influence of anthropogenic air pollution sources, in this case, metallurgical processes in copper smelting plants. Because the new copper smelting plant started operating in 2016, it is necessary to conduct a new measurement campaign to determine whether there are changes in the concentration levels and chemical composition of PM in the indoor air of public and residential buildings in Bor.*

Key words: particulate matter, monitoring, air pollution, chemical analyses, arsenic.

INTRODUCTION

Exposure to particulate matter (PM) air pollution has been associated with respiratory and cardiovascular diseases [1-4]. Considering that people spend most of their lives indoors [5], it is very important to determine the impact of indoor PM pollution on human health.

In the Republic of Serbia, there is an insufficient number of studies about the PM levels and chemical composition of PM inside the buildings where people work and live. As a result, relations between PM inside and outside the buildings have not been sufficiently known and explored. The research of indoor air quality in public and educational buildings has been carried out periodically within the framework of scientific projects supported by EU funds or by the Ministry of Education, Science and Technological Development of the Republic of Serbia. This work is a part of the research on the characterization of suspended particles inside the educational and public institutions in Serbia. The town of Bor is assumed as a representative urban-industrial environment in Serbia because of the emissions of sulfur oxides and particulate matter from the copper smelter facilities situated close to the town urban areas.

In the past years (2011-2019), the measurements of indoor PM levels in Bor were carried out in the kindergartens, primary and secondary schools, hospitals, and residential apartments [6, 7]. This paper presents the results of measurements of PM in the town library in Bor aiming to determine the impact of outdoor PM pollution, as well as visitor and staff activities, on PM levels inside the library. The second aim is to assess the chemical composition of PM_{10} and $PM_{2.5}$ particle fractions in the library.

METHODOLOGY

Library characteristics

The town library in Bor is located in the so-called House of Culture, at a distance less than 500 m from the town centre on one side and the main entrance to the copper smelting plant on the other side, as shown in Figure 1. It is situated between the two main streets (less than 100 m far from the library) and Town Park, as shown in Figure 2. The library has a collection of around 80000 books in a purpose-built area of 1113 m². The library has several departments: the children's literature department, the informative department, the exhibition hall and a hall for public events, the adult literature department, and the special collection departments.

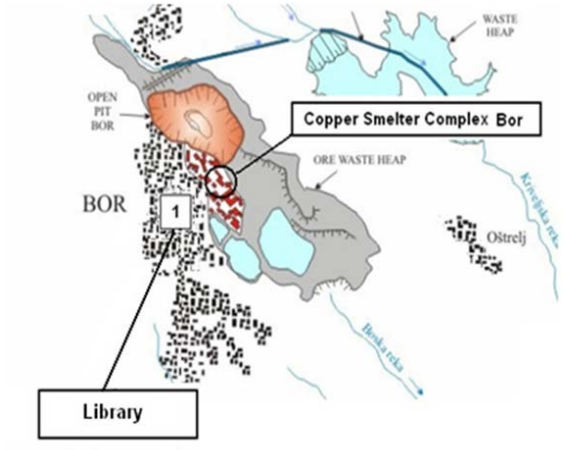

Figure 1. *Location of town library relative to the copper smelting plant in Bor*

Sampling location and equipment used during measurement campaigns

The measurements of PM concentrations in the library were carried out in two sampling campaigns during June 2015 and March 2016. The first campaign was carried out in the no-heating period, from June 12th to June 19th of 2015. The second campaign was carried out in the heating period from March 14th to March 22th of 2016. The samples were collected during working hours (WH) from 8 AM to 8 PM, and also during non-working hours (NWH) from 8 PM to 8 AM the next day.

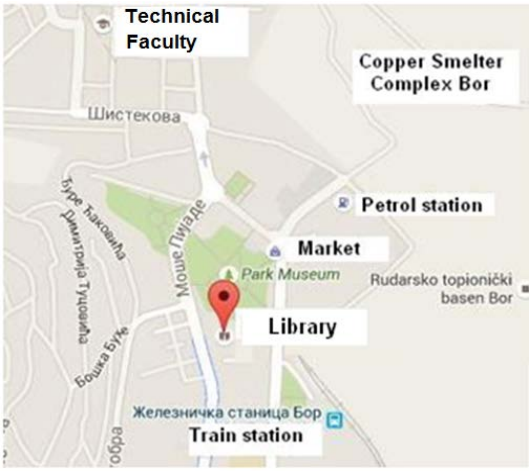

Figure 2. *Location of town library relative to two main roads in Bor*

The referent low-volume samplers, Sven/Leckel LVS3 [8], were used to simultaneously collect PM inside the library and in the ambient air, at the balcony. Two samplers were placed in the middle of the department for adults, on the library third floor, as shown in Figure 3. The department for adults has a volume of approximately 275 m^3. The area was carpeted, without an air conditioning system and with the surface of a window of 15 m^2. During the measurement campaign in the no-heating period, one window remained half-opened. The other two samplers were placed on the balcony at a height of 10 m above ground.

Figure 3. *Sampling equipment in the library*

The direct reading aerosol monitoring device, Turnkey OSIRIS Particle Monitor (Model 2315) [9], was placed near the LVS3 devices to access real-time changes in PM levels in the library. The data from the OSIRIS monitor were originally available as 15-min averages. For the calculation of daily averages, a minimum capture of 90% of 15-min averages was required. The results obtained by OSIRIS were corrected as it was suggested by Ramachandran et al. [10] by using the average daily indoor PM concentrations obtained by the gravimetric method.

Samples preparation and analyses

The flow rate of the LVS3 samplers (38.3 l/min) was calibrated at the beginning of measurements using a certified flow meter. PM mass concentrations were obtained from the gravimetric analysis of filters. Quartz fiber filters (Whatman QMA 47 mm diameter filters) were used to collect the PM samples. Pre-conditioning and post-conditioning of filters were undertaken in accordance with the general requirements of SRPS EN 12341:2015 standard.

After measuring the mass of the exposed filters, they were further prepared for chemical analysis in accordance with the procedure of SRPS EN14902: 2008 [11]. Major elements (Fe, Al, Na, Mg, Ca, and K) and trace elements (As, Cd, Pb, and Ni among others) were analyzed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES) and Inductively Coupled Plasma Mass Spectrometry (ICP MS), respectively. In this way, the mass concentrations of 15 chemical elements from the PM samples were determined. For the purpose of quality control and verification of the dissolution and analysis process, standard reference material (NIST 1648a [12]) was analyzed in the same way. Recovery rates were in the range from 90 to 110% for most of the chemical elements.

RESULTS AND DISCUSSION

Daily averages of meteorological parameters during the measurement campaigns are shown in Table 1. The meteorological data were taken from the automatic monitoring station (AMS Bor Park) situated in Town Park about 200 m from the library. During the first measurement campaign, the weather was mostly calm and stable. During the second measurement campaign, the weather was cold, with snow and icy rain.

Table 1. *Meteorological conditions during the PM measurement campaigns (daily averages)*

Measurement period	T (^{0}C)	RH (%)	WS (m/s)	P (mbar)
12.06. - 19.06.2015.	21.5	67.5	2.2	967.8
14.03. - 21.03.2016.	5.3	68.7	1.7	978.4

Table 2. *Average daily PM concentrations (μg/m³), and I/O ratios*

Measurement period	$PM_{10\ in}$	$PM_{10\ out}$	PM_{10} I/O ratio
12.06. - 19.06.2015.	33.2	31.2	1.06
14.03. - 21.03.2016.	28.8	39.4	0.73
Measurement period	$PM_{2.5\ in}$	$PM_{2.5\ out}$	$PM_{2.5}$ I/O ratio
12.06. - 19.06.2015.	22.2	20.4	1.09
14.03. - 21.03.2016.	23.3	27.6	0.79
Measurement period	$PM_{2.5\ in}$ / $PM_{10\ in}$	$PM_{2.5out}$ / $PM_{10\ out}$	$PM_{2.5}$ / PM_{10}
12.06. - 19.06.2015.	0.67	0.65	0.66
14.03. - 21.03.2016.	0.81	0.70	0.75

Average daily PM_{10} and $PM_{2.5}$ concentrations and their I/O ratios are summarized in Table 2. There was no significant difference between the average daily PM_{10} concentrations in the indoor and outdoor air in both PM measurement periods (at the level of significance 0.05). The same stands for the average daily $PM_{2.5}$ concentrations. According to the SEPA annual report for 2017 [13], the average annual PM_{10} concentration measured at AMS Bor Park was 45 μg/m³, and at AMS Bor Institute was 31 μg/m³. This is in good agreement with our results for outdoor PM_{10} concentrations presented in Table 2.

In the first measurement campaign, average daily PM_{10} concentrations in the ambient air, as well as in the library, didn't exceed the daily limit value (50 μg/m³). In the same period, the average daily $PM_{2.5}$ concentration limit value (25 μg/m³) wasn't exceeded in the ambient air but was exceeded in the library. In the second measurement campaign, the average daily PM_{10} concentration in the ambient air exceeded the daily limit once. In the same period, the average daily $PM_{2.5}$ concentration in the ambient air, as well as in the library, exceeded the daily limit value for three days.

Such a high number of daily limit values exceeded during the heating period can be attributed to fossil fuel burning and also to the calmer weather with lower average daily wind speed during the second measurement campaign. The PM size distribution helps understand the source of PM. For example, particles emitted as part of combustion are almost always entirely in the fine fraction. Also, windblown dust is almost entirely in the coarse fraction, with a small percentage of windblown dust in the fine fraction. The average daily $PM_{2.5}/PM_{10}$ ratios in the library were in the range from 0.67 to 0.81 and from 0.65 to 0.70 in the ambient air. Such a high $PM_{2.5}/PM_{10}$ ratio points out to considerable influence of anthropogenic air pollution sources, such as industrial activities, fossil fuel combustion, or traffic. For the observation period from 2005 to 2010, in the heating seasons, the average daily $PM_{2.5}/PM_{10}$ ratios were 0.69 in the surrounding settlements and 0.60 in the Bor town [14]. On the contrary, the daily mean $PM_{2.5}/PM_{10}$ ratios in no-heating seasons, for the same period (2005-2010), were 0.34 in the surrounding settlements and 0.53 in the Bor town. This is in good agreement with our results for outdoor $PM_{2.5}/PM_{10}$ ratios presented in Table 2.

The indoor/outdoor (I/O) PM concentration ratio is used to justify the presence of indoor sources (I/O >1) or infiltration of ambient air (I/O≤ 1). According to data shown in Table 2, average daily I/O ratios for PM_{10} and also for $PM_{2.5}$ concentrations in the first measurement campaign were above 1. This indicates the presence of indoor PM sources, such as resuspension of particles, caused by the visitor's movements in the library, or by cleaning activities. Also, it can be attributed to the ventilation practice during the warm period of the year (windows stay open during the whole day). In the second measurement campaign, in the heating period, average daily PM I/O ratios were lower than 1, which points out to seasonal changes in PM I/O ratios over the year.

The indoor environment in the library is influenced by environmental conditions such as humidity and temperature as well as gaseous and PM pollution. The chemical composition of particles is an important factor that affects the preservation of objects inside libraries due to soiling and chemical reactions from harmful compounds inside the particles or on the surface between the particle and the deposited surface.

Table 3. *Chemical composition of PM_{10} (working hours -WH, non-working hours - NWH)*

	$PM_{10\ in}$		$PM_{10\ out}$	
	WH	NWH	WH	NWH
	μg/m³			
PM_{10}	38.5	27.9	34.0	28.5
	ng/m³			
As	31.5	45.6	8.3	73.7
Cd	1.8	4.9	1.4	7.5
Pb	112.5	63.2	24.8	95.5
Cu	452.5	140.5	173.1	61.5
Zn	116.9	125.0	170.8	129.1
Ni	2.0	3.1	9.9	18.0
Se	4.5	1.7	2.5	3.5
Ag	4.4	1.3	5.0	2.4
Mn	13.1	10.9	20.7	9.7
Fe	1745.4	886.8	1664.4	1193.5
Ca	2624.1	1925.2	3308.8	1626.0
Al	634.7	518.7	1140.4	508.8
Mg	520.0	409.1	674.6	328.8
Na	130.9	122.3	200.3	97.9
K	759.6	392.3	793.5	465.5

Chemical compositions of PM_{10} and $PM_{2.5}$ samples during the first measurement campaign are presented in Table 3 and Table 4. I/O and WH/NWH ratios for

chemical elements determined in PM samples are presented in Table 5 and Table 6.

According to national legislation [15], the allowed annual limits for Pb, Cd, Ni, and As contents in PM_{10} are 500, 5, 20, and 6 ng/m^3, respectively.

From Tables 3 and 4 it can be noticed that the average daily concentration of As detected in the library as well as in the ambient air in both PM_{10} and $PM_{2.5}$ fractions was above the annual limit value.

Arsenic is a human carcinogen. People living near emission sources of inorganic arsenic, such as smelting plants, have a moderately elevated risk of lung cancer because there is no recommended safe level for inhalation exposure for As.

Table 4. *Chemical composition of $PM_{2.5}$ (working hours -WH, non-working hours - NWH)*

	$PM_{2.5\ in}$		$PM_{2.5\ out}$	
	WH	NWH	WH	NWH
	μg/m^3			
$PM_{2.5}$	25.1	19.1	21.5	19.3
	ng/m^3			
As	18.6	43.2	7.9	64.0
Cd	1.6	4.9	0.5	6.2
Pb	57.7	59.2	19.2	89.1
Cu	219.3	124.0	131.2	40.1
Zn	103.9	107.4	132.2	95.5
Ni	1.0	1.0	3.2	8.8
Se	3.3	1.4	2.3	2.3
Ag	2.8	1.2	4.0	2.3
Mn	12.5	7.4	13.1	5.4
Fe	1688.8	555.6	1236.5	768.0
Ca	2017.2	1609.7	2832.0	1382.2
Al	372.4	190.1	596.0	173.5
Mg	426.1	287.1	633.8	218.1
Na	123.0	67.5	189.7	67.5
K	447.2	145.9	771.4	233.4

Table 5. *I/O and WH/NWH ratios for chemical elements determined in PM_{10} samples*

	PM_{10} in/out		WH/NWH	
	WH	NWH	IN	OUT
PM_{10}	1.1	1.0	1.4	1.2
As	3.8	0.6	0.7	0.1
Cd	1.3	0.6	0.4	0.2
Pb	4.5	0.7	1.8	0.3
Cu	2.6	2.3	3.2	2.8
Zn	0.7	1.0	0.9	1.3
Ni	0.2	0.2	0.6	0.6
Se	1.8	0.5	2.7	0.7
Ag	0.9	0.5	3.4	2.1
Mn	0.6	1.1	1.2	2.1
Fe	1.0	0.7	2.0	1.4
Ca	0.8	1.2	1.4	2.0
Al	0.6	1.0	1.2	2.2
Mg	0.8	1.2	1.3	2.1
Na	0.7	1.2	1.1	2.0
K	1.0	0.8	1.9	1.7

The content of As in PM samples in both measurement campaigns was above the annual limit value. This requires concrete actions in order to reduce the anthropogenic emission of suspended particles enriched with arsenic in Bor.

The elements Ca, Fe, Mg, Na, Cu, and Zn were most present in all PM samples. The dust raised from the ground contains crustal elements Ca, Fe, Mg, Na, Al, K. Also, it is known that the major sources of Fe, As, Cd, Cu, Zn, and Pb particles are emissions of waste gasses from the metallurgical facilities such as the copper smelting plant in Bor. For most of the major elements (Ca, Fe, Mg, Na, Al, and K) detected in PM_{10} and $PM_{2.5}$ in the library, as well in the outdoor air, WH/NWH ratios were higher than 1.

This points to the fact that in addition to the activities in the library that cause the resuspension of particles from both PM fractions, another phenomenon arises in the outside air. Namely, under the influence of meteorological conditions, primarily changes in the direction and wind speed, there is a regular occurrence of increased PM pollution in the outdoor air during the day compared to the PM pollution during the night. This can be also attributed to lowering the production activities in the copper smelter during the night.

The average wind speed is lower over the night than over the day. Wind direction and temperature are also changed during the night, which changes particle resuspension dynamics in ambient air [14].

Table 6. *I/O and WH/NWH ratios for chemical elements determined in $PM_{2.5}$ samples*

	$PM_{2.5}$ in/out		WH/NWH	
	WH	NWH	IN	OUT
$PM_{2.5}$	1.2	1.0	1.3	1.1
As	2.4	0.7	0.4	0.1
Cd	3.4	0.8	0.3	0.1
Pb	3.0	0.7	1.0	0.2
Cu	1.7	3.1	1.8	3.3
Zn	0.8	1.1	1.0	1.4
Ni	0.3	0.1	1.0	0.4
Se	1.4	0.6	2.3	1.0
Ag	0.7	0.5	2.3	1.7
Mn	0.9	1.4	1.7	2.4
Fe	1.4	0.7	3.0	1.6
Ca	0.7	1.2	1.3	2.0
Al	0.6	1.1	2.0	3.4
Mg	0.7	1.3	1.5	2.9
Na	0.6	1.0	1.8	2.8
K	0.6	0.6	3.1	3.3

Figures 4 and 5 show PM concentrations in the library measured by the real-time PM monitor OSIRIS [9]. Both figures clearly show that variations of PM concentrations in the library follow almost similar measurement patterns. PM concentrations in the library rise at the start of the workday, at 8 AM, and fall at the closing time, after 8 PM. Significant fluctuations of PM_{10} concentrations in relation to $PM_{2.5}$ concentrations

are also observed, which indicates the occurrence of resuspension of larger particles due to activity in the library during working hours.

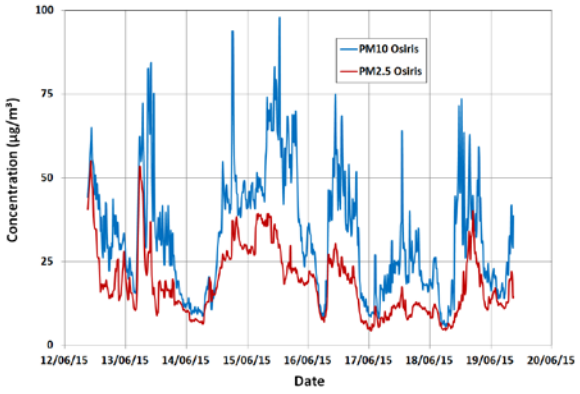

Figure 4. *PM concentrations in the library during the first measurement campaign*

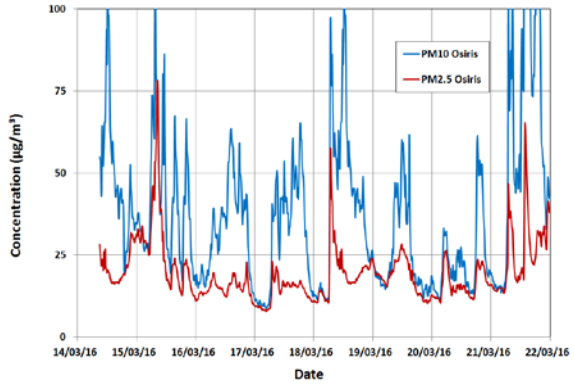

Figure 5. *PM concentrations in the library during the second measurement campaign*

In the literature, copper smelting is associated with significant concentrations of Cu, as well as with elevated levels of As, Zn, and Cd [16]. All mentioned chemical elements were determined in both PM_{10} and $PM_{2.5}$ fractions in the library.

Under the influence of changes in meteorological conditions, and lower production activities in the copper smelting plant over the night, the regular decrease in concentrations of the majority of chemical elements in PM samples has been identified.

The exceptions are the elements As, Cd, Pb, and Ni, whose concentrations in PM samples from both fractions in outdoor air are higher during non-working hours. This can be attributed to the increased impact of fugitive PM emissions from metallurgical plants during the night due to changes in meteorological conditions.

CONCLUSION

In this paper, the mass concentrations and chemical composition of PM_{10} and $PM_{2.5}$ particles in the library and the ambient air in Bor are presented. The results show that PM concentrations in the library were strongly connected with the respective PM concentrations in ambient air. Thus, most of the PM pollution in the library originates from the outdoor air.

High $PM_{2.5}/PM_{10}$ ratios in both the indoor and outdoor environments point out the considerable influence of pollution sources of anthropogenic origin, in this case, air pollution from the copper smelter.

Due to the fact that the new copper smelting plant started operating in 2016, it is necessary to conduct a new measurement campaign to determine whether there has been a change in the chemical composition of PM in the indoor air of public and residential buildings in Bor town.

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KONCENTRACIJE I HEMIJSKI SASTAV SUSPENDOVANIH ČESTICA PM_{10} I $PM_{2.5}$ U BIBLIOTECI U BORU, SRBIJA

Viša Tasić, Bojan Radović, Aleksandar Simonovski, Tatjana Apostolovski-Trujić

Rezime: *U radu su prikazane koncentracije suspendovanih čestica PM_{10} i $PM_{2.5}$ i rezultati hemijskih analiza PM uzoraka sakupljenih u gradskoj biblioteci u Boru, Srbija. Sprovedene su dve kampanje uzorkovanja u trajanju od po šest uzastopnih radnih dana u junu 2015. godine, i tokom marta 2016. Rezultati merenja ukazuju na to da su koncentracije PM_{10} i $PM_{2.5}$ unutar biblioteke bile jako korelisane sa odgovarajućim koncentracijama PM u atmosferskom vazduhu. Dakle, može se zaključiti da najveći deo PM čestica u biblioteci potiče iz spoljašnje sredine. Visoki odnosi $PM_{2.5}/PM_{10}$ u biblioteci kao i u spoljašnjem ambijentalnom vazduhu ukazuju na znatan uticaj izvora zagađenja antropogenog porekla, u ovom slučaju metalurških procesa u topionici bakra. Zbog činjenice da je nova topionica bakra počela sa radom tokom 2016. godine, potrebno je sprovesti novu kampanju merenja kako bi se utvrdilo da li postoje promene u koncentracijama i hemijskom sastavu suspendovanih čestica u unutrašnjem vazduhu javnih objekata i u objektima za stanovanje u Boru.*

Ključne reči: suspendovane čestice, monitoring, zagađenje vazduha, hemijske analize, arsen.

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ERGONOMIC APPROACH TO WORKPLACE (RE)DESIGN DURING LOADS HANDLING

Abstract: *Manual handling of loads is a set of activities that involve physical strain during work. For this reason, it is necessary to create ergonomically sound workplaces, which will help improve health and safety in the workplace. The paper describes an approach, which includes ergonomic and productivity factors, for choosing the optimal alternative for loads handling using multicriteria analysis. The purpose of this approach is to select the most important criteria to make decisions on how to reorganize the work process, as well as to meet ergonomic performance goals, all with minimal impact on the company's productivity. The objective of this paper is to analyse and select the optimal alternative for manual handling of loads using the Analytic Hierarchy Process method. The results of the research revealed that handling loads is a more optimal solution when performed by a single person, taking into account ergonomics and productivity aspects, compared to working in pairs or using conveying systems as transport aids.*

Keywords: ergonomics, productivity, AHP method, manual handling of loads, occupational safety and health.

INTRODUCTION

Ergonomics, as a multidisciplinary science, integrates knowledge and skills from various scientific fields (engineering, technology, philosophy, medicine, psychology, design, etc.) in a comprehensive manner. There is no single definition of ergonomics as a science, yet, in diverse areas, it is defined differently. The International Ergonomics Association (IEA) has provided a comprehensive definition of ergonomics as a scientific discipline concerned with the understanding of interactions among workers and other elements of the work environment, and the profession that applies theory, principles, data, and design methods in order to optimize human well-being and overall system performance [5]. Such a definition of ergonomics fully corresponds to the field of occupational safety engineering; it takes into account the impact of all elements of a system on man and his psychophysical abilities, limitations, and similar. The practice has shown that the application of ergonomic principles is most often aimed to satisfy legal requirements, on the one hand, i.e. to reveal the results pertaining to occupational safety on the other hand. This approach disregards the financial results of a company, which makes the application of ergonomic principles unacceptable. Therefore, all problems from an ergonomics perspective must be viewed in parallel with the company's business performance [17].

Rapid technical and technological development emphasizes the automation and mechanization of the system, thus neglecting the activities of workers who have to keep pace with modern technological system [8]. Therefore, the paper deals with one of the issues which appear in various systems as an integral part of all activities - manual handling of loads.

According to the national legislation of the Republic of Serbia, manual handling of loads means any transporting or supporting of a load weighing more than three kilograms, by one or more workers, including lifting, putting down, pushing, pulling, carrying, or moving of a load, which, due to its characteristics or unfavorable ergonomic conditions, particularly involves a risk of injuries or spinal disease to workers [12].

The objectives of this paper are to analyze and select the optimal alternative for manual handling of loads using a multi-criteria approach based on the Analytic Hierarchy Process (AHP) method.

On account of the identified problem and defined goals, the research covers the following tasks:

- Defining criteria that can have an impact on ergonomics workplace conditions and productivity at work;
- Structuring the problem in relation to the defined criteria and alternative solutions being considered;
- Data processing and drawing conclusions about the most acceptable solution.

LITERATURE REVIEW

By literature analysis, we can conclude that a large number of researchers worldwide deal with the issue of manual handling of loads and its consequences on the workers' safety and health and productivity at work. Shikdar et al. (2011) point out that improving worker productivity is a major problem in the industry, especially where tasks involve repetitive movements. These tasks are considered boring, monotonous, tedious and demotivating, and they result in reduced workers' productivity, poor job quality and habitual absence from work, which may have adverse effects on the psychophysical condition of workers. They also believe that the effective use of ergonomic principles in workplace design can help in creating a balance between employee characteristics and job requirements [16].

Otto and School (2011) point out that nowadays, in assembly-line production, where the share of manual labor is high, special attention is paid to ergonomics. They also believe that factors such as posture, force, repetitive movements and vibrations, which result in a higher injury rate, should be strictly considered when (re)designing the workplace and work environment [11].

Muhundhan (2013) emphasizes that the workplace must be designed by considering ergonomic principles in order to work efficiently, make high-quality products, and increase productivity. He also points out that a well-organized workplace minimizes material handling, improves efficiency and reduces worker fatigue, and that the implementation of appropriate work organization can improve productivity and efficiency of workers in terms of quality and quantity [9] On the other hand, Gurunath et al. (2012) believe that instead of investing money in materials, man, machines, working methods, etc., manufacturers should invest in providing an ergonomic workplace because it is cost-saving [4]. An ergonomically designed workplace in industries with proper modular structure provides many benefits, such as increased motivation and employee satisfaction, higher performance and processing quality, and the like [7].

According to Osabiya (2015), workers who are dissatisfied with workplace conditions are less productive regardless of their potentials. This dissatisfaction may jeopardize workplace peace and create increasing disequilibrium between the efforts made by the employees and the productivity achieved [10].

METHODOLOGY

The *Analytic Hierarchy Process* (AHP), developed in 1980 by T. L. Saaty [15], is a method of multi-criteria decision making that includes both qualitative and quantitative techniques, which reflects its usefulness for obtaining a unique assessment based on given criteria. It proposes the most acceptable solution from a set of defined criteria and attribute values for each alternative [2]. As such, this method simplifies the decision-making process by decomposing a complex problem into a series of structured steps, where each element in the hierarchy of criteria is independent of all the others, and where the analytical network process is used to denote the interdependence of criteria [1].

The AHP method is based on the comparison of pairs, according to criteria that differ in importance, it is mathematically well-defined and very close to the way an individual intuitively solves complex problems by breaking them down into simpler ones [13] and consists of 3 phases (steps):

The first step is decomposition, within which the hierarchical structure of elements that influence decision-making is made in such a way that the goal is set at the top; the next level (below) is the position at which the criteria are placed, while the alternatives are placed at the bottom. In this procedure, elements of a general character are placed at a higher level of the hierarchy, while those of a specific character are placed at lower levels of the hierarchy. The decision-maker can insert or delete individual elements in order to clarify the task of setting priorities.

The second phase is the pair-wise comparison, where a database comparing the set of alternatives to a reference alternative is made. Pairwise comparisons are done based on Saaty's Scale of Importance [14], by assigning values from the set {1/9, 1/8, 1/7, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 3, 4, 5, 6, 7, 8, 9}, where on the scale, 1 means that both factors (which we compare) are of equal importance, whereas 9 indicates that the first factor in the pair is more important than the other factor.

After pair-wise comparison, the decision-maker calculates their relative weights in relation to the goal; then compares the alternatives (in pairs) in relation to each criterion and assigns relative weights, thus creating the above-mentioned database on compared pairs. Mathematically, it is a matter of calculating characteristic roots and characteristic vectors.

The third phase is the synthesis of priorities, within which the vector of the relative weight of decision alternatives and the vector of the order of activities related to the criteria within the model are obtained. Based on that, the order of importance is calculated for each of the decision alternatives, for each observed criterion. Finally, the rate of each alternative is multiplied by the weight of the observed criterion, then these values are added for each alternative separately, and in the end, the weight of the observed alternative in the model is obtained (similar to all alternatives) [2]. In the end, the final order of alternatives in the model is determined and the most suitable option is selected according to the chosen criteria.

In particular, to check the subjectivity of decision making, the consistency of the model is monitored by calculating the ratio of consistency index (*CI*) and consistency ratio (*CR*), which represents the ratio of consistency index and random consistency index (*RI*):

CR=CI/RI

where *CI=(λ_max-n)/(n-1)*, *n* is the order of the observed matrix, while *λ_max* is the maximum characteristic root of the observed matrix. The value of the random consistency index (RI) is denoted by the order *n* of the matrix of randomly generated pair comparisons. In that way, in the case of the first 15 numbers, the table of values of the random consistency index has the following form [15]:

Table 1. *The table of values of the random consistency index*

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56	1,57	1,59

Otherwise, it is necessary to find the reasons for high inconsistency in the assessment [16]. A detailed explanation of the method is presented in the works of Saaty (1980), Inđić, et al. (2014) [15, 6].

RESULTS AND DISCUSSION

For the purpose of multi-criteria analysis in which AHP is applied, we can define the following goal: to organize the workstation during the handling of loads. In the first phase of application of the AHP method – decomposition - the authors set a goal and defined three alternatives to the process of organizing the workstation during handling of loads:

1. loads handling when stacking goods performed by a single person (A1),
2. loads handling when stacking goods performed in pairs (A2),
3. the use of conveyor during stacking (A3).

While choosing and formulating the alternative, the authors tended towards generality, i.e. to adjust the structure of the alternatives so that they can be applied to several different types of load handling activities in different companies.

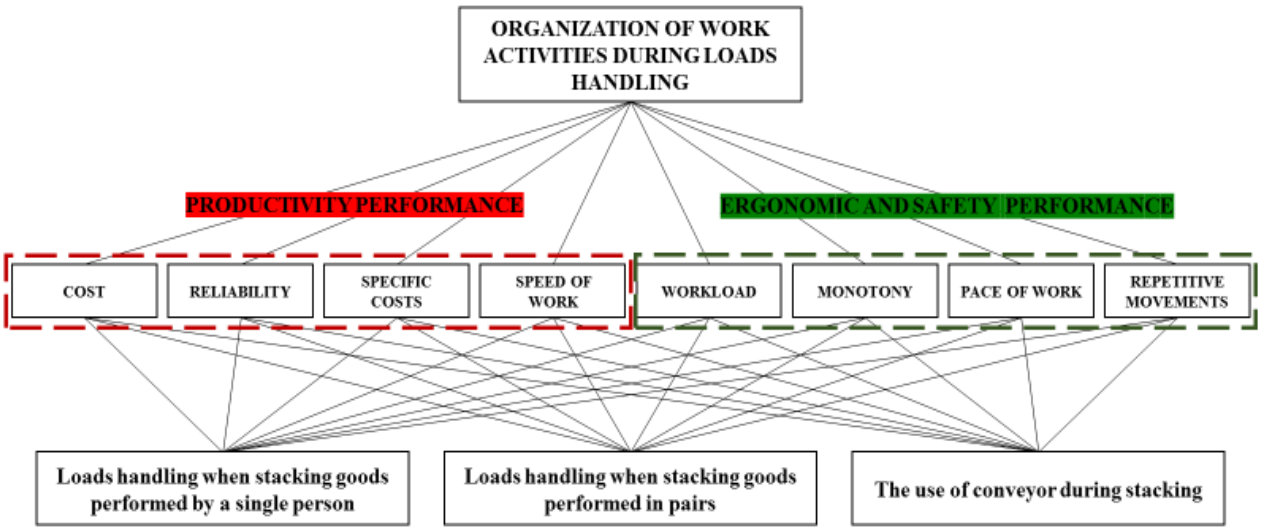

Figure 1. *The structure of workplace organization during loads handling*

According to the AHP structure, the next level in the hierarchy is the criteria. Based on a theoretical example from practice, the study identified indicators of productivity and ergonomics which are dominant in defining the criteria. Also, in order to emphasize the criteria according to importance, a grouping of smaller sub-criteria was performed in eight units divided into two groups. The first group of indicators refers to productivity and includes four criteria: cost, reliability, specific costs and speed of work. The second group of indicators refers to the ergonomics of work when handling loads, which also includes four criteria: workload, monotony, the pace of work and repetition of movements (see Figure 1). For the selection of the most suitable ergonomic solution for the organization of work in loads handling, the above criteria are described in Table 2.

Table 2. *Categorization of decision criteria*

Number of criteria	Decision criterion	Description of criteria
C1	Cost	It implies the necessary financial resources needed to organize work in case of all the above methods
C2	Reliability	It implies the reliability of performing load handling activities
C3	Specific costs	They include regular or unplanned downtime costs (maintenance, servicing, replacement of spare parts, resources, etc.)
C4	Speed of work	It implies the pace of work with regard to the speed and efficiency of the operation
C5	Workload	It involves the physical load of workers when handling loads
C6	Monotony	It involves repetitive movements and the social environment
C7	Pace of work	It implies dictated work pace
C8	Repetitive movements	It implies the required degree of repetitive movements in a unit of time

The second phase involved assigning importance to the attributes based on the pairwise comparison and creating a database on the pairwise comparison between given alternatives with regards to the given criterion. First, a pairwise comparison matrix for the criteria was created, in which each criteria pair was assigned the appropriate values according to the Saaty's scale, in the 1–9 range (see Table 3).

Table 3. *Matrix of pairwise comparison of criteria at the first level (decision matrix)*

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1	1/6	1/5	1/3	1/5	1/5	1/3	1/4
C2	6	1	3	4	1	2	1/3	2
C3	5	1/3	1	2	3	4	4	3
C4	3	1/4	1/2	1	3	4	1	1
C5	5	1	1/3	1/3	1	1	2	1/3
C6	5	1/2	1/4	1/4	1	1	1/2	1/3
C7	3	3	1/4	1	1/2	2	1	1/2
C8	4	1/2	1/3	1	3	3	2	1
∑	**32**	**6,75**	**5,867**	**9,917**	**12,7**	**17,2**	**11,167**	**8,417**

According to the AHP procedure, the upper matrix was normalized and the relative weights were calculated. Using Saaty's measurement scale, by comparing pairs of alternatives, the weights of the relative importance of alternatives were assigned to the observed criterion C1-C8 (see Tables 4-11, respectively).

The assessment obtained in this way represents the average preference of one alternative with regards to others, i.e. the value of the weight needed to make the final decision [18]. With this approach, we get more precise solutions, when it comes to pairwise comparisons, as well as steady solutions which make us assume that a small change in values will not cause large changes in the final assessment [18].

Table 4. *Matrix of alternative relative importance compared to the cost (C1 attribute)*

	A1	A2	A3
A1	1	4	8
A2	1/4	1	4
A3	1/8	1/4	1

λ	**3,0536**
CI	**0,0268**
CR	**0,0462**
CR<0.1	**YES**

Table 5. *Matrix of alternative relative importance compared to reliability (C2 attribute)*

	A1	A2	A3	λ	3,0712
A1	1	5	9	**CI**	**0,0356**
A2	1/5	1	4	**CR**	**0,0614**
A3	1/9	1/4	1	**CR<0.1**	**YES**

Table 6. *Matrix of alternative relative importance compared to specific costs (C3 attribute)*

	A1	A2	A3	λ	3,065
A1	1	3	7	**CI**	**0,0325**
A2	1/3	1	5	**CR**	**0,056**
A3	1/7	1/5	1	**CR<0.1**	**YES**

Table 7. *Matrix of alternative relative importance compared to the speed of work (C4 attribute)*

	A1	A2	A3	λ	3,029
A1	1	1/3	1/9	**CI**	**0,0145**
A2	3	1	1/5	**CR**	**0,025**
A3	9	5	1	**CR<0.1**	**YES**

Table 8. *Matrix of alternative relative importance compared to workload (C5 attribute)*

	A1	A2	A3	λ	3,0369
A1	1	1/4	1/9	**CI**	**0,01845**
A2	4	1	1/4	**CR**	**0,0318**
A3	9	4	1	**CR<0.1**	**YES**

Table 9. *Matrix of alternative relative importance compared to monotony (C6 attribute)*

	A1	A2	A3	λ	3,0037
A1	1	1/3	2	**CI**	**0,00185**
A2	3	1	5	**CR**	**0,0032**
A3	1/2	1/5	1	**CR<0.1**	**YES**

Table 10. *Matrix of alternative relative importance compared to the pace of work (C7 attribute)*

	A1	A2	A3	λ	3,019
A1	1	3	6	**CI**	**0,0095**
A2	1/3	1	3	**CR**	**0,0164**
A3	1/6	1/3	1	**CR<0.1**	**YES**

Table 11. *Matrix of alternative relative importance compared to repetitive movements (C8 attribute)*

	A1	A2	A3	λ	3,0327
A1	1	3	7	**CI**	**0,01635**
A2	1/3	1	4	**CR**	**0,0282**
A3	1/7	1/4	1	**CR<0.1**	**YES**

The verification of the subjectivity of decision making was followed by calculating the values of consistency index (CI) and consistency ratio (CR) which were less than 0.1 in the case of these matrices (see Tables 4-11, right column, respectively); therefore, the relative importance criteria were considered acceptable.

Table 12. *Optimal alternative selection table*

	w	A1	w×A1	A2	w×A2	A3	w×A3
C1	0,026	2,267	0,059	0,733	0,019	0,233	0,006
C2	0,214	0,187	0,040	0,709	0,152	2,104	0,450
C3	0,220	1,93	0,425	0,849	0,187	0,221	0,049
C4	0,124	1,959	0,243	0,753	0,093	0,288	0,036
C5	0,094	0,201	0,019	0,660	0,062	2,139	0,201
C6	0,065	0,689	0,045	1,944	0,126	0,367	0,024
C7	0,123	1,959	0,241	0,753	0,093	0,288	0,035
C8	0,133	1,967	0,262	0,794	0,106	0,239	0,032
			1,334		0,838		0,833
		LEVEL	**1**		**2**		**3**

By calculating the relative weights concerning each criterion, an optimal alternative is selected. The calculated weight vector of criterion *w* (see Table 12, column *w*), indicates that the criterion "specific costs" (C3) has the greatest significance (0.220) compared to other criteria. In addition to the above, the criterion "reliability" (C2) with a specific weight of 0.214 stands out, which indicates the influence of the productivity criterion on the final decision.

The optimal alternative was chosen by multiplying all relative weights of the alternatives (according to the appropriate criterion) by the weight vector *w*, and then by summing the corresponding results (see Table 11, last row). The alternative with the highest value (in this case A1) is the one that is considered optimal. Based on the obtained results, we can conclude that independent handling of loads when stacking goods by a single person is an optimal alternative for handling loads with a mass that does not exceed the prescribed maximum allowed values. Also, the research results show that people are most aware of their capabilities and limitations at the moments when they should take a break or stop working, and realize the pace of work that suits them best, etc. On the other hand, the specific costs that appear in the case of using a conveyor (A3) or other technical aid, are almost non-existent; however, these costs trigger many others, latent costs, which are mostly reflected in the loss of time and downtime due to various failures.

CONCLUSION

The paper presents the application of the multicriteria AHP method in the process of organizing work activities during the handling of loads, involving given criteria pertaining to productivity and ergonomics. Bearing in mind the fact that ergonomically (re)designed workplace greatly contributes to increasing workers' health and safety in the workplace, while increasing their satisfaction with work conditions at the same time, which, in turn, affects their productivity, the authors considered both economic and productivity criteria in deciding how to organize the workstation during handling of loads. Therefore, the paper analyzes both aspects, with the aim to make balanced decisions about the reorganization of the work process, and simultaneously satisfy ergonomic performance with minimal impact on the company's productivity. At the same time, one of the main problems (in terms of subjectivity) was to determine the criteria related to productivity and ergonomics. The subjectivity of decision-making by the author is reflected in the decision-making criteria and the assessment of their relative weights. The authors defined the criteria and evaluated their relative weights based on the available literature and their personal experience. The assessments of the relative importance were confirmed by checking the consistency ratio.

By applying the AHP method in this research, it was assumed that the alternative "handling of loads by a single person" has the highest total value of 1,334, which means that it is the most favorable alternative when it comes to choosing the type of work organization in loads handling. Although the alternative A1 may be the most favorable solution, it must include a series of measures, such as the introduction of breaks during the work, proper lifting and transfer of loads in accordance with safety instructions and procedures, and the like.

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ERGONOMSKI PRISTUP (RE)DIZAJNIRANJA RADNOG MESTA PRI MANIPULACIJI TERETOM

Lutvo Haznadarević, Novak Milošević, Dragana Gardašević, Nebojša Ćurčić, Evica Stojiljković

Rezime: *Ručno prenošenje tereta predstavlja skup aktivnosti koje od čoveka zahtevaju različite vrste fizičkog naprezanja pri radu. Zbog toga je neophodno da radna mesta budu ergonomski prilagođena zaposlenima, čime se doprinosi povećanju njihove bezbednosti i zdravlja na radu. U radu je opisan pristup, koji obuhvata faktore ergonomije i produktivnosti, za izbor optimalne alternative pri manipulaciji teretom primenom višekriterijumske analize. Svrha ovog pristupa je izbor najvažnijeg kriterijuma prilikom donošenja odluke na koji način se proces rada može reorganizovati, a da se u najvećoj meri zadovolje ergonomske performanse, uz minimalna narušavanja produktivnosti kompanije. Cilj ovog rada je analiza i odabir optimalne alternative za ručno prenošenje tereta primenom metode „Analitički hijerarhijski proces". Rezultati sprovedenog istraživanja pokazali su da samostalno manipulisanje teretom predstavlja optimalnije rešenje, uzimajući u obzir aspekte ergonomije i produktivnosti, u odnosu na rad u paru ili upotrebu transportera kao pomagala.*

Ključne reči: ergonomija, produktivnost, AHP metoda, ručno manipulisanje teretom, bezbednost i zdravlje na radu.

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FIRE MODELING IN A COMPARTMENT RAILWAY PASSENGER CAR

Abstract: *In this paper numerical modeling of fire development in a single compartment of a railway passenger car has been performed using the FDS software. The simulation was focused on the dynamic calculation of temperature field and heat release rate. Obtained simulation results were compared with experimental results and satisfactory agreement was detected. It can be concluded that FDS can be used for simulating different fire scenarios in railway passenger cars.*

Key words: fire modeling, FDS, CFD field model.

INTRODUCTION

The mathematical models describing the ignition and fire spread in open and confined spaces heavily rely on knowledge of fluid dynamics. Computational fluid dynamics (CFD) is a branch of fluid dynamics where physical processes of fluid flow are mathematically modeled and consequently solved using numerical methods [1]. A number of software tools, such as ANSYS, FLUENT, STAR-CD, have been developed for solving fire modeling problems in complex geometries. For example, in [2] ANSYS software was used for determining the fluctuations in temperature field in steel columns.

The mathematical modeling of combustion problems in fires is challenging and requires inputs from diverse disciplines. Models are often quite complex containing several equations: Navier–Stokes equations; equation of state; law of conservation of energy; equation of scalar quantities describing the concentration of a combustible substance, oxidant, combustion products, inert gas and nitrogen oxides, etc.

Fire modeling is further complicated due to the presence of turbulent convective and radiant heat transfer between combustible gases and constructive elements of the room. All this significantly contributes to heterogeneity of temperature, momentum and concentration fields in analyzed spaces [3].

In order to describe thermal and gas-dynamic parameters of fire, three main approaches of mathematical modeling of fire are applied: integral, zonal and differential (field).

The FDS software (Fire Dynamic Simulation) is developed by the National Institute of Standards and Technology (NIST), USA and is based on a field approach. In 2000 the first version of software package FDS and SmokeView were published. Nowadays FDS is a mature, proven and reliable tool for modeling and analysis of fires in confined spaces. The software has been successfully verified for different fire scenarios and the data resulting from FDS simulations have wide application in fire protection engineering. Simulations and verification of obtained results are very well documented in the literature [4].

FDS uses the Smagorinsky model, as a basic turbulence model for the Large Eddy Simulation LES method. The model is designed so that when the grid is compressed to the Kolmogorov scale, calculations transfer directly from LES to Direct Numerical Simulation DNS. The computational problem is simplified by restricting the validity of equations to low-speed, convective flows with an emphasis on smoke and heat transfer in case of fire. FDS solves numerically the Navier–Stokes equations, whereby their partial derivatives for mass conservation, momentum and energy are approximated as final results and the method of solving is updated in time and space based on a three-dimensional rectangular structured grid [5].

Law of conservation of mass [6]:

$$\frac{\partial \rho}{\partial t} + \nabla.(\rho \mathrm{u}) = \dot{m}_b''' \quad (1)$$

Law of conservation of momentum:

$$\frac{\partial}{\partial t}(\rho u) + \nabla.\rho uu + \nabla p = \rho g + f_b + \nabla.\tau_{ij} \quad (2)$$

where stress tensor is

$$\tau_{ij} = \mu\left(2S_{ij} - \frac{2}{3}\delta_{ij}(\nabla.u)\right);\ \delta_{ij} = \begin{cases} 1\ i = j \\ 0\ i \neq j \end{cases};\qquad S_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)\ i,j = 1,2,3 \quad (3)$$

Law of conservation of energy:

$$\frac{\partial}{\partial t}(\rho h_s) + \nabla.\rho h_s u = \frac{Dp}{Dt} + \dot{q}''' - \dot{q}_b''' - \nabla.\dot{q}'' + \varepsilon \quad (4)$$

where heat transfer is

$$\dot{q}'' = -k\nabla T - \sum_{\alpha} h_{s,\alpha}\rho D_{\alpha}\nabla Y_{\alpha} + \dot{q}_r'' \quad (5)$$

and energy of dissipation

$$\varepsilon \equiv \tau_{ij}.\nabla u = \mu\left(2S_{ij}.S_{ij} - \frac{2}{3}(\nabla.u)^2\right) \quad (6)$$

Equation of state of a hypothetical ideal gas:

$$p = \frac{\rho RT}{\bar{W}} \quad (7)$$

These six equations have six independent variable quantities: three components of rate, density, temperature and pressure.
LES is used for modeling dissipative processes (viscosity, thermal conductivity, diffusion), whose scales are less than the dimensions of a clearly defined numerical grid. This means that the μ, k, D parameters in the equations above cannot be directly used and therefore they are substituted for expressions modeling their effects

$$\mu_{LES} = \rho(C_s\Delta)^2\left(2\bar{S}_{ij}.\bar{S}_{ij} - \frac{2}{3}(\nabla.\overline{u})^2\right)^{\frac{1}{2}} \quad (8)$$

$$k_{LES} = \frac{\mu_{LES}c_p}{Pr_t} \;;\; (\rho D)_{i,LES} = \frac{\mu_{LES}}{Sc_t} \quad (9)$$

AIMS AND PURPOSES

The numerical modeling conducted aims at determining the parameters of fire in a compartment of a railway passenger coach type B84, that is most commonly used in the Bulgarian State Railways Company, by using the data for characteristics of materials used for the construction of that type of coaches, as well as validation of results by comparing them to a conducted experiment with a model of a railway passenger coach type B84.

INITIAL AND BOUNDARY CONDITIONS OF THE TASK

In order to assess the dynamics of the development of fire in the compartment, the following scenario has been assumed:

- fire in a separate compartment, developed in a closed room restricted in space is studied;
- the doors and windows of the compartment are closed, and the not tight closing is simulated through openings in the zone of the wall on the door and the door itself with a total size 0,08 m;
- the fire load consists of standard seats and partition walls used in railroad coach type B84.;

The following initial conditions have been assumed when modeling:

- primary ambient temperature 30°C;
- ignition source activates at a certain moment: t = 0 s;
- ignition model represents a source of typical ignition due to arson or vandalism, for instance using a newspaper. The ignition model is a combustion source with a flame with a 3 min duration and average power of 7 kW, creating a flow from 25 kW/m^2 to 30 kW/m^2 in accordance with Annex A of BDS EN 45545-1. The ignition model is a paper cushion specified in UIC 564-2 – Code of International Union of Railways with dimensions 0,39 x 0,17 m.
- duration of action of the ignition source on seats is 180 s;
- the doors of the compartment are closed;
- the glazing material of the windows and doors of the compartment is undamaged at the primary moment of fire.

The following conditions appear to be boundary:

- the compartment is with dimensions 2,1x2,1x2,5 m;
- material of the external wall of the compartment - metal;
- a standard window is intended to be on the external partition wall, parallel to the longitudinal axis of the compartment;
- material of the interior partition walls, floor and ceiling - particle boards 0,018 m thick;
- seat padding is of polyurethane foam and seats have fabric covers;
- the glazing material of the windows and doors of the compartment destroys when the temperature in the middle of the glazed zone reaches above 300°C.

SPECIFICATIONS OF THE MODEL

Geometry of the model in FDS-version 6 includes the tested compartment with dimensions 2,1 x 2,1 x 2,5 m (fig. 1) and computational grid consisting of 332 667 cells with dimensions 0,09 x 0,09 x 0,09 m.

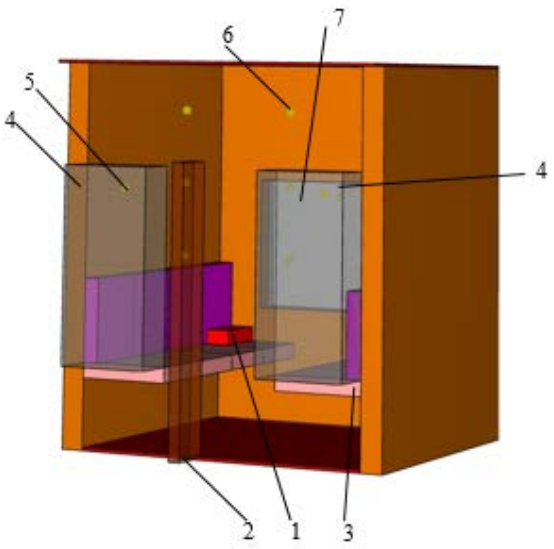

Figure 1. *Overall appearance of the model*

1-ignition source; 2- door; 3-seats; 4- windows near the door; 5-temperature sensor in the glazed area; 6-sensors for temperature measuring, O_2, CO, CO_2 concentration and visibility; 7-window on external wall

The LES model with simulation time 600 s has been used as a basic turbulence model. When applying LES simulation the size of the grid is the main parameter that has to be examined very carefully in order to obtain reliable results of the simulation. The size of the grid is determined by the expression D*/δx, where D* is the characteristic diameter of flame, and δx is the nominal size of the grid cell. The characteristic diameter of flame is defined in [7].

$$D^* = \left(\frac{\dot{Q}}{\rho_\infty C_p T_\infty \sqrt{g}}\right)^{2/5} \quad (10)$$

Where: Q* - heat release rate; cp – specific heat capacity of smoke; T∞ – ambient temperature

Using the tests of McGrattan and others [8] and [9] the size of the grid for the simulation presented must be 0,5D* in order to obtain correct results from the simulation forHRR Q=150 кW. Therefore, the dimensions of the grid were determined to be 0,09 m in the three-dimensional directions (x, y and z). The number of grid cells is 332 667 (fig.2).

45 sensors for measuring temperature, the concentration of oxygen, carbon oxide, carbon dioxide and visibility are located in the capacity of the compartment at height respectively 1,2 m, 1,7 m and 2,2 m, as well as 3 sensors measuring temperature in the zone of glazing of the compartment.

To validate the results of the simulation, the temperature sensors are arranged in a similar way to the sensors used in the real-size coupe experiment described in [10] and shown in Figures 10-11.

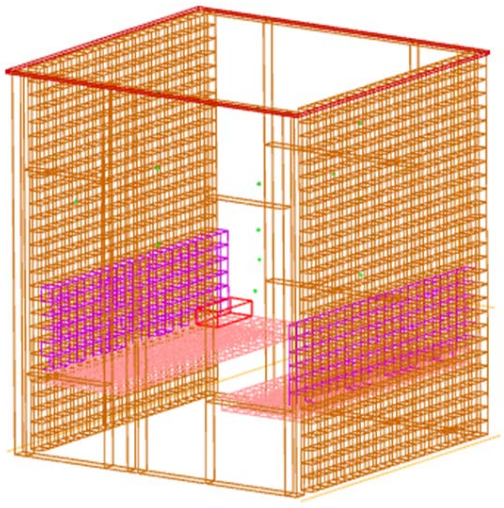

Figure 2. *Kind of grid of the tested object*

For the properties of the partition walls such as density, ignition temperature, heat release temperature, ignition temperature the data from [11,12] have been used.

Since data about heat release rate, density and ignition temperature of seats used in passenger cars type B84 were not present, they were tested in the Fire Testing Laboratory, Faculty of Occupational Safety with the University of Nis, Republic of Serbia. Tests have been conducted on the cone calorimeter. The cone calorimeter meets the requirements of EN ISO 13927. The basic working element in it is a source of heat with a conical shape, that provides permanent heat flow within the range from 0 to 150 KW/m2. Testing at different levels of radiation is needed for a detailed analysis. According to ISO 5660-1: 2013, three samples of the tested material must be tested per flow: 25, 35, 50 and 75 KW/m².

The test is conducted by placing the sample on a scale that measures the mass loss of the sample during combustion. The source of ignition is an electric spark. After the ignition, the fire effluents are lead through a conical heater and chimney into the ventilation system. During the experiment number of parameters are closely measured and archived. These measurements allow the calculation of heat release rate.

The test model has an area of 88,4 cm², a thickness of 17 mm and a mass 27,1 g. The test is performed in accordance with the requirements of EN ISO 13927.

The moment of flame spreading is at 21 s, and the time of combustion end at 342 s.

Variation of average heat release rate and effective heat of combustion of the models of seats tested are displayed in fig. 3 and fig. 4.

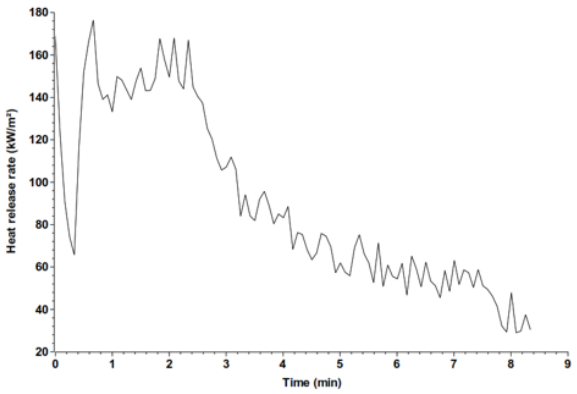

Figure 3. *Variation of average heat release rate*

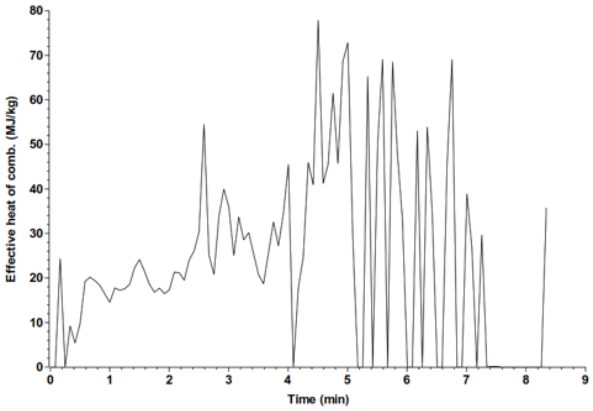

Figure 4. *Variation of effective heat of combustion*

RESULTS

At initial moments fire develops with fixed power of 97,71 KW/200 s. In the time range from 288 s to 296 s the glazing of windows in the zone of the door destroys, and at 375 s the glazing of the window of the compartment destroys. From that moment on the heat release rate sharply increases to values from 1694,3 кW/400 s to 4387,6 KW/600 s (fig. 5.). The sharp increase in fire intensity can be explained by oxygen entering the compartment, as well as by the moment of the beginning of explosive combustion of the seats heated to their temperature of ignition. The obtained results correspond well enough to the data from other publications[11,13].

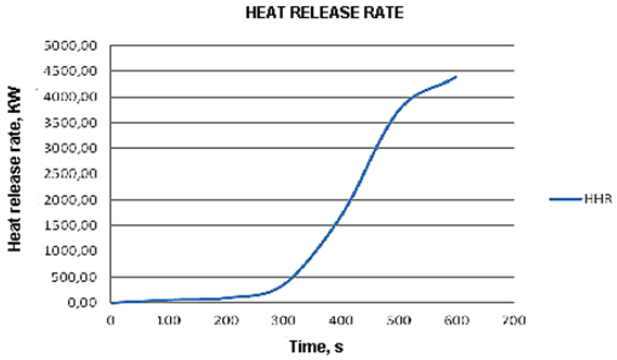

Figure 5. *Dependence of fire intensity on time*

Stages of fire development at 296 s, 375 s, 400 s and 600 s are shown in fig. 6 – 9.

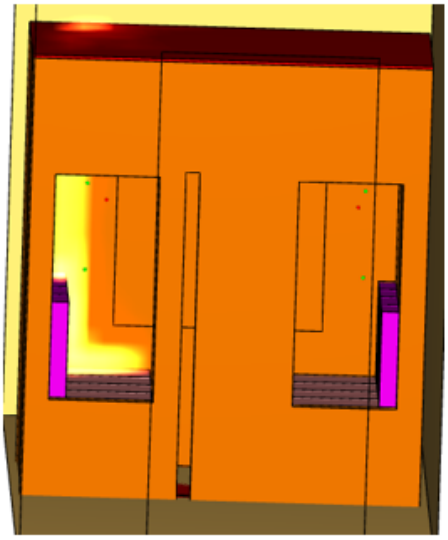

Figure 6. *Fire development at 296 s*

Figure 7. *Fire development at 375 s*

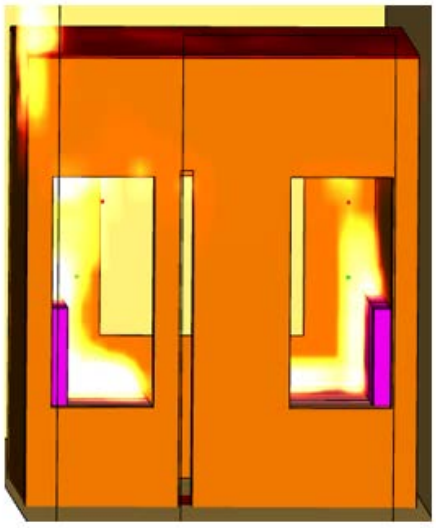

Figure 8. *Fire development at 400 s*

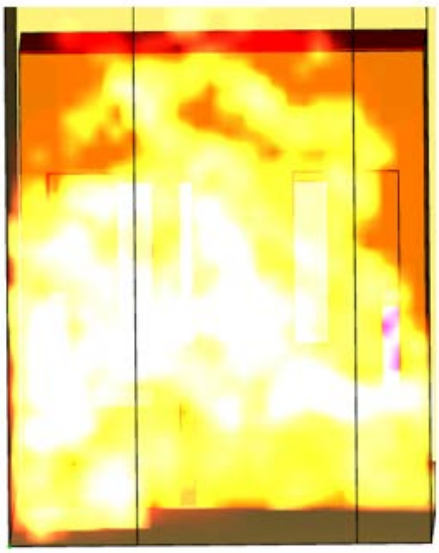

Figure 9. *Fire development at 600 s*

A similar development of the fire was observed in a real experiment described in [10].

To study the dangerous factors of the fire, a model of a second-class coupe, designed for the transport of passengers, in real size was built (Fig. 10-11).

Figure 10. *Model of a coupe on a railway car type B84*

Figure 11. *Model of a coupe on a railway car type B84*

To study the temperature change in the volume of the cabin, 24 thermocouples were installed, nine were placed in the volume of the cabin, eight on the walls above the seats, two on the inside of the window of the cabin, two on the wall above the window, three in height of the inside cabin door. The report analyzes data from eight thermocouples mounted at a height of 1.7 m, the height that is assumed to be the average respiratory level of a person in an upright position. The temperature is measured every 30 s. Values in the range of 70°C, with an exposure time of a few seconds to a minute, are considered to be critical closed temperature values.

The comparison of the change in temperatures in the volume of the cabin (Fig. 12) clearly shows the very good correlation between the data obtained from the real experiment and the simulation.

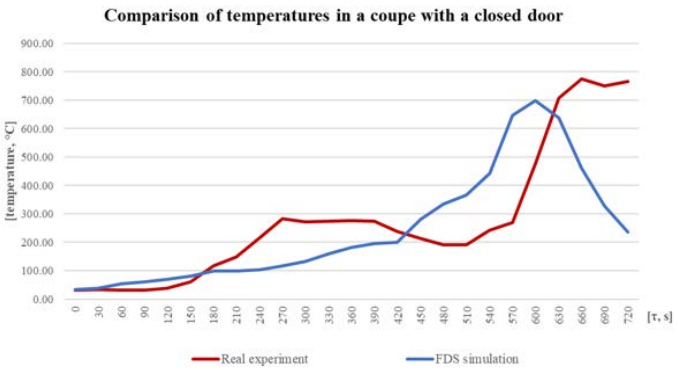

Figure 12. *Change in mean volume temperature*

The obtained results correspond well enough to the data from other publications [11, 13].

CONCLUSION

In this work, numerical simulation of fire onset and development in a railway passenger car has been performed using the FDS software. Additionally, the experiment was performed where temperature, heat release rate, and fire effluents were closely monitored. Moreover, samples of passenger seats were tasted in a cone calorimeter according to EN ISO 13927.

Conducting real experiments under these conditions is difficult; therefore, the results of the test presented show that the computational fluid dynamics (CFD) can be successfully used for simulation of the spread of fire in a compartment of a railway passenger coach. A clear definition of parameters of the object tested (geometry, kind and amount of the source of fire, initial and boundary conditions) is a necessary condition for performing successful tests.

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ANALYSIS OF ENERGY EFFICIENCY AND SAFE HANDLING OF HEATING BOILERS ACCORDING TO SRPS EN 303-5

Abstract: *Optimization of heat transfer process during combustion of solid fuels in heating boilers as well as constant monitoring of energy flows, contribute to energy efficiency improvement. Standard SRPS EN 303-5: 2016 defines requirements, methods and test procedures for evaluating safety, combustion quality and particulate emissions into the environment, performance characteristics and criteria for energy efficiency, as well as labeling and safe handling. Accordingly, the paper examines the efficiency of heating boilers based on the reduction of heat losses that occur due to radiation, convection and conduction, and analyzes the integrated aspects of safety through permissible emission limit values, as well as safe handling and fire protection.*

Key words: *heating boilers, energy efficiency, safe handling, SRPS EN 303-5:2016.*

INTRODUCTION

Accelerated development and implementation of technologies for the production of heat and electricity from renewables have not significantly reduced the use of renewable energy sources. It is estimated that by 2030, fossil fuels will account for 85% of the global energy mix [1].

The concept of energy efficiency has always been popular when it comes to energy issues. Recently, this concept has become not only a question of the economic viability of certain systems but also a very significant factor in a struggle to protect the environment [2,3]. In this sense, energy efficiency measures in coal-fired heating plants and thermal power plants are particularly important, as they reduce fuel consumption for the same amount of useful energy, resulting in lower emissions of carbon monoxide, nitrogen oxides, bound hydrocarbons and other particulate matter [4].

Construction Product Regulation (Official Gazette of RS, no. 83/2018) stipulates that space heating devices must comply with technical requirements that rely on conformity standards that specify not only the required characteristics but also methods for testing the mentioned characteristics. Measurement of these characteristics is carried out with the aim to determine the performance of the device - efficiency, gas emissions, particulate emissions and reliability under changing operating conditions.

Therefore, the paper analyzes the efficiency of manually filled solid fuel heating boilers with a nominal heat output of up to 500 kW, according to the SRPS EN 303-5: 2016 Heating boilers - Part 5: Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW - Terminology, requirements, testing and marking.

CALCULATION OF BOILER EFFICIENCY

The degree of utilization of heating boilers is calculated on the basis of: heat losses during combustion, losses due to incomplete combustion, losses that occur due to radiation, convection and conduction, and unburned carbon loss in ash:

$$\mu_k = (1 - Q_a - Q_u - Q_s - Q_b)\ 100\% \quad (1)$$

where:

μ_k - degree of utilization of heating boilers;

Q_a - heat losses during product combustion;

Q_u - losses due to incomplete combustion;

Q_s - losses that occur due to radiation, convection and conduction;

Q_b - unburned carbon loss in ash.

It is estimated that the boiler efficiency can be improved by reducing losses that occur due to radiation, convection and conduction.

When examining surface temperature, mean surface temperature must be measured at rated heat output. In order to do that, a measurement must be performed on each surface of the boiler at five sport at least. Under the same conditions, critical temperatures must be measured (for example, boiler doors, control levers, etc.). Losses are calculated taking into account total energy input. In that sense, we have examined two cases in which insulation losses and the degree of efficiency differ.

Case I, the measurement method involves temperature measurement at heated surfaces where the insulation losses are 3.4% and the total efficiency is 88.3%, Table 1.

Table 1. *Surface temperatures – case I*

	front door	back	right	left	up	down
a [m]	1,34	1,34	1,34	1,34	0,91	0,91
b [m]	0,61	0,61	0,91	0,91	0,61	0,61
T1 [°C]	90	24	32	29	44	25
T2 [°C]	82	28	30	33	36	25
T3 [°C]	114	29	29	52	40	24
T4 [°C]	61	30	24	30	34	26
T5 [°C]	95	33	26	30	28	26
T6 [°C]	98	37	25	45	41	24
T7 [°C]	97	38	24	28	57	24
T8 [°C]	118	24	22	29	30	23
T9 [°C]	82	25	23	42	31	25
T10 [°C]	45	24	24	34	37	24
T11 [°C]	49	25	25	50	41	24
T12 [°C]	37	23	26	40	60	23

In Case II, insulation made of 5 cm thick glass wool with thermal conductivity λD = 0.04 W/mK was placed on the front side, i.e. on a metal support. In this case, the insulation losses are 1.2%, the overall efficiency is 91.0%, Table 2

Tabela 2. *Surface temperatures – case II*

	front door	back	right	left	up	down
a [m]	1,34	1,34	1,34	1,34	0,91	0,91
b [m]	0,61	0,61	0,91	0,91	0,61	0,61
T1 [°C]	32	27	36	28	47	24
T2 [°C]	29	26	29	27	38	25
T3 [°C]	30	33	29	28	36	24
T4 [°C]	30	27	26	25	39	25
T5 [°C]	30	25	25	24	28	26
T6 [°C]	32	23	30	26	44	23
T7 [°C]	33	21	28	26	48	24
T8 [°C]	32	22	25	23	30	22
T9 [°C]	34	21	25	22	29	25
T10 [°C]	25	22	22	22	41	24
T11 [°C]	24	22	23	22	60	24
T12 [°C]	26	22	27	26	33	22

Comparative analysis of the tables leads to the conclusion that energy efficiency is better in the second case, but the impact of other elements should also be taken into account. When calculating the overall efficiency, the improvement may be perceived in terms of insulation improvement.

Heat loss

In the indirect method, it is necessary to be familiar with this loss type of loss. It can be obtained by the following procedure. The outer boiler casing is divided into areas of similar temperature (insulated surfaces, doors, flue gas connections, connecting pipes, the boiler base) and their temperatures are measured through the surface thermostat. The heat emission from the surface section is calculated as follows:

$$Q_x = F_x \alpha (t_m - t_L) \quad (2)$$

Where:

Q_x - heat emission from a surface section in W;

F_x - the surface area of the section in m^2;

α - heat transfer coefficient in $W/(m^2K)$;

t_m - mean surface temperature of the section in °C;

t_L - room temperature (measured at 7 points, 1,5 m from the front of the boiler at a height equal to half the boiler height) in °C.

Approximate heat transfer coefficients relative to the temperature of the surfaces can be obtained from Figure 1.

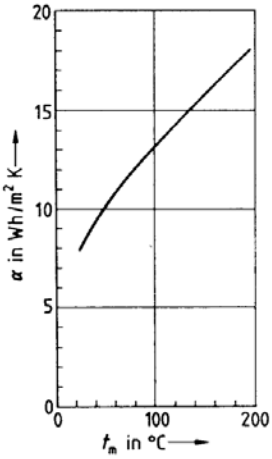

Figure 1. *Total heat transformation figure by radiation and free convection to the horizontal and vertical surfaces at an ambient temperature t_L=20 °C as a function of the mean surface temperature t_m*

SAFETY REQUIREMENTS OF THE STANDARD SRPS EN 303-5:2016

According to the general requirements of SRPS EN 303-5:2016 standard, the minimum performance requirements, as well as the safety requirements for heating boilers have been defined. Performance requirements are related to the power supplied to water and energy efficiency relative to the calorific value of solid fuels. However, both aspects largely depend on boiler construction and technical and technological solutions applied during construction. Decision criteria for determining boiler class are clearly defined by the standard SRPS EN 303-5. These requirements are usually met during boiler testing, and the measured values for the reference operating conditions are within

the limits specified in Table 3, which has an impact on the class of boilers.

Table 3. *Emission limit values according to SRPS EN 303-5*

Heating	Fuel	Nominal heat output	Emission limit values								
			CO			OGC			Dust		
			mg/m^3 at 10 % O_2								
		kW	class	class	class	class	class	class	class	class	class
			3	4	5	3	4	5	3	4	5
Manual	Biogenic	≤ 50	5 000	1 200	700	150	50	30	150	75	60
		> 50 ≤ 150	2 500			100			150		
		>150 ≤ 500	1 200			100			150		
	Fossil	≤ 50	5 000			150			125		
		> 50 ≤ 150	2 500			100			125		
		>150 ≤ 500	1 200			100			125		
Automatic	Biogenic	≤ 50	3 000	1 000	500	100	30	20	150	60	40
		> 50 ≤ 150	2 500			80			150		
		>150 ≤ 500	1 200			80			150		
	Fossil	≤ 50	3 000			100			125		
		> 50 ≤ 150	2 500			80			125		
		>150 ≤ 500	1 200			80			125		

Note: *The dust values in this table are based on the gravimetric filtration method. The test report should indicate the method used. The emission of particulate matter, measured in accordance with the European Standard, does not include condensing organic compounds which may form additional particulate matter when the flue gas is combined with ambient air. Therefore, the values cannot be directly compared with the values measured using the dilution tunnel method. Nor can they be converted into particle concentrations in the surrounding air.*

Measuring emissions of gases and particles is performed for periods required for the combustion of the amount of fuel that corresponds to the quantity of one filling inside the boiler furnace [5].

Boiler construction should meet general safety requirements in order to:

- prevent dangerous accumulations of flammable gases (> 5% CO) in the combustion chamber and in the flue gas ducts;
- withstand stresses that occur during normal operation;
- enable heat transfer media (water) not to be heated to the dangerous limit (≤ 110 ° C);
- avoid flame rollout and falling embers, in case when the boiler is properly handled;
- avoid hazardous gas leakage from a heating boiler, heating device or built-in bunker into the boiler installation place.

Components - built-in electrical components used during regulation and safety must meet the general requirements for electrical appliances safety - SRPS EN 60335-1 [6].

The manufacturer must do a risk assessment after the use of an appliance and give instructions for safe operation in the Operating Instructions, making sure that installation and commissioning have been completed by fully qualified personnel. Particular attention should be paid to the following hazards that can occur during heating boiler operation:

- elevated temperatures at the outer casing of the heating boiler and other boiler components used for operation;
- possible electric shocks;
- injuries from mechanical force during handling.

Components of the outer casing of the heating boiler, thermostat, safety appliances, and electrical components must be installed in such a way that the temperatures of their surfaces, while in operating mode, do not exceed the temperatures specified by the manufacturer or the temperatures specified in the component standard.

The materials for the components exposed to pressure must comply with generally accepted technical requirements. They must be suitable for that purpose and intended use. The supplier must deliver the proof of mechanical and physical properties of the materials used, as well as their chemical composition.

Safety during handling should be essential when designing the heating boiler. Also, the heating boiler must be designed and packaged so that it can be stored safely and without damage.

Heating boilers shall be equipped in such a way that they could be easily moved by means of internal transport in cases when they cannot be moved manually due to the weight, size, or shape of the boiler or its components.

Parts of the structure that are accessible during use and maintenance shall not have sharp edges and corners that could cause damage or injury to the person during handling or maintenance.

Engines and fans must be installed in a way to comply with the requirements for noise and vibration during use [7].

CONCLUSION

The significance of energy efficiency of heating boilers is reflected not only in its cost-effectiveness but also in environmental protection. By reducing energy losses in the process of heat production, regardless of the condition of the existing equipment, it is possible to significantly increase the efficiency of the boiler plant. In addition to the operating mode, losses have a serious impact on the costs of thermal energy generation. Of course, the loss of energy cannot be reduced to zero, but it tends to be reduced to a minimum. In case of heating boilers, it is assumed that highly efficient heating boilers are those scoring over 90% for energy efficiency. In harmony with this, the reduction of heat losses must be done by radiation, convection and conversion, which was done in case II by making insulation from glass wool. The safety of device handling must comply with a harmonized standard.

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Nikola Igić was born in Niš in 1970. He graduated from the Faculty of Mechanical Engineering in Nis and acquired the title of a graduate mechanical engineer. He was a Lead Engineer in the Laboratory for Gas Appliances Joint Stock Company for Quality Testing "QUALITY" Nis. He is currently the Head of the Sector for Assessment of Quality Management Systems.

ANALIZA ENERGETSKE EFIKASNOSTI I BEZBEDNOG RUKOVANJA KOTLOVIMA ZA GREJANJE PREMA SRPS EN 303-5

Nikola Igić, Goran Stevanović

Rezime: *Optimalnim iskorišćenjem prenosa toplote pri procesu sagorevanja čvrstih goriva u kotlovima za grejanje, kao i stalnim praćenjem energetskih tokova, postiže se veća energetska efikasnost. Standard SRPS EN 303-5:2016 definiše zahteve, metode i načine ispitivanja za bezbednost, kvalitet sagorevanja i emisije čestica u okolni prostor, radne karakteristike i kriterijume za energetsku efikasnost, obeležavanje i bezbedno rukovanje. U skladu sa tim u radu je izvršeno ispitivanje performansi kotlova za grejanje na osnovu smanjenja gubitaka toplote zračenjem, konvekcijom i prevođenjem i analizirani su integrisani aspekti zaštite kroz dozvoljene granične vrednosti emisija, kao i bezbednog rukovanja i zaštite od požara.*

Ključne reči: kotlovi za grejanje, energetska efikasnost, bezbedno rukovanje, SRPS EN 303-5.

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ANALYSIS AND MEASURES OF LANDFILL FIRE PREVENTION

Abstract: *Large quantities of solid municipal waste containing a variety of flammable substances, that are disposed of in sanitary and non-sanitary landfills and even illegal dump sites, usually entail a high risk of fire. The level of risk is increased by the presence of methane which is released by municipal waste decomposition. The number of landfill fires varies depending on the morphological composition of the waste, ignition sources, meteorological conditions, time of year, as well as fire protection measures. The paper describes the impact of flammable waste on landfill fires, as well as causes, frequency and procedures in preventing and extinguishing landfill fires.*

Key words: landfill fires, flammable waste, methane.

INTRODUCTION

In the Republic of Serbia, municipal waste is collected in an organized manner and disposed of in 164 registered municipal landfills. Each local government has its own landfill which, in most cases, is not sanitary. About 70% of municipal landfills operate without required permits and environmental impact assessments and are, therefore, categorized as unsanitary landfills. The existing landfills in most municipalities are already filled, while the majority of landfills do not meet the minimum technical requirements. The Waste Management Strategy proposes the construction of 26 regional sanitary landfills, 10 of which have been built so far. According to statistical data, about 20% of generated municipal waste ends up in illegal dump sites, which in Serbia amount to 2170 [1].

When it comes to landfill design and the conditions of safe waste disposal with the aim to reduce the risk of fire and explosions, air, water and soil pollution, we can distinguish 5 levels of landfill protection (Table 1).

In the territory of the Republic of Serbia, the level of protection for illegal dump sites is 0, the level of protection 1, 2 and 3 is given to non-sanitary municipal landfills, while sanitary landfills have the highest level of protection - 5.

Table 1. *Fire protection levels and negative environmental impacts [2]*

Levels	Level of control	Management & operation	Operational facility
0	**None**	Uncontrolled dumping–no controls	Uncontrolled burning, lacking most ‘‘control” functions
1	**Low**	Site staffed; waste placed in the designated area; some site equipment	Site staffed, some containment and management of combustion process; basic operating procedures to control nuisance
2	**Medium**	Waste compacted using site equipment; waste covered (at least irregularly)	Emission controls to capture particulates; trained staff follow set operating procedures; equipment properly maintained; ash properly managed
3	**Medium/high**	Engineered landfill site: use of daily cover material; some level of leachate containment and treatment; a collection of landfill gas	High levels of engineering and process control over residence time, turbulence and temperature; emission controls to capture acid gases and capture dioxins; active management of fly ash
4	**High**	Fully functional sanitary landfill site: properly sited and designed; leachate containment (naturally consolidated clay on the site or constructed liner); leachate and gas collection; final cover; post-closure plan	Built to and operating in compliance with an international best practice including e.g. EU or other similarly stringent stack and Green House Gas emission criteria fly ash managed as a hazardous waste using best appropriate technology

1. Impact of flammable waste on landfill fires

About 50% to 80% of municipal waste components are flammable substances. Organic waste is the most flammable compared to other components of landfilled waste (Figure 1). Waste can be of organic and inorganic origin. Waste of organic origin decomposes faster than a waste of inorganic origin. Organic matter disposed of in landfills are classified into two major categories:

- substances that decompose faster (from 3 months to 5 years)
- substances that decompose slowly (up to 25 years).

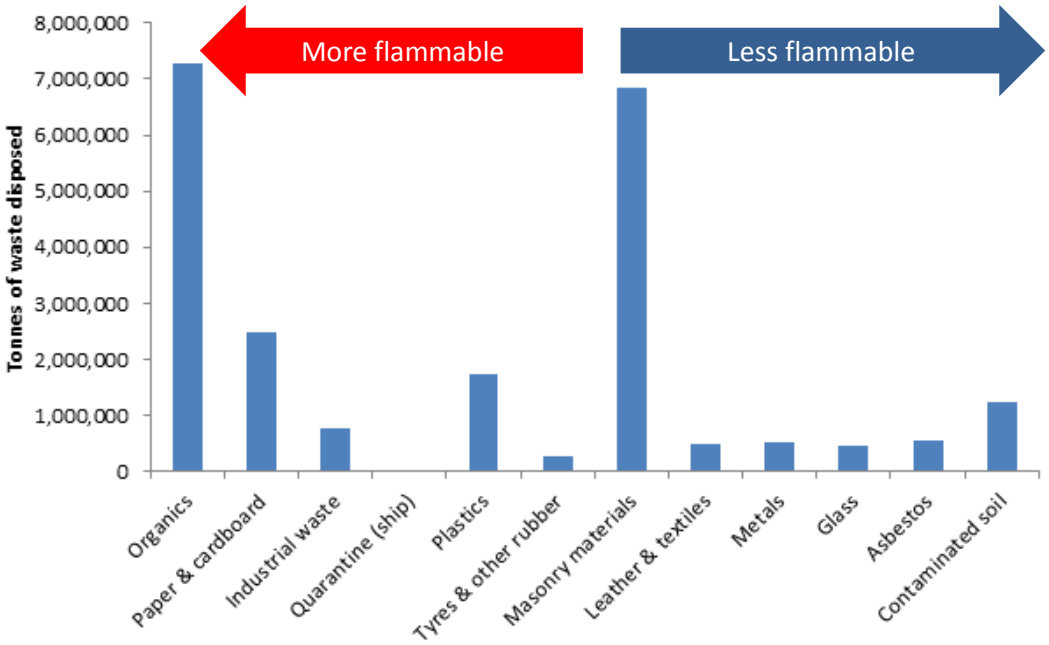

Figure 1. *Flammability of different waste types [3]*

Waste age influences the flammability of municipal solid waste because the ignition temperature and humidity percentage decrease as the waste age increases. Table 2 shows the values of smoldering and ignition temperature, time of smoldering and ignition, as well as humidity percentage for waste with morphological composition as follows: organic waste, paper, textiles, plastics, waste from public areas, metal, glass, construction material.

Table 2. *Smoldering and ignition temperatures depending on the age of waste deposits [4]*

Waste Category	Smoldering Temperature (°C) / Time (min)	Ignition Temperature (°C) / Time (min)	Moisture Content (%)
Fresh Waste	125 / 32	266 /47	53.75
3 Months Old Waste	120 / 31	227/36	36.35
6 Months Old Waste	105 / 26	195/30	29.84
36 Months Old Waste	102 / 25	181/26	5.21
60 Months Old Waste	98 / 23	179/27	2.63

In addition to landfilled waste, one of the main causes of fires and explosions is methane, which is the main component of landfill gas generated by waste decomposition. The risk of fire and explosion occurs within the flammability limits or explosive range from 5 to 15% vol. Based on the Decree on waste disposal in landfills ("Official Gazette of RS", No. 92/2010), sanitary and non-sanitary landfills are monitored to record the emission of landfill gases from reservoirs for landfill degassing, and methane gas is also monitored besides to other components. [5]

Table 3. *Monitoring the concentration of landfill gas components [6]*

Reporting	CH_4	O_2	CO_2	CO	H_2S	No. gas wells
2015	4.9 - 6.8%	10.9 -12.98%	13.4-15.9%	<1(mg/m^3)	<1(mg/m^3)	5
2015	5.1-11.4%	9.5-13.34%	16.1-19.5%	<1(mg/m^3)	<1(mg/m^3)	7
2016	0.1-1.9%	20.0-21.5%	0.1-1.6%	0 (ppm)	0 (ppm)	6
2017	0-16.3%	13.11-21.15%	0-6.1%	0 (ppm)	0 -11.8 (ppm)	22
2018	0-39%	1.87-21.02%	0-6.7%	0 (ppm)	0 -21.8 (ppm)	21

2. Causes and frequency of landfill fires

The most frequent types of fires are fires in the active area of the landfill (77%). The most common causes of fire on the landfill body are spontaneous combustion of landfill materials (54.6%), while the unknown causes of fire (21.2%) include arson as well as natural phenomena due to atmospheric discharge and solar radiation. The least frequent causes of landfill fires are explosions (0.4%).

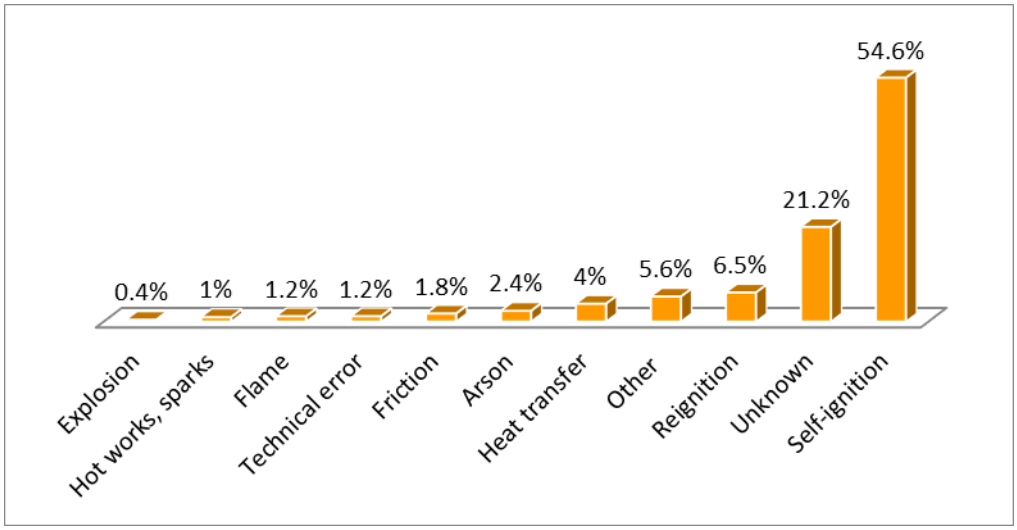

Figure 2. *Landfill fires cause statistics [7]*

Fires on landfill construction facilities – office and administrative buildings and other facilities (porter's lodge, weighing scales) comprise 7%. Possible causes of fires in the landfill buildings are: employee inattention, improper use of thermal devices, malfunction of electrical installations, work equipment, static electricity, emergencies (earthquakes, lightning strikes, etc.), deliberate fires, explosive devices, ignition of flammable substances near heat sources, spontaneous combustion of certain substances. Other fires at the landfill occur on refuse collection vehicles and in the green belt inside the landfill area.

Fires are categorized by the way they burn:

- flaming - burning with an open flame and
- burning fires - burning by smoldering without flame.

Flaming fires are characteristic of surface fires while burning fires are characteristic of underground fires.

In order to provide a more comprehensive insight into the frequency of landfill fires on the global level, Figure 3. shows the number of fires at the landfills in the USA and Canada for the 2016-2021 period.

From Figure 3, it can be concluded that the largest number of landfill fires occurred during the summer months. Records for the month of June indicate the greatest number of fires in 2018 and 2020; in July the largest number of fire outbreaks was reported for the years 2016 and 2017, while in August the largest number of fires was in 2019.

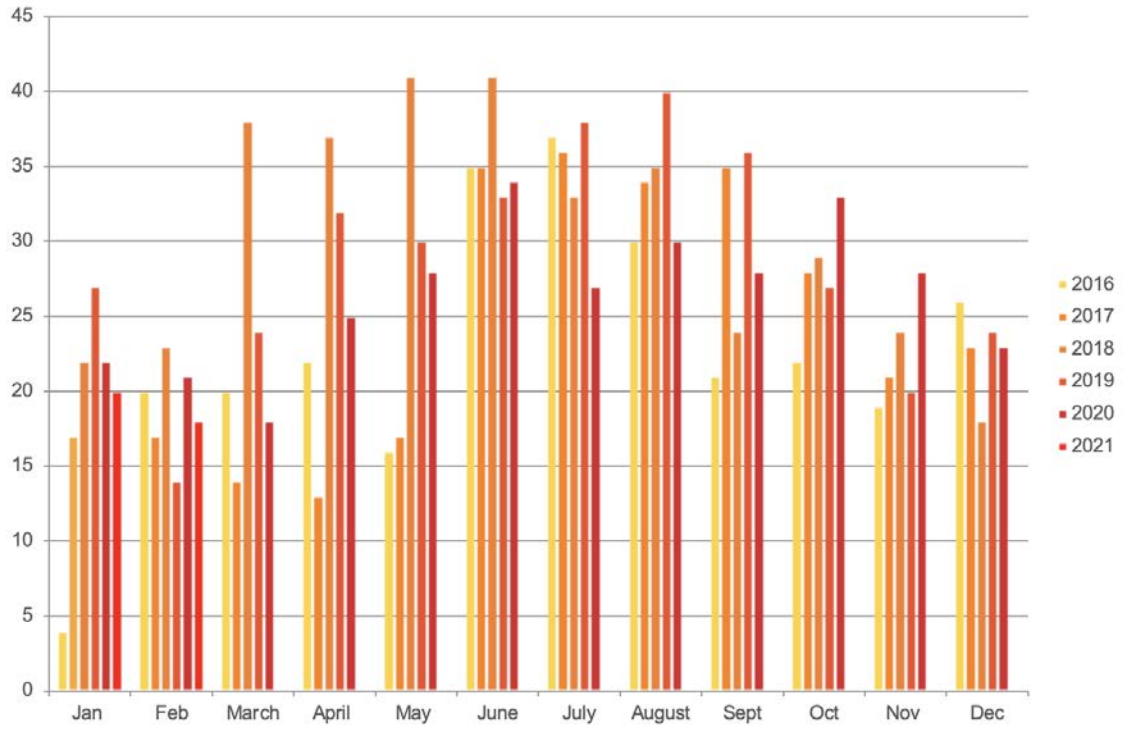

Figure 3. *Landfill fire outbreaks in the USA and Canada for the 2016-2021 period [8]*

3. Procedures for preventing and extinguishing landfill fires

To prevent the risk of fire outbreak and spread of a fire, as well as to mitigate its consequences, it is necessary to carry out the following:

- Proper construction of sanitary landfills implies selecting a proper location for landfill construction, Strategic Assessment and Environmental Impact Assessment Study, approved Main Technological Project, Environmental Impact Assessment Study, issued Decision on approval for construction of sanitary municipal solid waste landfill for the working area, Decision on the use permit for constructed sanitary municipal solid waste landfill for work area as well as the Decision on issuing hazardous waste disposal permit at the operator's location.

- Proper functioning and development of fire protection plans implies the following - According to the Law on Fire Protection, sanitary landfill belongs to the third category with a certain risk of fire and is obliged to organize the implementation of preventive fire protection measures with the necessary number of persons professionally trained to implement protection measures, as well as to provide adequate firefighting equipment and devices. In this regard, the following documentation is required:

- Fire protection rules
- Recovery plan for eliminating consequences of fire outbreak
- Accident protection plan
- Basic employee training in the field of fire protection
- Fire emergency evacuation plan

- Waste collection implies the transfer of waste from the point of use and disposal to the landfill, control of waste collected and classifying waste components for recycling. Waste residues are transported to the active area of the landfill by landfill roads. Disposal of municipal waste is done in stages, and afterward, waste is compacted in layers across the waste cells.

- Proper waste handling and storage are done on the active waste disposal area. Inert waste material is used as a layer to compress municipal waste. At the landfill site, there is always enough landfill cover material for the whole month. At sanitary landfills in the Republic of Serbia, there are passive degasification systems for collecting landfill gas from the landfill body. Daily covering by a layer of inert material on the deposited waste provides protection against wind-blown litter in and around the waste, birds, rodents and insects. The specialized service performs regular rodent pest control at the landfill sites and disinsection in the landfill facilities.

- Landfill firefighting depends on the landfill regulation and characteristics, combustible material at the landfill, ignition source, type of fire, meteorological conditions, the proximity of the fire brigade, firefighters' protection, water supply, access and mobility of heavy firefighting equipment, logistics, etc.

The following methods are used for fire extinction:

- cooling - lowering the temperature of combustible waste and lowering the temperature of self-ignition and flammability of combustible waste that is not caught by fire;
- separating fuel source from the air or oxygen - eliminating the inflow of oxygen and reducing the concentration of oxygen;
- intensive flame deceleration;
- removing the heat (flame) mechanically - as a result of water jetting or soil backfilling;
- fire partitioning, or
- the combination of the above-mentioned.

According to statistical data, the most common methods of extinguishing fires at the landfill are excavation (40%), soil covering (29%), water addition (17%), foam extinguishing (11%) and inert gas injection (3%).

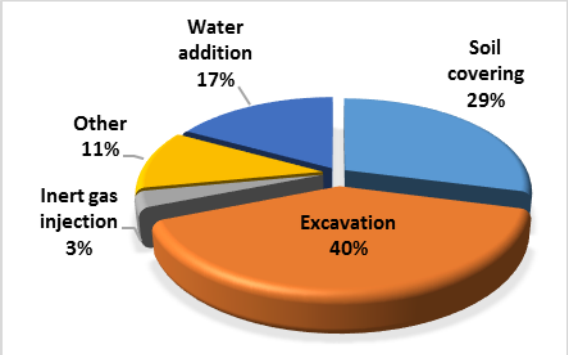

Figure 4. *Landfill fire extinguishment methods [9]*

- Recovery after a fire - If a fire occurs on the landfill body, it is necessary to properly handle the disposed waste that was affected by the fire and landfill leachate. In order to make a post-fire assessment, it is necessary to assess the damage to buildings caused by a fire within the internal waste reception and dispatch areas at the landfill, to assess the need for rehabilitation of buildings, as well as when and to what extent the damage can be restored and under what conditions a normal work process can be established. It is also necessary to consider how many employees have lost their jobs and whether employees can be engaged in repairing the damage caused by the fire. It is necessary to monitor the post-accident situation and eliminate the possible danger of recurrence of fire or explosion.

CONCLUSION

The Republic of Serbia has the lowest number of sanitary landfills with proper fire protection systems and without negative environmental impacts. Landfill fire outbreaks are initiated by various types of combustible waste, their age and methane as the most common flammable and explosive constituent of landfill gas. The most common cause of landfill fires is the self-ignition of combustible waste. Landfill fires are most prevalent in the summer months (June, July, August). Proper landfill construction, adequate functioning and development of fire protection plans, waste reception and proper waste management, firefighting interventions and remediation of fire damage are significant steps in preventing the risk of fire and stop fires from spreading.

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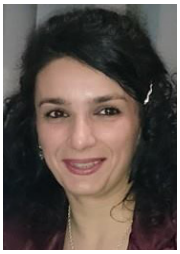
BIOGRAPHY of the first author



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ANALIZA I MERE ZAŠTITE OD DEPONIJSKIH POŽARA

Lidija Milošević, Emina Mihajlović, Jelena Malenović Nikolić

Rezime: *Velike količine čvrstog komunalnog otpada koje se odlažu na sanitarnim, nesanitarnim, a ne retko i na divljim deponijama, u čiji sastav ulazi veliki broj zapaljivih materija, predstavljaju visok rizik nastanka požara. Nivo rizika se povećava prisustvom metana koji se oslobađa razlaganjem komunalnog otpada. Broj deponijskih požara varira u zavisnosti od morfološkog satava otpada, izvora paljenja, meteoroloških uslova, doba godine, kao i mera zaštite od požara. U radu je prikazan uticaj zapaljivih vrsti otpada na deponijske požare, uzroci, učestalost i postupci u sprečavanju i gašenju deponijskih požara.*

Ključne reči: deponijski požari, zapaljivi otpad, metan.

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WEAKNESSES REGARDING OCCUPATIONAL HEALTH AND SAFETY IN MACEDONIAN COMPANIES

Abstract: *The current situation regarding Occupational Health and Safety in Macedonian companies and institutions is not satisfying. Very often these issues are neglected by the management. There is also a lack of transparency in terms of accident reporting. Therefore, Macedonia is far behind the EU average in terms of registered injures at works. This paper deals with some of the most frequent barriers and irregularities in this field, by analyzing the results from the survey conducted among the employees in Macedonian companies and institutions. The participants are divided into 3 groups - public entities and state administration, large companies and small and medium enterprises. The survey outcome indicates that the awareness, transparency as well as investments in this area are still not sufficient. Moreover, there is a lack of skilled and trained professionals in this field, especially in state-owned entities.*

Key words: occupational health and safety, implementation, barriers.

INTRODUCTION

The costs (economic, social and especially human) of occupational accidents, injuries and diseases as well as major industrial disasters have been a significant alarm at all hierarchy levels for a long time - from the individual workplace to the national and international level. Many measures and strategies are designed in order to prevent, control, reduce or eliminate occupational hazards and risks. They have been developed and applied continuously over the years, and in parallel with current technological and economic changes. Yet, despite continuous improvements, occupational accidents and diseases are still too frequent and their cost in terms of human suffering and economic burden continues to be a significant concern. The cost of accidents at work and occupational diseases in the EU-15 ranges from 2.6% to 3.8% of gross national product [1]. Occupational Health and Safety (OHS) is an extensive multidisciplinary field, which tackles issues related to different scientific areas such as medicine – including physiology and toxicology, ergonomics, physics and chemistry, as well as engineering, economics, law and other areas specific to various industries and activities [2]. Implementation of an Occupational Health and Safety Management System (OHS MS) is a valuable approach, but the effectiveness is influenced by a range of internal and external factors [3]. These factors include:

- inadequate resources (equipment, human resources, etc);
- lack of management commitment;
- limited mechanisms of accountability
- insufficient investments in training, protection equipment, risk evaluation, etc.;
- investments in OHS are mainly regarded as costs;
- frequent internal reorganizations.

The effective implementation of OHS MS has other benefits despite its principle role - prevention of work injures and professional diseases. A consistent approach in terms of OHS improves the image and helps generate positive public relations (PR) for the business, improves the business efficiency, has lower maintenance costs, leads towards lower insurance premiums (since the company shows that can manage the risks), etc.

Corporate Social Responsibility (CSR) considers how a business deals with its economic, social and environmental impacts in the way it operates. OHS can play a major role in the effectiveness of these principles. The following activities have particular relevance:

- including OSH in wider corporate governance initiatives;
- ensuring OSH risks are adequately addressed by contractors and suppliers, and
- motivating other enterprises to make OSH improvements through peer pressure.

Besides the described benefits from OHS practices and systems implementation, unfortunately, a number of obstacles, barriers and even irregularities are omnipresent especially when it comes to developing countries. The causes of barriers and irregularities in this field should be addressed both on the relevant authorities' level and companies' level. These countries are facing underdeveloped technological culture, corruption, inefficient public administration and public utilities, etc. Moreover, the current situation could be described as quite resilient to change.

Hence, this paper addresses the main weaknesses, obstacles and even irregularities in the Macedonian companies regarding OHS, having into consideration

the employees' perception. It is focused on the identification of these weaknesses in terms of their origin (lack of expertise, resources, awareness, training, etc) and their disparity among the 3 types of entities (according to their ownership and size).

PROBLEM DEFINITION

Background

OHS is a legal obligation in Macedonia, encompassed with the correspondent Law as well as about 30 bylaws. European regulations and standards are transposed into the national legislation. Despite the solid legislative environment, there are difficulties in terms of a practical approach towards creating the OHS preventive culture. Moreover, the instruments for detection of the individual responsibility must be established. The reporting for the accidents at work should be more transparent and in due time. In addition, the national system for health statistics which includes the OHS should be improved in terms of reporting, monitoring and prevention. According to WHO Health for All Data Base (WHO HFA DB, 2010), [4] the rate of work injures incidence per 100 000 workers in the European region is 585.39, in the EU member states it is 916.71, while in Macedonia is only 51.03. The number of injures with fatal consequences based on the same source is as follows: European region – 1.45, EU countries – 1.14 and Macedonia – 0.1. This is an indication of the irregularities in the reporting of these issues in Macedonia. Moreover, there is a problem with the registration of occupational diseases. Namely, the register for occupational diseases in the country is not functioning at all. Failure to report is identified as one of the main problems in the country in the field of OHS [5]. One of the main reasons for underreporting is considered the no readiness of the managers to accept the responsibility for a certain event because they are concerned about the consequences from the inspection bodies. Moreover, the annual reports on fatalities should include the cause for the accident with fatal outcome (electrocution, fall, etc.) in order to target future prevention and education activities in certain industries [6].

Although the majority of Macedonian companies and institutions have implemented OHSAS 18001 and/or ISO 45001: 2018, there is still a significant lack of commitment towards these issues, which mainly arise from the company's management team. Moreover, very often OHS activities and obligations are marginalized. In some cases, the obligations of OHS professionals are underestimated as well as the criteria for OHS responsible officers' appointment. To perform their professional functions, OHS responsible officers must have proper education (engineering degree), training and corresponded practical experience [7]. Although the national OHS Law requires a bachelor's degree in engineering, very often appointed responsible officers do not satisfy the job requirements, or their educational background is not corresponding with the core activity of the company. Based on a study from 2018, out of 711 certified OHS officers in Macedonia, only 10% are engineers in OHS [8].

The majority of OHS activities in the Macedonian companies are *pro forma* implemented, only because they are required by the Law. On the other side, there is a significant lack of preventive activities (especially in terms of education and training), risk analyses and safety improvements (investigation of the causes for the accidents and/or "near miss" situations), etc. Different patterns of companies' behaviors could be identified based on the company type and ownership. Large companies, especially foreign investments have solidly established OHS principles and standards, which are strongly integrated within their corporate culture. Small and medium enterprises (SMEs) are often facing a lack of finances for implementing certain OHS measures and activities, although they pay attention to hiring good OHS professionals. The biggest concerns in terms of barriers and irregularities in OHS implementation arise from public companies, as well as public and state administration. Political influence, corruption, nepotism and cronyism lead towards over-employment as well as employment of not suitable candidates for these posts. Very often, OHS officers are appointed workers without appropriate education, and even without working experience. Thus, OHS in such institutions is continuously neglected. When an accident or injury occurs, the management is trying to avoid reporting. In the case of irregularities that are somehow linked with the accident, they will also try to discourage the injured workers from starting a lawsuit against the company. Moreover, the lack of knowledge and awareness for detailed investigation of the causes for certain accidents creates a fertile ground for future similar safety problems and remains a long-term burden for the company. Namely, the proper conduction of such investigation could derive a new technological or engineering solution that could be not only safer but also more efficient.

Survey preparation

The above-mentioned obstacles and barriers could be summarized based on their area of origin - a source of the particular weakness. Based on this approach, Figure 1 presents the main groups of factors - sources for barriers and irregularities in terms of OHS in Macedonian companies. Some of them are related to organizations and behaviour, while others are related to engineering specifics (workplace safety). The latter is strongly related to the particular industry characteristics and requires skilled engineers in the role of OHS officers. When it comes to manufacturing industries, the implementation of health and safety principles during the product (manufactured good) design is of key importance. Thus, the elimination or control of OHS hazards is best accomplished at the machine, tool, or facility design stage. Retrofit control must be added

when a hazard exists, but it is usually more costly and less effective than control in the initial design. Nevertheless, the well-established role and responsibilities, as well as good competencies and established control procedures are present in all groups of factors and are of key importance for overcoming the barriers and irregularities in OHS.

Based on the identified factors shown in Figure 1, a questionnaire was prepared and distributed among employees in different positions and with different levels of education. The survey encompasses employees who are not directly involved in OHS activities and are employed in different companies (both in terms of type and ownership). The answering of the questionnaire was anonymous, assuming that the participants will be more honest in presenting their perception of the problems. The questionnaire was answered by 52 persons, from different types of companies and/or institutions. The persons' affiliations are the following:

- 24 from SMEs;
- 16 from large companies;
- 7 from the state administration, and
- 5 from public utilities.

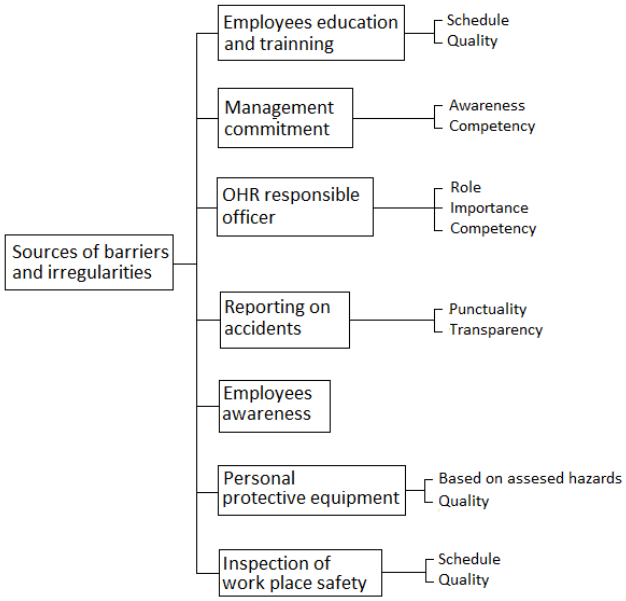

Figure 1. *Main groups of factors affecting OHS in Macedonian companies*

Having into consideration the ownership, the participants from state administration and public utilities (12 in total) are merged as one group of participants. The questionnaire was focused on the employees' comprehension and acquaintance in terms of their OHS rights, as well as their perception regarding implemented OHS measures and practices. Several questions were related to the educational background and skills of the OHS officers in the companies, while other sets of questions were correlated with accidents reporting, frequency of OHS audits, investigation of the accidents and "near-miss" incidents, as well as the assessment of management commitment. The total number of questions was limited to 17 (multiple choice questions), in order to keep the focus of the participant in as much as the possible shortest time required for answering. Nevertheless, the survey was intended to encompass the relevant OHS aspects and to quantify their weaknesses in the Macedonian companies and institutions from the employees' perspective. The findings from the survey are summarized and analyzed based on the type of the company as well as on the question's topics. In accordance with that, this paper presents specific comments and conclusions on the following issues: OHS officers quality and visibility in the company (appointment, license, elected representative from the employees), employee's rights in terms of OHS (statement, personal protective equipment (PPE), education and training), management behaviour (awareness, investment in OHS, audits) and accident reporting (transparency and established practices).

RESULTS AND DISCUSSION

The results indicate that the employees have a significant lack of knowledge and information in terms of OHS and their OHS rights including the ones stipulated by the Law. The survey results in terms of responsible OHS officers are shown in Figure 2.

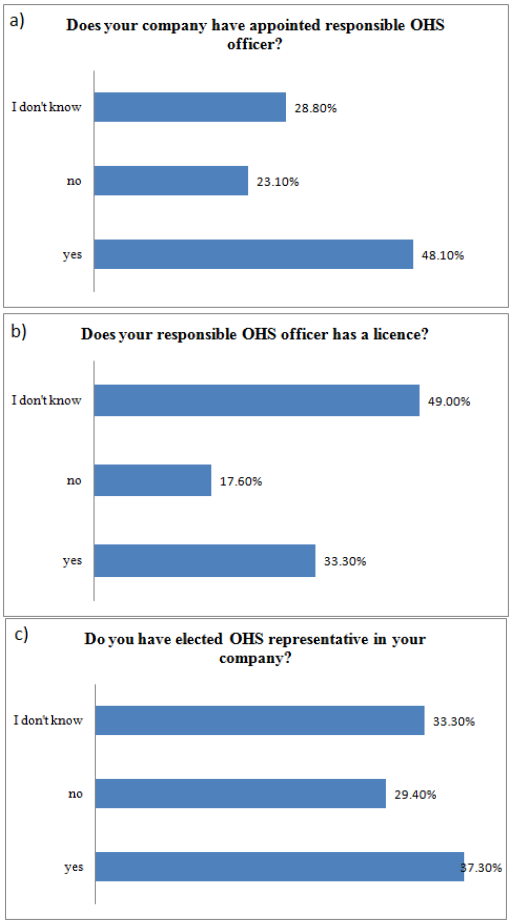

Figure 2. *Survey's findings in terms of OHS officers*

It indicates that the number of companies without appointed responsible OHS officers could not be neglected. Namely, 23.1% of the participants answered that their company doesn't have a responsible OHS officer, while only 33.3% of the appointed OHS officers have a licence issued by the Ministry of Labour and social policy. Thus a significant number of companies and institutions are actually on the other side of the Law when it comes to their OHS obligations, which refers to the management's ignorant behaviour. Not less concerning is the fact that the percentage of participants that are not familiar with these issues (whether a company has appointed an OHS officer and what his/her qualifications are) is quite significant. In addition, a large part of the employees doesn't know if they have elected OHS representatives (elected by the employees). Hence they are not familiar with their rights stipulated by the OHS Law. Moreover, the results indicate that the recruiting process in this area is faced with serious challenges, especially when it comes to state-owned companies and institutions. Namely, even 27% of state-owned and public companies are without responsible OHS officers, while only 6% of large companies failed to comply with this obligation.

Figure 3 deals with the training and education weaknesses as well as the availability of the required PPE.

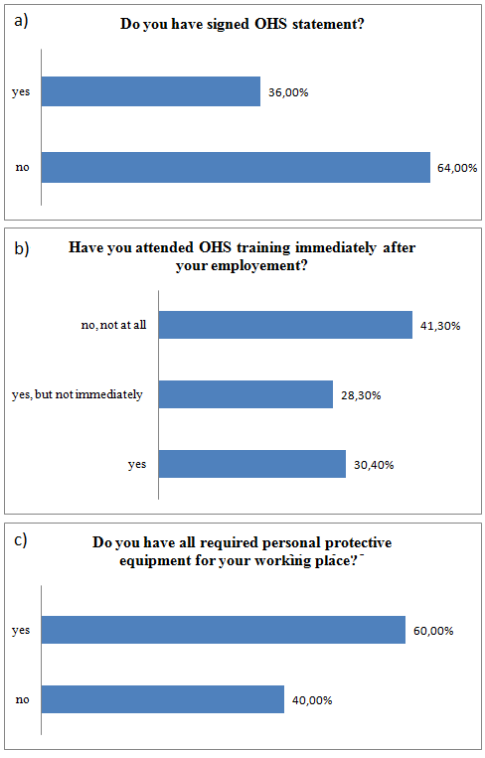

Figure 3. *Results regarding OHS training and education*

OHS training and education is a crucial element in creating OHS culture and awareness. OHS training is a legal obligation, and it must be realized every 3 years. However, the fact that 64% of the survey's participants don't have signed OHS statements is quite concerning. As per Figure 3, it could be also noticed that a large majority of the participants don't have signed an OHS statement, which is a legal obligation and its absence is very serious irregularity. Once again, it is confirmed that the situation is the worst in public and state entities, where are located 83.4% of the participants without an OHS statement, while in the large companies there is only a small number of participants without it. When it comes to OHS training, there is a significant share of participants who didn't have OHS training at all. The majority of them come from public and state institutions (56.3%), while only 12.5% from large companies. In terms of PPE availability, 40% of the participants are facing a lack of PPE. The situation is the most concerning in SMEs, where almost 1/3 of the participants come without the required PPE. Surprisingly, that share is the lowest among public and state entities. On the other side, this fact could indicate a situation of oversupply and misuse of public funding for unnecessary procurement in public and state-owned entities.

Figure 4 presents the survey outcome in terms of management awareness, investments in OHS and frequency of performed OHS internal audits.

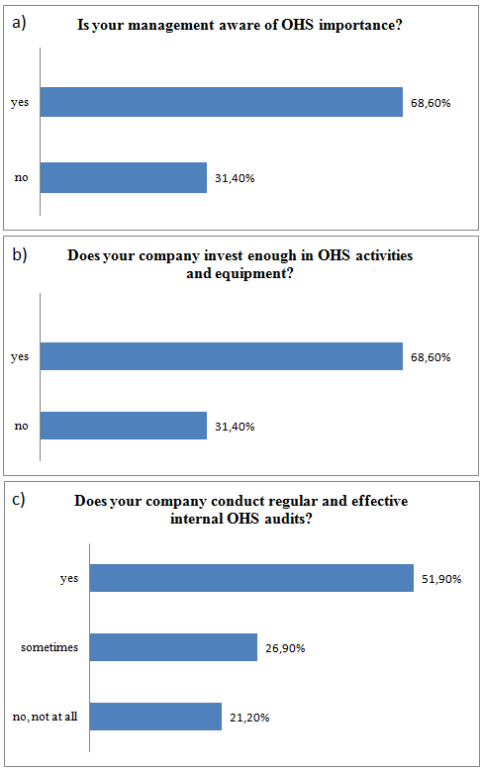

Figure 4. *Survey's findings regarding management awareness and commitment for OHS*

The majority of participants consider that their management is aware of OHS issues' importance (68.6%), and think that their company invests enough in OHS. As per the OHS audits, the situation is more concerning. Only half of the participants (51.9%) confirm that their company performs internal OHS

audits on a regular basis, while 21,2% of the companies have never conducted it. Among the companies that have never conducted an internal OHS audit, the most numerous are public and state-owned, while this number is the lowest when it comes to large companies. Thus, the large companies which are mainly part of the multinational corporations (foreign investments) have established solid OHS practices especially when it comes to recruitment of OHS officers, providing regular employee training and education as well as their attention on fulfillment of the legally binding obligations in terms of OHS statements. On a contrary, these issues are quite neglected in state-owned entities, where there is significant political influence over the employment process. Besides the aforementioned, Figure 4 shows that the management's awareness of the importance of OHS should be improved, and additional investments in these issues are required. The system of regular and effective internal OHS audits is often not established, and the corresponding strengthening of the capacity is required, in particular for public and state-owned entities.

Last but not the least, Figure 5 is presented the current situation in terms of transparency and punctuality regarding accident reporting.

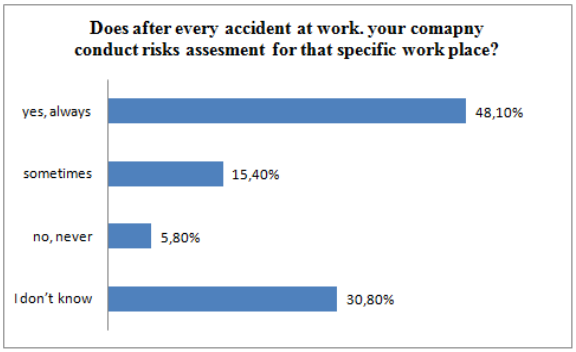

Figure 5. *Survey's findings regarding accident reporting*

According to Figure 5, only one-half of the answers confirm that after each accident a comprehensive risk assessment for that specific work is a regular procedure. It is rather surprising to note that even 25% of the participants from public and state entities said that such an assessment had never been performed. On a contrary, none of the participants from SMEs and large companies alleged such behaviour. Since the accident reporting has already been pointed as one of the main weaknesses of OHS in Macedonia, the straightening of the institutional capacities (in particular State Labour Inspectorate) and more severe penalties for the managers and other responsible persons could lead towards improvement of this situation.

The overall survey results show that the major weaknesses could be located in internal and effective internal audits and regular and proper conducting of the accident investigation causes including risk assessment of the workplace. Training and education must not be neglected. Such an approach could foster improvements in safety and efficiency aspects and will contribute to lower maintenance and insurance costs on a long-term basis.

CONCLUSION

This paper addresses some of the main weaknesses, barriers and irregularities in terms of OHS in Macedonian companies and institutions. Hence, it could be noted that raising awareness both regarding employees and the management is quite important. Regular training as well as solid human resources policy when it comes to OHS officers' appointments is also quite significant. OHS issues are particularly neglected in state and public companies. Moreover, regular inspection in terms of risk reduction and elimination of possible sources for accidents and injuries is also one of the fields that must be improved. The overall results from the conducted survey refer to the large companies as the most aware and organized in terms of OHS, while state and public companies are the least aware. The latter is an advantage only in terms of PPE procurement. For this reason, focused and coordinated actions are necessary in order to overcome such obstacles. Moreover, in a lot of cases it doesn't require additional financial resources, but a good organization, awareness and commitment for OHS issues. Hence, the improvements in OHS systems in Macedonian companies and institutions could be done via the establishment of solid criteria for OHS officers appointments (especially in state-owned entities), development of good engineering and safety skills using continuous training and education, regular and optimal budget allocation for PPE as well as regular inspection of working places and tools in order to prevent hazards. Moreover, the inspection of the machines and the closest working environment after every accident and/or "near miss" is very important for the prevention of future similar events. This aspect is quite neglected and requires significant efforts for its proper implementation. One of the main preconditions is the solid engineering knowledge of the OHS officers gained through formal education and years of practice experience. On the other side, the employment awareness for their rights in terms of OHS should be improved by means of training and lectures, public campaigns, etc. Only through a comprehensive approach and involvement of all stakeholders, will the weaknesses in OHS in Macedonian society be conquered, and the country statistics on work-related injuries and fatalities be at the same time transparent, prompt and corresponding to the reality. Needless to say, the common interest is that these numbers are as lowest as possible; however, they must be real.

ABBREVIATIONS AND ACRONYMS

EU European Union
OHS Occupational Health and Safety
WHO World Health Organization
OHSAS Occupational Health and Safety Assessment Series
SMEs Small and Medium Enterprises
PPE Personal Protective Equipment

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PROCENA PROBLEMA U VEZI SA PRIMENOM BEZBEDNOSTI I ZDRAVLJA NA RADU U MAKEDONSKIM KOMPANIJAMA

Daniela Mladenovska, Ilina Dubravac

Rezime: *Trenutna situacija u vezi sa bezbednošću i zdravljem na radu u makedonskim kompanijama i institucijama nije zadovoljavajuća. Menadžment vrlo često zapostavlja ova pitanja. Takođe nedostaje i transparentnost u pogledu izveštavanja o nezgodama. Zbog ovoga, Makedonija je daleko iza proseka EU u pogledu registrovanih povreda na radu. Ovaj rad se bavi nekim od najčešćih prepreka i nepravilnosti u ovoj oblasti, analizirajući rezultate ankete koja se odnosi na ova pitanja sprovedene u makedonskim kompanijama i institucijama. Rezultati pokazuju da svest, transparentnost, kao i ulaganja u ovu oblast još uvek nisu dovoljni.*

Ključne reči: bezbednost i zdravlje na radu, primena, barijere.

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STRESS AND IMPORTANCE OF PSYCHOLOGICAL PREPARATION OF FIREFIGHTERS

Abstract: *A firefighter career is one of the most demanding in the world. Everyday effort and stress, as well as the dangers of this profession, make it one of the most difficult occupations. Firefighters are exposed to various sources of stress that can cause certain psychological issues. Indicators of stress in firefighters can be classified into physical, emotional and behavioral. There are various ways to prevent the occurrence of stress, as well as how to reduce the effects of stress if it occurs. Significant factors affecting the effectiveness of firefighters during intervention are firefighting equipment, techniques and tactics. However, if the firefighter is not mentally prepared, motivated and trained, the outcome of firefighting intervention could be unpredictable. Therefore, the role of the psychologist is to provide psychological assistance to firefighters after difficult interventions.*

Key words: *firefighters, psychological selection, occupational stress.*

INTRODUCTION

The job of a firefighter is, by all means, one of the most demanding occupations in the world. Everyday effort and stress, as well as the dangers and risks of this profession, make it one of the noblest and one of the most difficult occupations at the same time. If we take into account the state of Serbian institutions, we conclude that firefighters in Serbia have an even more difficult task to respond to constant challenges.

In the United States, among "civilian occupations", the job of a firefighter is assessed as the most stressful [1]. During work, firefighters are exposed to various sources of stress that can cause psychological difficulties [2]. Psychologists deal with these problems of mental readiness, professional stress and motivation. By acting at different command levels in firefighting, psychologists can make a strong contribution to readiness and contribute to human resource challenges.

The job of firefighters

The work of firefighters is characterized by exposure to all forms of physical, chemical and biological endangerment of life and health, and is often performed in uncontrolled working conditions. Its key features are stress and risk. Their long-term impact on health and work ability is constantly emphasized. In the Republic of Serbia, firefighting is defined as a professional, but also humanitarian activity of exceptional national importance. Firefighting also involves the implementation of preventive measures against fire and explosion, firefighting and rescue of people and property endangered by fire and explosion, providing technical assistance in accidents and dangerous situations and performing other tasks in various accidents. Given the many potential dangers, harms and damage to health to which firefighters are exposed during firefighting interventions, firefighters' health surveillance must be comprehensive and continuous if we want to detect deviations on time and prevent further deterioration of health. If we desire to assess the degree of difficulty and the psychophysical efforts of firefighters, the following criteria should be taken into account: the urgency of action, the unpredictability of operations, long-term shift work and constant state of readiness, and psychophysical responses during the intervention [3].

Firefighters mainly work during peacetime; however, they are equally involved in war-related interventions. In peacetime, firefighters participate in disaster response, emergency actions to rescue people and material goods. The modern way of life requires the use of new chemicals and materials with different properties and behavior in the combustion process as well as the use of novel technologies, so it is very difficult to predict and plan all types of interventions [4]. Interventions can be roughly divided into three types: accidents, fires, technical interventions. Accidents can be classified as follows: water accidents, construction site accidents (pumping water-closing water-gas), accidents in industry, traffic accidents and accidents-events where no people are involved. Fires can be divided as follows: chimney fires, landfill fires, surface fires that are fueled by grass, shrubs, low-lying vegetation, and forest fires; transportation fires, fires in buildings, fires in industry or production facilities and fires-events where no people are involved. Technical interventions in the frame of firefighting include: technical assistance such as the emergency opening of apartments, technical interventions on a building, technical interventions in the open space - repairing / removing obstacles, firefighter interventions to rescue people and animals, technical interventions in traffic

[5]. The likelihood of risk occurrence for a particular intervention is represented in five categories: very unlikely, unlikely, possible, likely, and very likely.

It is theoretically possible that all types of risks occur with each intervention under certain conditions. These risks, as well as the probability of their occurrence during the intervention, were assessed based on the experience of the interviewed firefighters. In all types of interventions, there is a physical effort (dynamic and static), as well as psychophysiological effort (stress), which differ in type and intensity depending on the work performed within a particular job [6]. Workplace risks have been assessed for the following jobs: unit commander, deputy unit commander, shift commander, deputy shift commander, fire brigade leader, firefighter/driver, firefighter.

Risks, hazards and efforts that firefighters face can be divided into the following groups [7]:

- mechanical hazards: handling chainsaw, hydraulics, falls from heights, falls on a single level and falls to a lower level, dangers of mines and explosives, dangers of landslides
- dangers of electric shock
- thermal hazards: hot parts, subcooled parts (technical gases)
- chemical hazards: dust, gases, vapors, mists, liquids, etc.
- biological hazards: bacteria, fungi, viruses (all human and animal secretions)
- dangers from domesticated and farm animals, and wild animals (e.g. bites, etc.)
- microclimate: work in all weather conditions (heat, cold, humidity)
- insufficient lighting during the intervention
- physical exertion: lifting, carrying loads, working in an unfavorable posture, overhead working, kneeling, lying position
- psychophysiological efforts (stress, uncertainty, working in a time gap, human casualties, etc.).

Due to the very specific working conditions and numerous risks that cannot be completely eliminated, it is important to keep records of fire brigade interventions and possible injuries at work, in order to apply the best possible measures and reduce the occurrence of injuries.

Sources of psychological stress

Stress is a topic that has been extensively discussed in the last twenty years since the modern way of life triggers various situations that are inherently stressful. As a result, an increasing number of people are affected by stress and suffer from its consequences. There are different types of stress - physiological, sociological and psychological.

Physiological stress occurs as a reaction of the organism to harmful stimuli, while sociological stress is a reaction of a social community exposed to stressors [8]. Psychological stress has the strongest negative impact on firefighters. Stress, generally, represents a situation in which the balance is disrupted in a certain way and the resulting change requires a person's psychological adjustment.

If the personal balance is shifted or disrupted significantly and if the pressure is extremely high, the person must make considerable effort to adapt. This is known as the situation of intense psychological stress. Whether a situation will be stressful for a person depends on whether the person perceives the situation as threatening or not [9]. The same situation can be experienced by two or more people in different ways, i.e. for some it can be extremely stressful, and for another person, it may not be stressful at all, and they can even enjoy it. For example, driving a fire truck at high speed to arrive at the scene of an intervention can be extremely stressful for some firefighters, while others could enjoy this kind of driving. Moreover, there are differences in stress tolerance among people. Some people can easily manage higher levels of stress compared to others. We usually distinguish between high, limited and low resistance to stress. This should be taken into account when assessing the individual abilities of firefighters and assigning individual tasks within the unit. Firefighters are exposed to various sources of mental stress during work. In firefighters, we distinguish between "organizational" and "non-organizational" sources of stress, and sources of stress that are related to the "state of readiness" and those directly related to firefighting intervention [10]. In addition to the usual sources of stress that have a negative impact, there are specific sources of stress for firefighters. The most significant sources of stress related to the work of firefighters are:

- feeling of lack of personal competence and/or competence
- lack of prescribed procedures or standard operating procedures,
- unclear, ambiguous, incomplete or contradictory procedures,
- insufficient training and work with rescue equipment,
- the need for quick decision-making, with insufficient information,
- high risk of collapse and risk of injury or victims trapped under the rubble,
- inability to quickly access a victim in need of immediate assistance,
- exposure to disturbing, highly stressful and potential traumatic events (severely injured and/or fatally injured persons, seeing mutilated bodies, body parts, etc.),
- exposure to the media and the public,
- contacts with the victims' family and friends,
- the need to assist victims (eg first aid, psychological assistance, etc.),
- limitations in objective rescue possibilities (lack of resources, extremely unfavorable rescue conditions, etc.),

- managing untrained groups of volunteers who spontaneously get involved in search and rescue,
- poor coordination and difficult cooperation with other rescue teams at the scene of an accident or disaster, etc.

Certain signs help firefighters more easily recognize the state of stress among them and other fellow firefighters. Signs that indicate the existence of stress in firefighters can be classified into physical, emotional and behavioral [11].

Physical signs of stress in firefighters are:
- frequent headaches,
- rapid heartbeat,
- stiff neck and pain in the shoulders,
- rapid breathing,
- back pain,
- trembling or muscle tension,
- sweating, sweaty palms,
- stomach pain,
- high blood pressure,
- dry throat,
- dizziness, etc.

Emotional signs of stress in firefighters are:
- fear or anxiety,
- emotional tension,
- aggressiveness,
- guilt,
- job dissatisfaction,
- tension,
- anxiety,
- irritability,
- boredom,
- apathy,
- sadness,
- depression.

Cognitive symptoms are:
- forgetfulness,
- fluctuation of attention,
- observation errors,
- decreased concentration,
- slow or too fast decision making,
- decline in creativity,
- thought blocking, intrusive thoughts and increased suggestibility.

Behavioral changes:
- reduced productivity,
- absences from work,
- eating disorder,
- increased consumption of addictive substances,
- sleep disturbance,
- propensity of conflict,
- withdrawal.

Psychological preparation and training

Given that psychological stress can have an extremely negative impact on firefighters, during the action itself, but also after its completion, it is important to prepare and train firefighters to successfully deal with stressful and potentially traumatic situations. It is necessary to conduct psychological preparation of firefighters, on several levels. Planning and implementation of psychological support for firefighters are carried out by qualified psychologists in cooperation with fire commanders at the strategic, tactical and operational levels [12]. Psychological preparation should be carried out:
- during the implementation of various training programs for members of the fire brigade, or
- immediately before taking action (if possible in time), and in particular before sending the rescue team as part of international assistance to other countries affected by a major disaster or catastrophe.

In such situations, it is necessary to implement the psychological preparation programme of the families of firefighters who are sent to international rescue operations. The appropriate form of psychological support is mandatory after the rescue operation, especially if firefighters were members of the Rescue Team exposed to highly stressful or potentially traumatic events (finding and caring for the dead and seriously injured, serious injury or death of rescue team members, etc.). The task of the psychologist is to carry out the procedure of disaster relief training and thus accelerate the psychological recovery, and prevent the occurrence of severe psychological difficulties such as post-traumatic stress disorder (PTSD) and suicide among firefighters.

As part of the psychological preparation, firefighters need to be trained in the basics of psychological first aid as early intervention during the rescue operations under the rubble [13]. Accidents, and especially major accidents and catastrophes, have a strong psychological effect on both firefighters, and Rescue Team members, and the injured. Rescuers should be aware not only of the material needs of the victims but also of their psychological needs and be prepared to provide first aid.

Effects and consequences of psychological stress

Exposure to highly stressful and/or traumatic experiences during rescue operations can result not only in certain psychological difficulties but also mental disorders. As a result of experiencing a traumatic event, a person may suffer from anxiety, depression and PTSD, and even the risk of suicide and suicide attempts [14]. An analysis of a large number of professional and scientific papers in the field of accident and disaster psychology [15] found that disasters cause a strong psychological impact on

rescuers, which is associated with various factors divided into three categories:

- factors before the rescue operation (working conditions, special training and preparation, life experience and health),
- factors related to the accident (exposure to the undesirable event, engagement at the scene and time of arrival, emotional involvement, exposures to trauma, role-related stressors, safety perception, level of threat and risk, personal injury, social and professional support) and
- factors after a disaster (professional psychological support, the impact of a harmful event on life, life experience, media, etc.) [16].

The importance of education and training of the fire brigades and teams

The level of competencies and training of the Rescue Team, in addition to efficiency, also contributes to psychological resilience to highly stressful and potentially traumatic situations. In addition to training to work with wreck rescue equipment and implementing standard operating procedures, it is very important to train firefighters and team members on how to successfully deal with stressful situations during the rescue. The high level of competence and training of the Rescue Team strengthens self-confidence and self-esteem and indirectly alleviates the level of psychological stress during the rubble rescue operation. This is supported by a study comparing the psychological status of members of rescue teams who had formal training (firefighters, members of the Red Cross and Red Crescent) and student volunteers who did not have formal training to deal with traumatic situations during rescue under the rubble in the earthquake in the city of Bamu in Iran in 2003. The quake affected the province of Kerman in southeastern Iran, and the city of Bam was the worst hit, killing more than 26,000 people and injuring more than 30,000. The results of the study showed that student volunteers who did not have formal training to deal with stressful and traumatic situations found a significant number of those who had criteria for diagnosing PTSD and showed more pronounced anxiety compared to those who underwent formal training to deal with stressful situations [17].

The importance of psychological orientation and selection

Saving human lives is one of the most demanding jobs that firefighters do. In addition to extremely high physical fitness, ability to handle various tools, skills and knowledge of various rescue techniques, an extremely important aspect is a high level of cognitive functioning, mental stability and resistance to psychological stress. In determining the ability of knowledge and skills of candidates, it is necessary to conduct screening of candidates (psychological testing and psychological interview). Psychological selection aims to select the candidates who are strongly predisposed to work as firefighters [18]. By giving a good assessment of suitability for the role of firefighters, and candidates for the Rescue Team, we select the candidates who will be ready to deal with the greatest challenges and difficulties. No matter how strong one's motivation to join the Rescue Team, it is necessary to select those candidates who will be able to rescue the injured in the most difficult physical and mental conditions relying on their abilities, knowledge and skills.

Ways of overcoming stress in firefighters

There are various ways to prevent the occurrence of stress, or how to mitigate the effects of stress if it occurs. One of the most effective and simplest ways to prevent and alleviate stress in firefighters is physical exercise [19]. The fire brigade should develop a positive attitude towards exercise and encourage firefighters to acquire and maintain the required level of daily physical fitness, and create conditions for its practice. Diet plays an important role in maintaining health and preventing many diseases. Proper nutrition, with foods that belong to "healthy food", affects various body systems that have an impact on the occurrence of stress. Various breathing and relaxation techniques, stretching exercises, yoga, massage, aromatherapy, etc., help the firefighter feel relaxed and thus strengthen the body's resistance to stress [20]. It is important to avoid excessive consumption of alcohol, cigarettes, taking medication without medical supervision, etc. Developing a positive attitude towards life and optimism, creating good social relationships, and laughter which is a great form of stress relief can help people relax and reduce stress. Finally, it is necessary to emphasize the importance of psychological evaluation of candidates - Firefighter Candidate Assessment - for enrollment in the School of Fire Services. In that way, only candidates who, among other necessary predispositions, have a high resistance to stress will be selected.

CONCLUSION

Common factors affecting the effectiveness of firefighters during interventions are firefighting equipment, techniques and tactics. However, if a firefighter is not well-prepared, motivated and psychophysically trained, the outcome of firefighting intervention remains uncertain. Therefore, the role of the psychologist is to prevent and provide psychological assistance to firefighters after difficult interventions. Unfortunately, in the Republic of Serbia, there is no organized system of providing such kind of help since psychology has been completely left out from the curriculum. Through teaching psychology, firefighters would gain, among other things, a basic knowledge of stress psychology. It is especially important to emphasize the activities on the organization and coordination of teams to provide psychological assistance to firefighters after "severe" interventions (interventions in which there are severely

injured and/or fatally injured). Talking to a psychologist is a form of psychological support that teaches people how to help themselves, and prevent the development of more severe psychological issues that may result in the occurrence of post-traumatic stress disorder. Luckily, the need for psychologists who will help firefighters has been recognized, which is supported by the research results conducted among professional firefighters, and an increasing number of journal papers on this topic.

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STRES I ZNAČAJ PSIHOLOŠKE PRIPREMA VATROGASACA

Snežana Živković, Milan Veljković

Rezime: *Posao vatrogasaca je jedan od najzahtevnijih zanimanja na svetu. Svakodnevni napor, stres i opasnosti na radu, čine je jednim od najzahtevnijih i najtežih zanimanja. Vatrogasci su izloženi različitim izvorima stresa koji mogu izazvati određene psihološke teškoće. Znakovi koji ukazuju na postojanje stresa kod vatrogasaca mogu se klasifikovati u fizičke, emocionalne i bihevioralne. Postoje različiti načini da se spreči i ublaži stres. Važni aspekti koji utiču na efikasnost vatrogasaca u vatrogasnim intervencijama su svakako vatrogasna oprema, tehnika i taktike, ali ako vatrogasac nije dovoljno psihofizički spreman, motivisan i obučen, ishod vatrogasne intervencije je vrlo neizvestan. Uloga psihologa bila bi u pružanju psihološke pomoći vatrogascima nakon teških intervencija.*

Ključne reči: vatrogasci, psihološka selekcija, profesionalni stres.

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SAFETY AND MENTAL HEALTH OF EMPLOYEES DURING COVID 19 PANDEMIC: MEDICAL AND LEGAL ASPECT

Abstract: *Supporting mental health has nowadays become the main concern of employers since a growing number of employees is facing the problem of anxiety, loneliness, depression and the like. These problems were particularly emphasized with the outbreak of the Covid-19 pandemic. In significantly changed working conditions around the world, employees and employers have faced mental health problems that are related to numerous stressors and factors related to the pandemic. Given the circumstances, the question is how to protect the mental health of employees in order to preserve their productiveness and well-being after the crisis. The legal system has a very important role in this process, especially the regulations concerning occupational safety and health and labor law in general because it sets the framework which enables the subjects of employment to maneuver their rights and obligations during the pandemic. Therefore, this framework is a key element in taking occupational safety measures in order to preserve the mental health of employees.*

Key words: mental health, regulations, protection of employees, Covid-19.

INTRODUCTION

Fast-spreading infectious diseases are well known in history. Epidemics that were limited to a specific area or region are now rapidly spreading around the world. In addition to epidemics caused by old and familiar pathogenic microorganisms, they can also be brought about by newly formed viruses, as is the case with the current epidemic of the new coronavirus (Covid-19). The Covid-19 pandemic is a global challenge that requires the introduction of a global strategy and teamwork among governments, associations, international organizations and economic and financial institutions at all levels. Mitigating the negative effects of this type of health crisis in the business world is a key investment in protecting the health of workers. The World Health Organization and the International Labor Organization have been actively developing guidelines for occupational safety and health of workers during the pandemic [1].

Considering the epidemiological situation, the Republic of Serbia declared a state of emergency on the territory of the entire country on March 15, 2020 [2]. According to the valid regulations in Serbia, a state of emergency is declared when the risks, threats, or consequences of a catastrophe for the population, material and cultural goods or the environment are of such scope and intensity that their occurrence or effects cannot be prevented or eliminated by regular action of competent bodies and services. Therefore, their mitigation and elimination require special measures, additional forces and means with an enhanced mode of operation [3]. A state of emergency is also declared in cases of epidemics [4].

After the cessation of danger, i.e. when the need for the implementation of protective measures ceased, the Republic of Serbia lifted the state of emergency on May 6, 2020 [5]. In addition, local governments can declare and lift the state of emergency on their own territory, depending on the epidemiological situation, which is a possibility provided by law to the president of the municipality or mayor [3]. During the state of emergency, emergency headquarters monitor the activities and coordinate emergency situations in order to reduce risk. Those are the republic headquarters for the territory of the republic, provincial headquarters for the territory of the autonomous province, district headquarters in the administrative district and city or municipal headquarters in the city or municipality.

In case of declaring a state of emergency caused by an epidemic, it is necessary to implement preventive measures and measures to reduce the scope of danger [6]. Measures taken in the event of a state of emergency caused by an epidemic of viral disease where there is an imminent danger of mass transmission of the infection are:

- planning, organizing and providing measures to prevent and control an infectious disease, in this case - Covid-19,
- rapid epidemiological assessment in order to take urgent measures to protect the population,

- epidemiological surveillance by introducing an early warning system while there are reasons for the state of emergency,
- isolation and quarantine when indicated,
- activation of the emergency communication system,
- pursuant to the order of the Minister, it is required to include the participation of health institutions, private practice, entrepreneurs and citizens in order to reduce the risk to public health. It is also necessary to use certain facilities, equipment and means of transport in order to suppress the transmission of the infectious disease.
- personal protective measures.

Some of the measures introduced during the state of emergency due to the epidemic are isolation and quarantine. Isolation is an anti-epidemic measure of isolating infected persons to places where contact with other persons can be prevented during the period of infection, which thus prevents direct or indirect transmission of the virus from person to person. Quarantine is a measure that restricts freedom of movement and establishes mandatory medical examinations for healthy persons who have been in contact or are suspected of being in contact with infected persons or with persons suspected of having a contagious disease during the period of contagiousness. It is carried out in the case when a contagious disease poses a danger to public health. A competent medical doctor, a specialist in epidemiology, decides on which persons are to be subjected to quarantine. A person who is in quarantine must adhere to the measures. Otherwise, they could be quarantined forcibly. Employees who are subjected to a quarantine measure receive a salary in accordance with the law [6].

Bearing in mind the situation during the state of emergency, and also after it, the question of preserving the mental health of the population is justified. Since in such circumstances it is of crucial importance to protect the economy of the state, but also of each work organization individually, the issue of mental health of employees who, together with employers and the state, were forced to adjust their work to such extraordinary circumstances, is even more complex. This introduces a number of issues, such as work reorganization (working from home, shift work, moving to an online platform, using paid leave, etc.), how workers are adjusting to unexpected and sudden changes in their work, how those changes affect their mental health etc. The idea of work reorganization is to preserve the physical health of employees, but the question is how it affects their mental health.

MENTAL HEALTH PROBLEMS OF EMPLOYEES CAUSED BY COVID-19 EPIDEMIC

Mental health is the basis for emotions, thinking, communication, learning, resilience and self-esteem. It is key to establishing relationships, personal and emotional well-being, community or social contribution, and effective functioning in daily activities, such as work or school. It also includes reacting to problems, adapting to them and dealing with them. The World Health Organization defines mental health as a state of well-being in which individuals exercise their abilities, cope with common stressors, work productively and successfully and are able to contribute to the community [7]. Unlike experiencing mental illness, which affects a limited number of people, most people during their lifetime experience a problem or challenge that has consequences for their mental health (mental health distress). Some types of mental health problems include stress, sadness, low mood, or fear/uneasiness. They differ from mental illnesses as these conditions do not meet the criteria for diagnosis and are usually temporary. Mental health problems can become a mental illness when the duration of the disorder and its symptoms become chronic and interfere with or limit the ability to perform everyday activities. Nowadays, a large number of people suffer from mental health problems, as evidenced by the report in which about 165 million people in the EU deal with mental disorders, mainly anxiety, mood disorders and the use of substances every year [8]. Mental disorders are associated with severe disorders and functional impairments (these are mandatory diagnostic criteria when diagnosing mental disorders) that can have consequences, not only for patients, but also for their families and their social and work environment [9].

The workplace has a significant impact on the mental health and well-being of employees. One of the risk factors for developing a mental illness or mental health problem is experiencing stress, which can be exacerbated or caused by workplace conditions. Chronic exposure to stressful workplace conditions can lead to a variety of mental health problems including depression, anxiety, impaired concentration and emotional exhaustion. Mental health support is becoming a major concern of employers, as a growing number of employees experiences the problem of anxiety, loneliness and depression associated with altered work patterns during the coronavirus pandemic (remote work and other stressors and pandemic impacts). In the population affected by a natural disaster, the prevalence of mental health problems is 2-3 times higher than in the general population (it varies from 8.6 to 57.3%) [10]. For instance, as a result of Hurricane Katrina, the prevalence of serious mental illness has doubled, and almost half of the subjects in the study have post-traumatic stress disorder (PTSD) [11].

The Covid-19 pandemic will have an impact on behavioral health in society, as it has disrupted the regular lifestyle of millions of people, increasing stress both at home and at work. Prior to the Covid-19 pandemic, occupational health survey "The State of Mental Health in America 2017" found that 63% of the respondents felt that workplace stress had a significant impact on their mental and behavioral health. More than a third of the respondents exhibited unhealthy behaviors in response to occupational stress [12]. About 31% of Americans said that they were unable to pay for food, heating or rent because of the pandemic, that they used most or all of their savings, borrowed money or took out a loan. A smaller percentage of people with economic difficulties were registered in the Netherlands (7%), Germany (6%), and the United Kingdom (18%) [13].

The Covid-19 pandemic and the consequent economic recession have negatively affected the mental health of many people and created new barriers for those who are already suffering from mental illness and substance use disorders. As Covid-19 has caused a sharp economic downturn and a rise in unemployment, job loss is associated with increased depression, anxiety, distress and low self-esteem and can lead to higher substance use and abuse, substance use disorders and suicide [14]. People who lost their jobs during or due to the pandemic have a more pronounced simultaneous presence of anxiety and depressive disorders (42:35%); only anxiety disorders (26:23%); only depressive disorders (6:5%); no anxiety and/or depressive disorders (26:37%) compared to the general population. With respect to the stress caused by the pandemic, it has been reported that those who lost their job or reduced their volume of work have a high degree of distress (34: 27%), moderate distress (53%) and low or no stress (13: 20%) compared to the general population [15]. During the Covid-19 pandemic, approximately 31% of the US residents and 32% of the UK residents reported that they could not get help from mental health professionals when they needed it (54% of Australians and 47% of Canadians said they did have access to mental health protection) [16]. All these data point to the need to consider and improve the quality of occupational safety and mental health of employees during the pandemic.

LEGAL PROTECTION OF EMPLOYEES

The Labor Law, as the basic legal document regulating work relations in Serbia, guarantees employees the right to occupational safety and health [17]. This right is elaborated by a series of legal provisions with specific labor law institutes. Some of the legal provisions can be interpreted in the context of protection during an epidemic. In this regard, the legislator provides the possibility of remote work. In extraordinary circumstances, the employer has the opportunity to organize remote work for employees with a precise definition of mutual rights and obligations. Also, the Labor Law provides the possibility of paid leave of absence and offers the employer additional space to anticipate other situations when paid leave can be allowed. In essence, if the employer deems it a good solution, certain employees are to take a paid leave of absence until the conditions for safe and healthy work are met. There is also a legal possibility of unpaid leave of absence, but it is believed to be an inadequate measure, which is not in accordance with the idea of protecting the complete integrity of employees, including their social welfare.

Some other important legal provisions could be applied for the purpose of protecting employees in the event of an epidemic. The employee is entitled to compensation in the amount of at least 60% of the average salary in the previous 12 months, provided that it cannot be less than the established minimum wage, during the discontinuation of work or reduction in workload not requested by an employee, up to 45 days in a calendar year. Exceptionally, in case of the discontinuation of work or reduction in workload that requires longer leave, the employer may, with the prior consent of the line minister, determine paid leave for the period longer than 45 working days, with the abovementioned salary compensation. Also, the employee has the right to salary compensation in the amount determined by the general act and the employment contract during the interruption of work which was assigned by the competent state body or the competent body of the employer due to the failure to ensure occupational safety and health without endangering the life and health of employees and other persons [17]. These legal provisions signify that the employee shall have income for a limited period of time even if the employer temporarily discontinues its work, which can happen in an emergency situation.

Occupational safety and health in Serbia are regulated by the Law on Safety and Health at Work, which stipulates that employees have the right to safe work and protection of life and health at work [18]. Employees are also obliged to respect all regulations, so as not to endanger their safety and health, but also the safety and health of others. In addition to a significant number of obligations of the employer, which are determined in detail by this law, it should be taken into consideration that the employee has certain obligations, such as informing the employer about any potential danger and risk that could affect their safety and health and safety and health of other employees. This provision can also be applied in relation to epidemics and possible health problems.

Based on the Law on Safety and Health at Work, the Rulebook on Preventive Measures for Safe and Healthy Work to Prevent the Occurrence and Spread of an Epidemic of Infectious Diseases was adopted in the middle of 2020 [19]. It prescribes preventive measures that the employer needs to implement in order to prevent the spread of infectious diseases and eliminate the risk to safe and healthy work of employees and all persons in the work environment at the time of declaring an outbreak of an infectious disease. The

rulebook applies to all jobs, except fieldwork and remote work.

The employer is obliged to adopt a plan for the implementation of measures for the prevention of an epidemic of infectious diseases, which is an integral part of the Risk Assessment Act, adopted in accordance with the law and regulations in the field of occupational safety and health. The employer is obliged to implement all the measures prescribed due to the changes that affect safe and healthy work during the epidemic [19]. The plan of measures determines measures and activities that increase and improve the safety and health of employees and persons in the work environment in order to prevent the outbreak of infectious disease, as well as measures to be taken in case of the outbreak of an infectious disease. The plan for the implementation of measures has to contain:

- Preventive measures and activities to avoid the outbreak of infectious disease,
- Responsibility for the implementation and control of the implementation of preventive measures and activities,
- Measures and activities for action in case of the outbreak of an infectious disease.

Preventive measures that the employer is obliged to implement during the epidemic at each workplace include providing written instructions on measures and procedures to prevent the outbreak of infectious disease and informing workers about the infectious disease before starting work. The employer is obliged to organize the redistribution of working hours by introducing shifts in order to provide a smaller number of employees in one place and carry out increased hygiene and disinfection of all rooms and regular ventilation of the working space. The employer is also obliged to provide sufficient quantities of soap, paper towels, running water, alcohol-based disinfectants, and organize regular cleaning of all frequently touched surfaces, ensure regular waste removal and regulate the manner of keeping records on disinfection of premises and ensure the development of guidelines for safe and healthy work with contractors, suppliers, distributors and external associates.

The inspection of the implementation of occupational safety and health measures is performed by the person in charge of occupational safety and health who, in cooperation with the employer, plans, implements and encourages the implementation of preventive measures, participates in the development of the implementation plan, prepares instructions for safe and healthy work in order to provide protection against the epidemic, controls the implementation of measures, controls the use of means and equipment for personal protection at work, provides all necessary information on the implementation of preventive measures for occupational safety and health and cooperates with state authorities [19].

CONCLUSION

Following the outbreak of the Covid-19 epidemic, many countries have introduced a number of measures, including those related to work organizations and workplaces, in order to prevent the spread of the disease. Both employer and employees need to withstand the pressure caused by such a crisis, but measures within occupational safety and health provide support for continuing work in the workplace. Such specific and unforeseen circumstances have forced employers to seek alternative solutions which would not affect the productivity and profitability of the organization, and, at the same time, preserve the health of the employees. This emphasized some labor law institutes that had not been used in practice often, such as remote work [20]. In order for such work to be functional, it needs to fulfill several conditions, one of which is not to be dangerous and harmful to health and the working environment. Moreover, the transition of a large number of employees to the home office can inspire employers to organize work in this way in regular conditions as well. This is an opportunity to popularize work from home, which is a form of work that is still not very popular in Serbia [21]. When work from home or any other atypical type of work is present for a longer period of time, it can have a negative effect on employees in terms of feelings of isolation, additional stress, problems of setting boundaries between work and private life, and the like. All this can adversely affect the worker's psycho-physical condition and occupational safety and health. For this reason, constant communication between the employer and the employee is important.

Certain jobs cannot be performed from homes, such as work in healthcare institutions or some state institutions. One of the ways to reduce the risk of infection in case of more workers being in one space can be a reduction in the number of workers in one place, the introduction of shift work, etc. More shifts with fewer workers in one place provide physical distance - a measure of limiting the number of people in one space. One of the more radical possibilities is a temporary cessation of work when the employee is entitled to salary compensation, but we believe that this should be the last option when none of the other possibilities could provide the required level of employee protection.

All these circumstances affect the mental health of employees who cope with them in different ways. Moreover, the number of mental health problems increases with a growing number of measures introduced to slow the spread of the virus due to physical distancing, closing down businesses and schools and restricting movement, which leads to greater isolation and potential financial problems. It is clear that this affects the mental health of the population in general, including employees, who face additional risk at work. Different countries have diverse experiences regarding the protection of the mental

health of employees. It depends on their legal system, which either implements the obligation of the employer to take certain measures, e.g. in order to prevent stress at work (the case of Croatia) [22] or still does not recognize this problem to a sufficient extent (the case of Serbia).

Actively protecting, supporting and preventing damage to the mental health of employees and providing support to employees with mental illness is crucial to creating a truly safe and supportive workplace. Employers should develop short-term and long-term plans to preserve and improve the mental health and well-being of employees. In that sense, prevention and early detection of employees' mental health problems should be the focus of employers in the future. Measures that employers could take are as follows: annual mental health check-ups of employees financed by the employer, focusing on policies and programs at the organization level that reduces or eliminate common stressors in the workplace, providing opportunities for education and learning about mental health, prevention of fatigue and stress in the workplace, etc.

Finally, it can be concluded that the pandemic of the infectious disease caused by the coronavirus Covid-19 indicated the importance of safe and healthy work and a healthy environment for employees, employers and the state. The need to protect workers in the work environment in order to minimize the effects of the coronavirus is now more than clear. During the outbreak of an epidemic, occupational safety and health experts play the most important role since they facilitate access to all reliable information in order to promote the knowledge of the disease and its symptoms, as well as personal preventive and protective measures. In that sense, they also have the role to consider the need to preserve the mental health of employees, which is a topic that deserves special attention.

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BEZBEDNOST I MENTALNO ZDRAVLjE ZAPOSLENIH U USLOVIMA PANDEMIJE COVID-19: MEDICINSKO-PRAVNI ASPEKT

Vladica Sibinović, Aleksandra Ilić Petković

Rezime: *Podrška mentalnom zdravlju postaje glavna briga poslodavaca danas, jer sve više zaposlenih ima problem anksioznosti, usamljenosti, depresije i slično. Ovi problemi su naročito došli do izražaja nastupanjem pandemije virusa COVID-19. U značajno izmenjenim uslovima rada u čitavom svetu, zaposleni i poslodavci su se suočili sa problemima mentalnog zdravlja koji su povezani sa mnogim stresorima i uticajima vezanim za pandemiju. U okvakvoj situaciji postavlja se logično pitanje kako zaštititi mentalno zdravlje zaposlenih sa ciljem da, nakon izlaska iz krize, oni budu produktivni poslodavcu i, još važnije, da ostanu fizički i psihički zdravi uz puno fizičko, psihičko i socijalno blaostanje. U ovom procesu veoma važnu ulogu ima pravni sistem, naročito regulativa koja se tiče bezbednosti i zdravlja na radu i radnog prava uopšte, jer on postavlja okvire unutar kojih se subjekti radnog odnosa mogu kretati u svojim pravima i obavezama tokom pandemije. Ti okviri su ključan manevarski prostor za preduzimanje mera zaštite na radu u cilju očuvanja mentalnog zdravlja zaposlenih.*

Ključne reči: mentalno zdravlje, propisi, zaštita zaposlenih, Covid-19.

BOOK REVIEW / PRIKAZ KNJIGE

ENERGIJA, ENERGETSKI PROCESI I ŽIVOTNA SREDINA

Jelena Malenović Nikolić

Energija, kao jedan od osnovnih uslova razvoja čovečanstva, doprinosi u velikoj meri unapređivanju životnih uslova, ali dovodi i do narušavanja kvaliteta života. Uticaj energetskih procesa je opisan u okviru tekstova koji čine celinu pod nazivom Energija, energetski procesi i životna sredina, koja je rađena s ciljem da se koristi kao udžbenik za potrebe izvođenja nastave iz predmeta Energetski procesi i okruženje. U okviru deset bazičnih poglavlja predstavljene su karakteristike, rezerve, eksploatacija, transformacija energije, lokacije, uticaj eksploatacije i posledice primene energije uglja, nafte, gasa, uljnih škriljaca, nuklearnih goriva, biomase, solarne, hidromehaničke, geotermalne i eolske energije.

Materijal ima multidisciplinarni pristup, jer pored pomenutih oblasti koje se odnose na uticaj energetskih procesa, sadrži u okviru prve oblasti, opis problema energetskog razvoja, vrste raspoloživih izvora energije, način distribucije energije, vrste energetskih bilansa, smernice energetskih trendova, opise energetskih ciljeva i prikaz pravne regulative u oblasti energetike.

U okviru materijala predstavljen je detaljan prikaz:

- karakteristika energetskih rezervi,
- načina eksploatacije energetskih izvora,
- lokacija energetskih postrojenja,
- uticaja procesa eksploatacije energetskih resursa i
- posledica primene energetskih postrojenja.

Poseban akcenat je stavljen na predstavljanje procesa transformacije energije fosilnih, nuklearnih goriva, biomase, kao i solarne, hidromehaničke energije, eolske i geotermalne energije, u toplotnu i električnu energiju.

Poslednja oblast predstavlja načine koji mogu da vode ka rešavanju problema nastalih radom energetskih postrojenja, bazirane na planiranju razvoje energetskog sektora, principima održivog energetskog razvoja, značaju sprovođenja mera energetske efikasnosti, primeni standarda koji se odnose na upravljanje energetikom, značaju primene energetskih indikatora i ukazivanju na značaj prevencije vanrednih situacija u oblasti energetskog sektora.

Materijal je pisan s ciljem da se ukaže na probleme u životnoj sredini koji nastaju kao posledica eksploatacije energetskih izvora i transformacije primarne energije u sekundarne i u finalne oblike, ali i da podstakne razvoj ekološke svesti, kako bi se stvorili uslovi za rešavanje nagomilanih problema funkcionisanjem energetskog sektora. Autor nema za cilj da detaljno predstavi energetske procese, koji se izučavaju u okviru velikog broja predmeta, već da stvori uslove za multikriterijumsko razmišljanje i razvoj svesti o značaju sprovođenja preventivnih mera i upoređivanju težine posledica po kvalitet životne sredine. Posmatrajući, s tog aspekta, autor je mišljenja da materijal pruža osnovu za edukaciju studenata, ali i da može da koristi stručnim licima iz različitih oblasti tehnike, jer se ukazuje na potencijalne opasnosti u primeni energetskih procesa i uticaj posledica po kvalitet životne sredine.

Autor je svestan da energetika zauzima posebno mesto u razvoju čovečanstva i da nisu procesi transformacije energije detaljno opisani u materijalu, ali se nada da će čitaoci ukazati na savremene tehnologije koje bi želeli da obuhvati prošireno i dopunjeno izdanje, kao i na uočene propuste.

BOOK REVIEW / PRIKAZ KNJIGE

VODA I NJENA ZAŠTITA

Marina Stojanović
Dejan Vasović
Ana Miltojević

Ubrzani demografski razvoj, praćen procesima intenzivne urbanizacije i industrijalizacije, dovodi do intenziviranih antropogenih pritisaka na različite medijume životne sredine, koji najčešće rezultiraju negativnim promenama stanja kvaliteta životne sredine. Sa druge strane, promene u obrascima funkcionisanja društva, modifikovanje tehnoloških obrazaca proizvodnje, kao i korišćenje novih materijala, dovode do potrebe sagledavanja i naučnog objašnjenja mehanizama delovanja ovih fenomena na životnu sredinu.

Ne manje važne su i posledice koje su uslovljene klimatskim promenama, koje često izazivaju različite ekstremne situacije u životnoj sredini i remete ustaljene ekosistemske procese i funkcije. U odnosu na bilo koji pomenuti aspekt, vode, odnosno vodna tela i pridruženi akvatični ekosistemi, predstavljaju verovatno najznačajniji i najosetljiviji medijum životne sredine kome se mora posvetiti odgovarajuća pažnja. U tom kontekstu se kreiranje politike zaštite voda odnosno vodnih resursa mora bazirati na savremenim naučno-stručnim dostignućima u oblasti zaštite voda ali i poznavanju mehanizama i procesa funkcionisanja akvatičnih ekosistema koji su predmet zaštite.

Imajući u vidu napred izloženo, autori su nastojali da napišu udžbenik koji će pružiti ne samo osnovna, već i šira znanja potrebna za razumevanje problematike kvaliteta voda, zaštite voda, kao i metoda prečišćavanja voda. Udžbenik je namenjen studentima osnovnih i master akademskih studija tehničkih fakulteta, posebno

Fakulteta zaštite na radu. Takođe ga mogu koristiti i studenti doktorskih akademskih studija, kao i studenti drugih fakulteta na kojima se izučava zaštita životne sredine, odnosno zaštita voda. Pored toga, namenjen je i svima koji se bave zaštitom voda.

Prilikom pisanja udžbenika autori su vodili računa o potrebama i predznanju studenata Fakulteta zaštite na radu. Sadržina je izložena kroz nekoliko celina u kojima je dat prikaz rasprostranjenosti vode u prirodi, fizičke, hemijske i biološke karakteristike vode, mogućnosti upotrebe, vrste zagađenja, zaštite voda uz primenu različitih metoda prečišćavanja. Zbog ograničenog obima materijala, proces tretmana otpadnog mulja je obrađen u kratkim crtama. Udžbenik treba posmatrati kao svojevrsan doprinos unapređenju oblasti upravljanja vodama, sa posebnim fokusom na razumevanje vode kao medijuma životne sredine i mehanizama njene zaštite.

Autori zahvaljuju recenzentima prof. dr Slobodanu Milenkoviću, prof. dr Ivanu Krstiću i prof. dr Danilu Popoviću na kritičkom čitanju rukopisa, korisnim predlozima i sugestijama, što je doprinelo poboljšanju njegovog kvaliteta i učinilo da se materija na adekvatan način približi čitaocima.

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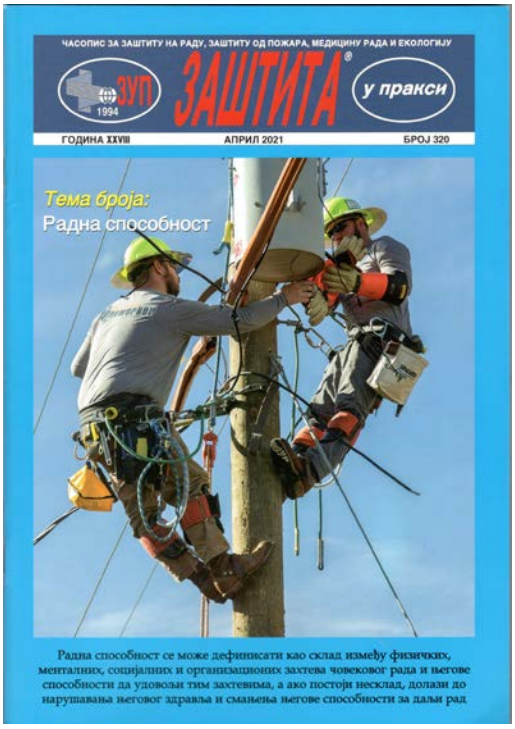

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Bilsom antifoni i Howard Leight čepovi za uši su sinonim za tehnološke inovacije, fleksibilnost i nenadmašnu udobnost uz maksimalnu zaštitu.

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Na osnovu rezultata snimanja ili posmatranja kroz objektiv kamere, registruje se infracrveno ili toplotno zračenje i najnižeg stepena, a omogućava se izuzetno precizno merenje temperature bez ikakvog kontakta sa objektom čije se fizičke karakteristike mere. Na osnovu rezultata dobijenih testiranjem moguće je napraviti preciznu evaluaciju mehaničkih, termičkih, električnih i bioloških procesa. Informacije o struji, voltaži, otporu i energiji su dragoceni za adekvatno postavljanje električnih instalacija i njihovo puštanje u rad.
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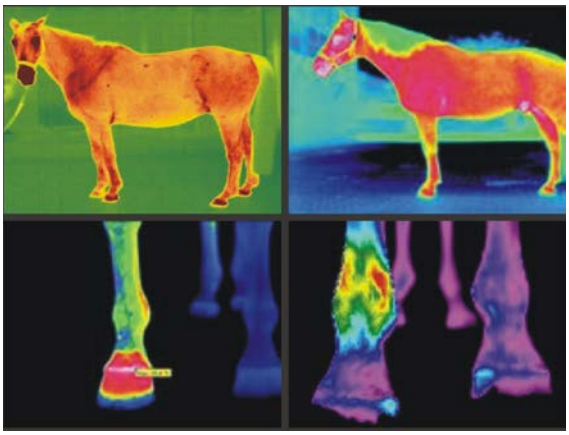
Termovizijske kamere vrlo lako i precizno detektuju detektuju temperatune razlike pojedinih delova površine tela čoveka i životinja i mogu se koristiti u mnogim medicinskih granama kao u epidemiologiji, virusologiji, reumatologiji, hirurgiji, dijagnostici kancera, metaboličkih bolesti, vaskularnih promena, stomatologiji, kao i za otkrivanje različitih bolesti i pre nego što su doživeli punu kliničku sliku pa je značajna njena uloga u ranom otkrivanju i prevenciji.



Za zaštitu od požara, zaštitu radne i životne sredine
Protivpožarna ručna termička kamera IR1190 je opremljena sa detektorom ultravisoke rezolucije, što joj omogućuje prikazivanje slike besprekorne jasnoće, a time se pomaže vatrogascima da vide kroz oblake dima i da identifikuju moguće žrtve pre nego što do dođe do povrede, ili smrti

Napredna tehnologija infracrvenog merenja temperature vam pomaže da odredite tačan izvor vatre, a time da donesete tačnu i blagovremenu odluku, koja neće biti ugrožena od strane nepreciznosti merenja detektora. Na raspolaganju je i bežični prenos video informacija, kojim se može ostvariti slanje žive slike iz prve ruke u komandni centar, gde se onda mogu doneti brze i precizne odluke.

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