18th INTERNATIONAL CONFERENCE

MANAGEMENT AND SAFETY

M&S 2023

Friday, June 9th and Saturday, June 10th, 2023

MARIBOR, SLOVENIA, EU AND ONLINE

THE EUROPEAN SOCIETY
OF SAFETY ENGINEERS

EUROPEAN
SAFETY
ENGINEER

MANAGEMENT OF CHEMICAL, BIOLOGICAL AND RADIOLOGICAL RISKS AND SAFETY

PROCEEDINGS 1

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Invited lecture paper

Tatjana Golubović, Srđan Glišović

POLYBROMINATED DIPHENYL ETHERS: HUMAN EXPOSURE AND TOXICITY

Abstract

Polybrominated diphenyl ethers are classes of structurally similar brominated hydrocarbons. There are three main categories of commercial PBDE mixtures: penta-, octa-, and deca-brominated diphenyl ethers. In 2003, the European Union passed a Directive to ban the marketing and use of penta- and octa-BDEs that took effect in 2004. In 2008, the use of deca-BDE was restricted by a EU's Restriction of Hazardous Substances Directive. Regardless of the phase out of penta-, octa-, and deca-BDEs, enormous content of consumer products still contain PBDEs. Humans are exposed to PBDEs by ingestion of contaminated foods, dusts or soils, inhalation of air, and via dermal exposure. Occupational exposure occurs primarily by inhalation of particulate phase of PBDEs, while inhalation of vapor-phase PBDEs is low. Occupational exposure to PBDEs occurs in workers in the production and manufacture of PBDE-containing plastics, workers at plants that dismantle electronic equipment, computer monitor repair technicians etc. Targets for PBDEs toxicity are nervous system, liver and thyroid gland. Regulatory focus on PBDEs exists, in particular for manufacture, distribution and import of substances and products. However, there is a need for focus on end-of-life management of PBDE-containing products, including recycling, disposal and monitoring.

Key words: exposure, polybrominated diphenyl ethers, toxicity.

INTRODUCTION

Polybrominated diphenyl ethers are a class of substances that contain a same base structure, but vary in the number of substituents (1–10 bromine atoms), resulting in 209 individual congeners [1]. Polybrominated diphenyl ethers do not occur naturally in the environment. They are normally produced synthetically as mixtures, referred to as commercial penta-bromodiphenyl ether (ComPeBDE, which is predominantly a mixture of TeBDE, PeBDE, HxBDE and trace amounts of TrBDE), commercial octa-bromodiphenyl ether (ComOcBDE, which contains mainly HeBDE, OcBDE, HxBDE and NoBDE but may also contain small amounts of DeBDE) and commercial deca-bromodiphenyl ether (ComDeBDE, of which current formulations are almost entirely DeBDE, with a small amount of NoBDE and trace amounts of OcBDE homologs) [2]. Due to their thermal stability, low price, and outstanding flame-retardant properties, the overall demand for polybrominated diphenyl ethers has been growing rapidly in recent years. Polybrominated diphenyl ethers, as well as other brominated flame retardants (tetrabromobisphenol A, hexabromocyclododecane, and polybrominated biphenyls) were usually added to various plastic articles in order to prevent or retard the propagation of fire. The articles treated with these chemicals include the hard plastic casings for electrical equipment and appliances, household and vehicular textiles, certain types of building insulation foams, etc. [3]. Humans can be exposed to polybrominated diphenyl ethers through inhalation of contaminated air, oral intake of contaminated food and/or dust, and dermal contact with dust and/or soil. Human toxicity data demonstrated that polybrominated diphenyl ethers have extensively endocrine disruption effects, developmental and carcinogenic effects among different populations. Due to adverse health effects, commercial penta- and octa-BDEs were banned by the European Union in 2004 and voluntarily phased out in the US [4,5]. Deca-BDE was finally restricted in March 2019 (only allowed for the production of spare parts of cars, trucks, and aeronautic vehicles). In 2009, commercial octa-BDE and penta-BDE were recognized as persistent organic pollutants (POPs) with the potential of causing harmful effects, why they were added to the list of POPs under the Stockholm Convention [6], and the deca-formulation was added in 2017 [7]. However, existing products containing toxic or potentially toxic polybrominated diphenyl ethers will remain in use for decades, even after regulatory controls have been implemented. Namely, polybrominated diphenyl ethers will continue to be released during end-of-life activities from products produced before their use was banned. To reduce continued human and environmental exposures to hazardous polybrominated diphenyl ethers from discarded products, waste management technologies and processes must be improved. Responsible treatment of products containing polybrominated diphenyl ethers implies numerous challenges, and will require engagement and interaction among diverse sectors.

BROMINATED FLAME RETARDANTS

Flame retardants can be classified into the two major groups, inorganic and organic (halogenated and organophosphate) compounds.

Halogenated flame retardants are particularly based on chlorine and bromine and they can be divided into three classes: aromatic, cycloaliphatic and aliphatic. It is important to note that aromatic flame retardants includes the main brominated flame retardants, tetrabromobisphenol A and decabromodiphenylether, while cycloaliphatic group include the hexabromocyclododecane isomers. Aliphatic substances are minor group of flame retardants.

With the increasing consumption of thermoplastics and thermosets for applications in electrical engineering and electronics, buildings, transportation, a diversity of flame retarded materials have been developed over the past four decads. Table 1 gives an overview of flame retarded materials applicatios.

Table 1. Application of flame retarded materials

Industry	Application
electrical engineering, electronics	cover of television sets and computers, plugs, spacers, shield of cables
buildings	building materials, paints, isolations, heating materials
mining industry	isolations, gas sealing materials, heating materials
furniture industry	upholesty containing polyurethane foam, adhesives
transportation	interior fittings of private vehicles and public transport
textile industry	work clothes, upholstery, space research purposes, military purposes

Source: own source

Brominated flame retardants can be used as additive as well as reactive.

Additive flame retardants are included into the polymer before, during, or after polymerization, without chemical bonding. As a result they may be released from the polymer to the environment.

Reactive flame retardants are added during the polymerisation process and become a structural part of the polymer. The result is a modified polymer with flame retardant properties and different structure in contrast to the native polymer molecule. This prevents flame retardants release from the polymer and keeps the flame retardant properties intact over time with low emissions to the environment [3,8].

In spite of the fact that the use of halogeneted flame retardants is strongly questioned because of their potentially adverse effects concerning environmental and health they represented around 25% by volume of the total global production of flame retardants with a growth of around 5% per year [3,9].

Brominated flame retardants are increasingly present in the environment and humans. The adverse health effects of these chemicals can be connected to their persistence, bioaccumulation and biomagnification potential [10].

The main routes of exposure are some kind of food, inhalation and ingestion via dust in indoor environments and occupational exposure.

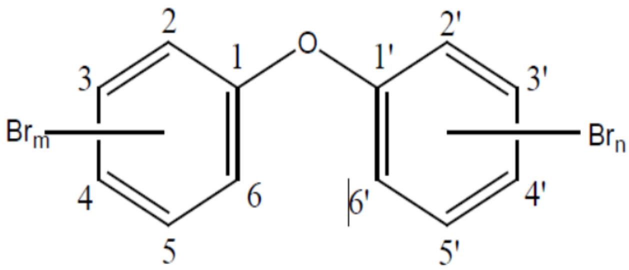
Some of the adverse health impacts causing by brominated flame retardants are improper function of thyroid hormones, damage to the nervous system, liver, kidney, and the reproductive and immune systems [11].
Brominated flame retardants should be studied systematically to assess their possible influence to human health and environment.

POLYBROMINATED DIPHENYL ETHERS

Physical and chemical properties

Polybrominated diphenyl ethers (PBDEs) are classes of structurally similar brominated hydrocarbons. There are 209 different congeners, although only a limited number exist in commercial mixtures. There are three main categories of commercial PBDE mixtures: penta-, octa-, and deca-brominated diphenyl ethers. Commercially available product mixtures of PBDEs are not pure substances, but instead are mixtures of congeners. The commercial mixture penta-BDE denotes the main component of the mixture contains the penta-BDE homologs. However, the commercial penta-BDE mixture actually contains tetra-BDE (24–38%) and penta-BDE (50–62%) homologs with small amounts of hexa-BDE (4–8%) and trace amounts of tri-BDE (0–1%) homologs. Commercial octa-BDE is a mixture of hexa-, hepta-, octa- and nona-BDE homologs with trace amounts of deca-BDE. The composition of commercial deca- BDE is 97% of the deca-BDE, the remainder is nona-BDE homologs and trace amounts of octa-BDE homologs. The general chemical structure of PBDEs is given in Figure 1.

Figure 1. Chemical structure of polybrominated diphenyl ethers (PBDEs)



where m + n = 1 to 10

Source: own source

Information found in the literature regarding the physical and chemical properties of selected technical PBDE mixtures is presented in Table 2.

Table 2. Physical and chemical properties of technical polybrominated diphenyl ether (PBDE) mixtures

Property	penta-brominated diphenyl ether	octa-brominated diphenyl ether	deca-brominated diphenyl ether
Molecular weight	Mixture	Mixture	959.22
Color	Clear, amber to pale yellow	Off-white	Off-white
Physical state	Highly viscous liquid	Powder	Powder
Melting point	-7 to -3°C (commercial)	85–89°C (commercial)	290–306°
Boiling point	>300°C (decomposition starts above 200°C)	Decomposes at >330°C (commercial)	Decomposes at >320, >400, and 425°C
Odor	No data	Faint	Odorless
Solubility in water	13.3 µg/L (commercial)	<1 ppb at 25°C (commercial)	<0.1 µg/L
Solubility in organic solvent(s)	10 g/kg methanol; miscible in toluene	Acetone (20 g/L); benzene (200 g/L); methanol (2 g/L) all at 25°C	No data
Flashpoint	No data	No data	None
Flammability limits	Not applicable (flame retardant)	Not applicable (flame retardant)	Non-flammable

Source: [12]

Production and use of polybrominated diphenyl ethers

Polybrominated diphenyl ethers are effective brominated flame retardants, and their high efficiency, good thermal stability, and low cost make them widely used in a range of products, such as plastics, textiles, building materials, and electronics. Estimation of the historic annual usage of total PBDEs are around 10,000–11,000 tonnes/year in the EU and 40,000 tonnes/year globally [13]. PBDEs have been used since the 1970s, until their harmful characteristics brought them under the radar of environmental authorities (e.g., the European REACH regulation and Stockholm Convention) in the early 2000s, which led to the termination in the production of the commercial penta and octa-BDE mixtures in 2004 and the use of the deca-BDE mixture in electrical and electronic equipment in 2008. The USA followed suit by discontinuing production of the penta and octa-mixtures in 2004 and of deca-BDE in 2013 [14]. Penta and octa-BDE were listed in Annex A of the Stockholm Convention in 2009, and deca-BDE was listed in 2017 [15]. As previously mentioned, deca-BDE, along with other PBDEs, has been banned for use in electrical and electronic equipment since 2008 under the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment. This Directive was recast in June 2011 by Directive 2011/65/EU. Most other uses of deca-BDE (at or above 0.1%) have now been restricted under the REACH regulation since March 2019 (Commission Regulation (EU) 2017/227). The only remaining permitted uses are in aircraft, and spare parts for vehicles and machinery manufactured prior to the restriction. The EU Regulation on POPs was recast in June 2019 (Regulation (EU) 2019/1021) to include deca-BDE and specifies concentration limit for PBDEs, including deca-BDE, in waste of 1000mg/kg. The proposal was „considering that scientific and technical progress are rapidly evolving, the Commission should review that concentration limit and, where appropriate, adopt a legislative proposal to lower that value to 500 mg/kg. The Commission should act as quickly as possible and, in any event, not later than 16 July 2021“.

Penta-BDE was mainly used in foam for cushioning in upholstery, printed circuit boards, cable sheets and furniture (Figure 2). Production of penta-BDE occurred in Israel, the United States, China and EU. Production in the EU ceased in 1997, and c-pentaBDE was thereafter mainly produced in the US and China until 2004 when production stopped [16]. Most (>90%) penta-BDE was used as additives in polyurethane (PUR) foam. Of this 36% was used in automotive production (e.g. seating, head rests, car ceilings, acoustic systems, back-coating of textiles) and 60% in furniture upholstery [16].

Figure 2. Printed circuit boards, foam for cushioning in upholstery, cable sheets

Source: [17]

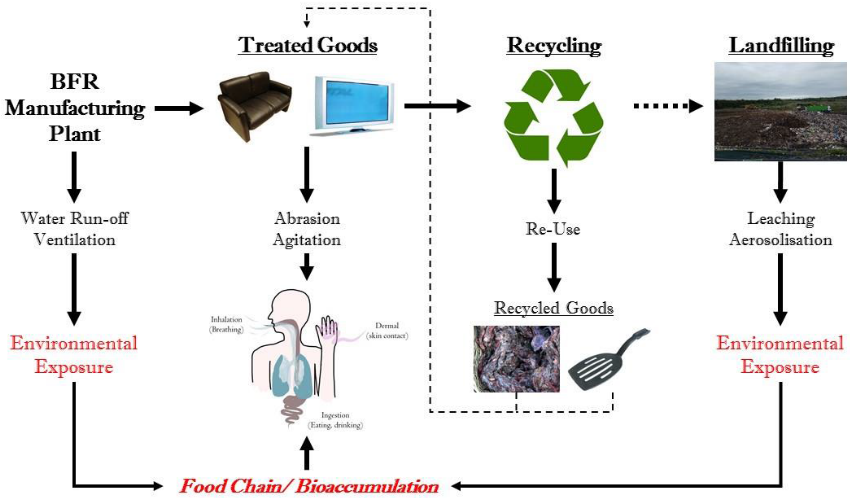
Octa-BDE has been used as an additive flame retardant mainly in the plastics industry for polymers used for business equipment, television sets, computer housings, small electronics, etc. The estimated annual world-wide production of octa-BDE in 1994 was 6,000 tonnes which decreased to 3,800 tonnes by 2001. Globally 70% of octa-BDE has been used in acrylonitrilebutadiene styrene (ABS). Other minor uses include high impact polystyrene (HIPS), polybutylene terephthalate (PBT) and polyamide polymers [18].

Deca-BDE has been used as an additive retardant in a wide variety of applications such as plastics/polymers/composites, textiles, adhesives, sealants, coatings and inks. Deca-BDE containing plastics are used in housings of computers and televisions, wires and cables, pipes and carpets [19]. The amount of deca-BDE used in plastics and textiles in various countries varies, but up to 90% of deca-BDE ends up in plastic and electronics, while the remaining ends up in coated textiles, upholstered furniture and mattresses. EEE applications of deca-BDE include equipment casings, wires and cables, and small electrical components. Other identified uses of flame-retarded plastics are in buildings, construction materials, in storage and distribution products such as plastic pallets, in the transportation

sector (cars, airplanes, trains and ships). The aviation industry still uses deca-BDE in electrical wiring and cables, interior components, and EEE of older airplanes and spacecrafts. Information available to the POPs Review Committee indicated that while the consumption of commercially available deca-BDE peaked in the early 2000s, it was still extensively used worldwide [19].
Regardless of the phase out of penta-, octa-, and deca-BDEs, enormous content of consumer products still contain PBDEs.

Environmental fate
As additives, PBDEs are physically mixed into product applications, rather than chemically bound. Therefore, they have the potential to migrate from the plastic matrix into the environment. PBDEs can be released into the air, water, and soil at places where they are produced or used. The important characteristics of PBDEs, persistent, low water solubility, high binding affinity to particles and a tendency to accumulate in sediments, explain their fate in the environment.

Figure 3. Some pathways for the environmental contamination and human exposure to BFR (PBDEs)



Source: [20]

PBDEs as semivolatile substances get into the atmosphere as a result of combustion from domestic and industrial sources, emissions from waste incineration, as wll as from illegal and legal e-waste landfills. The occurrence and atmospheric behavior of polybrominated diphenyl ethers depend on the environmental conditions, amount, composition, and size of suspended particles, as well as physicochemical characteristics of a particular PBDE congener. Deposition of PBDEs has subsequently been identified in soils, and water over the world, even in far areas including the Antarctica and Arctic. Aquatic environments are exposed to PBDEs not only through atmospheric deposition but also through effluent and sewage sludge from wastewater treatment plants and landfill leaches [21,22]. Owing to their low vapor pressure, low water solubility, and high octanol/water partition coefficient, PBDEs are, in aquatic environments, adsorb onto the organic fraction of sediments, suspended particulate matter, or enter aquatic organisms. The highly lipophilic properties of these compounds enable them to absorb into the fatty-tissues of living organisms and bioaccumulate through the various levels of the food chain.
The concentration levels of semi-volatile organic compounds in soil and air are highly influenced by air–soil gas exchange and atmospheric deposition, which may partly affect the regional or global transport/fate of semi-volatile organic compounds [23-25]. Atmospheric deposition is an important pathway of semi-volatile organic compounds to soil surface in remote areas. Atmospheric deposition of PBDEs at different areas (rural, urban/suburban, factory area, lake regions, and coastal areas) has been the subject of many scientific studies [26, 27]. On the other hand, studies on air–soil gas exchange of PBDEs are still scarce [28]. When certain amounts of PBDEs reached in the soil, such sites may become PBDE sources and re-emit these substances. Dry and wet particle deposition fluxes are primarily influenced by atmospheric particle concentrations and temperature, while wet dissolved depositions are controlled by precipitation and total atmospheric concentrations. According to the measurment of

atmospheric deposition and air–soil exchange fluxes of PBDEs in one of the regional background sites in Central China (Jinsha) it can concluded that he soil was an important sink for PBDEs, and atmospheric deposition played a more important role compared with air–soil gas exchange, especially particle deposition for high-brominated PBDEs and wet dissolved deposition for lowbrominated PBDEs. Air–soil gas exchange fluxes were largely lower than deposition fluxes, indicating that the re-volatilization of PBDEs from the soil was not significant [29].

Human exposure

Because PBDEs are chemical additives, they do not chemically bond with polymers and can be released into the environment through production processes, or from treated products during use. When they reached environmental compartments, they are persistent, with degradation half-lives in the order of years. Because of their high lipophilicity and stability in the environment, PBDEs are persistent, with potential for bioaccumulation in organisms and biomagnification through food chains.

Humans are exposed to PBDEs by ingestion of contaminated foods, inhalation of air, ingestion of contaminated dusts or soils, and via dermal exposure.

In recent years, it was hypothesized that the main route of human exposure to PBDEs could be dietary intake, especially food of animal origin with higher fat content (fish, meat, and dairy products), in which PBDEs tend to accumulate due to their lipophilicity. It has been estimated that excepting for occupationally exposed individuals, more than 90 % of total human exposure to organic pollutants such as PBDEs comes from food [30]. The human body absorbs pollutants from food and accumulates them in the tissues [31]. The concentrations of PBDEs in various foodstuffs commonly consumed in Italy (meat, eggs, milk, cheese, fish, fish oil, and mussels) were measured. The highest mass fraction of total PBDEs was identified in dairy products (18,537 pg/g ww), meat (12,672 pg/g ww), and eggs (9729 pg/g ww). Penta-BDEs were dominant in fish oil, while BDE 209 dominated in other food groups. Exposure to PBDEs through food varied considerably with region and personal food habits [22]. Due to their nutritional value, fish are high-quality foods. However, several studies show that the contaminants occurring in fish, such as PBDEs, are a potential health hazard and should be limited in the human diet. The levels of PBDEs in foods are not yet limited by the legislations. Nonetheless, the risk stemming from the consumption of contaminated foods can be evaluated by comparing the estimated PBDEs daily intake deriving from the consumption of fish and seafood to benchmarks doses [31].

The low vapor pressures of PBDEs mean that, in indoor environments, they remain usualy as dust. Most studies of indoor contamination are focused on human exposure via ingestion of settled dust, rather than via inhalation of indoor air. Inhalation exposure occurs as result of release of PBDEs from household products into the air. Namely, indoor environments are contaminated with PBDEs from flame retardants in a wide range of consumer products that remain in use for a long time, such as polyurethane foam in furniture, textiles, and electrical and electronic equipment. From these products, PBDEs are released into the ambient air through volatilization, mechanical abrasion, and/or sorption to dust particles. The exposure levels are mainly dependent on the amount of PBDEs emitted into the air, room size, ventilation, exposure time, and inhalation rate. According to the available literature data, higher PBDE concentrations in dust were detected in USA than from Europe, due to historical usage of PBDEs in USA. Also, higher PBDE human body burdens found in California and the UK than in the rest of the USA and Europe, which is probably related to very strict fire protection regulations in California and the UK. Regardless of the exposure routes, the most vulnerable group to PBDE exposure are children. Numerous studies found higher PBDE levels in children's blood than in blood of the adult population. The main exposure route is dust ingestion and inhalation related to their constant hand-to-mouth activity and the extensive contact with floors, carpets, and other dusty surfaces. The results of children's blood and hand wipe samples researche showed that children who licked their fingers while eating, who played more with plastic toys, and who were more active in general, had higher PBDE levels on their hands and in their serum [22]. Ingestion of contaminated dust can result in 100 times greater exposure than average for a toddler living in a home where PBDEs are present [31].

Occupational exposure occurs primarily by inhalation of particulate phase PBDEs, while inhalation of vapor-phase PBDEs is low due to the low vapor pressures of PBDEs. Occupational exposure may also likely involve oral exposure to particulate PBDEs as a result of hand-to-mouth activity.

Occupational exposure to PBDEs occurs in workers in the production and manufacture of PBDE-containing plastics and plastic products, workers at plants that dismantle electronic equipment, computer monitor repair technicians, and automobile drivers. Also, firefighters seem to have higher exposure potential to PBDEs and other types of flame retardants in view of the fact that they are exposed to the

combustion products of the flame retardants as well as the original forms of the chemicals. According to total PBDEs in the serum of the firefighters, it can be seen that the levels of total PBDEs are approximately 40% greater when compared to the general population [32,33].
During working hours, inhalation and dust ingestion are the primary exposure routes for workers in formal e-waste recycling plants. Occupational exposure risk varies significantly among different e-waste recycling processes. These differences in exposure risk may be attributed to the differing PBDE contents in raw materials, different e-waste recycling processes and the protection levels of workers. Thus, it is important to monitor the occupational exposure level of PBDEs in formal e-waste recycling plants. To date and to the best of our knowledge, only limited studies focused on the occupational exposure of PBDEs in formal e-waste recycling plants [34]. Legal e-waste recycling plants treated almost 25% of the total domestically generated e-waste in China. During the recycling process of e-waste, the dust and broken plastic pieces containing PBDEs were easily emitted from the e-waste dismantling and plastics crushing process, while lower-brominated PBDEs easily volatilized from the heating of the printed wiring board (PWB). Occupational exposure could be an important PBDEs exposure pathway for the workers working at e-waste recycling workshops. Sjodin et al. (1999) research showed that workers working at the dismantling plant had significantly higher serum levels of all studied PBDE congeners compared to both hospital cleaners and office clerks using computers [35]. Total PBDEs concentration in serum from inhabitants of an e-waste dismantling region was 3 times higher than in the control groups. Previous studies on the status of PBDEs in formal e-waste recycling plants primarily focused on PBDE levels in different areas of the plant, such as indoor and outdoor areas [36], and they did not take into account the different recycling materials (e.g., waste refrigerators, washing machines, and TV sets). Starting from the fact that TVs, washing machines, refrigerators and printed wiring board (PWB) represent the main domestic e-wastes, concentrations of total PBDEs in air and dust samples from recycling workshops handling these four major types of e-wastes were measured, and the occupational exposure risk for workers at the corresponding workshops was evaluated [37].Concentrations of examined PBDEs in air and dust varied. The highest concentration of total PBDEs in air was detected in the TV recycling workshop, while the refrigerator recycling workshop had the highest level of PBDEs in dust. The workers at these two e-waste recycling workshops were significantly exposed to BDE-209, which comprised for more than 85% of total PBDEs in both air and dust. At the PWB recycling workshop, BDE-47 and BDE-99 caused the main occupational exposure risk to the workers, while in the recycling plants handling other types of domestic e-waste BDE-209 was the major contributor to the risk faced by the workers [37].
Generally, body burden data indicate higher concentrations for workers exposed to PBDEs than for the general population. Based on experimental studies, targets for PBDEs toxicity are nervous system, liver, thyroid gland and development.

Toxicity

Knowledge about the mechanisms of toxic PBDE action and effects on human health is still quite limited. Toxicity has mainly been investigated in animal studies. However, it is important to note that congener characteristics (e.g., elimination) differ in animals and humans (PBDE half-lives in humans are much longer than in animal models). These differences complicate the extrapolation of data from animal models to humans. There are several studies that evaluated corelation between PBDE concentrations in human tissues (e.g., blood, breast milk) and various health effects [22]. As well, understanding that higher brominated PBDEs are more readily eliminated than are lower PBDE congeners, that congener concentration varies across body fluids, and that excretion rates vary for different congeners, was supported by human studies [38]. There are no published studies exploring mechanisms for the therapeutic elimination of PBDEs from the human body. According to the investigation of depuration using serial samples of breast milk, it was found that serum levels of PBDEs were not substantially reduced in samples after six months of breastfeeding [38]. Animal studies report adverse effects at low doses of penta-BDEs and octa-BDEs and much higher doses of deca-BDEs and include effects on neurobehavioral development and thyroid hormone levels for penta-BDEs, fetal toxicity/teratogenicity for octa-BDEs, and morphological effects in the thyroid, liver, and kidney of adult animals for deca-BDEs [39]. Carcinogenicity studies have for now been limited to deca-BDEs and show some effects only at very high doses, which is probably why the International Agency for Research on Cancer (IARC) still has not classified deca-BDEs in respect to its carcinogenicity to humans [22]. Lower levels of thyroid-stimulating hormone (TSH), lower intelligence quotient (IQ), increased incidence of hyperactivity disorder, and impaired cognitive, motor, behavioral neurodevelopment, and lower birth weight were brought into relationship with prenatal PBDE exposure [40]. Possible explanation for the observed neurological impairments might be related to changes in the thyroid hormone status. The evolution of the nervous system is controlled by thyroid hormones, thyroxine (T4) in particular, and is the most sensitive to environmental effects from the last trimester of pregnancy to two years of age. *In vitro* evidence suggests that PBDEsmay disrupt thyroid hormone production by binding to thyroid hormone receptors, because PBDEs and T4 have a similar stereochemical structure. Human and animal studies point out that PBDEs may change the circulating levels of thyroid hormones.

MANAGING WASTE THAT CONTAIN POLYBROMINATED DIPHENYL ETHERS

PBDEs are a class of fire retardant chemicals added to products during manufacture to increase their resistance to fire. They are and will be present in a wide range of end-of-life products and consequently in the waste. PBDEs belong to hazardous substances and some types are classified as persistent organic pollutants (POPs). Therefore, any end-of-life product or waste stream from products containing PBDEs must be managed in a way that minimises the potential impact on human health and the environment. When used, FRs amount to 5–30% of flame-retarded plastics and foam by weight [41-43]. Assessment of waste stream flow of flame-retarded materials is difficult, whereas there is limited data on use levels and product content.

Products containing brominated flame retardants can undergo a number of waste management options at the end of their life. The option depends on the quantity and quality of the waste stream, as well as on local conditions.

For many years, mechanical recycling of products containing brominated flame retardants has been possible and delivers very rewarding results. Electronics and vehicle components in the mechanical recycling process goes through multistep presorting and pretreatment process. Obtained plastics (with brominated flame retardants) can have excellent stability during recycling which allows recycled plastics to meet the same levels of fire safety as origin material. The purified plastics may be compounded and pelletized so that they can be sold to manufacturers of new products.

When mechanical recycling is not possible, a wide range of eco-efficient waste management opportunities are possible, such as incineration with energy recovery, precious metal smelting, as well as chemical recycling, leading to the recovery of bromine which allows the re-entry of this valuable resource into the circular economy.

The brominated flame retardant industry is committed to working closely with authorities and other stakeholders cooperating along the value chain. Better collection processes, high quality recycling, appropriate regulatory framework, eradication of illegal practices and product design integrating a life-cycle approach is prediction of European Electronics Recyclers Association (EERA) as professional association for the recycling and reprocessing industry.

According to EERA, the amount of electrical and electronic equipment put on the market in the EU evolved from 7.6 million tonnes in 2012 to a peak of 12.4 million tonnes in 2020. Within this period, the lowest level was recorded in 2013, with 7.3 million tonnes. Over the period 2012-2020 as a whole, the amount of EEE put on the market grew by 62.2 %. The total collected WEEE increased from 3.0 to 4.7 million tonnes (+57.8%), while the total treated WEEE grew from 3.1 to 4.6 million tonnes (+49.1%). Recovered WEEE developed from 2.6 to 4.3 million tonnes (+65.2%), and WEEE recycled and prepared for reuse grew from 2.4 to 3.9 million tonnes (+61.7 %) from 2012 to 2020. Only 5% of these plastics contain BFRs.

BFRs used in electrical and electronic equipment, such as printed circuit boards, not pose a problem for WEEE recycling under controlled conditions. The printed circuit boards contain valuable precious and other metals and are separated and sent to specialized metal smelting/recovery operations. After that the metals are recovered, and the resin matrix is consumed as energy.

For waste treatment purposes, there are currently five brominated flame retardants (tetra- and penta-BDE; hexa- and hepta-BDE; and deca-BDE) that are restricted under the Stockholm Convention on persistent organic pollutants (POPs Convention). From an end of life perspective, they are all subject to the Basel Convention where specific treatment techniques and importantly, Low POP Concentration Limits (LPCL) are set, above which the waste containing the POP must be disposed of in an environmentally sound manner. The Table 3. shows the LPCL values for the sum of the PBDEs (both except deca-BDE and as present in c-decaBDE).

Table 3. Persistent Organic Pollutant (POP)/ Low POP Concentration Limits (LPCL)

POP	LPCL
PBDEs (except deca-BDE) Hexabromodiphenyl ether heptabromodiphenyl ether tetrabromodiphenyl ether pentabromodiphenyl ether	50 mg/kg or 1000 mg/kg as a sum
PBDEs (as present in c-decaBDE) [Hexabromodiphenyl ether heptabromodiphenyl ether tetrabromodiphenyl ether pentabromodiphenyl ether decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether	[[50 mg/kg] [500 mg/kg] [1000 mg/kg] as a sum]

The bracketed text indicates the proposed LPCL values according to the version of the General Technical Guidelines on POP waste, which was under discussion in preparation of the 10th meeting of the Conference of the Parties.

The EU Regulation (recast) on Persistent Organic Pollutants (POPs Regulation) (EU) 2019/1021 has set in Annex IV (List of substances subject to waste management provisions) a LPCL of 1,000 mg/kg for the sum of all PBDEs (including deca-BDE). The Annex indicates that the Commission shall review this limit by 16 July 2021 and, where appropriate and in accordance with the Treaties, adopt a legislative proposal to lower that value to 500mg/kg. Also, under Annex I Part A (Substances listed in the Convention and in the Protocol as well as substances listed only in the Convention), an unintentional trace contaminant (UTC) value is set at 500 mg/kg for the sum of all PBDEs (including dec-BDE), where they are present in mixtures and articles. A UTC value of 10 mg/kg is set for the PBDEs as individual substances. This is important for recycling of end of life plastics waste from WEEE, textiles and automotive waste given that no recycling exemption was provided for deca-BDE under the Stockholm Convention. It allows recyclers to produce articles/recycled products that may contain PBDEs with a maximum concentration of 500ppm.

Regulation (EU) 2022/2400 of the European Parliament and the Council of 23 November 2022 amending Annexes IV and V to Regulation (EU) 2019/1021 on persistent organic pollutants (Text with EEA relevance): “As regards PBDEs listed in Regulation (EU) 2019/1021, the concentration limit for the sum of those substances in waste should be set at 500 mg/kg. Taking due account of the declining concentrations of PBDEs in certain waste, resulting from existing limitations on the placing on the market and use of PBDEs, and in light of the possible evolution of relevant sorting and analytical methods, the limit value should be lowered to 350 mg/kg 3 years after the entry into force of this Regulation and 200 mg/kg 5 years after its entry into force”.

CONCLUSION

Polybrominated diphenyl ethers (PBDEs) are a group of man-made organobromine compounds. They have been used as flame retardants in a wide range of products including textile materials, furniture fillers (polyurethane foam), and electronic equipment. For commercial use, they are mixed in various percentages and marketed in three formulations named after the prevalent congener group in the mixture (penta-, octa- and deca-polybrominated diphenyl ethers. Due to their toxicity and persistence, several families of brominated flame retardants have been listed as persistent organic pollutants in the Stockholm Convention. Humans are exposed to PBDEs by ingestion of contaminated foods, inhalation of air, ingestion of contaminated dusts or soils, and via dermal exposure. The health effects related to exposure to BFRs were summarised into five sub groups: thyroid disorders, diabetes, reproductive health, cancers and neurobehavioral and developmental disorders. When products containing PBDEs reach the end of their useful life, proper disposal methods are needed to avoid health and ecological risks. To minimize continued human and environmental exposures to hazardous PBDEs from discarded products, waste management technologies and processes must be improved.

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ANALYSIS OF PHASES AND STEPS OF LOCAL SELF-GOVERNMENT IN RESPONSE TO A CHEMICAL ACCIDENT

Abstract
According to the Law on Disaster Risk Reduction and Emergency Management, the Disaster Risk Reduction and Emergency Management System is part of the national security system and is an integrated form of management and organization of entities under this system to implement preventive and operational measures and perform protection of people and material goods from the perils of catastrophic events. This Law defines 11 catastrophic events, one of which is a technical-technological accident, which includes a chemical accident. This paper analyzes several of the most important documents related to the field of disaster risk reduction and chemical accident, both in the world and in the Republic of Serbia. In addition to the above, the paper also gives a special review of SEVESO operators, considering that they carry out activities in which dangerous substances are present or may be present in equal or greater quantities than prescribed. The key finding indicates the need to further strengthen the capacity of local self-governments to respond to emergency situations, i.e. chemical accidents.

Key words: chemical accident, prevention, local self-government, emergency management, SEVESO operators

INTRODUCTION

Over the past decades, major chemical accidents have caused death, numerous injuries, significant environmental pollution and huge economic losses, but despite these facts, the production and use of chemicals is predicted to continue to grow worldwide, as a consequence of humanity's increased needs for energy and synthetic materials. While industrialized countries still account for most of the world's chemical production, the production, use and disposal of chemicals is steadily expanding into developing countries and countries with economies in transition. These countries are often at particular risk of the negative effects of chemical accidents due to limited regulations or incomplete implementation of existing rules, reduced awareness of risks and preventive measures, and inadequate resources for prevention, preparedness and response [1].

A chemical accident is defined as a sudden, unexpected and uncontrolled release of large amounts of toxic, flammable or explosive substances into the atmosphere, waterways and soil, which can have a harmful effect on people, material goods and the environment [2]. These events are mainly the result of unintentional technological and/or human errors (or a combination thereof), but chemical accidents can also occur as a consequence of natural disasters (earthquakes or floods) or certain sudden intentional actions, such as for example sabotage, terrorism, vandalism or theft [3]. Chemical accidents include fires, explosions, toxic spills, toxic gas releases, or dust explosions. Such accidents can occur in small facilities such as pesticide warehouses, but also in large installations such as refineries, public facilities including water treatment plants that use chlorine, or private production plants for the chemical, pharmaceutical and consumer products industries [4].

At the Organization for Economic Co-operation and Development (OECD) conference on accidents involving hazardous substances in 1988, the ministrys launched an ambitious program in this area. The program developed four Council acts that helped shape major accident policy in member countries. Moreover, in 1992, the Guiding Principles for Chemical Accident Prevention, Preparedness and Response were published [3]. According to OECD data, it is estimated that 30 to 35 chemical accidents of lesser or greater intensity occur in the world every day [5].

Considering the different approach to accident protection at the local level in the countries, the United Nations, through its program for environmental protection (UNEP), and in cooperation with international organizations CEC, OECD, WHO, professional and non-governmental organizations, prepared a Manual on information and preparedness for accidents at the local level (APELL - Avereness and Preparedness for Emergencies at local Level), which can be considered as an internationally standardized approach for responding to technological accidents at the local level. APELL is a UNEP program designed to help governments, local governments, managers and experts in businesses to inform and prepare plans to respond to disasters that could threaten people's lives, property and the environment, however, this does not mean that APELL should replace or to interfere with existing national regulations on protection against technological accidents.

METODOLOGY

This paper is based on a survey of online and print sources, including several important documents related to chemical accidents and chemical accident risk management. The paper analyzes the phases and steps in the response of the local self-government unit to a chemical accident, given that the Ministry of Internal Affairs of the Republic of Serbia in its National Disaster Risk Assessment identified a technical-technological, i.e. chemical accident as one of the dangers that threaten the national security system [6]. Effective action to ensure the prevention and preparedness of accidents involving chemicals requires the coordinated efforts of various stakeholders at the local and national level, such as government bodies, industry, workers and community groups [4]. The local self-government unit is responsible for, through its organs, and in accordance with the Constitution of the Republic of Serbia, the Law on Local Self-Government and the Law on Disaster Risk Reduction and Emergency Management, to take care of environmental protection, to adopt programs for the use and protection of natural values and protection programs environment and to organize protection against natural and other major disasters, as well as fire protection, and to create conditions for their removal, i.e. mitigating their consequences. The following section presents the identified phases and steps, as well as the establishment of a chemical accident notification system for Seveso operators.

RESULTS AND DISCUSSION

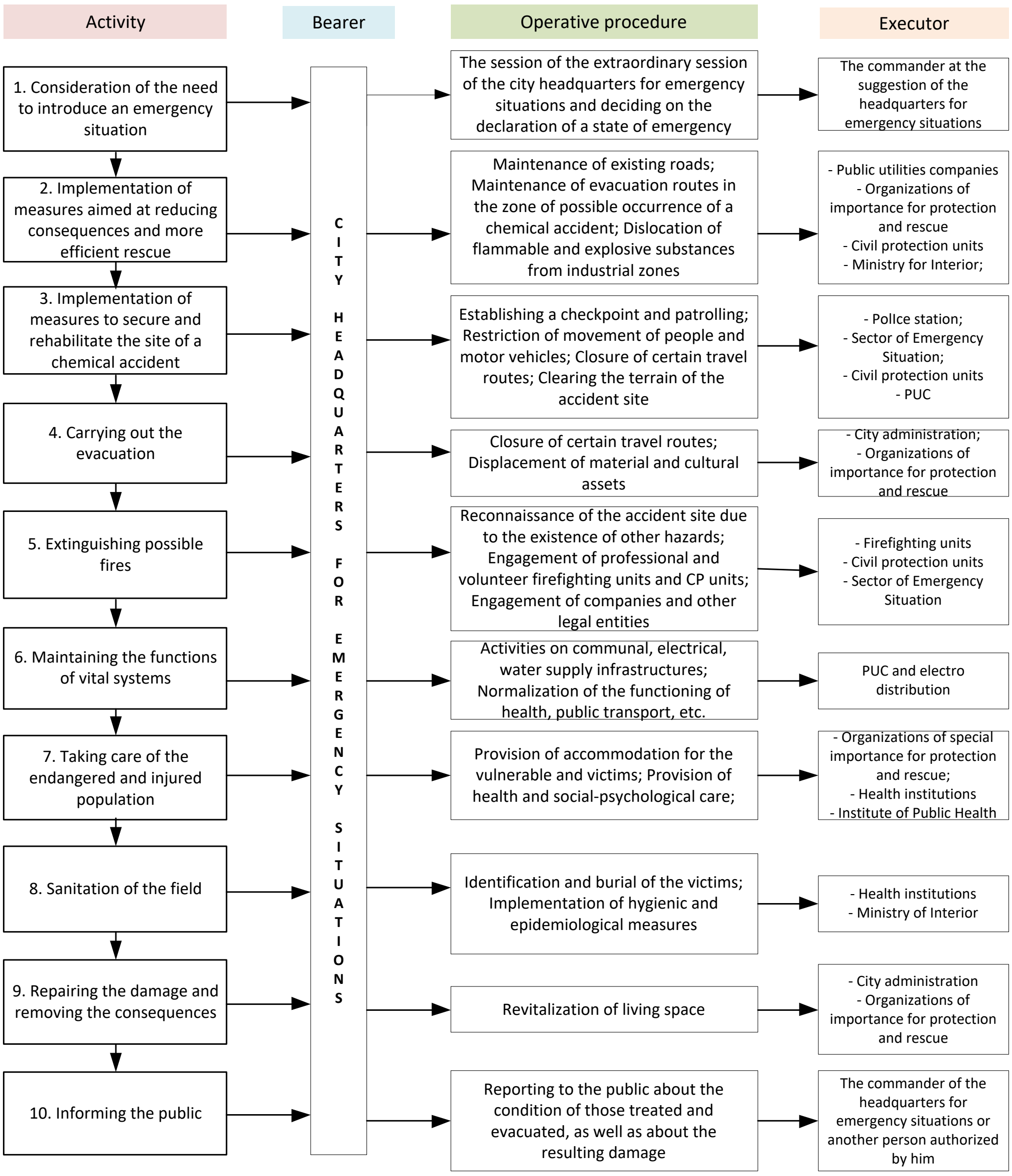
The response of the local self-government unit to the chemical accident

As a rule, every accident is accompanied by injuries and deaths of people, large material losses, as well as a high level of environmental pollution. Particularly large consequences of chemical accidents are manifested at the level of local communities. The question is how to better and more effectively organize and prepare the local community for these threats; ensure the best possible coordination and functioning of activities and measures to prevent the occurrence of accidental conditions and how to introduce significant long-term and short-term changes in social and technological development that will be sustainable [5].

According to the Law on Disaster Risk Reduction and Emergency Management ("Official Gazette of RS", No. 87/2018), local governments are obliged to develop their own disaster risk reduction plans [7]. The coordinator for disaster risk management in the Republic of Serbia is the Department for Emergency Situations, part of the Ministry of Internal Affairs. Its responsibility covers all stages in the disaster risk management cycle, from prevention to response. The emergency sector is represented at all levels of government, with units at the national, district, city and municipal levels [8]. According to the integral model of risk management of chemical accidents, local government bodies are responsible for environmental protection, and are the bearers of protection and rescue activities in the event of an accident. The mentioned model is adapted and harmonized with the current political and economic changes in the Republic of Serbia, with the needs, possibilities and perspectives of integration into the modern European and wider international community [5].

Chemical accidents often happen without warning, and when they happen it is too late to plan, organize, equip and train. It is of great importance to establish and maintain a state of readiness, so that the subjects of the system participating in protection and rescue are quick enough to respond to risks that may lead to an accident. The best response to a chemical accident is achieved from the design phase of the company, then construction and in the production process, through the constant development and implementation of prevention, preparedness, etc. measures. Response refers to all actions to be taken when an accident occurs or there is an imminent threat of an accident, including mitigation of adverse effects on health, the environment and property. Examples include informing the public and authorities, dispatching emergency services, conducting detailed analyzes and assessments of environmental and health impacts, and coordinating the arrival of aid [1]. The response to an accident begins the moment the first information about the accident is received, which contains information about: the place and the accident; the type of dangerous substances that are present; assess the course of the accident; assess the risk in the environment as well as other important data. Figure 1 shows a schematic representation of the competence of the local self-government unit in the implementation of measures and activities in response to a chemical accident.

Figure 1. Competence of the local self-government unit in the implementation of measures and activities in response to a chemical accident



Source: Author

Each of the participants in the response to a chemical accident has its own defined obligations. At the first sign of an accident, the government services that are specially prepared for this (police, ambulance, firefighters) react first. When the responding government services themselves are threatened and their inability to provide real help to the vulnerable, the role of local communities and the population (individuals) in taking measures to mitigate the impact of the accident is emphasized. Governance at the local level is an integral part of any national planning and the essence of the Law on Disaster Risk Reduction and Emergency Management.

Preparedness is a state in a company or local community that is achieved by preparing all competent entities, equipment and techniques for the most adequate response to an accident with the least possible consequences, and this is ensured by the adoption of protection plans. For the best possible response to the accident, it is necessary to adopt response plans at all levels of government and competent services. The plan is only a general framework and is based on theoretical knowledge, experience and measures that should be applied to prevent, take care of and reduce in the first place human casualties and material losses caused by natural, technological and other accidents. Detailed plans must be prepared in each of the emergency services, at all levels of the community (local, county, national, regional and global), in all commercial, professional and voluntary organizations. No plan can provide solutions for each accident individually and for each type of accident due to the unpredictability and variants of mass accidents. The local community has the primary responsibility for care because the human and material resources are located on its territory and must be quickly and properly used until the help of the wider community arrives. Most accidents have different consequences, so treatment requires a joint and coordinated response, connecting human and material resources of professional services (police, firemen, ambulance, hospital), social communities at all levels, army, gendarmerie and volunteer organizations.

Restoration and remediation of damage involves much more than simple physical repair of material goods and reestablishment of utility services. Rebuilding is a process that certainly takes weeks and months. Reconstruction of a local community after a disaster implies the recovery of the basic functions of that community, social structures and systems. The community's ability to achieve this implies the mutual relationship and interaction of the community on the one hand and the social, economic, natural and construction environment on the other. In the case of a chemical accident, the remediation of the consequences of the accident is carried out based on the identification of the type and quantity of the released hazardous substance and the spatial scope of the contamination. Based on the rehabilitation plan and determination of the situation on the spot, the procedures and scope of the necessary rehabilitation, as well as the necessary means and forces, are applied.

The Law on Disaster Risk Reduction and Emergency Management provides that local self-government units allocate funds from their regular budget for disaster risk reduction and emergency management [9]. Also, financing can come from capital and other projects, however, it should be noted that municipalities in the Republic of Serbia have few resources to generate their own income.

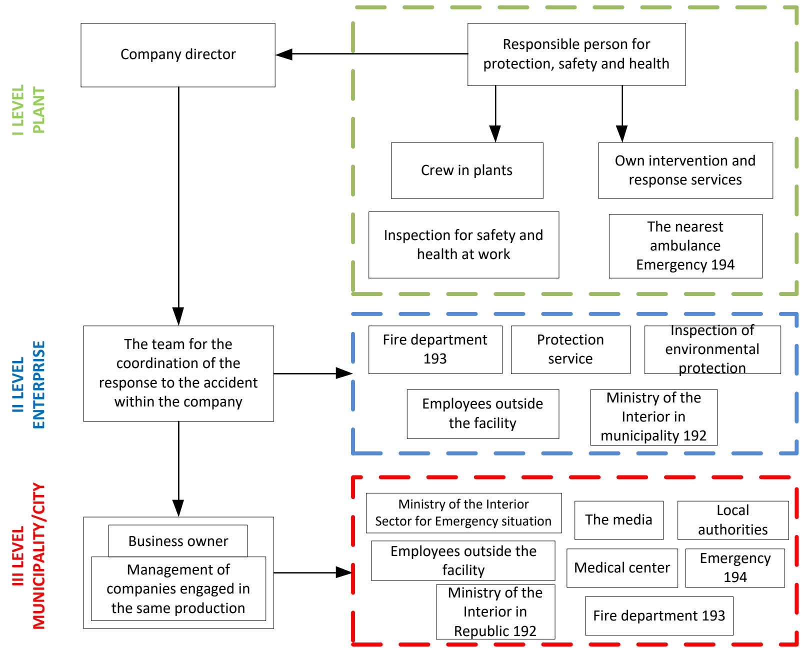
Response of the SEVESO operators

The Seveso accident that happened in 1976 in Italy, in a pesticide chemical factory, had a significant impact on the development of European Union (EU) policy and regulation in the field of prevention and control of industrial pollution and risk management. In 1982, the Council of the European Community adopted Directive 82/501/EEC on the hazards of serious accidents in certain industrial activities, better known as the Seveso Directive. After reviewing the accidents that followed in the years following the adoption of the mentioned directive and its amendments, in 1996, a special Directive 96/82/EC on the control of major accidents involving dangerous substances, better known as the Seveso II Directive, was adopted. This directive, which was amended three times, completely replaced the original Seveso directive and since 1999, the provisions of this directive have become mandatory for the industry and public authorities of EU member states. At the moment, EU member states regulate the field of chemical accidents with the provisions of the Seveso III Directive. Compared to Seveso I and II, Seveso III provides better access to citizens (local communities) to information about the risks arising from the operation of facilities that use or transport dangerous substances, about behavior in the event of an accident, and about more effective rules regarding public participation.

The provisions of the Seveso II Directive have been significantly adopted in the Serbian law on environmental protection [10]. In order to take all necessary measures to prevent chemical accidents, limit the impact of those accidents on the life and health of people and the environment, as well as to create conditions for risk management, in 2009, amendments to the Law on Environmental Protection were adopted. With the adoption of those amendments as well as the accompanying by-laws into national law, the provisions of Directive 96/82/EC on the control of major accidents involving dangerous substances (Seveso II Directive) have been fully implemented. Since May 2019, the Ministry of Environmental Protection has been preparing the Law on the Control of the Risk of Major Accidents Involving Hazardous Substances for the complete transformation of the EU Seveso III Directive, including Annex I of that directive, which defines hazardous substances and their limit quantities that

have already been fully implemented in the existing legal framework. The Republic of Serbia currently has 109 Seveso facilities, and the operators are obliged to prepare (depending on the amount of hazardous materials) a Safety Report and an Accident Protection Plan (for the so-called "higher" level complexes), or an Accident Prevention Policy (for the so-called "lower" level complexes). The Ministry of Environmental Protection adopts the Safety Report and the Accident Protection Plan, while the implementation of the Accident Prevention Policy is checked during inspection. The Ministry of Environmental Protection works closely with other ministries and the Sector of Emergency Situations, in order to prevent major accidents, always taking into account external sources of danger that could cause chemical accidents (for example, earthquakes and floods).
Seveso operators submit data to local authorities for the preparation of external Accident Protection Plans, which are an integral part of the Protection and Rescue Plan in emergency situations. Figure 2 shows a schematic representation of the establishment of a system for notifying persons participating in accident response and the public for I, II and III level accidents.

Figure 2. Establishing a notification system for persons participating in the response to an accident and the public for Level I, II and III participation.



Source: Author

At the company level, the accident response manager is the accident response coordinator. The coordinator establishes an on-call book in which the following are recorded: all disruptions in the technological process of production, manipulation of raw materials and finished products, injuries at work, disruption of work discipline. The coordinator informs the relevant Ministry of the Republic and assesses whether they can respond to the accident with their own forces or whether the Republic needs help. Also, basic data from the hazard assessment is provided to the municipal fire department, the nearest police station and the emergency medical aid station, and the management is informed about the need to familiarize themselves with the method of notification, alerting and the possible engagement of units in response to an accident, through evacuation and the provision of emergency medical aid.

CONCLUSION

Chemical safety is a cross-cutting issue for countries and contributes to the overall sound management of chemicals and countries' disaster risk reduction efforts. As proclaimed in the Yokohama Strategy declaration, every country has the sovereign responsibility to protect its citizens from accidents and disasters, to develop and strengthen state capacities and corresponding state legislation to combat the harmful effects of hazards, to improve and strengthen regional and international cooperation in activities for prevention, reduction and mitigation of accidents and disasters [5]. The main problem at the municipal level in the Republic of Serbia is the lack of finances, personnel, expertise, training and equipment. Although local governments are obliged by law to allocate funds from their budgets for disaster risk reduction and emergency management, they allocate only 0.01-1.7% [6]. In general, it can be said that in the Republic of Serbia, significant efforts have been made in the last few years to improve the situation in the field of industrial plant safety, however, in the future, it is necessary to further strengthen the capacity at the local level for preparedness and response in case of incidents and disasters, and all this through improvement of early warning, risk assessment, as well as improvement of the health system. In addition, through trainings and the acquisition of specialized equipment, investments should also be made in the civil protection system at the local level. All these measures would significantly strengthen the existing infrastructure of the Emergency Situations Sector of the Republic of Serbia, especially in response to chemical and other types of technical-technological accidents.

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ANALYSIS OF THE SPECIFICS OF BIOLOGICAL RISK MANAGEMENT AT SOLID WASTE AND WASTEWATER TREATMENT PLANTS

Abstract
According to several legal acts currently valid in the Republic of Serbia, employees are obliged to fulfill their work obligations, but also to work in a safe, first of all, organized and stimulating working environment. In this context, as a special challenge in the coming years, specifically by 2045 in the Republic of Serbia, a significant increase in the number of solid waste and waste water treatment plants is expected, and therefore the number of workers-operators on them. As there is currently no dedicated instruction, specification or legislation for occupational risk management at such facilities, the aim of this work is to analyze existing practices and approaches in this area, as well as to characterize certain harmful biological agents. The main conclusion of the paper indicates the necessity of creating innovative, dedicated instructions for managing biological hazards at such facilities (together with physical, chemical and radiological risks) similar to documentation related to safe work with asbestos, as example.

Key words: biological risks, solid waste treatment, waste water treatment, management.

INTRODUCTION

An efficient, effective, reliable, continuous and sustainable waste and wastewater treatment systems (as a part of broader public utilities sector at the local scale) is a prerequisite for the social well-being of modern human society, but also for the protection of the living environment in urban areas. This is especially important in the era of intense urbanization, where the percentage of the population in urban agglomerations is constantly growing, which creates new challenges in the domain of meeting essential human needs, on the one hand, and effective environmental protection, on the other. As an adequate mechanism for meeting such dual needs of society, the waste and wastewater treatment system has long been recognized as a necessary element of human communities. Bearing in mind the already mentioned effects of urbanization, climate change, but also changes in the habits and needs of the average member of a modern household, consumerism, new technologies, new products and therefore emergent pollutants, the necessity of transformation and reorganization of waste and wastewater treatment related activities in the context of an effective response to modern challenges is a necessity [1].
Waste and wastewater treatment systems includes both technical and financial resources, but also organizational and legal elements that aim to improve the quality of life in the territory of a certain local self-government unit. An efficient and effective waste and wastewater treatment system is essential in any large city, small municipality or village (which may also have some rudimentary utility system, primarily due to water supply needs). Moreover, the importance of waste and wastewater treatment system and public hygiene, gained even greater importance during the pandemic caused by the Covid-19 virus, given that the local self-government is obliged to take care of the prevention of the spread of infectious diseases, regardless of origin, intensity and virulence of pathogens [2].
On the other hand, additional dedication to the prevention of the spread of the pandemic caused by the Covid-19 virus has encouraged a certain, albeit modest number of researchers, to study the working conditions of operators in the areas of waste and wastewater treatment systems, that is, to define models of "*occupational protection of public health protectors*". This is particularly important considering the fact that the recording and analysis of occupational injuries is regulated in great detail by the work of Eurostat, i.e. the ESAW database, while on the other hand, the recording and analysis of occupational diseases particularly coupled with biological risks in any workplace, in the fields of waste and wastewater treatment, even at the level of the European Union, shows very modest progress at the time

of writing this paper, that is, it can be said that it is still in the development phase (namely European Occupational Diseases Statistics - EODS). No less important is the fact that certain instructions and guidelines for the safe work of operators in the fields of waste and wastewater treatment exist at the level of the work of the US Environmental Protection Agency and the Centers for Disease Prevention, which represents an additional motivating factor for research and creating contributions in this field.

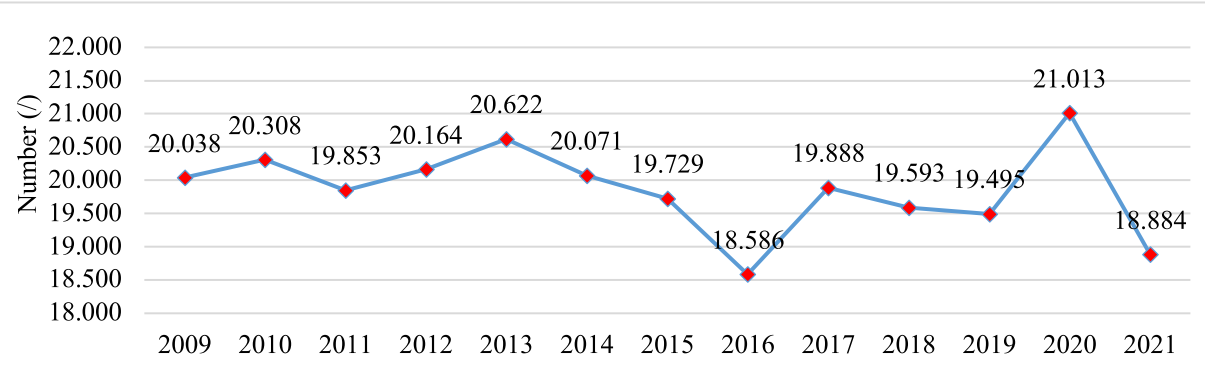
METHODS

For the purposes of this research, i.e. results of which part are presented within this paperwork, a combined-collaborative desktop research of relevant literary content and corresponding online available databases was conducted, where the experiences and approaches of different organizations working in this field were analyzed [3]. A summary report as a result of the synthesis of identified key components of biological risk management in waste and wastewater treatment systems is provided in the results section with an accompanying discussion. In addition, a descriptive description of some biological hazards is given within the paper.

RESULTS

Pursuant to the Law on Communal Activities, communal activities represents the production and delivery of communal products and the provision of communal services, which are an irreplaceable condition for the life and work of citizens and other subjects in a certain area, where waste and wastewater treatment activities form part of the overall communal system of an settlement (as a rule, waste and wastewater treatment connected communal activities often employ more than two-thirds of the total number of employees in the overall communal sector, either at the local or national level). A relatively large number of employees leads to a significant diversification of tasks, especially those for which there is a need for professional risk assessment. An illustration of the number of employees in the public water supply and sewerage sector in the Republic of Serbia is given in Figure 1.

Figure 1. Total number of employees in RS PUC, water supply and sewerage sector.



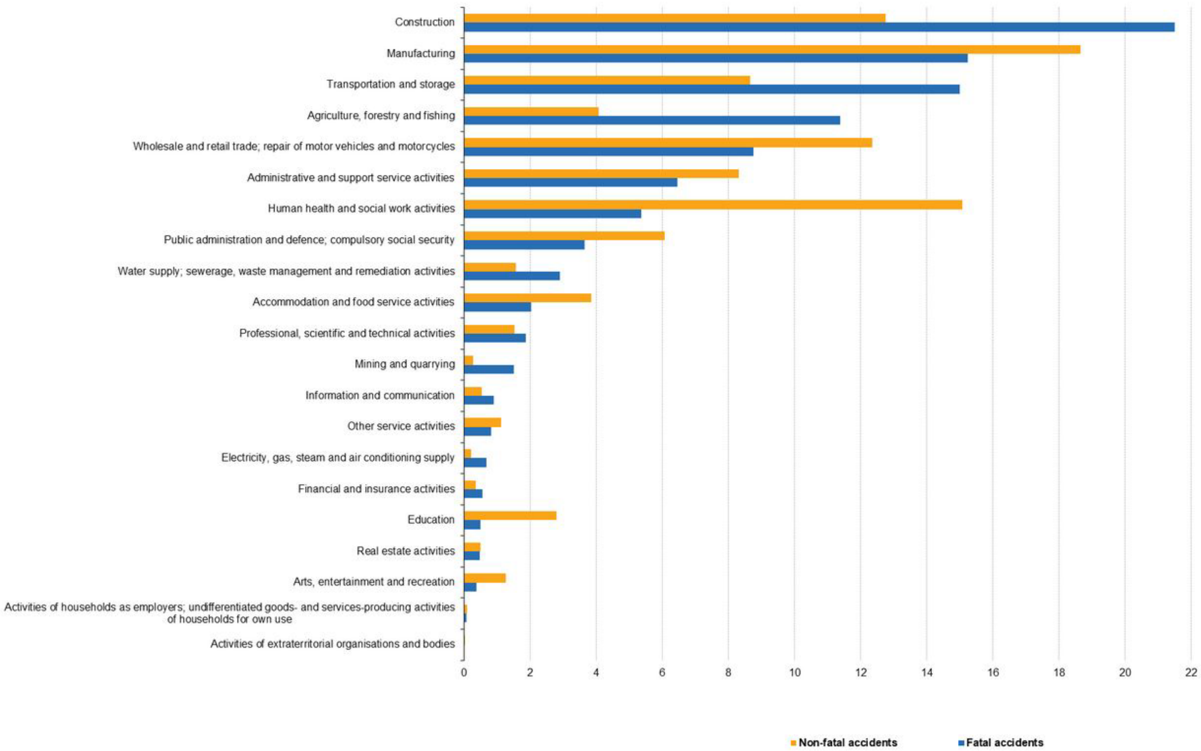
Source: Statistical office of the Republic of Serbia - SORS

Specifically, the treatment of waste and wastewater is a part of communal activities:

- purification and removal of atmospheric and waste water is the collection, removal, purification and discharge of waste, atmospheric and surface water from public areas, i.e. from the user's connection to the street sewer network, treatment of wastewater in a plant for purification, pumping, removal and treatment of faeces from septic tanks,
- municipal solid waste management is the collection of municipal waste, its removal, treatment and safe disposal, including management, maintenance, sanitation and closure of landfills, as well as the selection of secondary raw materials and maintenance, their storage and treatment.

In the waste and wastewater treatment system set up in this way, a strong emphasis is placed on the quality and continuity of communal services, while the needs of environmental protection or improvement of the working conditions of engaged operators are not taken into account at all, or very little. On the other hand, subjects of public health preservation, according to the Law on Public Health, in addition to other institutions, are also public utility companies, especially those operating in the field of sanitary and hygienic supervision of waste and wastewater treatment. Therefore, the obligations and importance of employees in the waste and wastewater treatment system are unquestionable, but without specific guidelines for the education needs of "occupational protection of public health protectors", especially in the domain of biological risk management (this needs to be emphasized especially since other aspects (mechanical, chemical) of occupational risk management are appropriately regulated by documents that form part of the workplace risk assessment) [4, 5]. As illustration, the comparison between occupational injuries statistics provided by the ESAW (European Statistics on Accidents at Work) and the EODS (European Occupational Diseases Statistics) is provided, with focus on Figure 2. and subsequent comments.

Figure 2. Fatal and non-fatal accidents at work in the EU by NACE codes in the 2020.



Source: Eurostat, ESAW

While the ESAW database represents the well-proven source of the data that enables various analyses, namely number of accidents, incidence rates, standardised incidence rates, analysis by activity, analysis by type of injury, trends from 2010. to 2020. etc., EODS is quite limited database, although recognized as essential element in the European Commission’s strategy to assess the efficiency of the EU legislation on Health and Safety at Work. In particular, because of the limited data available, the objective of EODS pilot database is to respond to the data need by gathering national data in a unique database and to provide basic trends on the most recognized occupational diseases in the European Union, as requested by requirements that are underlined in Annex V of EU Regulation 1338/2008. As defined by article 2 of the EU Regulation 1338/2008, EU member states should supply data to the Eurostat statistics on the following domains:

- health status and health determinants,
- health care,
- causes of death,
- accidents at work,
- occupational diseases and other work-related health problems and illnesses.

Beyond the occurrence of diseases, these data will provide useful information about causality, exposure and medical consequences which are needed for the prevention and the evaluation of the issue in all occupational fields, even in the field of waste and wastewater treatment systems. However, the occupational disease statistics are based on administrative data collected at national level by various organizations under the auspices of the national statistical office, which have not yet been converted into interoperable EU indicators, thus provide only a partial insight into occupational diseases associated with biological risks at the level of individual member states. Therefore, in this form, the EODS pilot database cannot be the basis for root-cause-and-effect analyzes between biological hazards and occupational risks and diseases in any economic activity, and therefore also in the field of waste and wastewater treatment. At the moment, it is only possible to have an overview of summary data on occupational diseases, without the possibility of analyzing specific shares caused by biological hazards at workplaces in the field of waste and wastewater treatment, namely within NACE section code E: Water supply, sewerage, steam and air conditioning supply. In this way, the possibility of characterizing biological hazards in this NACE section and defining the measures of the biological risk management process is not avalilable.

DISCUSSION

Bearing in mind the previously stated facts about the impossibility of using the EODS database in its current form for the characterization of various aspects of the biological risk management process, particularly in the field of waste and wastewater treatment, it is necessary to compile guidelines, conclusions, recommendations, etc. published by various competent institutions in this field (ILO, WHO, US EPA...) and the results of published works related to this issue. The result of this analysis are the following conclusions.

In the municipal solid waste management system, there is a steady trend of increasing occupational exposure levels to biological hazards, which is primarily caused by an increase in the average amount of generated waste per inhabitant, an increased frequency of collection, an increase in the percentage of diapers and pet feces, hygiene product residues, etc. which leads to gastrointestinal problems, irritation of the eye and skin and problems with the respiratory organs of operators. The dominant biological agents (pathogens) found in municipal solid waste connected to increase of the biological risk are: fecal coliforms, salmonellae, human enteroviruses, human noroviruses, protozoan parasites, yeasts and micro fungi [7].

Within the municipal wastewater treatment processes, particular problem represents the occupational exposure to traditional biological hazards linked to the occurrence of the high concentrations of the fecal coliforms and resistant viruses, particularly HBV, and in recent years, Covid-19 [8]. A particular problem within the biological risk management system in wastewater treatment processes is the increase in the amount of coarse suspended impurities that represent absorbers/carriers of pathogens, such as non-biodegradable wet wipes [9].

CONCLUSION

In relation to the relatively frugal scientific experience in the field of biological risks management (BRM) in the waste and wastewater treatment systems, it is possible to notice very varied approaches in defining the scope, content and structure of BRM practices. The main conclusion of this paper is that there is not a sufficiently detailed system of recording occupational diseases in all sectors (either through the use of the NACE approach or the ISO division of economic activities), especially those occupational diseases related to biological risk factors. The existence of a suitable database is a prerequisite for the creation of guidelines/instructions for managing biological hazards, for instance, similar to those instructions that exist for safe work with asbestos, which already was mentioned in the introductory part of the paper. Equally important is the fact that the creation of such instruction represents only an initial step, which must be complemented by appropriate training for either responsible persons or employees in the waste and wastewater treatment system.

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Darko Palačić

CHEMICAL HEALTH AND SAFETY RISK MANAGEMENT MODEL

Abstract
Chemicals used in the work processes may include products for use in the core business, for equipment maintenance, or for general cleaning, and can also include hazardous substances that are produced as part of work processes. Chemical safety can be achieved by undertaking all activities with chemicals in such a way as to ensure the safety of human health and the environment. Regulations require the employer to control the use of chemicals at work. Therefore, chemical safety risks in the workplace must be assessed and effective control measures must be implemented and maintained. Risk management is the foundation for overall occupational health and safety management. The first part of the paper presents the theoretical principles of health and safety at work related to the use of chemicals, the theoretical principles of risk management and the theoretical presentation of the risk management model. The second part of the paper describes a chemical health and safety risk management model. The chemical health and safety risk management model includes identification the scope of management, the context of the organization, criteria, risk assessment, risk management, monitoring and review, and communication and consultation, and recording and reporting. The discussion and conclusion outline opportunities and recommendations for improving the process of managing chemical health and safety risks.

Key words: chemical, management, model, occupational health and safety, risk.

INTRODUCTION

The importance of chemical health and safety risk management in occupational health and safety processes

A chemical is any substance that has a defined composition. In other words, a chemical is always made up of the same "stuff." A chemical substance is a form of matter having constant chemical composition and characteristic properties. Some chemicals occur in nature, and other chemicals are manufactured. Chemicals are all around: the food, the clothes etc. A chemical reaction refers to a change in a chemical. More generally, a chemical reaction can be understood as the process by which one or more substances change to produce one or more different substances. Chemical changes are different from physical changes, which don't result in a change in substances. One example of a physical change is when water freezes into ice. While ice may have different physical properties, it is still just water. Another example is when you dissolve salt into a cup of water. While the salt may appear to disappear into the water, you still have water and salt, no substance changed into a completely new substance.

A chemical substance may well be defined as "any material with a definite chemical composition" in an introductory general chemistry textbook. According to this definition a chemical substance can either be a pure chemical element or a pure chemical compound. But, there are exceptions to this definition; a pure substance can also be defined as a form of matter that has both definite composition and distinct properties. [6]

Chemicals are essential for the well-being, high living standards and comfort of modern society. They are used in many sectors, including health, energy, mobility and housing. However, most chemicals have hazardous properties which can harm the environment and human health. [Chemicals strategy for sustainability, European Commission]

According to World Health Organization in 2019, a small number of chemicals for which data are available were estimated to cause 2 million deaths from a variety of health outcomes including poisonings, heart diseases, chronic respiratory diseases and cancers. Chemical pollution also negatively impacts a range of facets of the ecosystem, which can harm human health. [4]

Some hazardous chemicals are of particular health concern because of their widespread presence in the environment, their toxicity and capacity to magnify and accumulate in environmental and human media, and the fact that many humans easily come in contact with them thereby harming the health of large populations. Chemicals or groups of chemicals of major public health concern include air pollution, arsenic, asbestos, benzene, cadmium, dioxin and dioxin-like substances, inadequate or excess fluoride, lead, mercury and highly hazardous pesticides. [18]
Pursuant to the Occupational Health and Safety Act (N.N. 71/14, 118/14, 154/14, 94/18, 96/18), the employer is obliged to implement occupational safety and health on the basis of the following general principles of prevention:

- risk avoidance
- risk assessment
- preventing risks at their source
- adjustment of work to workers in relation to the design of the workplace, the choice of work equipment and work methods and work procedures to mitigate uniform work, work with imposed rhythm, work on performance in a certain time (standard work) and other efforts to reduce their harmful effects on health
- adapting to technical progress
- replacing the dangerous with non-dangerous or less dangerous
- developing a consistent comprehensive prevention policy by linking technology, work organization, working conditions, human relations and the impact of the working environment
- giving priority to collective protective measures over individual ones
- appropriate training and informing for workers
- free prevention, ie occupational safety measures for workers.

The employer is obliged to determine and perform occupational safety activities in accordance with the risk assessment, the state of occupational safety and the number of employees.
In the field of occupational health and safety when working with chemicals, risk management is of particular importance. The employer is responsible for managing the protection of the health and safety of workers and other persons who may be affected by the work activities of the organization. The processes of the occupational health and safety management system apply the general principles of occupational risk prevention and health protection, rules for the elimination of risk factors, employee training procedures and procedures for informing and consulting employees and their representatives with employers and their representatives. [10]
The employer is obliged, taking into account the jobs and their nature, to assess the risks to life and health of workers and persons at work, especially in relation to the means of work, working environment, technology, physical hazards, chemicals and biological agents used, workplace management, organization of work process, uniformity of work, statodynamic and psychophysiological efforts, work with imposed rhythm, work by performance in a certain time (work on norm), night work, mental workload and other risks present, in order to prevent or reduce risks. According to the Ordinance on risk assessment preparation (N.N. 112/14, 129/19), risk assessment is a procedure that determines the level of danger, harmfulness and effort in terms of injuries at work, occupational diseases, work-related illnesses and work disorders that could have harmful consequences for the safety and health of workers.
Also, the employer is obliged to have a risk assessment made in written or electronic form, which corresponds to the existing risks at work and in connection with work and which is available to the worker at the place of work. Based on the risk assessment, the employer is obliged to apply safety rules, preventive measures, organize and implement work and production procedures, *ie* methods and take other activities to prevent and reduce workers' exposure to identified risks, in order to eliminate or minimize the likelihood of occurrence, injuries at work, occupational or work-related illnesses and to ensure a better level of occupational safety at all levels of work organization and management.
Workers must be involved in the risk assessment process. [10]

Aim and purpose of the research

Risk management in dealing with hazardous chemicals is becoming more and more important every day. It is not enough just to determine the level of risk, but it is necessary to establish the entire risk management system.
The aim of the research is to analyze and present the chemical health and safety risk management model.

Research tasks

In accordance with the set goal, the research tasks are:

– to analyze and present the basic theoretical assumptions of occupational health and safety
– to analyze and present the basic theoretical assumptions of chemicals
– to analyze and present the basic theoretical assumptions of risk
– to describe the chemical health and safety risk management model, with its principles, framework and processes
– to present a chemical health and safety risk management model in the processes of occupational health and safety.

METHODS

Research methods are a way of purposefully solving problems. Based on the identified problem, set goal and tasks of scientific research, appropriate scientific methods that make up the methodology of work have been selected. For this purpose, a number of scientific methods are applied, which by their combination and sequence form an established research methodology that should meet the requirements of the planned theoretical research. The method of studying documentation and content analyzes:

– basic assumptions of the theory of occupational health and safety
– basic assumptions of risk management theory
– the manner of implementing regulations in the field of occupational health and safety from the aspect of implementing of the risk management system.

The theory settings of risk management and occupational health and safety are analyzed from the selected scientific literature. Also, with the aim of detecting the implementing management theory, regulations in the field of occupational health and safety are analyzed. A combination of deductive and inductive analysis is used in order to classify and summarize the theoretical foundations of the research subject. The method of content analysis is used to analyze theoretical assumptions. The method of description describes the essential features and the chemical health and safety risk management model. After conducted analysis and comparison, the essential properties are synthesized, conclusions are drawn and a chemical health and safety risk management model is defined.

RESULTS AND DISCUSSION

Chemical health and safety risk management

Even in prehistoric times, there was a risk of the impossibility of achieving basic living conditions when it was not known what to find in the day to eat, whether to catch an animal and etc. Nowadays, risks in everyday life there are various risks such as participation in traffic in which there is a real danger of a traffic accident, and so on. Therefore, we can say that risk develops over time and that our daily activities have become increasingly insecure. The concept of risk due to its ambiguity and complexity has always attracted the attention of scientists from various fields and branches of science. Risk has been approached from different aspects, so that even today there is no single definition of risk. Therefore, risk is defined in many ways, of which the most significant are listed below:

– risk is the uncertainty of outcomes within the exposure range, which arises from a combination of the impact and probability of potential events [16]
– risk is the uncertainty of an event that could affect the achievement of objectives, the risk is measured in terms of consequences and probability [7]
– risk is a condition in which there is a possibility of a negative deviation from the desirable outcome that we expect or hope for. [2]
– risk is the possibility of something bad happening at some time in the future; a situation that could be dangerous or have a bad result [Oxford English Dictionary]
– risk is a combination of the probability of an event and its consequences, and the consequences can be positive or negative [The Institute of Risk Management]
– risk is the degree of uncertainty [15]
– risk is the effect of uncertainty on objectives (an effect is a deviation from the expected - positive and/or negative) [ISO 31073:2022 Risk management - Vocabulary]

– risk is the effect of uncertainty [ISO 9000:2015 Quality management systems - Fundamentals and vocabulary]

Risks, in their different forms and inter-relationships, may be the subject of observation and management based on different perspectives. The main risk observation perspectives stem in particular, from studies in the economic-corporate and production areas, and may be summarized as, strategic perspective, corporate governance perspective, financial perspective, and operational perspective. Therefore, it emerges that, with a view to detecting the many facets and forms under which they appear, risks should be simultaneously observed from many and different perspectives. [3]

A breakthrough in risk assessment occurred in 1654 when Pierre de Fermat and Blaise Pascal laid the foundations of risk theory. [13] Risk management is the method used to control, eliminate, or reduce the hazard within parameters of acceptability. Risk management is unique to each individual, since there are no two people exactly alike in skills, knowledge, training, and abilities. [15]

Risk management are the coordinated activities to direct and control an organization regarding risk. [ISO 31073:2022 Risk management - Vocabulary]

Risk management and risk 'talk' are all around us. The risk-based description of organisational life is conspicuous. Not only private sector companies, but hospitals, schools, universities, and many other public organisations, including the very highest levels of central government, have all been invaded to varying degrees by ideas about risk and its management. [14]

Risk management organises what cannot be organised, because individuals, corporations and governments have little choice but to do so. The risk management of everything holds out the promise of manageability in new areas. But it also implies a new way of allocating responsibility for decisions which must be made in potentially undecidable situations.

Risk is a complex concept that occurs in all areas of life, in private and business terms. Risk constantly accompanies all human activities.

Occupational health and safety

Economically, morally, and legally, occupational safety and health has become an important issue. Companies are attempting to remain profitable in an ever more competitive global economy. For these companies, addressing safety, health, and environmental issues may mean more than good business practice. For many companies, strong safety, health, and environmental programs may actually mean survival. [5]

Occupational health and safety in practice is terminologically identified with occupational safety. Since security is the superior term to the term protection, it can be concluded that terminologically these two terms cannot represent and mean the same thing.

Occupational health and safety (OHS) generally defined as the science of the anticipation, recognition, evaluation, and control of hazards arising in or from the workplace that could impair the health and well-being of workers, considering the possible impact on the surrounding communities and the general environment. This domain is necessarily vast, encompassing many disciplines and numerous workplace and environmental hazards. A wide range of structures, skills, knowledge, and analytical capacities are needed to coordinate and implement all "building blocks" that make up national OHS systems so that protection is extended to both workers and the environment. [1]

Therefore, safety at work can be defined as a system of technical, health, legal, psychological, pedagogical, and other activities, which detect and eliminate dangers and harms that can endanger the life and health of people at work. [8] On this basis, it is concluded that the purpose of safety at work is to create safe conditions to prevent injuries at work, occupational diseases, and accidents at work.

Due to its multidisciplinarity, occupational safety is studied from several aspects: legal (its normative regulation); economic (study of the economic effects of lost working days and other costs incurred due to injuries at work and the organization of professional work of occupational safety in organizations); organizational (a way of effectively organizing all elements of the work environment); psychophysiological (the way the human body reacts in the process of work); technical (finding optimal technical and technological measures to improve working conditions); sociological, where the protection of human integrity in the work environment is understood and explored as an element of its social security that contributes to the realization of more humane relations in society; medical, etc. [17]

Occupational safety is part of the organization of work and performance of the work process, and is achieved by performing occupational safety and applying the prescribed, agreed, as well as recognized rules of occupational safety and ordered measures and instructions of the employer. [4] The employer is responsible for the organization and implementation of occupational safety on the basis of objective responsibility, regardless of whether it has hired an occupational safety expert, or organized an occupational safety service or has contracted cooperation with an authorized person for occupational safety, institution or company for occupational safety. [9]

The scope of occupational safety and health has evolved gradually and continuously in response to social, political, technological and economic changes. In recent years, globalization of the world's economies and its repercussions have been perceived as the greatest force for change in the world of work, and consequently in the scope of occupational safety and health, in both positive and negative ways. Liberalization of world trade, rapid technological progress, significant developments in transport and communication, shifting patterns of employment, changes in work organization practices, the different employment patterns of men and women, and the size, structure and life cycles of enterprises and of new technologies can all generate new types and patterns of hazards, exposures and risks. Demographic changes and population movements, and the consequent pressures on the global environment, can also affect safety and health in the world of work. [1]

The state of safety at work, in other words, the efficiency and effectiveness of the prevention of injuries at work and occupational diseases, depends on the success of the implementation of occupational safety in relation to the existing risks at work. Therefore, the key precondition for the planning and implementation of occupational safety is the assessment of occupational risks, and further and continual management of occupational risks. Risk management is a preventive process by which risks at work are identified and further procedures are carried out to avoid and/or reduce them.

The evaluation of risks in the workplace starts with the identification of the types of hazards existing at the facility. Establishing a process to ensure hazards are identified as the primary goal of a progressive organization with a strong safety management program. The organization eliminates or reduces the risks associated with those hazards to the lowest achievable and reasonable level. [5]

Principles of chemical health and safety risk management

Risk management is based on the principles, framework, and process. The purpose of risk management is the creation and protection of value. It improves performance, encourages innovation, and supports the achievement of objectives.

The principles of risk management provide guidance on the characteristics of effective and efficient risk management, communicating its value and explaining its intention and purpose. The principles are the foundation for managing risk and should be considered when establishng the organization's risk management framework and processes. These principles should enable an organization to manage the effects of uncertainty on its objectives. [ISO 31000:2018, Risk Management – Guidelines]

Effective risk management requires the elements and can be further explained as follows .

- Integrated - Risk management is an integral part of all organizational activities.
- Structured and comprehensive - A structured and comprehensive approach to risk management contributes to consistent and comparable results.
- Customized - The risk management framework and process are customized and proportionate to the organization's external and internal context related to its objectives.
- Inclusive - Appropriate and timely involvement of stakeholders enables their knowledge, views and perceptions to be considered. This results in improved awareness and informed risk management.
- Dynamic - Risks can emerge, change or disappear as an organization's external and internal context changes. Risk management anticipates, detects, acknowledges and responds to those changes and events in an appropriate and timely manner.
- Best available information - The inputs to risk management are based on historical and current information, as well as on future expectations. Risk management explicitly takes into account any limitations and uncertainties associated with such information and expectations. Information should be timely, clear and available to relevant stakeholders .
- Human and cultural factors - Human behaviour and culture significantly influence all aspects of risk management at each level and stage .
- Continual improvement - Risk management is continually improved through learning and experience. [ISO 31000:2018, Risk Management – Guidelines]

Framework of chemical health and safety risk management

According to ISO 31000:2018, Risk Management – Guidelines, the components of a framework of chemical health and safety risk management are:

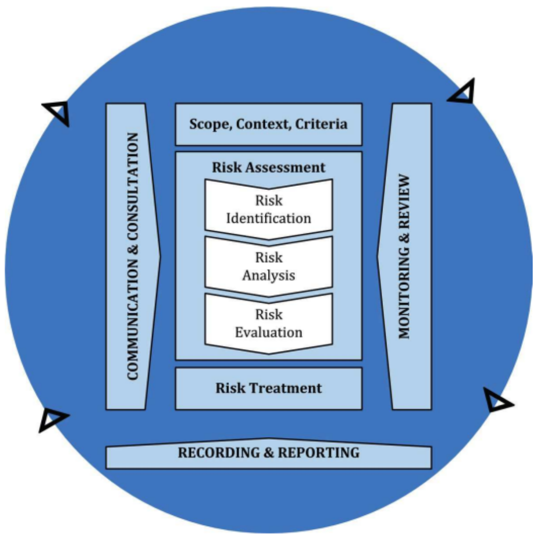
– Leadership and commitment - Top management and oversight bodies, where applicable, should ensure that risk management is integrated into all organizational activities and should demonstrate leadership and commitment.
– Integration - Integrating risk management into an organization is a dynamic and iterative process and should be customized to the organization's needs and culture. Risk management should be a part of, and not separate from, the organizational purpose, governance, leadership and commitment, strategy, objectives, and operations.
– Design - When designing the framework for managing risk, the organization should examine and understand its external and internal context.
– Implementation - Successful implementation of the framework requires the engagement and awareness of stakeholders. This enables organizations to explicitly address uncertainty in decision-making, while also ensuring that any new or subsequent uncertainty can be considered as it arises.
– Evaluation - The organization should periodically measure risk management framework performance against its purpose, implementation plans, indicators, and expected behaviour.
– Improvement - The organization should continually improve the suitability, adequacy and effectiveness of the risk management framework and the way the risk management process is integrated.

The purpose of the chemical health and safety risk management framework is to assist the organization in integrating risk management into significant activities and functions. The effectiveness of risk management will depend on its integration into the governance of the organization, including decision-making. This requires support from stakeholders, particularly top management. Framework development encompasses integrating, designing, implementing, evaluating, and improving risk management across the organization. [10]

Process of chemical health and safety risk management

The chemical health and safety risk management process should be an integral part of management and decision-making and integrated into the structure, operations, and processes of the organization. It can be applied at strategic, operational, programme or project levels. There can be many applications of the risk management process within an organization, customized to achieve objectives and to suit the external and internal context in which they are applied. The chemical health and safety risk management process involves the systematic application of policies, procedures, and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording, and reporting risk.

Figure 1. Process of chemical health and safety risk management



Source: ISO 31000:2018, Risk Management - Guidelines

The risk management process consists of the following elements:

- Communication and consultation - Communication and consultation with appropriate external and internal stakeholders should take place within and throughout all steps of the risk management process.
- Scope, context, and criteria - The organization should define the scope of its risk management activities. The external and internal context is the environment in which the organization seeks to define and achieve its objectives. Risk criteria should be aligned with the risk management framework and customized to the specific purpose and scope of the activity under consideration. Risk criteria should reflect the organization’s values, objectives and resources and be consistent with policies and statements about risk management.
- Risk assessment - Risk assessment is the overall process of risk identification, risk analysis and risk evaluation.
  - Risk identification - The purpose of risk identification is to find, recognize and describe risks that might help or prevent an organization achieving its objectives.
  - Risk analysis - The purpose of risk analysis is to comprehend the nature of risk and its characteristics including, where appropriate, the level of risk.
  - Risk evaluation - Risk evaluation involves comparing the results of the risk analysis with the established risk criteria to determine where additional action is required.
- Risk treatment - The purpose of risk treatment is to select and implement options for addressing risk. Risk treatment involves an iterative process of formulating and selecting risk treatment options; planning and implementing risk treatment; assessing the effectiveness of that treatment; deciding whether the remaining risk is acceptable; if not acceptable, taking further treatment.
- Monitoring and review - The purpose of monitoring and review is to assure and improve the quality and effectiveness of process design, implementation, and outcomes.
- Recording and reporting - The risk management process and its outcomes should be documented and reported through appropriate mechanisms. [10]

Chemical health and safety risk management model

As mentioned before, occupational health and safety can also be defined as a system of technical, health, legal, psychological, pedagogical, and other activities, which detect and eliminate hazards and harms that may endanger the life and health of persons at work [8]. Occupational health and safety is part of the organization of work and performance of the work process and is achieved by performing occupational safety and the application of prescribed, agreed, as well as recognized rules of occupational safety and ordered measures and instructions of the employer. [12] However, it should also be noted that the management of health and safety at work exceeds the minimum requirements defined by regulations in this area. [9]

In order to effectively manage occupational health and safety, it is not enough to simply procure protective equipment as a means of protecting workers and implement some other measures required by regulations. The occupational health and safety management system is based on the management of occupational safety and health risks inherent in the organization's business activities. [11]

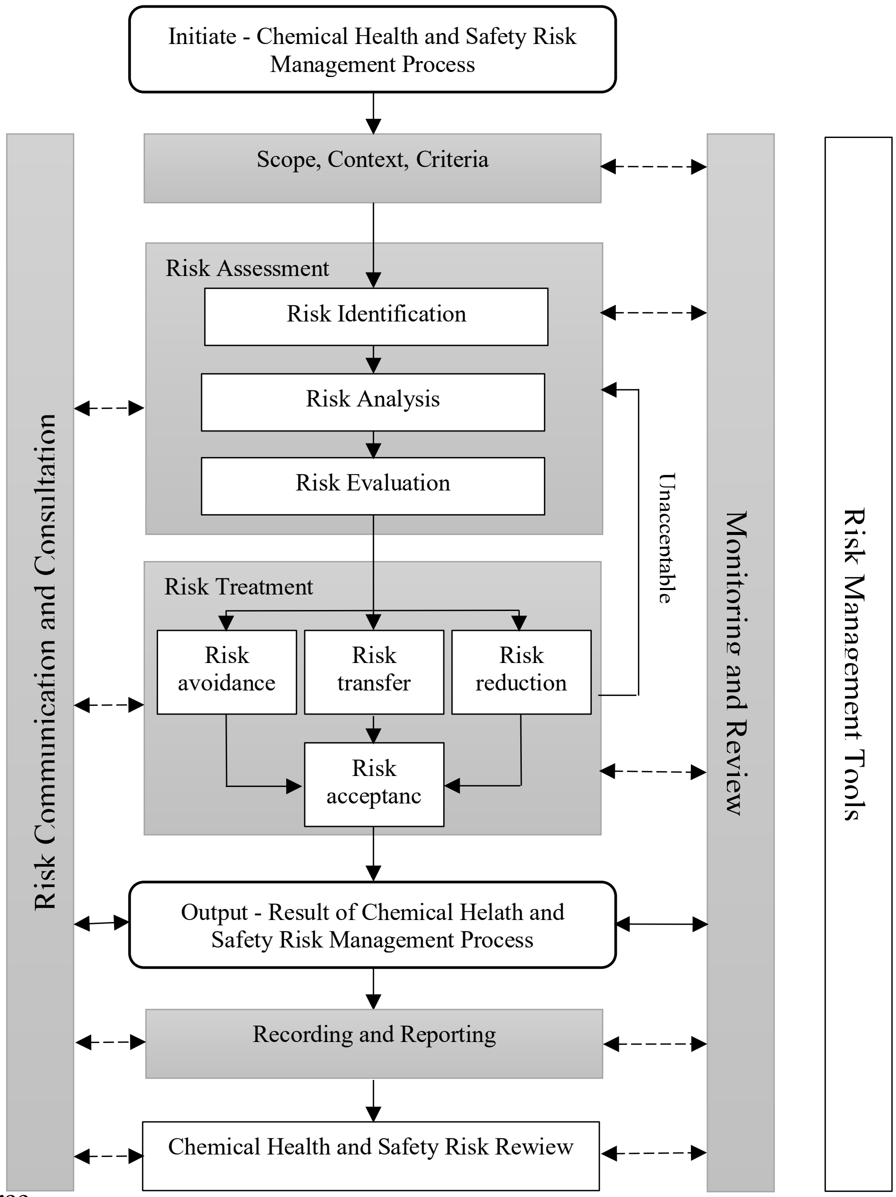
Based on the analysis and presentation of the basic theoretical assumptions of health and safety at work and the theoretical assumptions of risk, the model of risk management of health and safety at work is presented below.

In the previous chapters, the elements of chemical health and safety risk management are presented in detail. It should be emphasized that the model is generic, that is, it can be applied to any type of organization that uses chemicals and hazardous substances in its work, regardless of the size of the organization.

Risk exists in every job in which chemicals are applied, and the probability that a certain risk event will occur depends on its nature. Risk refers to the future and future events. In this case, the purpose of risk management is to increase the probability that the organization will achieve its goals of preventing injury and health damage, by managing the probability of an event occurring and the consequences of those events. The purpose of chemical health and safety risk management is to increase the probability of achieving the required level of occupational health and safety, through the management of hazards and extraordinary events. The chemical health and safety risk management system is a continuous process

by which the organization methodically takes into account the risks associated with its activities with chemicals.
In order for the chemical health and safety risk management system in the organization to be effective, it is necessary to develop a risk management culture that includes changing the existing way of thinking of all management levels. Every worker should be aware of the chemical risks in their area of activity in order to be able to assess the risks that they can influence themselves, as well as the risks that they should warn their superiors and occupational safety experts about.
Maintaining the existing level (if acceptable) and increasing the level of occupational helath and safety is achieved through effective risk management. Since it deals exclusively with possible future events, events that have not yet happened, risk management is the most effective preventive activity.
The normal performance of work activities with chemicals directly depends on the employees, that is, the executors of the work. Therefore, due to the need to implement effective business processes, it is extremely important to manage chemical health and safety risks. The goal of risk management is to use the available knowledge about chemical risks to define an approach for analyzing and managing the uncertainties we face, which may affect the occurrence of unwanted events, eg a chemical incident.
Effective chemical health and safety risk management allows us to understand and optimize the benefits and values generated from risk management and avoid unwanted consequences.
Based on the conclusions of the conducted analysis, a chemical health and safety risk management model can be set up.

Figure 2. Cemical health and safety risk management model



Source: own source

Risk identification, analysis and evaluation are of paramount importance. The frequency of implementation of this procedure itself depends on several factors. These are most often the requirements of national regulations which define the deadlines for the revision of the risk assessment. The very fact that the regulations define the timetable in which the audit must be carried out shows that the risks are not managed, but only the audit of the risk assessment is done. In doing so, the audit is done only for the risks of routine activities, while non-routine activities are generally assessed. Routine work activities are those that are described in the description of jobs and work tasks of a worker. Non-routine work activities are all those activities and jobs that occur outside the scope of normal work. We can state that routine work activities are mainly related to one place of work where the worker performs work (at a machine in a production plant, etc.) while non-routine work activities most often occur at workplaces such as construction sites, services, works etc. in such places, factors appear that affect the safety of performing tasks that we could not have foreseen or could not know about before. Therefore, the risk must be assessed before starting work activities almost daily.
The implementation of cemical health and safety risk management model may involve different specifics, depending on various factors:

- the specifics of certain processes of working with chemicals - extremely risky jobs that require constant analysis and evaluation of risks in order to make timely new decisions about the way of working and the necessary protection measures.
- national regulations - national regulations often regulate the way risk assessment is carried out
- internal procedures - the company's own requirements which regulate in more detail the method of risk management at a higher level than that prescribed by national regulations
- requirements of international standards - international standards for management systems usually contain requirements related to risk management
- interested parties - stakeholders (contracting authorities, customers, inspection, workers) may require stricter risk management criteria.

Considering that there are great risks when working with chemicals, it is recommended to assess the risks of all activities with chemicals on a daily basis.
If necessary, various methods of assessing current risks are applied before starting work, such as Last-Minute Risk Assessment (LMRA), Last Minute Job Analysis (LMRA), Job Safety Analysis (JSA), and Permit to work (PTW).).

CONCLUSION

It can be stated that the goals and objectives of this research have been achieved. The conducted research determined and analysed the theoretical assumptions of occupational health and safety, chemicals and risk management. The cemical health and safety risk management model is described, with its principles, framework, and process. The chemical health and safety risk management model was presented and a discussion was held on the application of risk assessment and management. It was determined which key elements of the risk management process are context determination, risk assessment, risk management, risk communication and risk management reporting. Risk management implies some of the acceptable strategies such as risk avoidance, mitigation, and risk transfer. National regulations generally impose risk assessment requirements for routine activities, while international standards in the field of occupational health and safety require the management of risks dealed by routine and non-routine activities.
As shown in this paper, the process of chemical health and safety risk management is clearly determined, as shown by the presented model. The interdependence of all elements of the process has been confirmed and is significant. An oversight or error in the implementation of any element of the risk management process can result in an incorrectly chosen risk management strategy, which can lead to employee injury and environmental pollution. The effectiveness and efficiency of the application of the model depends on all participants working with chemicals.
After this research, it is proposed to start empirical research on the management of chemical health and safety risk management. The results of such research could confirm thoughts about the need to introduce the obligation to apply chemical health and safety risk management.

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Regulations

- Occupational Health and Safety Act (N.N. 71/14, 118/14, 154/14, 94/18, 96/18)
- Ordinance on risk assessment preparation (NN 112/14, 129/19)

Standards

- ISO 31073:2022 Risk management - Vocabulary
- ISO 9000:2015 Quality management systems - Fundamentals and vocabulary
- ISO 31000:2018, Risk Management - Guidelines
- ISO 45001:2018 Occupational health and safety management systems - Requirements with guidance for use

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5.
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CHEMICAL RISK MANAGEMENT AND SAFETY IN BUSINESS PROCESSES OF CEMENT PRODUCTION CEM II/B-V 42.5N

Abstract
By conducting scientific studies on the harmful effects of chromium (VI) in cement, it has been proven that hexavalent chromium can cause health and allergic reactions. Directive 2003/53/EC restricts the use and distribution of cement containing more than 2 ppm chromium (VI), there by ensuring the protection of health, the environment and consumers' lives. Within this work, the impact of the reductant, encapsulated antimony trioxide, as an additive to cement was investigated in order to satisfy the legal legislation, and thus to protect the health of employees in the production plant, producing the baggy CEM II/B-V 42.5N. From 2005, the reduction of chromium (VI) with chromium reducers is the obligation of all producers in EU member states, as well as those that are not, and if they export the product there, so that the soluble hexavalent chromium (CrVI) turns into insoluble trivalent chromium (CrIII). Reducing agents must be added in multiple excesses, so that when leaving the factory, the content of soluble chromium is significantly lower than the permitted 2 ppm, because otherwise it is impossible to keep that amount below the maximum permitted limit within the declared period.

Key words: cement in bags general purpose CEM II/B-V 42.5N, encapsulated antimony trioxide, hexavalent chromium (CrVI), HRN EN 197-1:2012 and 197-2:2020.

INTRODUCTION

New concrete technologies Ltd. manufacture's general-purpose cement of type CEM II/B-V 42,5 N. The quality management system is the way in which the company manages and develops its activities, and at the same time it is the way for constant improvement and increasing of the process efficiency, in order to demonstrate the ability of the cement quality to fulfill the requirements of the Construction product act, Act on construction products regulation and technical standards, namely HRN EN 197- 1 and HRN EN 197-2, as well as the Law on technical requirements for products and conformity assessment.

The established and documented system in accordance to the requirements of HRN EN 197-1 and HRN EN 197-2 comprises:

- quality objectives and the organizational structure, responsibilities, and powers of management, with regard to cement quality and means for monitoring and the achievement of the required cement quality, and also the effective operational of internal quality control,
- production technology, quality control, procedures, and systematic actions to be used, and
- the inspections and tests that will be carried out before, during and after production, and the frequency by which they will be carried out.

New concrete technologies Ltd. is a company located in Luka Metković. The company's primary activity is cement mixing, i.e., the production of general-purpose cement, type CEM II/B-V 42,5 N type. Namely, the distribution of cement takes place in two ways; in bulk and bags packaged cement. By testing the content of the original raw material, which is imported, large amounts of hexavalent chromium (Cr VI) were found. Chromium metal itself is not toxic, but its compounds are. Compounds with an oxidation number of +6 are considered to be the most toxic. Exposure to hexavalent chromium compounds has been linked to many health problems in humans. Acute and long-term exposure to Cr

(VI) is associated with allergic skin reactions, gastrointestinal and respiratory problems, and also the damage to the male reproductive system.

It has been observed that redness and itching appear on parts of the unprotected skin that come into contact with cement, and the reaction is more acute the longer the exposure is. Later, it was found that two types of dermatitis appear on the unprotected skin [1]:

a) Inflammatory dermatitis that is conditioned by the alkaline nature of cement, and
b) Allergic dermatitis, caused by hexavalent chromium, which dissolves in contact with water. It penetrates through the unprotected surface of the skin, and with the proteins from the epidermis it converts into trivalent chromium.

The cement industry has informed cement users about the need to protect their hands and also brought recommended protective measures, i.e., the use of protective creams and gloves. In some countries are provided the same instructions that were included in their national documents, and required from the cement producers to emphasize the need clearly and unequivocally for consumer protection that is included in the documents that are accompanying the product. From January 17, 2005, the information on reduction of chromium (VI) has become compulsory for all of producers in the EU member states, as well as those that are not member states, and if they export their cement there. The EU directive does not apply to a controlled, closed and fully automated process. The definition of this process was given by Cembureau: A closed system is the one in which cement is loaded, transported, unloaded, and used without further contact with people (in our case, the bulk cement). It should be noted that all bagged cement must have a declared deadline by which the manufacturer guarantees the permitted amount of chromium (VI). This usually spans from three to six months, after which the cement should be considered unusable.

In order to meet the aforementioned conditions, during the production of cement and cement products, it is necessary to add an agent that will convert soluble hexavalent chromium into insoluble trivalent chromium, during the process of hydration. Reducing agents have different lifetimes, i.e., after a certain amount of time we cannot longer guarantee that they will keep the amount of soluble chromium within the given limits. Therefore, it is necessary to choose the reducing substance that will maintain the constant level of chromium (III), until the specified declared period. The manufacturer is obliged to state for all delivered cement the following [2,3]:

- bag packaging date,
- the declared period by which the manufacturer guarantees the permissible content of chromium (VI) in cement (*shelf life*), and
- recommended storage conditions, related to the declared term. This means that for well-stored cement used within the declared period, the activity of the reducing agent will maintain the proportion of soluble chromium (VI) below $0.0002\% = 2\cdot10^{-6}$ kg/kg = 2 ppm, calculated to the dry weight of the cement.

Description of the subject of the research and identification of the research problem

Chromium is a transition element and it is amongst the most abundant elements found in the Earth's crust. The name chrome comes from the Greek word "chroma", which means color, because chromium salts are usually brightly colored. Chromium can exist in nine different oxidation states, but in the environment are usually found the two most stable: Cr (III) and Cr (VI). Trivalent chromium is naturally present in the Earth's crust in the chromite ore, $FeCr_2O$. Hexavalent chromium is toxic to living organisms, and it is less often naturally present. The primary chrome production is constantly increasing and takes place in the areas of The Republic of South Africa, the Republic of Zimbabwe, India, Kazakhstan, the Philippines, Finland, and Turkey, where the largest chromite mines are located. Annual world production is estimated at 24 million tons. [4]

The production process begins with the exploitation of raw materials, which takes place in the quarry. In order to exploit the raw material, drilling and blasting techniques are used. The raw materials that necessarily contain the main chemical ingredients, such as: CaO, SiO_2, Al_2O_3 and Fe_2O_3 are exploited. The carbonate components are limestone and chalk or marl. Clay components are: alkaline aluminon-silicates, feldspars, and mica. After exploitation, the raw material is crushed. Crushed stone is furthered crushed from a lump size of 120 cm to a size of 1,2 to 8 cm. By crushing, the material is pulverized by method of compression or impact on different types of mechanical crushers; see Figure 1.

The raw material is then transported from the quarry by means of conveyors, rail cars or by using other specific transport depending on the cement factory location. Crushed limestone and clay are pre-homogenized by filling and subtracting in long, layered piles. Such material is then ready for the grinding and drying process in the raw material mill. Raw materials are then ground and dried in a vertical or ball mill. During grinding, a problem may arise regarding to the material being ground that is sticking to the ball shaped forms. In order to prevent this problem, additives are added, so that agglomeration does not occur and therefore, such treated particles are more mobile. The purpose of grinding is to create a large reactive surface and to take control of the hardening process.

The ground material is taken out of the mill via the central outlet, and is transported by means of air transport hutch (trough) to the elevators, which raise the material to a height of 35 to 40 m above the Humboldt preheater. Cyclonic heat exchanger enables preheating of the raw material before entering the furnace. With this procedure is increased the furnace energy efficiency, so that the material is already 20 to 40% calcined when entering the furnace. The furnace is designed in a way that the fuel combustion energy is given to the raw material as efficiently as possible. In the preheater, the raw material is rapidly heated to a temperature of approximately 1000 °C, during which the limestone turns into quicklime.

In the rotary kiln, temperatures reach up to 2000°C. At these temperatures, minerals form mainly calcium silicate crystals, i.e., the cement clinker. Then the molten cement clinker is cooled. For cooling is used atmospheric air. Clinker is stored and ground in the factory or transported to other users. Final grinding is the grinding of cement clinker together with the addition of approximately 5% of natural or artificial gypsum. Other cement additives such as slag, fly ash, pozzolan and others may also be added to the final cement powder.

Cement can be transported packed in bags or as a bulk product. The method of transport depends on the location of the factory - it can be by truck, ship or rail. [5] Furthermore, in the company New concrete technologies Ltd., the finished raw material is mixed with an admixture, i.e., with the fly ash, and the cement is packed in bags or transported in bulk, see Fig. 2.

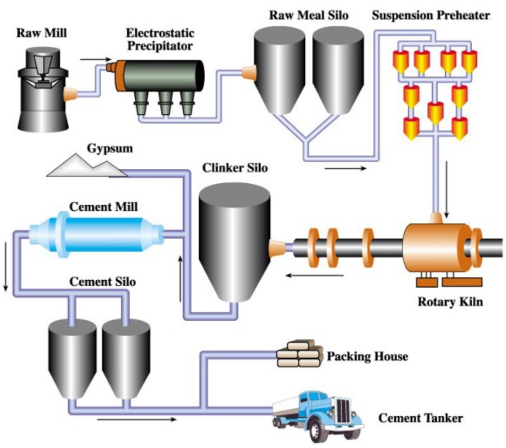

Fig. 1. *Technological process of cement production*

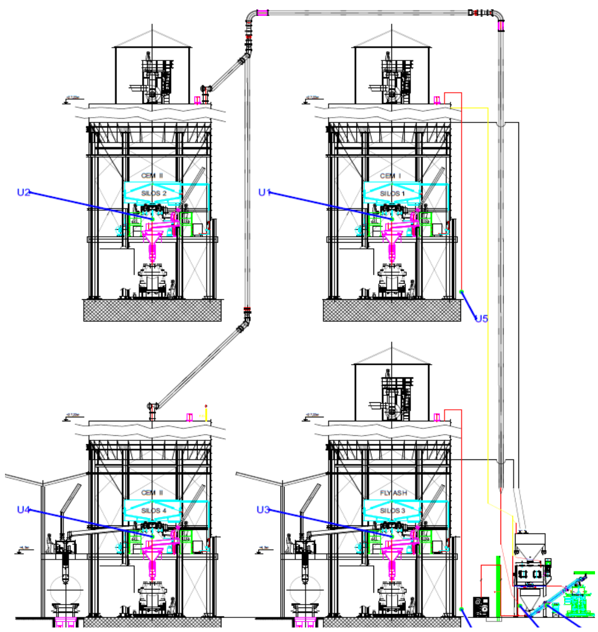

Fig. 2. *Schematic representation of the production plant PJ Luka Metković*

If the product CEM II/B-V 42,45 N is packed in bags, it is compulsory to add chromium reducers. Cr (VI) in cement originates from the oxidation of Cr (III) from the mineral of the raw materials used for the cement production (clay, limestone), or from the furnace linings, coated with fireproof materials containing chromium. In order to meet the requirements for the highest permissible concentration of soluble Cr (VI) in cement, an agent must be added to the cement during production, which will convert soluble chromium into insoluble chromium by means of hydration.

Elaboration and aims of the research problem

By directive 2003/53/EC, which refers to restrictions of the sale and use of certain dangerous substances and preparations, the use and distribution of cement containing more than 2 ppm ($2 \cdot 10^{-6}$ kg/kg) of soluble chromium (VI) is restricted, except for the use of cement in a fully automated work process, where the skin contact can be excluded. During the production of cement, it is necessary to add a reducing agent that will reduce soluble hexavalent chromium to trivalent chromium. Determination of the required amounts is the task and aim of this research. Until now, the use of iron (II) sulfate has been known as the most widely used, as well as addition of tin sulfate, and also the newest agent based on antimony. [6,7]

Reducing agents have different lifetimes, i.e., after a certain passing of time they no longer guarantee that they will keep the amount of soluble chromium within the given limits. Therefore, it is necessary to choose such reducing substance that will maintain the level of chromium (III) until the specified declared period.

Laboratory quality control

Laboratory quality control of cement production **is** performed by the New concrete technologies Ltd. in Test laboratory. The quality control of incoming raw materials, production, products and shipping is carried out with regard to determining the conformity of the product quality with international standards, determining the quality of the packaging (packaged cement), and also for the determining of the dependability of the product properties, primarily in accordance with the norms HRN EN 197-2:2020 and HRN EN 197-1:2012, which above all, when included in the research hypothesis, depends on the quality and dependability of the properties of the input materials, the quality of the production process and production-technological equipment used. At the same time, special attention is paid to deviation from the limits that were prescribed by the standards, in terms of mandatory and additional test parameters, which, among other things, are also defined in the technological documentation.

Laboratory quality control of cement production is used to determine the extent to which the level of product quality that is defined on the basis of standards and the technological recipe of cement, has been achieved, thereafter to actually determines the probability that the product will have constant properties under certain conditions, during the expected period of exploitation, and to preserve the defined quality within tolerance limits. The testing laboratory carries out laboratory quality control of cement production in terms of ensuring the properties and characteristics of cement CEM II/B-V 42,5 N, namely and first of all - utility value of the product, technological characteristics, functional characteristics and physical characteristics. Current research in the form of laboratory control is carried out continuously, with permanent recording of test results in the Test log book.

METHODS, RESULTS AND DISCUSSION ON CONDUCTED RESEARCH

The conformity of cement with the requirements for mechanical, physical, and chemical properties is confirmed, if the conformity criteria are met. Compliance is assessed on the basis of continuous sampling, based on the samples taken at the point of discharge and based on the test results that were obtained on all auto-control samples taken during the control period. In the Table 1, there are listed original results of the conducted scientific tests on a sample of general-purpose cement type CEM II/B-V 42,5 N that was tested in the laboratory of the company New concrete technologies Ltd., while in Tables 2 and 3, reference values are shown, i.e., limit values for individual results that are taken from the HRN EN 197-1:2012 standard. In Table 1 are shown the test results of the CEM II/B-V 42,5 N sample, without the addition of a reducing agent, from the sampling site at the silo, and the results of the CEM II/B-V 42,5 N sample with the addition of a chromium reducing agent, i.e., an additive based on antimony trioxide, MA.P.E. Cr 07. By the comparison of the obtained results, it is evident that the used reducing agent does not affect the physical and mechanical characteristics of the tested cement, i.e., the results were obtained with minimal deviation (with and without the reducing agent MA.P.E. Cr 07).

Table 1. *Examples of displaying test results of the sample CEM II/B-V 42,5N*

Mark	Test value	Test value
Date of sampling	January 27, 2022	March 8, 2022
Sampling location	Silo	Bag - shipping
Sample mark	155	292
Batch designation	106/21	143/21
Test start date	January 27, 2022	March 8, 2022
Specific surface area	4379	4327
The residue on the 90-micron sieve	2,92	2,89
Loss on annealing in %	3,14	3,10
Standard consistency in %	39,6	39,8
Constancy of volume in mm	0	0
Firmness bending /pressure (2d) MPa	29,9	4,24
Firmness bending /pressure (28d) MPa	54,34	31,52
Sulphate content in %	3,24	3,12
Chloride content in %	0,008	0,01
Determination of the amount of water-soluble chromium (VI) in cement in %	/	**0.0001**
Binding regulator, R, in %	5,18	5.28
Content of calcium filler, C (proportion / proportion without gypsum) in %	4,64/4,9	4,62/4,87
Fly ash content, V (proportion / proportion without gypsum) in %	20,18/21,3	21,58/22,71
Content of clinker, K (proportion / proportion without gypsum) in %	71,69/75,61	70,21/73,9

Table 2. *Chemical requirements listed as characteristic values, HRN EN 197-1:2012*

1	2	3	4	5
Property	**Test reference**	**Cement type**	**Strength class**	**Requirements**[a]
Loss on ignition	EN 196-2	CEM I CEM III	All	≤ 5,0 %
Insoluble residue	EN 196-2 [b]	CEM I CEM III	All	≤ 5,0 %
Sulfate content (as SO_3)	EN 196-2	CEM I CEM II[c] CEM IV CEM V	32,5 N 32,5 R 42,5 N	≤ 3,5 %
			42,5 R 52,5 N 52,5 R	≤ 4,0 %
		CEM III[d]	All	
Chloride content	EN 196-2	all [e]	All	≤ 0,10 %[f]
Pozzolanicity	EN 196-5	CEM IV	All	Satisfies the test

[a] Requirements are given as percentage by mass of the final cement.

[b] Determination of residue insoluble in hydrochloric acid and sodium carbonate.

[c] Cement types CEM II/B-T and CEM II/B-M with a T content > 20 % may contain up to 4,5 % sulfate (as SO_3) for all strength classes.

[d] Cement type CEM III/C may contain up to 4,5 % sulfate.

[e] Cement type CEM III may contain more than 0,10 % chloride but in that case the maximum chloride content shall be stated on the packaging and/or the delivery note.

[f] For pre-stressing applications cements may be produced according to a lower requirement. If so, the value of 0,10 % shall be replaced by this lower value which shall be stated in the delivery note.

Table 3. *Limit values for individual results, HRN EN 197-1:2012*

Property		Limit values for single results — Strength class								
		32,5 L	32,5 N	32,5 R	42,5 L	42,5 N	42,5 R	52,5 L	52,5 N	52,5 R
Early strength (MPa), lower limit value	2 days	-	-	8,0	-	8,0	18,0	8,0	18,0	28,0
	7 days	10,0	14,0	-	14,0	-	-	-	-	-
Standard strength (MPa), lower limit value	28 days	30,0			40,0			50,0		
Initial setting time (min), lower limit value		60			50			40		
Soundness (expansion, mm), upper limit value		10								
Sulfate content (as % SO_3), upper limit value	CEM I CEM II[a] CEM IV CEM V	-	4,0		-	4,0	4,5	-	4,5	
	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5[b] CEM IV/A-SR CEM IV/B-SR	-	3,5		-	3,5	4,0	-	4,0	
	CEM III/A CEM III/B	4,5								
	CEM III/C	5,0								
C_3A (%), upper limit value	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5 CEM IV/A-SR CEM IV/B-SR	1 4 6 10 10								
Chloride content (%)[c], upper limit value		0,10[d]								
Pozzolanicity		-	Satisfies the test at 15 days		-	Satisfies the test at 15 days		-	Satisfies the test at 15 days	
Heat of hydration (J/g), upper limit value	LH	300								

[a] Cement types CEM II/B-T and CEM II/B-M with a T content > 20 % may contain up to 5,0 % SO_3 for all strength classes.

[b] For specific applications CEM I-SR 5 may be produced according to a higher maximum sulfate content (see Table 5). If so, the upper limit value is 0,5 % above the declared value.

[c] Cement type CEM III may contain more than 0,10 % chloride but in that case the maximum chloride content shall be declared.

[d] For pre-stressing applications cements may be produced according to a lower requirement. If so, the value of 0,10 % shall be replaced by this lower value which shall be stated in the delivery note.

Determination of water-soluble chromium (VI) proportion in cement (EN 196-10:2006)

After adding the required amount of reductant, the samples are sent for testing to an external accredited laboratory. When sending cement samples, CEM II/B-V 42,5 N, the chromium content is checked. Chromium content is tested according to the EN 196-10:2016 method that is, according to the Laboratory quality control plan for cement production of the New concrete technologies Ltd. that is done in the testing laboratories.

By this European standard, a method for determining the content of water-soluble chromium (VI) in a reference sample of cement is established, in accordance with the relevant standard. The reference method is described, which consists of two phases, namely, the extraction procedure and the analysis of the filtered extract. Guidance is given for other extraction procedures that are suitable for pilot professional and scientific tests, for factory production control or other purposes, but in case of dispute or non-compliance with a regulatory limit, only the reference method is used. The reference method has alternatives, according to which the filtered extract can be subjected to an oxidation step or not. Criteria have been established in accordance to which the appropriate procedure has been selected. Other instrumental procedures can be used for the analysis of the filtered extract, provided that they are calibrated according to the analysis of the filtered extract when the reference procedure is used.

The standard included in the Annex A establishes the normative procedure that should be followed to in case this test method is used as a basis for evaluating the conformity of cement, with the regulatory limitation of Directive 2003/53/EC. Guidance on the possible application of this European standard to the determination of water-soluble chromium (VI) content in preparations that contains cement, is given in Annex B. Annexes C and D provide information’s on other test procedures that are based on paste extraction, and therefore they are deviating from the performance of cement under normal conditions of use. They can be made with or without an oxidation process. Users should be aware that results, when using these methods may significantly differ from those obtained with the reference method, and in case of dispute or non-compliance with the regulatory restriction, only the reference method is used. [6]

The sampled cement CEM II/B-V 42,5 N is then sent for testing to an external accredited laboratory; - in this case to the INSTITUT IGH JSC, to the Laboratory for materials and structures. The test methods used for the determination of soluble chromium (VI) in cement were performed in accordance with the HRN EN 196-10:2016 standard (method used from the determined field of accredited laboratory). From the submitted sample, with the use of the so-called method of quartering, samples were separated for testing, which were then processed and prepared according to point 6 of HRN EN 196-10:2016 (part 10), with the results shown in Table 4. The equipment used for testing was the reference one that was specified in point 5 according to the HRN EN 196-10:2016 standard, according to which the testing was carried out, and which is regularly controlled and calibrated.

The materials that were used for the confirmation of the conducted scientific analysis were; demineralized water and reagents of recognizable quality in accordance to point 4 of the HRN EN 196-10:2016 standard.

Table 4. *Test results of the proportion of water-soluble chromium (VI) in cement sample.*

Designation of the customer's sample	Laboratory analysis of the sample
Property	The result
Amount of chromium (VI) in cement	0.0001%

Reducing agents

Hexavalent chromium is reduced to trivalent chromium, whereby it precipitates in the form of harmless chromium (III)-hydroxide, while calcium sulfate precipitates in the form of gypsum. It is important to point out that the dosage of the reducing agent is carried out in multiple excess, so that the cement leaving the factory has a much lower content of hexavalent chromium than it is allowed, because it must be below $2 \cdot 10^{-6}$ kg/kg within the declared period guaranteed on the accompanying document, and otherwise it is impossible. [2]

In this work has been investigated the influence of the reducing agent, antimony trioxide as an additive to cement, in order to meet the EU directive, and thereby protect the health of employees within the production plant, producing bagged cement CEM II/B-V 42,5 N.

Antimony trioxide

Additives based on antimony trioxide are at the level of stannic sulfate in terms of efficiency, but their biggest drawback is their toxicity, except in the case of the patented product MA.P.E. Cr 07 with "controlled release"; - a compound that is composed of antimony trioxide is encapsulated in a special soluble polymer, with the purpose of exclusively adding it in the cement before shipping it into bags, see Figure 3. The identical additive in liquid form, the MA.P.E. Cr 05 is exclusively added into the cement mill during grinding, and into the finished cement after grinding, before storage of such cement in the silo.

As it was previously stated, chromium reduction is not necessary for cements containing more than $2 \cdot 10^{-6}$ kg/kg of chromium, unless packaging and subsequent handling are fully automated. Therefore, there was a need to reduce chromium in cement, which is the basic raw material for the production of general-purpose cement; CEM II/B-V 42,5 N, which is packed in the production facility of Luka Metković. Namely, the chromium content in the basic raw material in so-called Portland cement, amounts 69 ppm. In order to reduce the chromium content, research was carried out, and it was established which was the most suitable and favorable reducer.

The CEM II/B-V 42,5 N sample was sent for analysis to the MAPEI laboratory, where according to the conditions of standard 196-10, they found the amount of reducer that needs to be dosed in order to reduce the chromium content below 2 ppm. Encapsulated antimony trioxide was used as a chromium reducer.

Expensive compounds for reduction must be added in multiple excesses, so that when leaving the factory, the content of soluble chromium is to be significantly lower than the permitted 2 ppm, because otherwise it is impossible to keep that amount below the maximum permitted limit, within the declared time period.

The initial step of the supplementary research was the determination of the amount of soluble Cr (VI) in cement, according to the ISO 196-10 standard series. Furthermore, a smaller amount of MA.P.E./Cr 07 was added to the cement sample, and the method was repeated. This step was scientifically necessary in order to find out what was the specific dose of the reducer, i.e., the actual ratio between the amount of additive and the reduction of the certain amount of soluble Cr (VI). Finally, based on the specific dose, the amount of MA.P.E. Cr 07 needed to completely reduce the amount of soluble hexavalent chromium was added to the cement, and then the test was repeated several times.

Without the presence of additives, the tested cement has 60 ppm. In order to reduce the amount of soluble Cr (VI) to 20 ppm, an amount of 669 g/t of reductant was needed. In order to completely reduce soluble Cr (VI), approximately 1000 g/t of MA.P.E./ Cr 07 is required, i.e., for the reduction to take place, 17 g/t MA.P.E./ Cr 07 is required for each ppm of soluble Cr (VI); see Table 5.

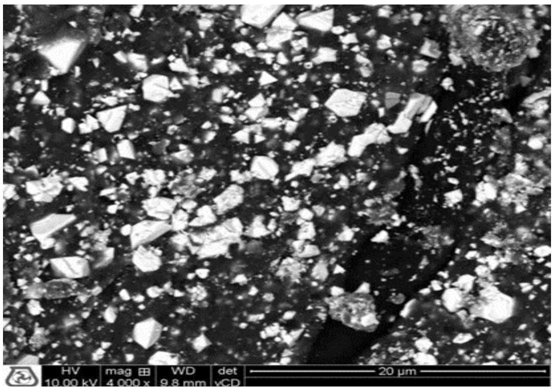

Figure 3. *Microscopic view of encapsulated antimony trioxide*

Table 5. *Chromium reducers dosing*

Dosage MA.P.E./Cr07 (g/t)	Releasing of Cr (VI)	Specific doses of MA.P.E./Cr07 (g/t)ppm*
-	60	-
669	20	17
1003	0,3	17

*1ppm (*parts per million*) 1:1.000.000, unit of measurement is mg/L

Harmful influence of hexavalent chromium

Bronchial asthma and irritant bronchitis are diseases caused by the long-term exposure to soluble compounds of hexavalent chromium, and are accompanied by chest pain, cough, and dyspnea. Pneumopathy creates small regular shadows in the lung parenchyma that is caused by trivalent chromium. The connection between exposure to hexavalent chromium and lung cancer in workers that were exposed to chromium compounds, that comprise mainly zinc, calcium and lead chromates, and also to chromium trioxide fumes for more than a decade, was established. Carcinomas are most often located in the peripheral parts of the bronchial tree. Although all types of cancer can be present, histologically the most common is anaplastic oat-cell carcinoma. The main routes of chromium intake are the lungs, digestive tract, and adsorption through the skin. Chromium is distributed in the liver, kidney, spleen, and smaller amounts are found in the brain, muscles, and testicles. Mobilization of trivalent chromium from tissues is carried out by a factor called Glucose tolerance factor (GTF). The GTF factor is a complex of one chromium atom, one molecule of nicotinic acid and two molecules of amino acids, - cysteine and glycine. [8]

Chromium has the strongest allergenic properties when compared to the other metal allergens, such as cobalt, and nickel. Various types of chronic effects are manifested on the skin, in the form of chrome ulcers, eczema, ulcers and dermatitis. With regard to the excessive skin exposure, on the skin appears changes in the form of eczema and chromic ulcers, which represent point-like wounds on the skin surface, while they also spread in depth, under the subcutaneous tissue. Such changes in patients cease shortly once the patient is removed away from the source of exposure. Vulgar eczema can be caused after a long exposure to a cement, and it arises as a result of specific sensitization to allergens found in cement, the now known chromium and cobalt soluble salts. [9]

CONCLUSION

Directive 2003/53/EC was published in June 2003. The abovementioned directive ensures the protection of health, the environment, and the lives of consumers. By carrying out the scientific studies on the harmful effects of chromium (VI) in cement, it has been proven that hexavalent chromium can cause allergic reactions, if there is a long-term and direct exposure to the human skin. If the process is fully automated, there is no risk of direct contact with the skin, however, if the process is not fully automated, there is a risk of prolonged and direct contact of cement with the skin. Scientific Committee on Toxicity, Ecotoxicity and the Environment, with its research has determined the harmful impact of hexavalent chromium in cement on the health. Once explaining in their work, wet cement has a high pH of 12,5 so it can change the outer layer of the skin, in a way to facilitate the penetration of water-soluble substances. Therefore, skin contact with an alkaline cement-water suspension leads to irritation, thereby increasing the absorption of chromium (VI), and its sensitizing effect and causing allergic reactions.

In order to protect the health of employees in the production process, according to the Council Directive 98/24/EC, the exposure of employees to all harmful agents at work must be brought to a minimum. However, if there is no suitable replacement, it is necessary to use protective equipment in order to avoid health problems for workers, and everyone who handles cement with a chromium content higher than 2 ppm. Therefore, in order to protect human health when handling cement with a higher then permitted content of chromium (VI), its distribution and usage must be limited. In such a case, cement has been used in the manufacturing plants of the New concrete technologies Ltd., with the chromium reducing agent MA.P.E./Cr 07, added. Before the general-purpose cement type CEM II/B-V 42,5 N is shipped, a sample is taken and a laboratory quality test is carried out, by which is confirmed the suitability of the methods used. Furthermore, when packing such a product, the bags contain information's for users about the need to use protection, and also the declared period until which the permitted amount of chromium (VI) is guaranteed, also the delivery date and recommended storage conditions.

Finally, in accordance with the EU REACH Regulation, and in accordance with the goal of this research, we can state that the content of soluble chromium (VI) in hydrated form, in the cement total dry mass, does not exceed the limit larger than 0.0002%, which confirms the set hypothesis of the need for permanent and continuous determination of the share of toxic elements in cement, and the influence of the reducing agents in the production process.

Furthermore, the used reducing agent, in this case MA.P.E. Cr 07, is used as encapsulated, so there is no direct contact with the agent itself. In addition to the abovementioned, the presented results confirm that the use of the encapsulated reducing agent, MA.P.E. Cr 07, does not affect the test results themselves, i.e., it does not affect the physical and mechanical properties of the cement. With adequate protection, handling of cement and dosing of chromium reducers, the risk of adverse effects on human health has been set to a minimum.

Regarding the harmful, allergenic, toxic and/or carcinogenic properties of heavy metals, the World Health Organization (WHO) has proposed standards that specify the maximum allowed concentrations of harmful pollutants in the environment and the work environment. Occupational exposure limit values on the hazardous substances at work and on biological limit values, and also during the short-term exposure are given, and all chromium compounds with toxic, carcinogenic, or mutagenic properties were included.

In the production process of general-purpose cement type CEM II/B-V 42,5 N, the observed system of laboratory control and quality management, represents a method to improve and increase the efficiency and safety of the process of reducing the chemical and biological risks of the harmful influence of hexavalent chromium within the production process of cement packaging, regarding of increasing of the quality, and therefore proving the production ability to meet the demands in line with the Construction products regulation, other technical regulations on construction products, technical standards HRN EN 197-1:2012 and HRN EN 197-2:2020, and the Law of technical requirements of products and conformity assessment, which is an opportunity and possibility for further, continuous research.

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Standards

- HRN EN 197-1:2012, (preuzeto; 08. studenog, 2022. god.)

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Ph.D. Sarajko Baksa, professor with tenure, has been a pioneer in 3D spatial visualizations, simulations, animations and scientific visualizations for more than 30 years. He was among the first two teams in the world to realize the virtual movement of a real human being on a scientific basis. He has also received numerous awards for his work within the subject area. Professor Baksa has written the book DESIGN METHODS OF COMPUTER 3D MODELING, has published a number of scientific research and professional papers in the field of 3D computer research, and is the holder of a number of university courses. During his many years in the field, Sarajko Baksa has developed a large number of computer programs and experimental equipment regarding research within the scope of computers in ergonomic research, so-called CAEA (*Computer Aided Ergonomy Analyses*).

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CONTAMINATION OF COMPUTER KEYBOARDS: IDENTIFIED RISKS AND CORRESPONDING SAFETY MEASURES

Abstract
The keyboard is one of the basic input devices for communicating with a computer. Its characteristics can significantly affect the efficiency and comfort of computer use, primarily from the point of view of communication speed and impact on the user's position while working. In addition to mechanical and ergonomic properties, as the main causes of the occurrence of adverse consequences for the health of users, the aspects of exposure to hazards in the context of contamination of the contact surface are increasingly being considered. The risks are even more pronounced in safety-critical environments, where contamination can lead to infections with fatal outcomes. No less important is the consideration of different decontamination procedures, which may involve the use of substances that cause adverse reactions in certain users. In this paper, potential risks are identified and corresponding safety measures are analysed.

Key words: risk, contamination, keyboard, safety measure.

INTRODUCTION

The role of computers in everyday work is becoming greater. Only a small number of work activities can be realized without the use of computer equipment. The number of activities monitored in different processes becomes so great that it is necessary to introduce different monitoring and control systems which efficiency and effectiveness significantly improves the operator's capacity in the process of making adequate decisions. The communication between the operator and the system is particularly important, as well as the way in which the data needed for decision-making is displayed. The complexity of these systems requires the development of special integral control models, in which operators are put in the foreground and everything that can improve their work efficiency is analysed.

Communication with complex systems is usually done via two basic input devices - keyboard and mouse. Although significant effort has been invested in the development of new input devices, these devices are still the basis of any modern control system. The use of mobile devices and the introduction of touchscreens have slightly changed the way systems are accessed, but in the case of desktop and laptop computers, the dominant mode of communication is still the use of these two basic input devices.

During the previous years, considerable effort has been invested to improve the physical characteristics of these devices to increase the comfort during their use. The basic characteristics of keyboards have not changed significantly, although there are analyses that alternative keyboards, with a different shape and layout, can affect the change in the learning curve and usability. A significant limitation of the keyboard as an input device was the poor ability to change the characteristics for the needs of adaptation to special working conditions and/or users. Increasing variability allows these devices to be more adaptable to users with different features and preferences. As a result, the usefulness of the device increases, but also the user's perception of the benefit of its use, as well as the possibility of adequate response in case of an adverse event.

In recent years, we have witnessed the emergence of various bacteria and viruses that can potentially turn into a pandemic, threaten the entire human population and stop its functioning. This significantly affects the functioning of safety systems in organizations, where increasing importance is attached to preventing the spread of diseases. A frequent cause of the spread of disease, especially in hospital and clinical environments, are keyboards. Employees exposed to various biological hazards can leave biological traces on the keyboard, usually different types of bacteria, and depending on their resistance in the external environment, this can be a potential cause of the spread of various diseases. Contamination of keyboards is also possible in other environments, such as a university environment, but also in home conditions.

LITERATURE REVIEW

The spread of diseases has become a very important topic in the living and working environment after the declaration of a pandemic due to the emergence of the COVID-19 virus, which led to major disruptions due to problems in global supply chains, frequent and long-term interruptions of important work processes, increased absenteeism due to illness, as well as consequences for people's mental health due to limiting direct contacts. It represents a special challenge for occupational safety and health management systems and their standardization [1], and the importance of preventing the spread of diseases in the work environment led to become an integral part of the ISO 45000 series of standards [2]. Particularly important topics for consideration are various modes of diseases transmission, and in addition to direct contact, the various contact surfaces with which people interact in the course of everyday life and work are especially critical in these considerations. Their contamination has been the subject of research before, especially in the context of microbiological contamination, primarily by different types of bacteria [3, 4].

Different trends in the development of information technology have a significant impact on safety systems, that is, on the perception and level of exposure to certain dangers [5]. Keyboards are input devices that have a long history of use. Improvements in computer systems have not been adequately accompanied by improvements in new types of devices, so keyboards still dominate as the primary input devices. Significant innovations have been introduced in the technology of development of these devices, but there remain numerous problems related to their use, optimal arrangement of keys [6], as well as ergonomic properties [5, 7]. The optimal layout of the keys, in addition to the increased speed of communication, leads to less strain when entering text, that is, less intense movements and stress on the joints. The complexity of the interaction problem requires the application of a systems approach [8], especially in complex control systems requiring efficient and effective interaction, which caused the development of different types of standards and methods [9], the analysis of different alternative solutions [10] and the development of integral models [11].

METHOD

In the process of the necessary materials collection, the KobSon database was used, which contains papers from the scientific journals of the world's most famous publishers. Based on the available information about the journals, primarily the impact factor (IF), the significance of the journal was determined. Further, using the World of Science (WoS), i.e. the Scopus database, the importance of individual papers was determined, based on the number of citations, i.e. the connection with further research.

The search process had the task of identifying the key directions of research, from the point of view of the hazards to which employees are exposed when performing their daily activities and the level of risk, i.e. potential measures that can be used to reduce the risk to an acceptable level. This was realized by the selection of adequate search keywords and phrases, which are related to biological hazards in the work environment. Given the potentially large number of different articles, only those related to the immediate work environment, including laboratories and hospital settings were considered.

In order to structure the search process, specific research questions were defined. These questions are defined in such a way as to determine, based on the data in the database, the importance attached to biological hazards in the work environment, which work environments are most often taken into consideration, what harms are involved, as well as how to approach solving problems with point of view of identification, reduction or elimination of risks. At the same time, the time distance was set to the previous fifteen years, on the basis of which the research plan was adopted.

RESULTS AND DISCUSSION

Although special importance has been attached to biological hazards in recent years, it can be concluded that contamination in a real working environment became a subject of research even earlier. Contamination of keyboards has been the subject of various studies and scientific debates [12, 13, 14], with different views on the dangers and possible consequences. First of all, the seriousness of the possible consequences is considered, how the causes are taken and how credible the risk assessment itself is.

Contamination of keyboards is especially problematic in healthcare institutions, as it can lead to consequences of different levels of danger. The process of microbiological contamination is given special attention in the hospital environment, primarily the operating room, bearing in mind the various actors who are necessary to implement a certain surgical procedure, that is, the specifics of the working environment in which the operation takes place. The role of the anaesthesiologist was identified as critical, not only for the course of the operation, but also as an actor in the contamination process after using the keyboard without removing the gloves [15]. Also important are the other hospital environments, such as dental settings [16], because dental radiographic images are often in digital form, or intermediate care [17], where all records are also saved and previewed on a computer. These environments have certain common characteristics, but also specifics that make them unique compared to other environments, so special attention should be paid to this when considering potential dangers, i.e. exposure to employees in the course of performing regular work activities.

In addition to hospital environments, other environments, at first glance less dangerous, are not immune to the aforementioned problems. Hygiene issues can lead to the spread of disease in any work environment [19]. Even the university setting is not an exception to the rule [20], regardless of whether it is a medical and veterinary field or a technical faculty. In fact, wherever there is a potential source of danger, a lot of people who can be in contact with employees, and employees use the keyboard while performing work activities, it can be a very suitable medium for transmission of infections [17, 19, 20]. Special attention should be paid to the frequent occurrence of Coagulase negative Staphylococci [3, 15, 16, 22], Gram positive bacilli [3] or Bacillus species [15, 16, 22], Micrococcus species [16], Staphylococcus aureus [3, 15, 16], Staphylococcus epidermidis [15, 22], Enterococcus [21], and Pseudomonas species [3]. Therefore, great attention should be paid to identifying potential hazards, as well as procedures and measures that can eliminate risks. Hospital environments always stand out, because there is contact between staff and patients, so there is a possibility of cross-contamination, but also mutations that can create microbes resistant to drugs that are standardly used in therapies [16, 18].

When it comes to risk reduction, there are the following basic principles cited in the literature. The first involves hygiene, primarily of hands, which is the basis for reducing the contamination of surfaces with which employees are in contact [19, 20]. Standard hand hygiene procedures before using the keyboard are the basis of prevention of unwanted events. Also, considerable attention is paid to the rapid identification of potential dangers, i.e. the development of such devices. A more thorough detection procedure should be developed, and a frequent objection to existing research was related to inappropriate sampling procedures. There are also special decontamination methods that are applied, such as different types of devices, lamps, liquids and wipes [21, 22, 23, 24]. Each decontamination method is not effective for all potential hazards, which should be taken into account. Therefore, special attention should be paid to the development of the best possible techniques for disinfecting keyboards in case of microbiological or bacterial contamination [16, 25, 26]. In [24], the authors presented the successful application of a UV-C device that emits rays with a wavelength of 253.7 nm to disinfect non-critical portable devices with initial moderate (more than 10 colony forming units, CFU) or high (more than 50 CFU) contamination and similar results were achieved in [21]. In [22], the authors point out that a significant reduction in bacteria was achieved using ordinary antibacterial wet wipes, while in [25] ethanol-based agents were successfully used.

When using disinfectants, it is necessary to know what they are intended for. Potential hazards from the use of disinfectants are often ignored. They may contain greenhouse gases or other toxic chemicals. Effects such as allergic reactions and, in extreme situations, asphyxiation and cardiac arrest can also be caused in a person directly exposed to their effects. A frequent objection of users to commercially available means is the vague declaration, which does not contain all the necessary data needed when considering the potential success of the action. In order to approach the cleaning process with greater certainty, the tool should contain appropriate documentation that describes all significant features. It should, among other things, contain information about potential hazards and warnings about the consequences, chemical composition, and the most significant physicochemical properties in terms of stability, reactivity and toxicity for humans and the environment, potential unwanted reactions in users, first aid measures or prevention of consequences in the event of an unwanted event, fire-fighting measures if the agent is flammable. Thus, users would have a clearer insight into what they have at their disposal, that is, what effects they can expect.

CONCLUSION

The working environment and contacts during working hours, regardless of the work performed, significantly increase the probability of spreading various diseases. Hand hygiene reduces the likelihood of gastrointestinal disease, while the positive effect is not so pronounced in case of respiratory infections. Greater sharing of content in the work environment, which is characteristic of using the same keyboard, increases the probability of infecting employees, or cross-contamination with patients, colleagues or customers. Personal hygiene and adequate disinfection of contact surfaces, with special emphasis on the keyboard, significantly reduces risks, and can eliminate them significantly. Special attention should be directed towards hygiene and prevention, which in this case represents the simplest and most effective solution.

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DEVELOPMENT OF RADIATION SHELDING MATERIALS

Abstract
Since the discovery of the harmful effects of ionizing radiation on the human body, scientists have been working to find materials that will provide them with the best protection. The first material that was used as protection was lead, because it is characterized by a high value of the attenuation coefficient, low price and easy processing. However, knowledge about the consequences of lead poisoning and environmental protection influenced the need to find a material that would successfully replace it. New materials are being developed for this purpose. The paper will give an overview of the materials that are expected to meet the requirements and that will be used to protect against ionizing radiation in the future. All of them belong to composite materials and can be divided into composite materials that contain and do not contain lead. Lead-containing composite materials are a mixture of lead and other heavy metals. They are lighter than pure lead and provide the same level of protection. Composites that do not contain lead are mixtures of different materials with very different properties (density, flexibility,...) which are expected to replace lead while being environmentally acceptable.

Key words: Radiation Shielding Materials, Lead Shielding, Lead Composite Shielding, Lead-Free Shielding.

INTRODUCTION

Ionizing radiation includes electromagnetic waves, such as gamma (γ)-rays, which emit radioactive substances or x-rays, also known as X-rays. There are also alpha (α) and beta (β) particles produced by the decay of radioactive nuclides, as well as charged particles (electrons, protons, ions of heavier elements), which gain energy by accelerating in accelerators. Neutrons, electrically neutral particles, perform ionization directly [1,2].
The interaction of radiation and the environment through which the radiation passes leads to changes in both the radiation and the environment. The energy of the incident beam is degraded and the irradiated environment changes both physically and chemically, and in living matter also biologically. This is the basis of the practical application of ionizing radiation in the diagnosis, treatment and research of diseases. Regardless of the purpose of application, ionizing radiation when passing through the organism leads to changes interacting with the atoms of living matter. These changes can have consequences on DNA molecules, cells and tissues, so they can cause the death of healthy cells and tissues, and death can occur if large doses are used. On the other hand, the behavior of radiation during interaction was also studied: how it interacts with matter, how it weakens the intensity of radiation, how much energy it loses per unit of travel. On the basis of this information, protection against ionizing radiation is built so that patients do not receive an excessive dose during irradiation, but also how to protect medical personnel and prevent the release of harmful radiation into the environment [1-3].

PARAMETERS SIGNIFICANT FOR PROTECTION AGAINST IONIZING RADIATION

Considering the consequences of exposure to ionizing radiation, it is always necessary to minimize exposure or eliminate it completely. That is why it is necessary to know all the facts that lead to the weakening (attenuation) of ionizing radiation. The degree of attenuation depends on the interaction of the radiation with the material through which it passes, that is, on its atomic number, density and thickness of the material [2]. All these quantities appear directly or indirectly in the attenuation law:

$$I = I_0 \cdot e^{-\mu x}$$

where are:

I - the intensity of the radiation that passed through the layer of material thickness *x*;

I_0 - intensity of incident radiation;

μ - linear attenuation coefficient (1/cm or 1/mm).

Linear attenuation coefficient Linearni atenuacioni koeficijent (μ)represents a characteristic of the material and describes the attenuation properties of that material. It is obtained as the product of the number of atoms per unit volume (n) of the given material and the total effective cross sectiona (σ):

$$\mu = n \cdot \sigma \ .$$

And considering that the total effective cross-section is the result of three effects of the interaction of radiation with matter (photoelectric effect, Copmpton scattering and creation of an electron-positron pair [1]), the linear attenuation coefficient can be written as:

$$\mu = n \cdot \sigma_{fe} + n \cdot Z \cdot \sigma_{Com} + n \cdot \sigma_{par}$$

where are σ_{fe}, σ_{Com} i σ_{par} effective cross sections of the corresponding interactions.

In practice, another quantity is used, namely the mass attenuation coefficient, μm (cm^2/g), which is defined as:

$$\mu_m = \frac{\mu}{\rho}$$

where is ρ - density of matter.

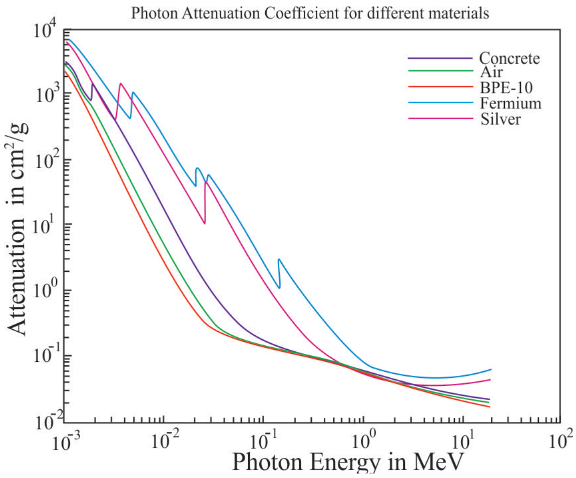
It is important to point out that the mass attenuation coefficient does not depend on the density of the material, which results in the fact that its values do not differ much for different materials. In contrast to it, the linear attenuation coefficient increases with the increase in material density. However, both attenuation coefficients show dependence on radiation energy. Figure 1 shows the dependence of the mass attenuation coefficient of different materials depending on the energy [3].

Apart from attenuation coefficients, another physical quantity is important when implementing protection against ionizing radiation - half-thickness (D1/2 - HVL, half value layer). The half-thickness is defined as the thickness of the material that reduces the intensity of incident radiation by half. The half-thickness value is determined experimentally for the observed material and certain radiation energy [3]. The relationship between the half-thickness of the material and the linear attenuation coefficient is obtained from the attenuation law, and reads:

$$D_{1/2} = \frac{\ln 2}{\mu} \ .$$

The possibilities of application of certain materials are determined precisely on the basis of the value of the mass attenuation coefficient and the half-thickness. Table 1 gives the values of these two parameters for several materials and several selected energies of ionizing radiation.

Figure 1 Mass attenuation coefficients for different materials as a function of energy [3]



The attenuation coefficient and half-thickness of the material are parameters that define the ability of the material to stop ionizing radiation, but when considering the selection of the most suitable protection in a specific case (rooms where radiation sources are located, rooms where patients who receive therapeutic doses stay, etc.) some other parameters should be taken into account. These are the occupation factor (T) and the specific gamma constant (Γ).

Table 1 HVL values for some materials and selected radiation energies
http://webfiles.ehs.ufl.edu/rssc_stdy_chp_3.pdf

Energija (MeV)	Lead $\rho = 11{,}35$ g/cm³		Iron $\rho = 11{,}35$ g/cm³		Aluminium $\rho = 11{,}35$ g/cm³		Water $\rho = 11{,}35$ g/cm³		Air $\rho = 11{,}35$ g/cm³		Stone Concrete $\rho = 11{,}35$ g/cm³	
	μ (1/cm)	HVL (cm)	μ (1/cm)	HVL (cm)	μ (1/cm)	HVL (cm)	μ (1/cm)	HVL (cm)	μ (1/cm)	HVL (cm)	μ (1/cm)	HVL (cm)
0,3	4,32	0,16	0,864	0,845	0,282	2,457	0,119	5,823	$0{,}135\cdot10^{-3}$	$5{,}133\cdot10^{3}$	0,251	2,76
0,5	1,75	0,396	0,652	1,062	0,236	2,936	0,092	7,532	$0{,}111\cdot10^{-3}$	$6{,}243\cdot10^{3}$	0,204	3,39
1	0,85	0,816	0,471	1,471	0,164	4,225	0,071	9,76	$0{,}082\cdot10^{-3}$	$8{,}451\cdot10^{3}$	0,149	4,65
1,5	0,59	1,174	0,378	1,833	0,137	5,058	0,057	12,157	$0{,}067\cdot10^{-3}$	$10{,}434\cdot10^{3}$	0,121	5,72
2	0,51	1,358	0,334	2,074	0,112	6,187	0,05	13,86	$0{,}056\cdot10^{-3}$	$12{,}375\cdot10^{3}$	0,104	6,66
2,5	0,48	1,443	0,302	2,294	0,102	6,794	0,044	15,75	$0{,}050\cdot10^{-3}$	$13{,}860\cdot10^{3}$		
3	0,47	1,474	0,279	2,843	0,094	7,372	0,039	17,769	$0{,}046\cdot10^{-3}$	$15{,}065\cdot10^{3}$	0,085	8,15
3,5	0,46	1,506	0,268	2,585	0,087	7,965	0,036	19,25	$0{,}042\cdot10^{-3}$	$16{,}500\cdot10^{3}$		

The occupancy factor, T, is a factor that takes into account the time spent by workers or patients in the room while the radiation source is active [4]. Its value depends on the nature of the work performed in a given room or space, where there is radiation, regardless of whether the source of radiation is in that or another room. The value of this factor depends primarily on the purpose of the room, and according to NCRP [5] it has the values given in the Table 2.

Table 2 Occupancy factor values for different rooms recommended by NCRP [5]

Type room	Occupation factor -T
Offices, laboratories, receptions, waiting rooms	1
Rooms for therapy and examination of patients	1/2
Corridors, patient rooms, bathrooms, employee rest rooms	1/5
Corridor door	1/8
Public toilet, cafeteria, storage, patient detention	1/20
Parking lots, sidewalks next to the building, stairs, elevator	1/40

The specific gamma constant, or gamma factor, Γ, is equal to the exposure rate in X-rays per hour at a distance of one meter from a point source of 1Ci activity [6]. It is generally expressed in the unit $R \cdot m^2/(Ci \cdot h)$. Its value is calculated on the basis of radiation energy as:

$$\Gamma = 0{,}5 \cdot E$$

where E is the radiation energy multiplied by the percentage of that energy in the energy spectrum of the given radioisotope. Its values for some radionuclides are given in the table 3.

Table 3 Gamma constant for some radionuclides [6]

Radionuclide	Cs-137	Co-57	Co-60	I-131	Mo-99	Ra-226	Sr-85	U-234
$\Gamma\ (\frac{R \cdot m^2}{Ci \cdot h})$	0,33	0,09	1,32	0,22	0,18	0,825	0,3	0,01

MATERIALS CANDIDATE FOR RADIATION SHIELDINGMATERIAL

It has been known since the earliest studies of x-rays and radioactive minerals that exposure to high levels of ionizing radiation can cause damage to human tissue. Also, epidemiological studies of people who survived Hiroshima and Nagasaki revealed the potential occurrence of malignant diseases as a result of exposure to this type of radiation. [1-3,7].

Protections used in medical diagnostics are extremely important for both patients and workers exposed to ionizing radiation. That is why the protection of both premises and people is carried out. The premises must be protected and isolated from the environment, and the walls of such premises must be fitted with lead plates or plates made of material that retains the penetration of X-rays to the same extent as lead. Partitions and screens are also made from the same materials, but adapted to the purpose, for the rooms behind which the technicians or doctors are located during the exposure of patients to radiation [5,6].

Decades ago, the material used for radiation protection was lead. It is suitable because it is cheap, easy to process, and in addition has a high value of linear and mass attenuation coefficient and provides permanent protection. However, in recent times there has been a huge increase in health, safety and environmental concerns during the mining of this metal. From the excavation process, through processing and handling, to final disposal. In fact, the use of lead is already banned for many applications, such as its presence in motor fuels, paints and water pipes. And it can be expected that the ban on its use will extend to the industry as well. Because of this tendency, researchers are working to find new materials to replace or reduce the lead content in ionizing radiation shields [1-3,5,6].

Lead composite protection

The first step in reducing the use of lead is the development of composite materials in which lead is mixed with other (lighter) materials. These are mainly materials in which lead oxide is added to heavy metal oxides to form glasses.

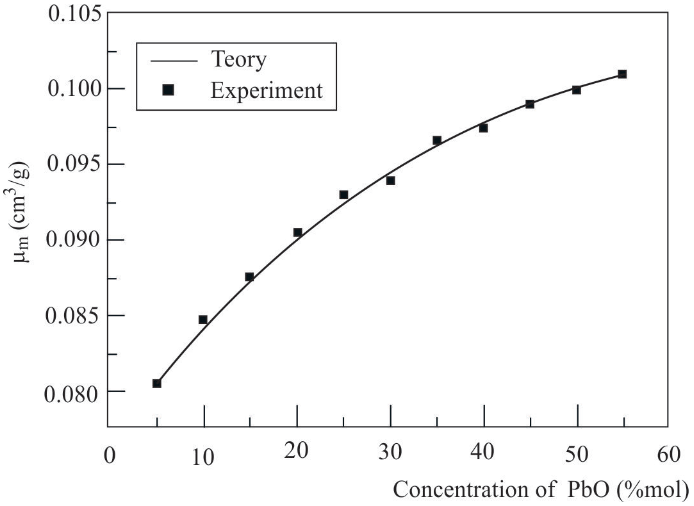
Glasses - $xPbO:20Na_2O:(80-x)B_2O_3$

Lead oxide began to be used as an integral component in several borate and phosphate glasses in order to improve their characteristics. Even if lead oxide does not form glass, it can be incorporated in significant quantities into oxide systems that form glass [8,9], which increases their density and makes them suitable for use in protection against ionizing radiation..

The research included glasses of the system xPbO:20Na2O:(80-x)B2O3 in which the content of PbO was varied (x had values of 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 and 55 mol%) and accompanied by changes in a large number of physical quantities. In the tested glass, the role of sodium oxide was to expand the area of glass formation and ensure a lower glass melting temperature [10], while lead oxide enters the glass network as a network modifier because it has an oxidation state of +2 [11].

This paper will present part of the results related to the influence of PbO on the values of the mass attenuation coefficient at the radiation energy of 662 keV, Figure 2. Analyzing the concentration dependence of the mass attenuation coefficient at the radiation energy of 662 keV, two significant characteristics are observed. The first is the great agreement between the theoretical calculations and the experimental values, and the second is the significant increase in the value of the mass attenuation coefficient with the increase in the PbO content.

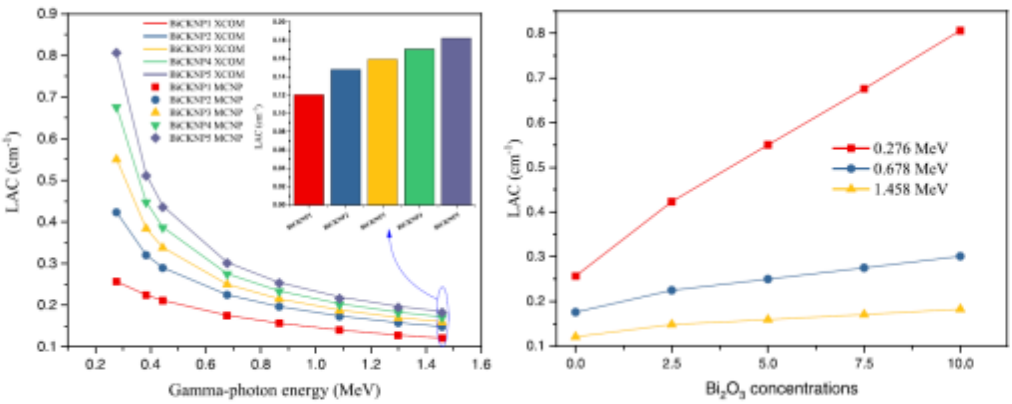
Figure 2 Theoretical and experimental concentration dependences mass attenuation coefficient at radiation energy of 662 keV [8]



Glasses - $xBi_2O_3+20CaO+10K_2O+(30-x)Na_2O+40P_2O_5$

Another group of glasses with a complex composition has been synthesized, which are expected to be used in protection against ionizing radiation. These are glasses of the type $xBi_2O_3+20CaO+10K_2O+(30-x)Na_2O+40P2O_5$, where x=0, 2.5, 5, 7.5, and 10 mol% [12]. Optical parameters (Direct band gap (eV), Indirect band gap (eV), Dielectric constant (ε), Refractive index (n), and others) were determined for synthesized glasses, as well as linear attenuation coefficients in order to determine the possible level of protection from ionizing radiation. The results of this part of the research are given in Figure 3.

Figure 3 Dependence of the linear attenuation coefficient on: a) radiation energy, b) from concentration *Bi_2O_3 [12]*



a) b)

The analysis of the obtained results shows that the LAC of all samples decreases with an increase in the incident radiation energy, Figure 3.a. This result is expected, because it is known that with an increase in energy, the penetration of photons increases and thus the ability to protect the material decreases. For the highest energy value of 1.458 MeV, the inset graph shows the values of LAC, where its increase with increasing Bi_2O_3 content from 0.1206 to 0.1825 cm^{-1} is noticeable. Therefore, it was important to see how the LAC changes with Bi2O3 content for more photon energies, Figure 3.b. It is clear from the graph that at all energies of the incident radiation there is an increase in LAC with an increase in the content of Bi2O3. This trend is expected because Bi_2O_3 has the highest density, and increasing its concentration increases the density of the glass as a whole, and thus the LAC value.

Lead-free composite shields

More and more attention is paid to finding materials that do not contain lead and provide equivalent protection (the same and close value of the attenuation coefficient). Some of these materials will be presented here.

Tungsten carbide

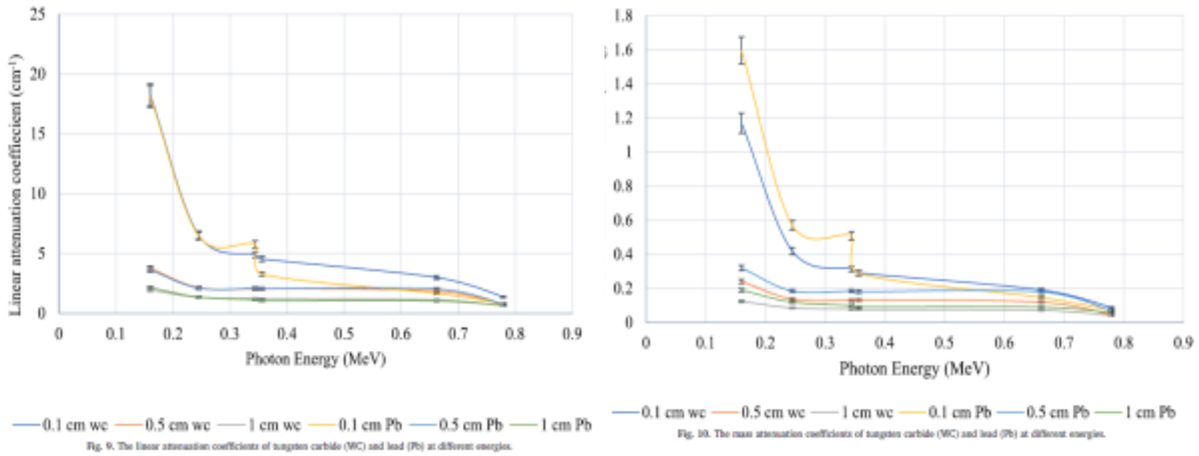
A group of researchers [13] examined the possibility of using tungsten carbide (WC) as a new protective material against ionizing radiation in nuclear medicine. The investigated carbide contained 98.65% tungsten and 1.35% carbon. For the purpose of research, discs of different thicknesses of 0.1 cm, 0.5 cm and 1 cm were made from tungsten carbide powder, using a hydraulic press, and then discs of the same thickness were made from lead in order to perform a comparative analysis.

Measurements of the attenuation coefficient were made by placing the samples between the γ-ray source and the NaJ detector. ^{123}I, ^{133}Ba, ^{152}Eu, and ^{137}Cs were used as sources of γ rays, and the energy interval was 0.160 MeV to 0.779 MeV. The measurement results are shown in the Figure 2.

It can be seen from Figure 4 that the values of the attenuation coefficients for the same thicknesses of tungsten carbide and lead materials are very close, with tungsten carbide showing slightly higher values for some energies. This result indicates that tungsten carbide has the potential to replace lead in radiation shielding in nuclear medicine. Statistical analysis (t-test with two paired pairs) showed that the mass coefficients of both samples had no significant difference.

Similar studies with pure tungsten [14] and tungsten carbide cobalt [15] have also been shown to be suitable materials to replace lead in shielding against ionizing radiation.

Figure 4 Attenuation coefficients of tungsten carbide and lead in the energy interval 0.16-0.779 MeV: linear; b) masses [13]

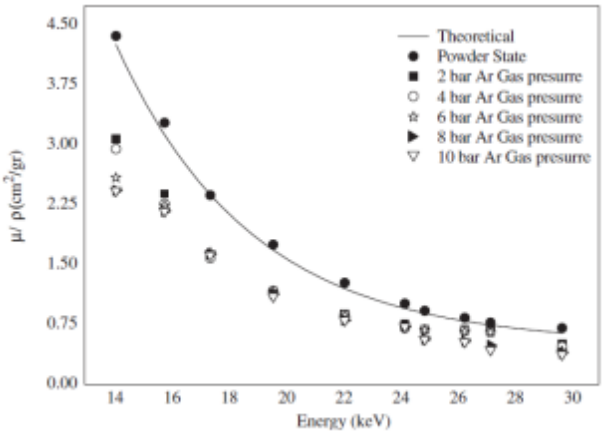


a) b)

Magnesium borate

Research on magnesium borate, MgB_2 as a potential material from which shielding for ionizing radiation could be made was carried out by a group of authors [16]. For the purposes of the research, commercial MgB_2 powder of high purity (99%) was used, from which tablets with a diameter of 13 mm were made under a pressure of 10 tons. Each tablet was then tubed and vacuumed to different pressures (2, 4, 6, 8 and 10 bar) and placed in a furnace at 1000°C. The mass attenuation coefficient was tested on the samples prepared in this way, and the results are shown in Figure 5.

Figure 5 Dependence of mass attenuation coefficient as a function of photon energy [16]



All obtained curves, Figure 5, have a well-known tendency to decrease the value of the mass attenuation coefficient with increasing radiation energy, but a deviation of the experimental points from the theoretically calculated values was observed. In addition, a small dependence of the parameter value on the Ar gas pressure was observed for the corresponding energy values. It was observed that samples obtained under low pressures have higher values of the mass attenuation coefficient, and with increasing photon energy, these differences become smaller. The cause of this is the displacement of Mg from the material when the pressure increases during the synthesis of the material.
The low values of the mass attenuation coefficient of MgB_2 glasses show that it is unlikely to be used as a material for protection against ionizing radiation.

CONCLUSION

The material that was used decades ago as a material to protect against ionizing radiation was lead. The widespread use of this material is due to a number of its good properties, the most significant of which are the high value of the linear and mass attenuation coefficient and the low price. However, by raising environmental awareness, there was a tendency to reduce the exploitation of this metal. That is why, today, efforts are being made to find new materials that will replace or reduce the lead content in shields for protection against ionizing radiation. The paper gives an overview of some materials that apply for it.

The first step in reducing the use of lead is to develop substances in which lead is mixed with other (lighter) materials. These are mainly materials in which lead oxide is added to heavy metal oxides to form glasses. The attenuation coefficients of two composite materials $xPbO{:}20Na_2O{:}(80\text{-}x)B_2O_3$ and $xBi_2O_3+20CaO+10K_2O+(30\text{-}x)Na_2O+40P_2O_5$ are presented and it is shown that they can both be used for protection against ionizing radiation. They are characterized by one important feature, which is that they are transparent in the visible area, and through them the process during the use of ionizing radiation can be observed..

The second step is to find a material that does not contain lead and provides equivalent protection (the same and close value of the attenuation coefficient). The paper presents two materials tungsten carbide (WC) and magnesium borate (MgB_2). Research has shown that tungsten carbide has the potential to replace lead in radiation shielding in nuclear medicine, while magnesium borate has not shown satisfactory characteristics and is unlikely to be used as a shielding material.

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EDUCATION FOR PEACE AS A PRECONDITION OF SUSTAINABLE DEVELOPMENT

Abstract
Historically, numerous wars and armed conflicts brought various chemical, biological and radiological hazards to the environment and the sustainable development of mankind. Promoting a culture of peace and non-violence through education is one of UNESCO's core missions. Education for peace refers to education which focuses on learning the skills necessary for living peacefully and promoting action to create peaceful alternatives. It represents a complex and multidisciplinary field that can be researched from various aspects - philosophical, sociological, pedagogical, andragogical, political, etc. However, little consideration was given to the integration of such programs into national education systems as part of an effort to introduce constructive attitudes, skills and behaviors for living together in order to prevent future conflict. Starting from that, the paper elaborates the conceptual and basic socially normative principles of education for peace, which is viewed as a precondition of sustainable development.

Key words: peace, education, sustainable development.

INTRODUCTION

In the modern social context, the promotion of the culture of peace has become a challenge and a mission of modern education. There are more and more authors who recognize the role and importance of educational systems in ensuring peace and developing a sustainable society. This is vital not only to support the post-2015 education agenda, but also to promote sustainable development and the right to education of all those who, due to emergency situations and disasters of different nature and character (natural disasters, armed conflicts, etc.), have this right denied. During the last few decades, numerous programs related to education for peace have been implemented and activities have been initiated with the aim of integrating such programs into national education systems. It is a reconceptualization of education towards Global Citizenship Education (GCED), which seeks to empower citizens with the knowledge, skills, values and attitudes needed to build fairer and more inclusive societies, more resistant to various disasters, challenges and threats of the modern age [1].

INITIAL BACKGROUND

In modern conditions, *"Education for peace"* has not yet taken root as a separate scientific and teaching discipline. Historical analyzes [2] show that the need for it arises mainly as a consequence of the escalation of strong political, economic and social conflicts[1], but also as a response to other security challenges of the modern age. The development of the idea of education for peace can be sought and found in the works of Ian Harris, J. A. Komenský, Maria Montessori, Johann Galtung, Paolo Freire, Betty Reardon and others. According to Harris [3] the first records of how to achieve peace can be found in religious writings, while Jan Amos Komenský [4] emphasized in the 17th century that peace can be achieved by spreading knowledge, that the ultimate goal of education is actually the goal of education for peace, and that we will prevail with common values and understanding of others' differences that lead to conflict. Maria Montessori also emphasizes the role of education in building a peaceful society, which is close to the modern value approach to education for peace, which is integratively concerned

[1] For example, in Japan, education for peace is developing after the suffering caused by nuclear bombing of Hiroshima and Nagasaki in 1945, in South America as a result of the fight against poverty, in Western Europe after the World War II, in the countries of the former SFRY after the 90s of the last century, i.e. after the collapse of the SFRY, etc.

with empowering students, accepting diversity and encouraging critical thinking with the aim of creating social change. According to Johann Galtung [2], the founder of the discipline of peace studies, peace research were initiated in universities in the middle of the 20th century but, unfortunately, did not achieve greater success when it comes to teaching and the educational system. According to this author, it is a matter of achieving a higher level of awareness of social reality and encouraging solidarity in the process of joint learning. Paulo Freire [4] believes that education for peace promotes "liberation" ("liberation pedagogy"). Freire foregrounds dialogue as a key component of problem-based teaching and contextual learning, grounded in the student's reality. Freire's concept of "sanctification" is the foundation of education for peace because it highlights the strong connection between education and social change. From the above, it can be concluded that the context and specific social needs influence the concept of (social) and, therefore, education for peace as it will develop in certain environments. In parallel with the research activities, there are numerous peace movements and congresses on the need for peaceful approaches and responses to security challenges and threats, and the public's attention to these problems was especially drawn by the founding of the Nobel Peace Prize in 1901. During the twentieth century, the author's attention (especially due to the Cold War) was focused on more studious research and determination of the problem of education for peace (Education for Peace, Brigit Brocke-Utne (1985), Comprehensive Peace Education, Betty Reardon (1988) and Peace Education, by Ian Harris (1988)).

CONCEPTUAL APPROACH

Terminologically, "education for peace" is used as a comprehensive term that can be applied to many initiatives designed to promote peace, safety and non-violence throughout the education system. Broadly speaking, this education is aimed at promoting a culture of peace through values, standards and principles articulated in fundamental UN instruments such as the UN Charter, Human Rights documents, the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW), the Convention on the Rights of the Child (CRC), the World Declaration on Education for All, etc. It is a completely participatory process that includes learning *about* and *for* democracy and human rights, non-violence, social and economic justice, gender equality, sustainable development, demilitarization, peace building, international law and human security, and as such cannot be closed within the framework of one discipline.

Relevant sources indicate the presence of different terms that imply the same or at least approximately the same contents or indicate different approaches to the problem of education for peace, such as: Human Rights Education, Multicultural Education, Global Citizenship Education, and Conflict Resolution Education. In fact, it is evident that the authors agree that one cannot consider education for peace without referencing gender equity, civics education and life skills. Ultimately, all of these concepts of learning "empower" students to "end violence and injustice and to create a culture of peace" [5]. Education for peace should enable students to "resolve conflict peacefully" and to do so at an "interpersonal, intergroup, national or international level". Promoting education for peace was taken to be the use of education to achieve peace in society: as such, it brings to the fore the social purposes of Peace Education, which prepares learners to acquire peace-building competencies [6]. Such education recognizes the value of all the concepts mentioned above and implies the creation of an educational environment based on respect for human dignity and human rights, which promotes critical thinking and values, skills and attitudes such as empathy, participation, non-violence, safety and peace. Of course, depending on the historical, political and social context of different countries, there is a variety of applied terminology. However, there is an evident agreement on the need for a holistic and systemic approach to education for peace, which, considered from the aspect of the educational system, means the integration of "peaceful" contents both in the formal and non-formal, i.e. informal educational system and their interaction with all elements of the educational process (curriculum, resources, educational technology, planning, non-teaching support, policy, personnel, supervision, etc.). The literature [7] emphasizes the need for integrating education for peace into the education sector planning in order to avoid "ad hoc" approaches to this problem, but the attention of the scientific public is mostly focused on issues of curriculum, which according to many authors is at the heart of education systems. The issue of incorporating content related to education for peace into curricula must be considered within the specific social, cultural and moral context of each country. There is no pre-determined recipe as each country must articulate its own goals and objectives in the area of education for peace and then consider its specificities to arrive at the best approaches to this issue. Certainly, the emphasis is on the approach based on learning outcomes, both in the cognitive and affective domains, which imply that students know and understand the importance of peace, environmental safety and the prevention of risks and conflicts, and accordingly, to develop, adapt or affirm appropriate values, beliefs and behaviors.

METHODS

The aim of the paper is to lay the foundations for understanding the concept of education for peace and to open space for further critical discussion in the direction of the complete integration of this problem into the education system. This paper was created as a result of a research of a broader holistic perspective of education for sustainable development. By analyzing relevant sources (desktop research), we tried to create a theoretical background for better understanding, further research and more successful advocacy of education for peace as a response to the security challenges of the century and society in which we live. This research was encouraged by the lack of scientific research on this issue both in Serbia and in the regional framework, but also by the fact that many UNESCO recommendations have not been integrated into national education systems. We created the presented basis through several parts: a brief historical overview of the development of the idea of education for peace, its conceptual definition, presentation and desk-analysis of the legal-normative and strategic-development framework of education for peace with analysis and elaboration of examples of good practice in this area.

EDUCATION FOR PEACE AT THE INTERNATIONAL LEVEL – NORMATIVE BASIS

It can be said that the promotion of education for peace at the international level began early, with the adoption of several key documents. Guided by the goal of making the right to education a guaranteed right for all people, in 1960 UNESCO adopted one of the first documents in this area, the *Convention Against Discrimination in Education*, which committed UNESCO member states to ensure equal access to education for all. In 1974, these countries adopted the *Recommendation concerning Education for International Understanding, Co-operation and Peace and Education relating to Human Rights and Fundamental Freedoms*, which confirmed their responsibility in ensuring education for all with the aim of promoting justice, freedom, human rights and peace. The importance of this document was confirmed in 1995 through the *Integrated Framework of Action on Education for Peace, Human Rights and Democracy*, while the key connection between education for peace and the creation of a culture of peace was highlighted in 1999 within the *UN Declaration on a Culture of Peace* [8]. According to Article 4 of this Declaration, education at all levels is one of the basic means of building a culture of peace, with particular importance being given to education for human rights [9].
An overview of key documents relevant to the field of education for peace is given in Table 1.

Table 1. Basic international and European documents in the field of peace and education for peace

Document name	Year	Responsible organization	Content
Universal Declaration of Human Rights	1948	UN	Recognition of human dignity through justice and world peace
International Covenant on Civil and Political Rights	1966	UN	Right to life, liberty and personal security, equality, etc.
International Covenant on Economic, Social and Cultural Rights	1966	UN	Right to self-determination, work and fair working conditions, participation in cultural life, scientific progress, upbringing and education, etc.
Declaration on the Right to Development	1986	UN	Progress and welfare of all mankind based on their active, free and meaningful participation in development and fair distribution
Convention on the Rights of the Child	1989	UN	Protection and assistance to children so that they can fully assume responsibility in the community
Copenhagen Declaration on Social Development	1995	UN (WSSD)	Social development through emphasizing the importance of lifelong learning
Convention against Discrimination in Education	1960	UNESCO	Equality of upbringing and education standards and conditions that determine the quality of upbringing and education
Recommendation concerning the Status of Teachers	1966	UNESCO	The importance of the role of teachers in the improvement of upbringing and education
Declaration and Integrated Framework of Action on Education for Peace, Human Rights and Democracy	1994	UNESCO	Emphasis on the important role of informal educational organizations and programs in shaping the personality of young people
World Plan of Action for Education on Human Rights and Democracy	1993	UNESCO	Upbringing and education for human rights at all levels of the school system, in an informal environment, and in special and difficult circumstances

European Convention for the Protection of Human Rights and Fundamental Freedoms	1950	Council of Europe	Agreement on areas and methods of protection of human rights and prohibition of discrimination
Final Declaration of the Council of Europe's Second Summit	1997	Council of Europe	Strengthening pluralistic democracy and citizens' awareness of their rights and responsibilities in a democratic society
Recommendation No. R (85) 7 of the Committee of Ministers on Teaching and Learning about Human Rights in Schools	1985	Council of Europe	The importance of teaching young people about human rights as part of their preparation for life in a pluralistic democracy; emphasis on skills, knowledge, school climate and teacher education
Declaration and Programme on Education for Democratic Citizenship, based on the Rights and Responsibilities of Citizens	1999	Council of Europe	The role of upbringing and education in promoting the active participation of all people in democratic life at all levels; as the right and responsibility of all citizens
Council of Europe Charter on Education for Democratic Citizenship and Human Rights Education	2010	Council of Europe	The need for education for democratic citizenship and human rights to be structured in the formal education system, but also through non-formal education programs
Report to UNESCO of the International Commission on Education for the Twenty-first Century	1996	UNESCO	Emphasis on the need to move towards a "learning society", a society that adopts, renews and uses knowledge - the irreplaceability of the formal education system in building long-term positive social changes
Recommendation of the European Parliament and of the Council on Key Competences for Lifelong Learning	2006	European Parliament and Council of Europe	Combating illiteracy and reducing unemployment; integration of unemployed and inactive people into the labor market

Source: Source of table [10, p. 44-46]

It is important to mention recent documents that promote the value of peace among young people: *UN Youth Strategy*[2] (2018), *Youth, Peace and Security*[3] (2020), *Youth Sector Strategy 2030*[4] (2020), *The Youth Action Plan in EU External Action (2022-2027)*[5] (2022) and others.

A document called *Transforming our world: the 2030 Agenda for Sustainable Development*, which was adopted by the United Nations General Assembly, is particularly important for the promotion of peace at the international level. It is a global development program which defines 17 sustainable development goals (SDGs), for the realization of which a period of 15 years is foreseen, starting from 2016, when they came into force. One of the goals, Goal 16, mandates the promotion of *peaceful, inclusive and just societies*, i.e. reducing violence, ending child torture, promoting the rule of law, fighting organized crime, significantly reducing corruption, etc. [11].

Since education is recognized as an important tool for the realization of all 17 SDGs [12-14], the realization of the goal related to peace also largely depends on education. The connection between education and Goal 16 can best be seen through the learning outcomes defined by UNESCO [13] as necessary to achieve this goal. Thus, in (1) the cognitive domain, it is foreseen that the student should understand concepts of justice, inclusion and peace and their relationship to law; local and national legislative and governance systems, how they represent them and that they can be abused through corruption; the importance of the international human rights framework etc.; (2) socio-emotional learning objectives require the student to be able to debate local and global issues of peace, justice, inclusion and strong institutions; show empathy with and solidarity for those suffering from injustice in their own country as well as in other countries; reflect on their role in issues of peace, justice, inclusion and strength etc.; while (3) the behavioral domain includes outcomes that promote the ability of students to collaborate with groups that are currently experiencing injustice and/or conflicts; become an agent of

[2] The strategy is based on three pillars: peace and security, human rights and sustainable development. Some of the priorities are work on amplifying the voices of young people in order to promote a peaceful, just and sustainable world, supporting young people as drivers for peace, security and humanitarian actions, etc. (Strategija za mlade u Republici Srbiji za period od 2023. do 2030. godine, Službeni glasnik RS, br. 9/23).

[3] The focus of this document is on the role of young people in building peace and security, thus calling for their inclusion in peace negotiations and efforts to build peace. One of the priorities is investing efforts in prevention through the development of adequate policies, quality education and the promotion of a culture of peace, intercultural and interreligious dialogue and tolerance (Ibid).

[4] The Strategy promotes respect for diversity, building peace, fighting against all forms of racism and intolerance, intercultural dialogue and learning, and specific work with communities of young people who are affected by such phenomena (Ibid).

[5] The full name of the action plan is *Promoting meaningful youth participation and empowerment in EU external action for sustainable development, equality and peace*, and it is aimed, among other things, at providing support for the role of young people in promoting lasting peace, contributing to justice and reconciliation, and opposing violent extremism (Ibid).

change in local decision-making, speaking up against injustice; contribute to conflict resolution at the local and national level etc. [13].

Education for peace is also incorporated into the legal and strategic documents of the Republic of Serbia. According to Kalezić Vignjević et al. [15], such documents are the following:

Law on the Basics of the Education System. Education for peace is emphasized in the Law (Službeni glasnik RS, br. 88/17, 27/18 – dr. zakoni, 10/19, 6/20 i 129/21) through: (1) principles that promote democracy, respect for human rights, fostering openness, tolerance, solidarity, etc.; (2) goals aimed at developing non-violent behavior, ability to live in a democratic and just society, respect for racial, national, cultural, etc. equality, respect for diversity, etc.; (3) outcomes that predict the student's ability to work effectively with others, respect human rights and freedoms, communicate assertively and non-violently; (4) the competence of responsible participation in a democratic society (Ibid.), as well as through (5) the prohibition status for discrimination, violence, abuse and neglect of children [15].

Quality standards of educational institutions. Within the Rulebook on Standards of the Institution's Work (Službeni glasnik RS, br. 14/18), there are several standards that promote the field of education for peace, and they relate to mutual respect between teachers and students, organizing programs/activities for the development of social skills (e.g. constructive problem solving, non-violent communication), promotion of healthy lifestyles, children's rights, etc. Education for peace is particularly related to the field of *Ethos*, within which the quality standards related to the establishment of good interpersonal relations[6] and the functioning of the system of protection against violence are defined[7].

Teacher competency standards. The competencies that teachers should have for a successful performance of educational work are defined by the Rulebook on Standards of Competences for the Profession of Teachers and Their Professional Development (Službeni glasnik RS, br. 05/11.). Kalezić Vignjević et al. [15] single out those related to education for peace, stating that it is particularly important that the teacher: understands the social context of education and actively contributes to a multicultural and inclusive approach to education; contributes to sustainable development and encourages healthy lifestyles; respects universal human and national values and encourages children to adopt them by supporting mutual understanding and respect, tolerance, respect for diversity, cooperation and companionship; provides support to children from sensitive social groups to achieve their educational potential in accordance with their own capabilities and gives an example by helping the formation of value systems and the development of positive characteristics of students. In addition, in order to contribute to efficiency and equal rights and quality education for all children, the teacher should have competencies related to the prevention of violence, motivation to learn, building tolerance and preventing discrimination [15].

The special protocol for the protection of children and students from violence, abuse and neglect in educational institutions and the *Rulebook on the protocol of actions in the institution in response to violence, abuse and neglect* oblige institutions to form a team and create a program for protection against violence. *The protocol* indicates that the institution's obligation is to provide conditions for safe and stimulating upbringing and development of children and protection from all forms of violence through preventive programs and activities, as well as through precise definition of procedures for responding to situations of violence. *The Rulebook* has a binding character for employees in the educational system and elaborates in more detail the levels of violence that should serve as a framework for intervening in situations of violence (Ibid).

Elements important for education for peace (tolerance, democracy, human rights, interculturality, non-violent conflict resolution, etc.) can also be found in the latest national documents dedicated to education and the youth population: *Strategy for the Development of Education and Training in the Republic of Serbia until 2030* and *Strategy for the youth in the Republic of Serbia for the period from 2023 to 2030*. The Strategy for the Development of Education points out the need to strengthen the educational role of educational institutions in order to affirm the values of a modern democratic society, mutual respect and appreciation, non-violence and anti-discrimination, etc. in the school environment. In addition, activities to strengthen the educational role of the school will be based on the postulates of intercultural education

[6] Adherence to the norms that regulate the behavior and agreements of all, the application of measures and sanctions for discriminatory behavior, the application of techniques of prevention and constructive resolution of conflicts (Pravilnik o standardima kvaliteta rada ustanove, Službeni glasnik RS, br. 14/18).

[7] Clear expression of a negative attitude towards violence, solving the problem of violence, organizing activities for the prevention of violence, as well as activities of support and educational work with students involved in violence (Ibid).

(Strategija razvoja obrazovanja i vaspitanja u Republici Srbiji do 2030. godine, Službeni glasnik RS, br. 63/21). The Strategy for the Youth promotes respect for human and minority rights, equality and the prohibition of discrimination, equal opportunities for all, social responsibility and solidarity while recognizing the role of young people in building a democratic civil society based on a culture of non-violence and tolerance (Strategija za mlade u Republici Srbiji za period od 2023. do 2030. godine, Službeni glasnik RS, br. 9/23).

EDUCATION FOR PEACE – GOOD PRACTICE EXAMPLES

Practical implementation of education for peace is connected to projects, publications, activities, and other initiatives of various organizations, but also to educational programs/courses dedicated to peace, which are implemented at various universities around the world.

Education for Global Peace (EGP) is an organization which is building a global network and movement that seeks to bring about a world based on cultures of peace. The focus of the organization is on the realization of three strategic goals: (1) to develop and offer innovative pedagogical strategies on peace education through concrete projects; (2) to advocate for peace education at different institutional levels; and (3) to promote peace education research[8]. Some of the projects of this organization are: Peace Lesson Talks[9]; Comic Strip on Peace Education[10]; PeaceEd Gateway[11]; Global Peace Education Research Center (GPERC)[12] etc.

Inter-agency Network for Education in Emergencies (INEE) is an open, global network of members working together within a humanitarian and development framework to ensure that all individuals have the right to a quality, safe, relevant, and equitable education[13]. This network provides a significant database - publications, training programs, manuals, reports, and other materials in the field of education for peace: "Learning to live together: Design, monitoring and evaluation of education for life skills, citizenship, peace and human rights"[14]; "Peace Education Manual"[15]; "Peace Education Programme"[16]; "Safety, resilience, and social cohesion: a guide for curriculum developers"[17]; "The Peace Education Programme Evaluation"[18]; "Teachers Activity Book Matrix of Activities"[19]; "A Mapping Exercise: Training Programs for Teachers and Education Workers in the Field of Peacebuilding and Conflict-Transformation"[20] etc.

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[8] Education for Global Peace, https://educationforglobalpeace.org/

[9] Peace Lesson Talks is an interactive learning platform on peacebuilding, i.e. a place to present and and share lessons on peace, through video, animations, podcasts, text and other media forms (Education for Global Peace, https://educationforglobalpeace.org/).

[10] Cartooning peace education represents a pedagogical strategy oriented towards understanding the implications of nonviolence, conflict transformation and developing measures promoting peacebuilding (Ibid).

[11] PeaceEd Gateway is an innovative web platform that will enable students around the world to choose and access existing peace education programs and curriculum based on their needs and connect with each other while learning and interacting in a safe, supportive environment (Ibid).

[12] GPERC's goal is to become the world's largest open peace education research platform, home, hub and network for peace education. The network will include peace education organizations, schools, educators, scholars and other institutions wanting to contribute to and benefit from the vast body of information to be collected and studied (Ibid).

[13] Inter-agency Network for Education in Emergencies (INEE), https://inee.org/

[14] The guide that focuses on the theme of 'learning to live together', which is one of four competencies identified as important by the International Commission on Education for the Twenty-first Century (Inter-agency Network for Education in Emergencies (INEE), https://inee.org/).

[15] The manual presents a total of 34 lessons aimed at enhancing youth understanding of peace & security issues, and building their capacity to participate meaningfully and contribute to peace processes (Ibid).

[16] This programme teaches the skills and values associated with peaceful behaviours. It enables and encourages learners to think constructively about issues, both physical and social, and to develop constructive attitudes towards living together and solving problems that arise in their communities through peaceful means (Ibid).

[17] This introductory booklet is the first in a series of eight which show how to address safety, resilience, and social cohesion at every stage of the curriculum development and implementation process (Ibid).

[18] This report contains several evaluative case studies regarding peace education in a variety of contexts (Ibid).

[19] The activities provided in this matrix may be used as a guideline for educators who want to teach topics related to Peace Education (Ibid).

[20] The aim of this research project is to gain an idea of the types of training programs available to and specifically geared towards teachers and education workers. This can be used as a point of departure to identify best practices in teachers training in the field of peace-building and conflict-transformation (Ibid).

The International Institute on Peace Education (IIPE) organizes one-week activities for teachers every other year in different countries with the aim of exchanging practical and theoretical experiences in teaching peace education and contributes to the further development of this field. IIPE functions as an applied laboratory for peace education, providing space for pedagogical experimentation; cooperative, deep inquiry into shared issues; and advancing theoretical, practical and pedagogical applications. Some of the topics of activities in previous years were: "Weaving Together Intercultural Peacelearning" (Mexico, 2022); "Educating for a Culture of Peace in Divided Societies: History, Dialogue, and Multiperspectivity Toward Reconciliation" (Cyprus, 2019); "Aesthetic Peaces: Social, Political & Embodied Learning - Responses for Human & Planetary Survival" (Austria, 2017); "Education for Urban Revitalization toward Social & Ecological Justice: Peace Education in an Era of Globalization" (USA, 2015); "Towards a Possible World Free From Violence: Pedagogies, Proposals and Politics for Human Rights and Peace" (Puerto Rico, 2013)[21] etc.

In addition, this Institute has launched many other initiatives: People of Peace Education[22], Mapping Peace Education[23]; Global Campaign for Peace Education (GCPE)[24]; Community-Based Institutes on Peace Education (CIPEs)[25] etc.

The initiative within which the Global Campaign for Peace Education, in partnership with the International Institute on Peace Education and the Peace Education Initiative at The University of Toledo, created a base of programs, courses and workshops in the field of peace education is particularly interesting. Examples of identified study programs and courses in the field of education for peace that have been implemented/are still being implemented are given in Table 2.

Table 2. Programs and courses in peace education

Program/Course	Institution	Degree Type	Location
Institute for Peace Studies Minor in Peace Studies	Center for Civic Engagement Hofstra University	Undergraduate	United States
Introduction to Peace Education	School of Arts & Social Sciences National Open University of Nigeria	Undergraduate	Nigeria
Negotiation, Conflict Resolution and Peacebuilding Pedagogy	College of Arts and Humanities California State University Dominguez Hills	Undergraduate	United States
Peace Education: Facilitating Learning for Change in Schools and Beyond	Judith Herb College of Education - Minor in Peace Studies The University of Toledo	Undergraduate	United States
Peace Education and Values in Pre-school Education	Granada University	Postgraduate	Spain
PhD in Peacebuilding	Department of Peace Studies Payap University	Postgraduate	Thailand
Postgraduate Program in Peace Studies & Conflict Transformation with Emphasis on Emotional Balance	Paz & Mente Brazil in partnership with Innsbruck UNESCO Chair for Peace Studies, Austria	Postgraduate	Brazil
Concentration in Peace and Human Rights Education	Teachers College Columbia University A Graduate School of Education, Health & Psychology	Postgraduate	United States
Doctor of Education (EdD) in International & Multicultural Education, concentration in Human Rights Education	School of Education University of San Francisco	Postgraduate	United States
International Master and PhD in Peace, Conflict and Development Studies	Interuniversity Institute on Social Development and Peace (IUDESP)/ UNESCO Chair of Philosophy for Peace Universitat Jaume I (UJI),	Postgraduate	Spain

[21] International Institute on Peace Education (IIPE), https://www.i-i-p-e.org/

[22] People of Peace Education is a publication and website that elevates the work of peace education to the general public by providing glimpses of the lives and work of peace educators from all around the world (International Instutute on Peace Education, https://www.i-i-p-e.org/).

[23] Mapping Peace Education is an open-access, online resource for researchers, donors, practitioners, and policy-makers who are looking for data on formal and non-formal peace education efforts in countries around the world to develop contextually relevant and evidence-based peace education to transform conflict, war, and violence (Ibid.).

[24] The GCPE is an international network that promotes peace education among schools, families and communities to transform the culture of violence into a culture of peace (Ibid.).

[25] CIPEs are sustainable, community-based, non-formal peace education teacher training initiatives designed to address the lack of formal opportunities for the preparation of educators in the methods and practices of peace education and for active citizen engagement (Ibid.).

Master in Humanistic Psychotherapy and Education for Peace	Institute of social sciences and administration Ciudad Juárez Autónomus University	Postgraduate	Mexico
Master of Arts in International Education Development - Focus in Peace and Human Rights Education	Department of International & Transcultural Studies Teachers College, Columbia University	Postgraduate	United States
Masters of Arts in Peace and Justice	Martin Luther Christian University	Postgraduate	India
Peacebuilding and Conflict Transformation	SIT Graduate Institute	Postgraduate	United States

Source: Source of table [16]

Education for peace is particularly represented within the programs and courses at *The University for Peace (UPEACE)*, which was founded by the United Nations in 1980. The university is located in the province of San Jose, Costa Rica and is a unique higher education institution dedicated to the study of peace. At this university, future leaders are being trained to explore and formulate strategies and practices in various contexts to address the causes of multiple problems affecting human and global wellbeing, and thus contribute to the processes of peacekeeping and peacebuilding. Within the Department of Environment and Development (DED) there are three study programs dedicated to the dimensions of sustainable development: (1) Ecology and Society, (2) Environment, Development and Peace, and (3) Responsible Management and Sustainable Economic Development. Numerous courses are studied within these programs, such as: Water Security and Peace, Climate Adaptation and Justice, Environment, Conflicts, and Sustainability, Energy Transitions, Justice, and Activism, Development and Conflict in Practice: role and application of sustainability frameworks in development projects, Development Studies and International Cooperation, Social Responsibility[26], etc.

Examples of education for peace can also be found in Serbia. At the University of Belgrade, within the Faculty of Political Sciences, there is a *Center for Peace Studies*, a scientific research center founded in 2008. The Center's research focus is directed towards a wide range of issues related to war and peace, and through its activities it encourages the cultivation of the values of peace and non-violence, as well as the understanding of conflicts, regional and global. The Center also offers the *Regional Master's Program in Peace Studies*. This program is interdisciplinary in nature, and is intended for social studies students and individuals dealing practically with peace and conflict issues, and offers specialization in several areas, including Conflict Resolution and Peace and Development[27]. In addition, at the Faculty of Political Sciences there is also a master's study program called Peace, Security and Development which aims to educate and train students to use the conceptual apparatus of peace, security, and development studies, to acquaint them with basic theoretical approaches and debates in these three areas, as well as to train them for further research in these and related fields of social sciences and humanities. The program also aims to educate and train students for professional work in scientific research institutions and other organizations and institutions that deal with peace, security, and development issues. Some of the courses within this program are: Critical Approaches to Peacebuilding, Democratization, Development Studies: Approaches, Actors, and Issues, Inequality, Migration and Development, Theories and Policies of Justice[28] etc.

The Faculty of Security of the University of Belgrade offers the course *Peace Missions and Conflict Resolution*, as an elective/applied professional course that is studied in the 4th year of studies within the study program Studies of Security Sciences (basic academic studies). The aim of this course is for students to acquire knowledge about conflicts, the peace process and instruments for conflict resolution, the gender dimension of the peace process, peace missions and their importance for establishing and maintaining peace; the ability to use relevant databases to map conflicts, compare peace processes and propose an instrument for conflict resolution; and a critical opinion on the role of the UN and regional organizations in preserving and maintaining peace.[29]

At the Faculty of Philosophy of the University of Prishtina there is an elective course *Conflictology and the culture of peace* which is studied at the doctoral academic studies of Sociology, within which students are introduced to content such as theories about conflicts and the culture of peace, conflicts in the organization, political conflicts, intercultural and intercivilizational conflicts, interethnic conflicts,

[26] University for Peace, https://www.upeace.org/

[27] Centar za studije mira, http://www.csm-fpn.org/

[28] Fakultet političkih nauka Univerziteta u Beogradu, https://www.fpn.bg.ac.rs/

[29] Fakultet bezbednosti Univerziteta u Beogradu, https://fb.bg.ac.rs/

conflict resolution technology and the actions of social actors, the culture of peace and peace movements in the modern world, etc.[30]

Private universities in Serbia also offer courses dedicated to peace. The University Business Academy in Novi Sad offers the course *Creating a culture of peace* as part of the study program of basic academic studies in Law, Security and Criminology at the Faculty of Law for Economy and Justice, which is studied in the fourth year of studies. It is an elective course aimed at acquiring an education that fosters a culture of peace and the adoption of values, attitudes and behavior that “reflect and inspire social interaction and sharing based on the principles of freedom, justice and democracy, all human rights, tolerance and solidarity, which reject violence and strive to prevent conflicts by solving their root causes through dialogue and negotiations that guarantee full realization of all rights and means for full participation in the development process of their society” [31]. In addition to this course, at the Faculty of International Politics and Security of the University “Union - Nikola Tesla” there is an elective course *Culture of Peace and Conflict Theory* in the study program of doctoral academic studies International Politics and Security.[32]

CONCLUSION

In the broadest sense, education for peace refers to the concept of value education that develops a culture of peace and non-violence, promotes the affirmation and protection of human rights, equality at all social levels, socially just relations and a sustainable approach to the development of communities and societies with active and responsible citizens in creating a safe and healthy environment. Relevant literature evaluates education for peace as extremely important for preparing citizens to deal with current social needs and challenges, especially for the purpose of reducing violence in society, ensuring safe living and working conditions, and participation in sustainable development. The values of education for peace are consistent in different cultures, and at the level of the area it covers and the approach it chooses, it is contextually determined (it covers contents and areas relevant to a certain geographical or political area).

The analysis of international and national documents indicates numerous recommendations that should be respected at all levels of the educational system. In order to prevent the ghettoization of education for peace, it is necessary to advocate its integration into the formal education system through cross-curricular, curricular and extracurricular inclusion of content and methods, whereas schools should be maximally opened to cooperation with civil society. It is important to translate the normative framework into practice and establish education for peace and nonviolence as an equal teaching area, both within education for human rights and democratic citizenship, and within the comprehensive curriculum.

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IMPORTANCE OF PERSONAL PROTECTIVE EQUIPMENT WHILE WORKING WITH CHEMICAL HAZARDS

Abstract
When manufacturing microsystems in a cleanroom environment there are many hazardous materials involved; therefore, in many cases, specific personal protective equipment is required. Personal protective equipment unit provides an introduction to the personal protective equipment that must be worn when working with hazardous materials in microsystems manufacturing. This information should be discussed before performing any activities involving the handling hazardous materials. There are many chemical processes involved in the manufacturing. When working in a cleanroom environment, it is necessary to wear personal protective equipment to protect yourself from exposure to cleanroom hazards as well as to protect the cleanroom environment.

Key words: Personal protective equipment, Aerosol, Biological agent, Engineering controls, Risk assessment.

INTRODUCTION

Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.
All personal protective equipment should be safely designed and constructed, and should be maintained in a clean and reliable fashion. It should fit comfortably, encouraging worker use. If the personal protective equipment does not fit properly, it can make the difference between being safely covered or dangerously exposed. When engineering, work practice, and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment to their workers and ensure its proper use. Employers are also required to train each worker required to use personal protective equipment to know:

- When it is necessary,
- What kind is necessary,
- How to properly put it on, adjust, wear and take it off,
- The limitations of the equipment,
- Proper care, maintenance, useful life, and disposal of the equipment,

If PPE is to be used, a PPE program should be implemented. This program should address the hazards present; the selection, maintenance, and use of PPE; the training of employees; and monitoring of the program to ensure its ongoing effectiveness [1].
There exist various kinds of physical, chemical, and biological hazards in the workplace. To protect workers from these hazards, it is not controversial that environmental management measures to remove or reduce these harmful factors and to improve the quality of workplaces through an engineering approach are fundamental solutions. However, in reality, there are many work sites where such decisively effective measures cannot be applied. In such situations, a work management approach utilizing personal protective equipment (PPE) is considered an alternative and significant means for protecting the safety and health of workers [2].

METHODS

The method is used in this research to find out the relationship between non using of PPE and using of PPE. Personal protective equipment (PPE) is an article used to prevent the wearer from coming in contact with hazardous, infectious, chemical, radiological, electrical, and physical agents. This research follows a method approach which collected and analyzed information from research.

RESULTS

Accident: An inadvertent occurrence that results in actual harm such as infection, illness, injury in humans or contamination of the environment.
Aerosol: Liquid or solid particles suspended in air and of a size that may allow inhalation into the lower respiratory tract (usually less than 10 micrometers in diameter). Aerosol/airborne transmission: The spread of infection caused by the inhalation of aerosols.
Aerosol-generating procedure: Any procedure that intentionally or inadvertently results in the creation of liquid or solid particles, which become suspended in the air (aerosols).
Biological agent: A microorganism, virus, biological toxin, particle or otherwise infectious material, either naturally occurring or genetically modified, which may have the potential to cause infection, allergy, toxicity or otherwise create a hazard to humans, animals or plants.
Biological safety cabinet (BSC): An enclosed, ventilated working space designed to provide protection to the operator, the laboratory environment and/or the work materials for activities where there is an aerosol hazard. Containment is achieved by segregation of the work from the main area of the laboratory and/or through the use of controlled, directional airflow mechanisms. Exhaust air is passed through a high efficiency particulate air (HEPA) filter before recirculating into the laboratory or into the building's heating, ventilation and air conditioning system. There are different classes (I, II and III) of BSCs that provide different levels of containment.
Biosafety: Containment principles, technologies and practices that are implemented to prevent unintentional exposure to biological agents or their inadvertent release.
Calibration: Establishment of the relationship between the measurement provided by the instrument and the corresponding values of a known standard, allowing correction to improve accuracy. For example, laboratory equipment such as pipetting devices may need calibration periodically to ensure proper performance.
Consequence (of a laboratory incident): The outcome of an incident (exposure to and/or release of a biological agent) of varying severity of harm, occurring in the course of laboratory operations. Consequences may include a laboratory-associated infection, other illness or physical injury, environmental contamination, or asymptomatic carriage of a biological agent.
Containment: The combination of physical design parameters and operational practices that protect personnel, the immediate work environment and the community from exposure to biological agents. The term "biocontainment" is also used in this context.
Core requirements: A set of minimum requirements defined in the fourth edition of the World Health Organization (WHO) Laboratory biosafety manual to describe a combination of risk control measures that are both the foundation for, and an integral part of, laboratory biosafety. These measures reflect international standards and best practice in biosafety that are necessary to work safely with biological agents, even where the associated risks are minimal.
Cross contamination: The process by which biological agents are unintentionally transferred from one substance or object to another, with potentially harmful effect. Decontamination: Reduction of viable biological agents or other hazardous materials on a surface or object(s) to a pre-defined level by chemical and/or physical means.
Disinfectant: Agents capable of eliminating viable biological agents on surfaces or in liquid waste. These will have varying effectiveness depending on the properties of the chemical, its concentration, shelf life and contact time with the agent.
Disinfection: A process to eliminate viable biological agents from items or surfaces for further safe handling or use.
Engineering controls: Risk control measures that are built into the design of a laboratory or laboratory equipment to contain the hazards. Biological safety cabinets (BSCs) and isolators are forms of

engineering control in order to minimize the risk of exposure to and/or unintended release of biological agents.

Exposure: An event during which an individual comes in contact with, or is in close proximity to, biological agents with the potential for infection or harm to occur. Routes of exposure can include inhalation, ingestion, percutaneous injury and absorption and are usually dependent upon the characteristics of the biological agent. However, some infection routes are specific to the laboratory environment and are not commonly seen in the general community.

Good microbiological practice and procedure (GMPP): A basic laboratory code of practice applicable to all types of laboratory activities with biological agents, including general behaviors and aseptic techniques that should always be observed in the laboratory. This code serves to protect laboratory personnel and the community from infection, prevent contamination of the environment, and provide protection for the work materials in use.

Hazard: An object or situation that has the potential to cause adverse effects when an organism, system or (sub)population is exposed to it. In the case of laboratory biosafety, the hazard is defined as biological agents which have the potential to cause adverse effects to personnel and/or humans, animals, and the wider community and environment. A hazard does not become a risk until the likelihood and consequences of that hazard causing harm are taken into account.

Heightened control measures: A set of risk control measures as described in the WHO Laboratory biosafety manual that may need to be applied in a laboratory facility because the outcome of a risk assessment indicates that the biological agents being handled and/or the activities to be performed with them are associated with a risk that cannot be brought below the risk tolerance level with the core requirements only.

Incident: An occurrence that has the potential to, or results in, the exposure of laboratory personnel to biological agents and/or their release into the environment that may or may not lead to actual harm.

Infectious dose: The amount of biological agent required to cause an infection in the host, measured in number of organisms. Often defined as the ID50, the dose that will cause infection in 50% of those exposed.

Initial risk: Risk associated with laboratory activities or procedures that are conducted in the absence of risk control measures. Laboratory-associated infection: Any infection acquired or reasonably assumed as a result of exposure to a biological agent in the course of laboratory-related activities. A person-to-person transmission following the incident may result in linked secondary cases. Laboratory-associated infections are also known as laboratory-acquired infections.

Likelihood (of a laboratory incident): The probability of an incident (that is exposure to and/or a release of a biological agent) occurring in the course of laboratory work.

Maximum containment measures: A set of highly detailed and stringent risk control measures described in the fourth edition of the WHO Laboratory biosafety manual that are considered necessary during laboratory work where a risk assessment indicates that the activities to be performed pose very high risks to laboratory personnel, the wider community and/or the environment, and therefore an extremely high level of protection must be provided. These are especially needed for certain types of work with biological agents that may have catastrophic consequences if an exposure or release were to occur.

Personal protective equipment (PPE): Equipment and/or clothing worn by personnel to provide a barrier against biological agents, thereby minimizing the likelihood of exposure. PPE includes, but is not limited to, laboratory coats, gowns, full-body suits, gloves, protective footwear, safety glasses, safety goggles, masks and respirators. Primary containment device: A contained workspace designed to provide protection to its operator, the laboratory environment and/or the work materials for activities where there is an aerosol hazard. Protection is achieved by segregation of the work from the main area of the laboratory and/or through the use of controlled, directional airflow mechanisms. Primary containment devices include biological safety cabinets (BSCs), isolators, local exhaust ventilators and ventilated working spaces.

Qualitative fit test: A pass/fail test method that relies on the sensory response of a person wearing a facepiece to detect a challenge chemical in order to assess the adequacy of the fit of the facepiece.

Quantitative fit factor: The numeric value of the fit of a particular tight-fitting facepiece to a specific individual.

Quantitative fit test: A test method that uses an instrument to assess (quantify) the amount of leakage of unfiltered external air into a facepiece through the face seal in order to assess the adequacy of its fit.

Risk: A combination of the likelihood of an incident occurring and the severity of the consequences (harm) if that incident were to occur.

Risk assessment: A systematic process of gathering information and evaluating the likelihood and consequences of exposure to or release of workplace hazard(s) and determining the appropriate risk control measures to reduce the risk to an acceptable risk.
Risk control measure: Use of a combination of tools, which include communication, assessment, training, and physical and operational controls, to reduce the risk of an incident/event to an acceptable risk. The risk assessment cycle will determine the strategy that should be used to control the risks and the specific types of risk control measures required to achieve this.
Safety culture: A set of values, beliefs and patterns of behavior instilled and facilitated in an open and trusting atmosphere by individuals and organizations working together to support or enhance best practice for laboratory biosafety, irrespective of whether it is stipulated in applicable codes of practice and/or regulations.
Sharps: Any device or object that is a puncture or wound hazard because of its pointed ends or edges. In the laboratory, sharps can include needles, syringes with attached needles, blades, scalpels or broken glass.
Soap: A water soluble cleaning compound used for cleaning skin and other materials. Note, soap does not necessarily inactivate biological agents. Standard operating procedures (SOPs): A set of well-documented and validated stepwise instructions outlining how to perform laboratory practices and procedures in a safe, timely and reliable manner, in line with institutional policies, best practice and applicable national or international regulations.
Tight-fitting respiratory facepiece: A respiratory facepiece that forms a protective barrier between the wearer's respiratory tract and the ambient atmosphere by forming a seal with the wearer's skin.
Transmission: The transfer of biological agent(s) from objects to living things, or between living things, either directly or indirectly, for example, via aerosols, droplets, body fluids, vectors, food/water or other contaminated objects.
Validation: Systematic and documented confirmation that the specified requirements are adequate to ensure the intended outcome or results. For example, in order to prove a material is decontaminated, laboratory personnel must validate the robustness of the decontamination method by measurement of the remaining biological agents against the detection limit [3].

DISCUSSION

Managing risk using PPE, as part of your risk assessment you should decide whether PPE is needed. Use the hierarchy of controls to make this decision.
Hierarchy of controls: PPE should be the last resort to protect against risks. Consider controls in the following order, with elimination being the most effective and PPE being the least effective:

- Elimination – physically remove the hazard;
- Substitution – replace the hazard;
- Engineering controls – isolate people from the hazard;
- Administrative controls – change the way people work;
- PPE – protect the worker with equipment

When your risk assessment shows you should provide PPE, you need to make sure you choose the right type to protect different parts of the body. This page explains how you can do that.
Hazards to the eyes include chemical or metal splash, dust, projectiles, gas and vapor or radiation. PPE options include safety spectacles, goggles, face screens, face shields and visors. Make sure the PPE you choose has the right combination of eye protection against various hazards of impact, dust, splash or molten metal. It should also be appropriate for the task and fit the user properly.
Hazards to the head and neck include falling or flying objects, risk of banging the head, hair getting tangled in machinery, chemical drips or splash, climate or extreme temperatures. PPE options include safety helmets, bump caps and hairnets. Some safety helmets incorporate or can be fitted with specially designed eye or hearing protection. Don't forget neck protection, for example, during welding. Always replace head protection if it is damaged.
Hazards to the ears from noise come from a combination of sound level and duration of exposure. Very high-level sounds are a hazard even with short duration. PPE options include earplugs, earmuffs or semi-insert/canal caps. Provide the right hearing protectors for the type of work, and make sure workers know how to fit them. Choose protectors that reduce noise to an acceptable level, while allowing for safety and communication.

Hazards to the hands and arms include abrasion, temperature, cuts, impact, chemicals, electric shock, radiation, biological agents or prolonged immersion in water. PPE options are gloves (including gloves with a cuff), gauntlets and sleeving that covers part or all of the arm. Avoid gloves when operating machines such as bench drills where they might get caught. Barrier creams are not a substitute for proper PPE. Using separate cotton inner gloves can help prevent skin problems from wearing gloves for long periods. Choose gloves made from materials that are not quickly penetrated by chemicals. There is more guidance on skin at work.

Hazards to the feet and legs include temperature, electrostatic build-up, slipping, cuts, falling objects, heavy loads, metal and chemical splash or being struck by a vehicle. PPE options include penetration-resistant safety boots and shoes with protective toecaps or specific footwear, for example foundry boots and chainsaw boots. Select appropriate footwear for the risks. It can have a variety of sole patterns and materials to help prevent slips in different conditions, including oil or chemical-resistant soles. It can also be anti-static, electrically conductive or thermally insulating.

Hazards to the lungs include oxygen-deficient atmospheres, dusts, gases or vapors. Respiratory protective equipment (RPE) options include respirators which rely on filtering contaminants from workplace air. These can be simple filtering facepieces and respirators or power-assisted respirators. Some RPE may be face fitted. Some types of RPE give an independent supply of breathable air, for example fresh-air hose, compressed airline and self-contained breathing apparatus. There is detailed guidance on RPE, including how to make sure it fits properly.

Hazards to the whole body include heat, chemical or metal splash, spray from pressure leaks or spray guns, contaminated dust, impact or penetration. PPE options include safety harnesses, life jackets, conventional or disposable overalls, boiler suits, aprons and chemical suits. Where it is needed, choose material that is flame-retardant, anti-static, chain mail, chemically impermeable or high-visibility.

Careful selection and maintenance and regular operator training is needed for equipment to use in emergencies, like compressed-air escape breathing apparatus, respirators and safety ropes or harnesses [4].

Personal Protective Equipment (PPE) and Safety Equipment Hazards There may be hazards that require specialized PPE in addition to safety glasses, laboratory gowns, and gloves. For example, a procedure that presents a splash hazard may require the use of a mask and a face shield to provide adequate protection. Inadequate training in the proper use of PPE may reduce its effectiveness, provide a false sense of security, and could increase the risk to the laboratory worker. For example, a respirator worn incorrectly may impart a risk to the wearer independent of the agents being manipulated. Safety equipment such as biological safety cabinets (BSCs), centrifuge safety cups, and sealed rotors are used to provide a high degree of protection for the laboratory worker from exposure to microbial aerosols and droplets. Safety equipment that is not working properly is hazardous, especially when the user is unaware of the malfunction. Poor location, room air currents, decreased airflow, leaking filters, raised sashes, crowded work surfaces, and poor user technique compromise the containment capability of a BSC. The safety characteristics of modern centrifuges are only effective if the equipment is operated properly [5].

CONCLUSION

PPE unused was related to organizational and individual level factors such as PPE unavailability, workplace disharmony, low perception of susceptibility, and belief of PPE interference with work performance. Improving institutional supplies in quantity and quality may, therefore, have a positive implication for the improvement of prevention practices. Also, designing sustainable strategies and raising workers’ awareness of a safe work environment may lead to the improvement of PPE use. Workers, on their part, are expected to demonstrate personal responsibility for observing PPE protocol as needed at the workplace. It is great first step in understanding the selection and use of PPE. It's not where you stop. If you're in a situation that requires PPE, you need to do more. Understand the hazards. Read and understand any safety data sheets that might exist for the specific product you'll be using or exposed to. Research your PPE. Read the instructions to understand how to use it, what it will protect you against, and what its limitations might be. PPE is crucial in minimizing the adverse effects of biochemical hazards on human health. While it cannot completely eliminate the risk of exposure, it can significantly reduce the risk. Workers should be educated of the importance of using appropriate PPE during all stages of handling. By using appropriate PPE, the health expenses of workers can be reduced.

National authorities must provide up-to-date and easy-to-understand information to workers on the safe use of chemical hazards and PPE.

The purpose of PPE is to minimize an employee’s exposure to chemical, physical, radiological, electrical and mechanical hazards on the job. Depending of the hazards, PPE may include gloves, ear plugs, masks, respirators, safety glasses, or reflective vests. An employer’s failure to provide employees with proper PPE can result in injury, illness, or even death. The injuries that can result from lack of proper PPE range from mild scrapes to amputations and even fatalities. Workers in manufacturing or construction can suffer from hearing loss without earplugs or ear muffs, without protective gloves, workers can suffer lacerations to the hands and fingers. Head injuries can occur due to a lack of hardhat protection. Lack of protective footwear, such as steel toe boots, can result in crushing injuries to the feet and toes. PPE includes overalls, aprons, footwear, gloves, chemical resistant glasses, face shields and respirators.
For some high risk activities, such as spray painting, abrasive blasting and some emergency response actions, PPE should always be used to supplement higher level control measures.
The effectiveness of PPE relies heavily on workers following instructions and procedures correctly. If PPE must be used for long periods, if dexterity and clear vision are needed for the task, or if workers have not been adequately trained on how to fit and use PPE properly, workers might avoid using it.

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POLITICAL AND LEGAL CONSEQUENCES OF ECOLOGICAL MIGRATION WITH SPECIAL REFERENCE TO CHEMICAL, BIOLOGICAL AND RADIOLOGICAL RISKS

Abstract
Man has always been exposed to the power of nature, both in terms of the wealth it provides and the disasters it causes. Environmental changes were the cause of forced population migration long before they became the subject of scientific study and research. Nowadays, environmental disasters can also be caused by the human factor. On all continents of the world, millions of inhabitants are migrating due to floods, droughts, earthquakes, soil erosion, sea level rise and other environmental disasters. Modern migratory movements increasingly cause chemical, biological and radiological risks. The ideal to be aspired to is the formation of international institutions with the instruments that will enable them to implement the policy of protecting ecological migrants. International regulations on the protection of ecological migrants play a significant role in this issue.

Key words: ecological migrants, ecological disasters, legal status, migration policy.

INTRODUCTION

For decades the environment has been studied from the perspective of various sciences that address environmental protection and improvement. Among other things, it is studied how natural disasters affect political and social aspects of society as well as societal security. Natural disasters, such as earthquakes, floods, droughts, tornadoes and hurricanes, have always affected people's lives, inflicted a large number of casualties and were the main drivers of migration. Observing the history of the mankind, environmental changes and natural disasters have caused unfavorable conditions for growing food, led to a shortage of drinking water and prevented people from living in such areas. It is generally agreed that natural disasters were one of the main reasons why the earliest civilizations disappeared.

In the last couple of decades, the number of deaths caused by natural disasters has ranged from 10,000 to 20,000. This trend does not mean that disasters have become less frequent or less intense, but that the world is nowadays preventing deaths due to disasters much more successfully than in the past. There has been a significant reduction in deaths due to better and timely forecasts, more resilient infrastructure, emergency preparedness and response systems. This will become increasingly important in our response and adaptation to environmental changes, particularly climate change [1].

Even though the system of environmental protection against environmental disasters has been improved, the number of inhabitants who are forced to leave their place of residence due to the consequences of environmental disasters is increasing. Due to the destructive effect of these phenomena on the environment and material goods, people are left without the possibility of survival in such areas. Those effects vary from the major damage to residential buildings and healthcare facilities, to the reduction of the quality of water, air and soil, which represent the basic prerequisites for a normal and healthy life. Considering great costs of further protection and rehabilitation of the area and considerable time required to restore the same habitat to its original state, the population often decides to migrate.

In this paper, the causes of environmental disasters, especially chemical, biological and radiological risks, will be investigated using the method of content analysis. Also, the subject of interest will be the consequences of environmental disasters on the population in terms of migration trends and legal and political effects on this category of migrants.

ECOLOGICAL DISASTERS AND THEIR CAUSES

People's attitude towards the environment, which has been more destructive than constructive for decades, has led to a series of global, regional and local environmental problems. These environmental problems often culminated in the emergence of environmental crises and disasters [2].
A disaster is a fatal event that results in the loss of human life, destruction of the natural environment with plant and animal life, and great material losses. The consequences of disasters can be seen in the damage to housing and infrastructural facilities, health institutions, lack of water, food, health services, serious injuries, diseases, deaths and population migrations [3].
The main feature for distinguishing ecological disasters from other problems is its inability to return to the original state [4]. Observing the history of the planet, there have often been situations that pose a danger and leave great consequences for the ecological system, habitats and functioning of the living world, as well as for material goods. These catastrophic events can be caused either by natural processes or human (anthropogenic) factors. This is also the main classification of all disasters, according to the manner of occurrence.
Natural hazards that can lead to disasters include: geophysical hazards (earthquakes, landslides, landfalls, volcanic eruptions), atmospheric hazards (intense precipitation, extreme temperatures, storms, frost, fog, drought); hydrospheric hazards (floods, tsunamis, avalanches) and biospheric hazards (epidemics, forest fires) [5].
Anthropological hazards that can lead to disasters primarily include various technical and technological accidents and hazards such as chemical accidents, accidents with ionizing radiation, nuclear incidents, fires, and the like [5].

The causes of ecological disasters can be natural phenomena, technical problems or accidents, harmful emissions from industrial enterprises, gradual accumulation of harmful elements due to human behavior and active removal of natural conditions of the environment, oil spills, use of biological and nuclear weapons [4]. Chemical, biological and radiological risks can also lead to ecological disasters.
In the matter of chemical risks for the environment, it should be taken into consideration that there is almost no human activity where a person has no contact with several chemical substances that, under certain conditions, can be harmful to human health. New substances which damage the environment are constantly being produced, transformed and redistributed. Chemical substances are synthesized in laboratories and each of them can, at a certain moment, reach the environment. The danger to health arising from substances that pollute the environment depends on the chemical properties, the way they are used, as well as the emitted quantities. Unexpected effects occur due to the lack of knowledge about their reaction in the body, method of their decomposition, accumulation, etc. Although the number of chemical substances is constantly increasing, the exposure of people is usually limited to a smaller number of those substances that are largely used [6].
Also, there is a high number of biological risks as well. The most common modifiable biological risk factors for health in the environment are risks associated with the place of residence and workplace and socio-economic factors. Risks associated with the place of residence and workplace can be inadequate water supply, inadequate disposal of solid and liquid waste, unsanitary living conditions, noise, air pollution, specific workplace risks, etc. Socio-economic factors are illiteracy, lack of higher education, unemployment, lack of personal property, poverty, single parenthood, rural and peri-urban population, etc.

Regarding radiological risks, the main sources of danger from radioactive substances are nuclear power plants, uranium enrichment facilities, facilities for the processing and treatment of nuclear fuel and their storage, research reactors, etc. In the event of a nuclear accident, radioactive substances may be released into environment. When released into the atmosphere, air masses can transport radioactive substances at a distance of more than 1000km from the accident site. The distance from the accident site depends on meteorological conditions and the topography of the land and radioactive substances are deposited in the form of dry or wet deposition. In the contaminated area, people and animals are exposed to ionizing radiation directly (external radiation) or by ingesting radionuclides into the body through food, water and inhalation. Radiation accidents are possible during the transport of sources of ionizing radiation, their use in industry, medicine or in research activities. In the Republic of Serbia, accidents are possible at nuclear facilities (the storage of radioactive waste and the zero-power nuclear reactor at the Institute of Nuclear Sciences "Vinča"). Also, radiological accidents can occur during the use of radioactive sources in industry and medicine for research purposes or when the radioactive source is out of control (stolen, lost, found, etc.), during transportation [6].

ECOLOGICAL MIGRATIONS AND ECOLOGICAL MIGRANTS

The concept of migration, initially borrowed from the domain of biology, is being increasingly used to describe all forms of spatial movement of people. Migration is the movement of people from one place to another for the purpose of finding permanent or temporary residence, usually across political borders [7].
Migration movements can have many different causes. Political reasons for migration can be the abolition of liberal rights in totalitarian systems, wars, etc. Socio-cultural factors are ethnic nationalism and cultural conflicts, religious fundamentalism, etc. Environmental factors are also a significant motive for residential migration. Moreover, the first theories defining migration also took into consideration ecological conditions as one of the main factors causing the displacement of residents. All elements of the environment affect the possibility and quality of life in a certain area. As technological development was at a much lower level in the past, the environment was not polluted to the extent it is today. Therefore, people migrated when there were major floods, droughts or some natural causes of disasters (storms, earthquakes, volcanoes). With technical and technological progress, the impact of ecological disasters on humans has been reduced. However, anthropogenic causes of population migration have increased.

Depending on the cause of ecological migrations, policies and responses to challenges related to this type of migration are formed [8]. Ecological migrations are often conditioned by climate change, but not necessarily. On the contrary, if environmental conditions are the key factors explaining the patterns of historical population settlements, it is likely that land degradation, ecosystem disruption and resource depletion caused by climate change are the cause of changing migration patterns [9].
The definition of ecological migrants has been a long-standing debate among international human rights experts. Also, the question of distinguishing ecological migrants from ecological refugees is present.
In practice, the international community resists any expansion of the definition of "refugee". Developed countries are reluctant to accept the term as it would force them to offer them the same protection that political refugees enjoy, which no country has yet been willing to do. The international institutions that are currently in charge of taking care of refugees, primarily the UN Refugee Agency, are already overburdened and unable to deal with the current number of refugees. The UNHCR itself takes on an expanded role in managing the care of internally displaced persons, and hence the resistance to any further expansion of its mandate [10]. Although the terms "ecological refugee" or "climate refugee" are not a perfect choice, they are still in use partly for the lack of a better alternative. "Climate evacuation" involves temporary relocation within national borders (as in the case of hurricane Katrina). "Migrant climate" implies a "pull" of the destination, rather than a "push" of the source of the problem [10].
Considering the difference between the terms refugee and migrant, refugees are resettled due to the threat of persecution because they lack protection in their own country. On the other hand, migrants may leave their country for many reasons unrelated to persecution, such as employment, family reunification or study. Migrants still enjoy the protection of their own government, even when resettled [11]. A person can no longer be a refugee when the basis for their refugee status ceases to exist (e.g. when refugees voluntarily return to their home countries when the situation allows it). Refugee status can also be lost when refugees integrate or become naturalized in their host countries and stay there permanently [11].

Refugees and migrants have the same universal human rights and fundamental freedoms that are to be respected, protected and fulfilled at all times. However, migrants and refugees are groups governed by different legal frameworks. Refugees have the right to specific international protection under the International Refugee Law [12]. Migrants are subject to different legal treatment, because the basis of their relocation is voluntary, but still unavoidable.

LEGAL AND POLITICAL CONSEQUENCES OF ECOLOGICAL MIGRATIONS

With regard to international documents on the rights of migrants, the Universal Declaration of Human Rights adopted by the United Nations in 1948 is considered a basic document [13]. It contains three articles concerning migration. Thus, everyone has the right to leave any country, including their own, and to return to it. Everyone has the right to seek and enjoy asylum from persecution in other countries. Everyone has the right to a nationality. No one can be deprived of their nationality or denied the right to change their nationality.

Another significant international document in the field of migration adopted by the United Nations is the International Covenant on Civil and Political Rights [14], which provides for freedom of movement within one's country and the right to enter one's country, as well as the protection of minorities.

The Council of Europe has also adopted certain documents related to asylum and freedom of movement, such as the European Convention on Human Rights [15]. The Additional Protocol to the European Convention on Human Rights prohibits the collective expulsion of foreigners. The Framework Convention for the Protection of National Minorities (Council of Europe) is also important for the issue of migration [15].

In the Republic of Serbia, the law that regulates migrant issues is the Law on Migration Management [16]. According to the Law, migration is voluntary or forced leaving of the country of origin or residence for the purpose of temporary or permanent residence in the Republic of Serbia and voluntary or forced leaving of the Republic of Serbia for the purpose of temporary or permanent residence in another country (external migration), as well as a change of the place of permanent residence within the territory of the Republic of Serbia, or a change of the place of temporary residence within the territory of the Republic of Serbia if the change occurred forcibly (internal migration). Based on this definition, it can be concluded that environmental reasons can create migrants. Immigration represents external migration to the Republic of Serbia that lasts or is expected to last longer than 12 months. Emigration is external migration from the Republic of Serbia that lasts or is expected to last longer than 12 months.

This law regulates migration management, principles, authority responsible for migration management and a unique system of data collection and exchange in the field of migration management. The principles of migration management are also established. The principle of respect for family unity implies that measures in the field of migration management are proposed and implemented so as to preserve family unity, in accordance with confirmed international treaties and law. The principle of prohibition of artificial changing of the ethnic composition of the population implies that measures in the field of migration management are implemented so as to preserve the ethnic composition of the population in areas where members of national minorities live traditionally and in large numbers. The principle of balanced and planned economic development through migration management implies that migration management is carried out in such a way as to contribute to the balanced and planned economic development of the Republic of Serbia, taking into consideration strategies and policies of economic development and economic relations with foreign countries, measures of the active employment policy, population policy and policies in the field of science and education, with strengthening relations with the Diaspora, and the integration of persons who have been granted the right to asylum and the reintegration of returnees based on the readmission agreement. The principle of strengthening relations with the Diaspora and Serbs in the region is also applied to migration issues, which implies that migration management is achieved by improving the position and protecting the rights and interests of members of the Diaspora and Serbs in the region, preserving, strengthening and establishing relations of the Diaspora and Serbs in the region with the Republic of Serbia. The principle of the protection of rights means that migration management is based on the protection of the rights of persons in the process of migration, while respecting, to the greatest extent possible, their specific needs and interests, in accordance with the capabilities of the Republic of Serbia. The principle of compliance with ratified international treaties and generally accepted rules of international law in the field of migration means that migration management is carried out in compliance with ratified international treaties and generally accepted rules of international law in the field of migration [16].

The political consequences of ecological migration depend on the intensity of the residents' reaction to the deterioration of the quality of the environment. They involve a change in the policy itself by the government, the resignation of officials who are responsible for certain problems, a referendum, etc. Regarding the arrival of a large number of ecological migrants to a territory, greater pressure is created on existing resources in that area, which can lead to social unrest that turns into a conflict. The likelihood of conflict in such situations is increased by the presence of religious and national intolerance. As the climate change is becoming increasingly noticeable, it is assumed that weather-related problems will be more frequent and there is an evident increase in the number of inhabitants in the world. With this in mind, we can conclude that the consequence of these issues is a greater number of ecological refugees. The likelihood of conflict and development of the situation depend on the reaction of the authorities. Governments face serious problems. In order to reduce the potential danger of such conflicts, governments of the countries at which environmental refugees arrive have to insist on passing appropriate legislation aimed at preventing discrimination, establishing greater rights for minorities and creating conditions for the integration of these groups into the political events of the host country. The probability of the emergence of problems is reduced if they are provided with basic human rights, as well as the rights that conventional refugees have, such as the right to freedom of movement, the right to education, the right to acquire goods and employment.

The Republic of Serbia was affected by milder forms of internal migration due to environmental changes in certain areas. In the last few years, environmental protection has become a matter of interest. Even though increasing environmental pollution is one of the main current events, it is still not the cause of larger migratory movements.

CONCLUSION

Due to frequent forced migrations caused by environmental changes, the issue of the position of migrants has been raised. It is becoming an increasingly important issue, as is the need to regulate their position. There are different dimensions of this problem and its impact on international relations. Participants in international relations are various entities such as states, non-governmental organizations, international companies, international organizations and others.

In the existing literature, the need to accept environmental changes as a basis for recognizing the status of ecological migrants is relatively clearly elaborated. However, there are still many open questions that should be the subject of more detailed studies. As the problem of ecological migration is mainly international in nature and defined by several areas of international law (humanitarian law, the right to environmental protection, human rights, etc.), it is necessary to make a comprehensive analysis at the international level and adopt regulations that will result in a better status of ecological migrants, primarily within the framework of international law.

Bearing in mind all of the above, it can be concluded that an international consensus regarding definitions in the field of ecological migration should be reached. Political consequences can be different depending on each specific case. Due to the limited chances of employment elsewhere, many people are forced to stay in polluted environments. Those are the cases where population pressures authorities to introduce new technologies in order to reduce pollution.

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PREVENTION OF THE CONSEQUENCES OF AN ACCIDENTAL NEEDLESTICK

Abstract
An accidental needlestick is a very likely incident at a workplace in the health system but also an accident that can be very dangerous regarding serious consequences that it can have regarding worker's health. The authors study statistical data on the frequency of such incidents, analyze the possible consequences for the health of workers, define the protocols used to prevent harmful consequences, stress up the obligations of workers in the event of an incident, and the obliged actions of the employers. Surveying of the statistically most vulnerable group of health workers, it is shown to what extent the workers are familiar with the procedures in the event of an incident, whether they were previously exposed to it and whether they acted according to the provided protocols in such a case. Finally, the paper analyses the possibility of liability for the employer's damage, especially regarding actions that the injured worker is obliged to take.

Key words: protection at work, accidental needlestick, prevention, worker injury.

INTRODUCTION

Definition and frequency of needlestick incidents

European Council Directive 2010/32/EU (Directive 2010/32/EU) of 10 May 2010 which prescribes measures for protecting European healthcare workers from blood-borne infections due to needle-stick injuries was implemented in the Republic of Croatia in Zakon o zdravstvenoj zaštiti, "Narodne novine" br. 100/18, 125/19, 147/20, 119/22, 156/22, 33/23 (Health Care Law) and Pravilnik o načinu provođenja i mjerama zaštite radi sprječavanja nastanka ozljeda oštrim predmetima, “Narodne novine” br. 39/2020 (Ordinance).

Ordinance defines injury by a sharp object as an injury to a healthcare or non-healthcare worker that occurred while performing a professional activity inside or outside a healthcare institution or another healthcare employer, caused by a sharp object with potentially contaminated material (blood, fluids, tissues) that may contain pathogens or contact with the blood of an infected person or other bodily fluids and tissues of an infected person that may contain blood (Article 3 (1) ninth subparagraph).

The main interest of this work is typical needlestick injury, i.e. the penetration of the skin by a hollow needle that has been in contact with blood, tissue or other body fluids before the exposure. This kind of exposure, taking in regard the fact that such a needle has an amount of patients blood, tissue or body fluids, has the exceed possibility of transferring bacteria, protozoa, viruses and prions, but also blood-borne infections such as:

- the hepatitis B virus (HBV),
- hepatitis C virus (HCV), and
- human immunodeficiency virus (HIV).

Among healthcare workers and laboratory personnel worldwide, more than 25 blood-borne virus infections have been reported to have been caused by needlestick injuries. The World Health Organization estimated that in 2000, 66,000 hepatitis B, 16,000 hepatitis C, and 1,000 HIV infections were caused by needlestick injuries [1].

Needlestick injuries occur in the healthcare environment for example: when drawing blood, administering an intramuscular or intravenous drug or performing any procedure involving sharps, needle recapping or via improper disposal of devices into an overfilled or poorly located sharps container, surgical needle or another sharp instrument may inadvertently penetrate the glove and skin of operating room personnel…

Lack of access to appropriate personal protective equipment, or alternatively, employee failure to use provided equipment, increases the risk of occupational needlestick injuries [1].

Even though the acute physiological effects of a needlestick injury are generally negligible, these injuries can lead to the transmission of blood-borne diseases, which can have severe and long-lasting consequences on workers' health, which can cause expenses for treatment, benefits while using sickness absence from work, temporarily or even permanent transfer to an easier working position and salary reduction. Infected workers can suffer pain, reduced working ability or even reduced life activity. Also, the psychological effects of occupational needlestick injuries can include health anxiety, anxiety about disclosure or transmission to a sexual partner, trauma-related emotions, and depression. These effects can severely affect the quality of daily life. Some people affected by needlestick injuries may even have lasting psychological effects, including post-traumatic stress disorder.

From a judicial case Rev 2920/2018 (Croatian Supreme Court, November 26th, 2019) regarding a nurse who was working in s hospital haemodialysis department and had a needlestick injury from a needle used by a chronic haemodialysis patient who had hepatitis B the chronic hepatitis B which she got because of the incident cause various material and non-material liabilities arose. Liabilities were: non-material damage (fear, pain), the cost for enhanced nutrition, lost earnings and lost alimony and allowance for assistance and care of others. Although the needlestick injury occurred in 1994, the liability was lasting and will be lasting in the future because of severe and permanent damage to the health of the worker. The final decision of the Croatian Health Insurance Institute of March 28th, 2000, recognized a liver disease of the nurse as an occupational disease. The amounts are substantial and the person responsible is the employer, in this case, the hospital.

Obliged actions of the employers and obligations of workers in the event of an incident

Increasing recognition of the unique occupational hazard posed by needlestick injuries, as well as the development of efficacious interventions to minimize the largely preventable occupational risk, encouraged legislative regulation in the European Union and the Republic of Croatia.

Health Care Law in Article 23 prescribes health protection measures related to work and the working environment (specific health protection of workers) that must be provided by employers:
1. measures to prevent and detect occupational and work-related diseases, prevent injuries at work and provide appropriate first aid
2. measures to protect the health of workers who are exposed to dangers, hazards, and efforts dangerous to health at the workplace
3. health protection measures determined by the regulations governing protection at work
4. protective measures to prevent injuries from sharp objects for healthcare workers who directly provide healthcare as a profession and for non-healthcare workers who can be injured by sharp objects.

Measures from Article 23 (1) forth subparagraph are prescribed by the ordinance of the minister, with the previously obtained opinion of the Croatian Institute of Public Health and the competent chambers, and the Croatian Medical Association.

Ordinance was delivered on March 27th, 2020, effective from April 9th, 2020. In Article 3 (1) fourteenth to seventeenth subparagraph, the following terms are defined: pre-exposure protection, post-exposure, post-exposure prophylaxis, and special prevention measures.

<u>Pre-exposure protection</u> consists of measures taken to prevent injuries from sharp objects and exposure of a person to blood and other body fluids/tissues or encourage the formation of a specific protective level of antibodies or otherwise reduce the possibility of a blood-borne infection. It includes special

prevention measures and medical procedures for protection against blood-borne infections (vaccination), including the use of personal protective equipment and the use of the safest equipment and safe methods of disposal of sharp objects following the regulations governing the prevention and control of hospital-acquired infections and healthcare-related infections (Ordinance, Article 3 (1) fourteenth subparagraph).

Therefore, pre-exposure protection measures are most commonly vaccination, use of personal protective equipment, and safe methods of disposal of sharp objects, but also all other measures that prevent injury itself, exposal to blood and other body fluids/tissues or encourage the formation of antibodies (Ordinance, Article 3 (1) fifteenth subparagraph).

Post-exposure protection is a set of activities aimed at reducing the possibility of a blood-borne infection in an injured healthcare or non-healthcare worker after the exposure incident has already occurred.

Post-exposure prophylaxis is the short-term administration of medicine (vaccines, immunoglobulins, antimicrobials) to an injured worker to prevent the occurrence of infection or disease with blood-borne pathogens after an exposure incident (Ordinance, Article 3 (1), first subparagraph).

Post-exposure protection is a set of activities aimed at reducing the possibility of a blood-borne infection in an injured healthcare or non-healthcare worker after the exposure incident has already occurred [2].

Occupational exposure of a healthcare worker should be treated as a medical emergency to ensure a timely and valid post-exposure procedure. The overall post-exposure procedure and its effectiveness depend on the confirmation or exclusion of infection in the original patient, which is why it is important to carry out a clinical and epidemiological evaluation of the risk of HBV, HCV, and HIV infection as soon as possible, as well as serological testing of the original patient and the exposed healthcare worker. The results of serological tests should be obtained on the same day to reduce the uncertainty and stress of the healthcare worker, but also to avoid the unnecessary use of post-exposure prophylaxis (PEP) in persons who were exposed to the blood of a negative (uninfected) original patient. Testing of both the healthcare worker and the original patient should be voluntary, with prior informed consent. If the original patient is unavailable, unknown, or otherwise refuses to test, the further procedure is based on a careful risk assessment, and must always include immune prophylaxis of HBV infection in susceptible healthcare workers [3].

Special prevention measures are measures taken to prevent injuries and/or the transmission of infection when providing services and performing procedures directly related to healthcare, including the use of the safest equipment and personal protective equipment based on risk assessment and safe methods of disposal of sharp objects, in accordance a special regulation regulating the prevention and control of hospital infections, i.e. infections related to health care (Ordinance, Article 3 (1), seventeenth subparagraph).

Obligations of the employer

The employer is obliged to implement general and special rules of occupational safety following the special regulations regulating occupational safety, as well as the regulations governing the handling of biological agents at work, according to the principle that preventive measures are the most important in preventing the risk of injury from sharp objects and infections of exposed workers. (Ordinance, Article 5, paragraph 1).

The employer is obliged to inform and raise the awareness of all workers about the safe use of sharp objects as work equipment following a special regulation which regulate work in a safe manner. Informing and raising the awareness of workers refers, in particular, to get to know the risks and methods of protection when working with sharp objects, getting to know the legislation, promoting good practices in terms of elimination, prevention, protection, and recording of injuries caused by sharp objects, ensuring the application of standard operating procedures and educational and informational materials, determined by the employer in cooperation with workers' representatives and occupational safety experts, to raise the level of awareness of the risks and methods of protection at work with sharp objects, providing information on pre-exposure protection and post-exposure protection measures in case of injury by a sharp object. (Ordinance, Article 6, paragraphs 1, 2)

Obligations of workers

Every worker is obliged to take care of his or her safety and health as well as the safety and health of persons affected by his actions at the workplace, following his or her qualifications and complying with the employer's instructions and notifications and the measures of special regulations regulating occupational safety and the prevention and suppression of hospital infections, i.e. infections related to health care. Workers are obliged to immediately report any injury with a sharp object to the employer and/or the responsible person and/or the person in charge of occupational safety, in the manner prescribed by the employer's standard procedure for reporting injuries with a sharp object to the nosocomial infection committee/employer's committee. (Ordinance, Article 7, paragraphs 1, 2).

Joint obligations of employers, workers, and workers' representatives

The joint obligation of employers, workers, occupational safety experts, occupational safety commissioners, and workers' representatives in the management body is to implement effective measures and raise awareness of the risks of working with sharp objects. The employer, workers, and workers' representatives must establish cooperation in the creation of strategies and standard operating procedures for occupational safety, in the implementation of occupational safety in practice to prevent and eliminate risks, protecting the health and safety of workers, and creating a safe working environment, which includes consulting on risks, selection and use of safety equipment, and determining the best ways to implement training, information and awareness-raising procedures on safe work. (Ordinance, Article 9, paragraphs 1, 2, 3).

Protocols used to prevent harmful consequences

As an example Protocol for a stabbing incident from Mercur Clinical Hospital, 2017 [4] was taken, and it stresses the importance of early treatment. The measures prescribed can be divided to:

1) Immediate treatment of the place exposed to infection which consists of the following instructions: allow the injection site to bleed for a few seconds, wash the exposed area with soap and water, disinfect with disinfectant for skin and mucous membranes, wipe the injured area with a disposable paper towel and cover it with a waterproof patch, rinse mucous membranes, eyes, mouth abundantly with saline solution or water

2) Notification of the employer (the head nurse/department technician, the Hospital Infection Control Team, and in their absence, notification of the Central Sterilization Team), contacting the competent epidemiological service, reporting every stabbing incident to the Croatian Institute for Health Insurance.

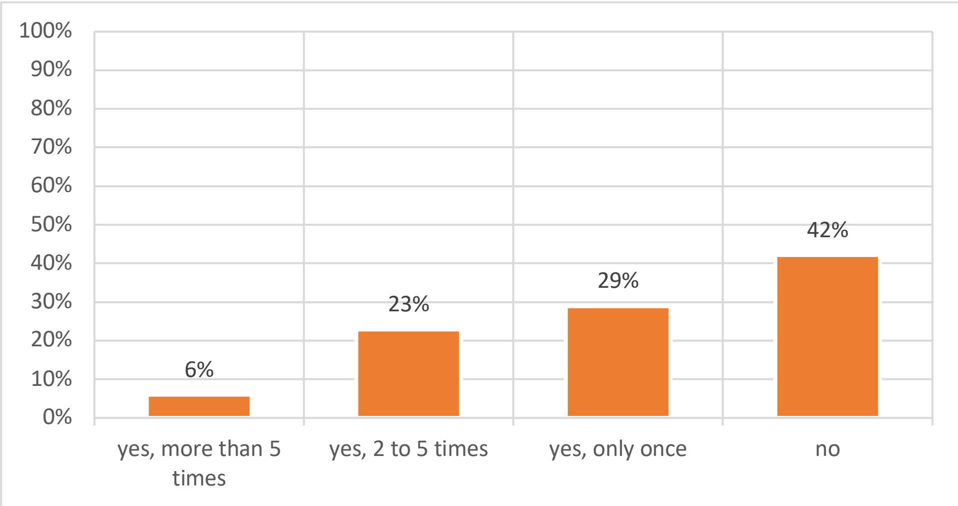
METHODS

The survey was conducted in the period from March 24, 2023 to April 2, 2023. The aim of this study is to assess and discuss the perceptions of the healthcare workers about needlestick injuries in healthcare institutions in Karlovac County and to evaluate the incidence and causes of needlestick injuries. The survey included 17 questions which can be classified into several categories. First category of questions (1 to 3) included general information about responders (gender, age, years of employment). Second category (4 to 7) were questions about needlestick injury and workplace where the injury occurred. Third category (8 to 15) were questions related to the analysis of the incident. The fourth category (16 to 17) consisted of questions related to information about protocols as well as education related to needlestick injury.

RESULTS

In the survey participated 83 healthcare workers from Karlovac County, of which 46 were females (55%) and 37 were males (45%). Most of the responders (45%) are up to 35 years old and most of responders have up to 5 years of employment in healthcare institutions (25%). According to Figure 1, 42% of the responders answered that they had never experienced a needlestick injury while working in healthcare institutions. It turns out that the majority of respondents (58%) experienced a needlestick incident at least once, with half of the responders repeating such an incident at least once more.

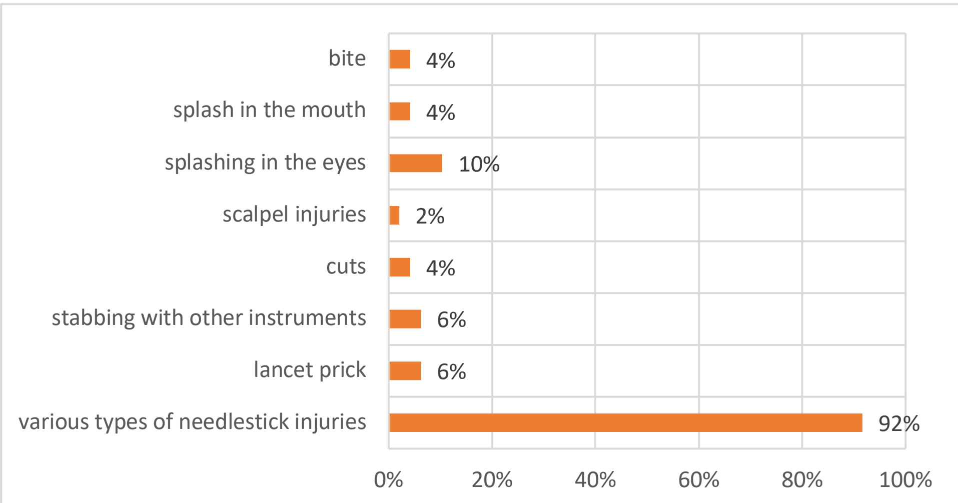
Figure 1. Distribution of responses to the question of whether workers had a stabbing injury while working in healthcare institutions



Source: own source

The majority of responders which experienced a needlestick injury, at least once or more times, were employed in a hospital at the time of injury (54%) and 35% of them worked in the department of internal medicine and 27% in a medical-biochemical laboratory. Also, 65% of responders were employed as nurses/ medical technicians. As shown in Figure 2, needlestick injuries occurred in the largest number of responders (92%).

Figure 2. Distribution of the type of injury that occurred to the responders (multiple answers possible)



Source: own source

According to the distribution shown in Figure 3, a large number of responders (46%) do not report a needlestick incident. From the distribution in Figure 4, it can be seen that 96% of responders report a stab wound to their employer.

Figure 3. Distribution of responses on the question of reporting a needlestick injury

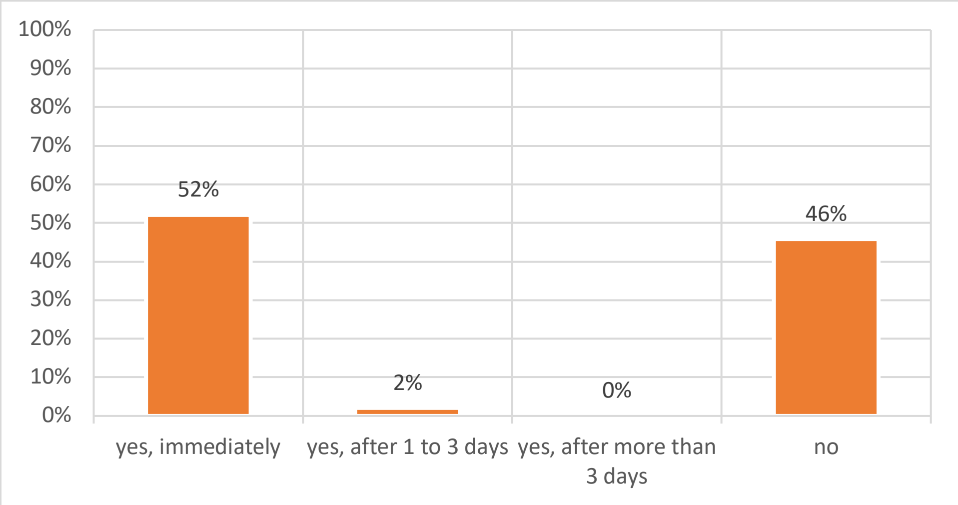


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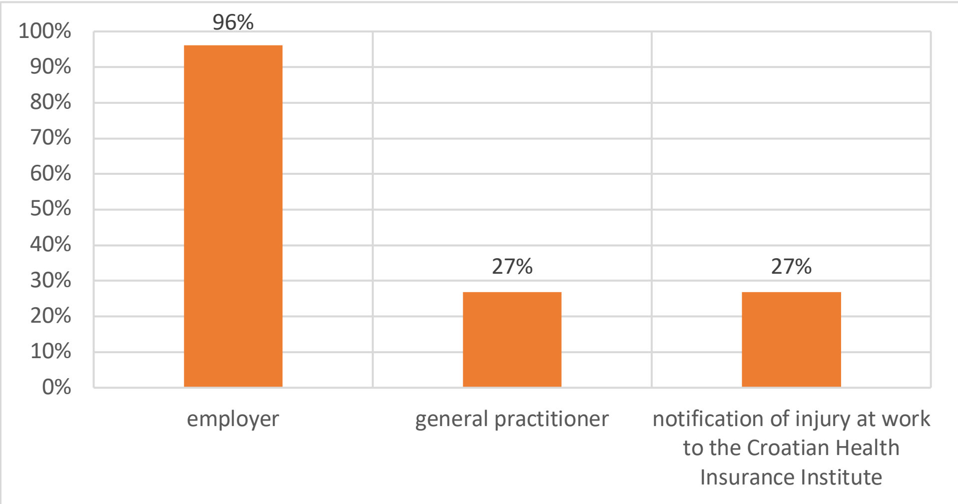
Figure 4. Presentation of the distribution of answers to the question to whom they report a needlestick injury



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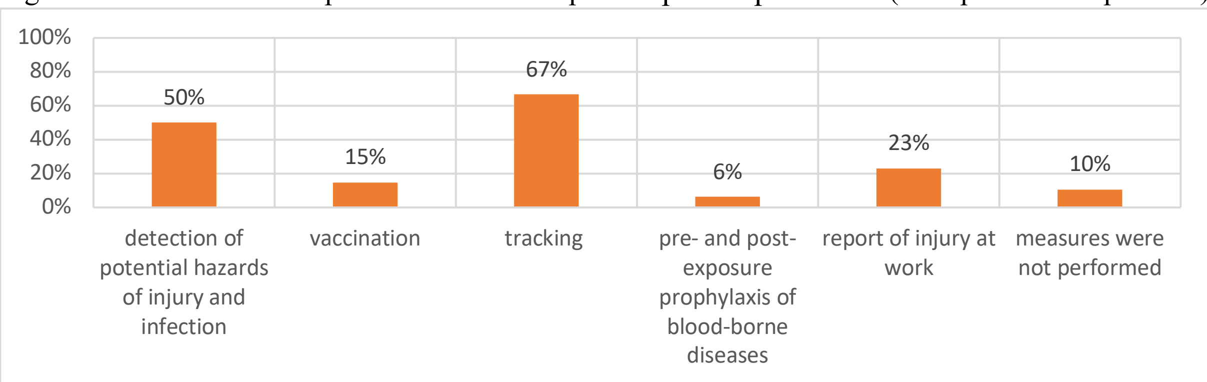
The majority of the responders (60%) believe that the injury was caused by fatigue, inattention, lack of time, and haste, while a large number of them (33%) also believe that the cause was improper handling with waste and improper disposal of waste. Most of the responders used personal protective equipment at the time of the injury. All responders used protective gloves, while 25% of them also used a face mask. In Figure 5, it is possible to see how follow-up measures (67%) and detection of potential risks of injury and infection (50%) were implemented after the needlestick incident.

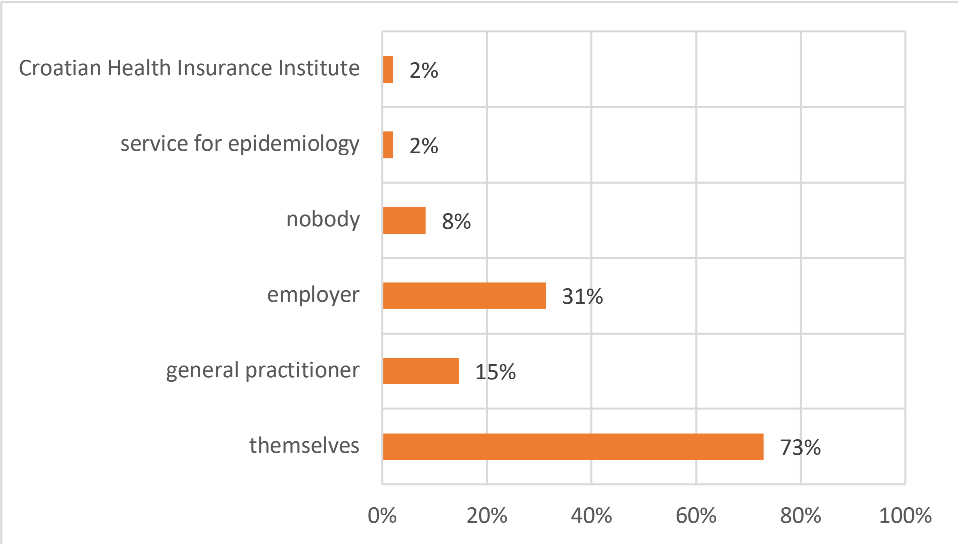
Figure 5. Distribution of responses related to the post-exposure procedure (multiple answers possible)



Source: own source

Figure 6 shows the insufficient role of the employer, as 31% of the responders answered that the employer implemented measures regarding the needlestick incident, but the majority of the workers implemented the measures themselves (73%).

Figure 6. Presentation of the distribution of responses related to the question, who implemented measures regarding the stabbing incident/incidents that occurred (multiple answers possible)



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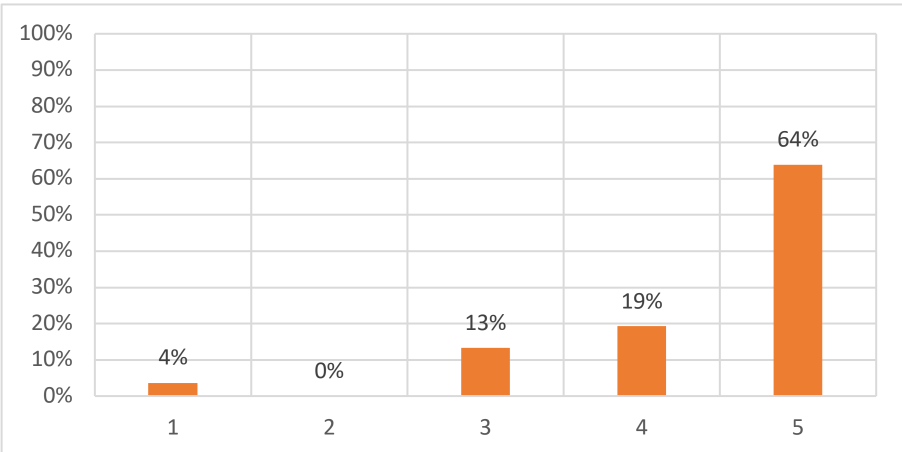
Regarding the responders' own assessment of how familiar they are with the personal protective equipment that they should use according to the risk assessment (Figure 7), the majority of responders (64%) believe that they know which protective equipment they should use.

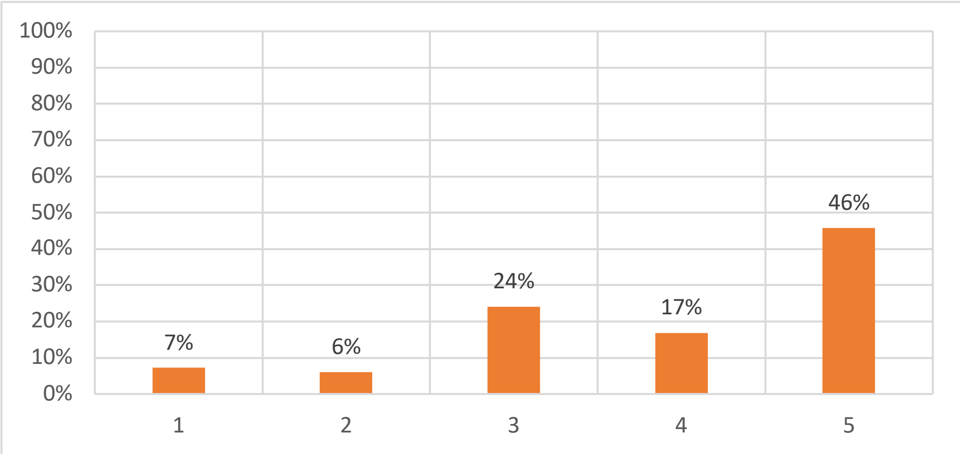
Figure 7. Presentation of the responders' assessment of how familiar they are with the personal protective equipment that they should use according to the risk assessment



Source: own source

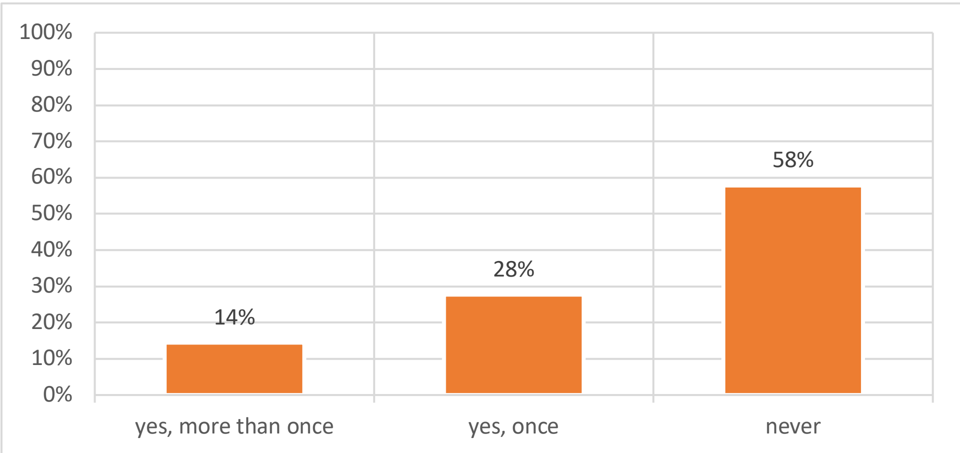
According to Figure 8, the majority of responders (46%) believe that they know the protocol about handling in the event of a needlestick incident well, but as shown in Figure 9, 58% of the responders have never attended education related to the prevention and the post-exposure procedures of needlestick incidents.

Figure 8. Distribution of responders' answers about how familiar are with the protocol in the event of a needlestick incident



Source: own source

Figure 9. Distribution of responders' answers to the question related to education on prevention and treatment of needlestick incidents



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DISCUSSION

Even though the acute physiological effects of a needlestick injury are generally negligible, these injuries can lead to the transmission of blood-borne diseases, placing those exposed at increased risk of infection from disease-causing pathogens. Generally, needlestick injuries cause only minor visible trauma or bleeding; however, even in the absence of bleeding the risk of viral infection remains. On the website of the Croatian Institute Of Public Health - Department Of Occupational Health, there is a warning that the employer must notify the Occupational Health Service of the Health and Human Services about every injury caused by a sharp object by filling out the Annex I form and sending it within one month at the latest. Also, the employer is warned that the employer is obliged to have in his records the completed forms from Annex I and Annex II of this rulebook.

In 2005, the WHO published a document on the problem of blood-borne infections in health workers after occupational injuries. According to this estimate, the incidence of injuries by sharp objects among healthcare workers in the Republic of Croatia (RO) is 0.64 incidents per healthcare worker per year. The assumption is that 32,000 stabbing incidents occur annually in the Republic of Croatia, most of which remain unreported [5]. Needlestick incidents are mostly not reported due to a lack of knowledge of the procedure, how, and to whom to report [4].

The data from the research indicates that the fact that many injuries were not reported, which means that prescribed post-exposure measures were not applied and also that the reporting obligation was not conducted

The reason for such non-reporting of incidents could be that the previously exposed measures related to education and information were not applied. The survey has shown that out of 16 persons who answered that they had 2-5 or more than 5 needlestick incidents but didn't report it, 9 of them never went to education, 3 once, and 4 more than once.

According to the Ordinance on the method of implementation and protective measures to prevent injuries from sharp objects (Official Gazette 39/2020), in case of worker injury by a sharp object, the employer is obliged to immediately take prescribed standard operating procedures for the prevention and control of hospital infections, i.e. infections related to health care, and to ensure health care for the injured worker, including the provision of post-exposure prophylaxis, necessary medical tests and serological tests, and health surveillance for further monitoring of the injured worker's health, with the aim of the highest possible level of worker health protection. Also, according to the Ordinance, the employer is obliged to determine the causes and circumstances under which the injury occurred, record all exposure incidents and take the necessary measures, and inform the Croatian Institute of Public Health about any injury with a sharp object within one month from the date of the exposure incident, and the competent of the insurer in accordance with the regulation governing rights and obligations from mandatory health insurance in case of work-related injury and occupational disease.

Therefore, the results of the survey (Figure 6) indicate an insufficient role of the employer, as 31% of the responders answered that the employer implemented measures regarding the stabbing incident. In addition, the survey certainly determined a large percentage of respondents who were not educated about the prevention and procedures for stabbing incidents (Figure 8, Figure 9). On the other hand, the results (Figure 7) showed that healthcare workers are familiar with personal protective equipment that they should use according to the risk assessment.

CONCLUSION

Needlestick injuries are very common among healthcare workers and also represent one of the most serious occupational hazards for healthcare workers. Because of that, it is important that workers are aware of many preventive measures and safe handling. If an injury occurs, it is necessary to promptly report the incident and seek appropriate care. Health workers probably neglect the seriousness of such incidents and all the consequences that can become regarding their health.

It is obligatory, according to the existing legal framework, to report all needlestick incidents, even those that became from needles that previously weren't used. So it is very important to make clear to the employers that possible legal consequences and liabilities are very large and to emphasize to the workers that danger to their health and severe health damages are possible, as well as that post-exposure measures can reduce this possibility, if post-exposure measures are administered short period of time after the incident.

Needle stick incidents must be reported and treated as a medical emergency. Therefore, it is important to additionally inform and raise awareness of employers and all workers to apply the prescribed legal procedures for reporting and carring pre- and post-exposure protection measures.

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Dragan Hristovski

THE ROLE OF EMPLOYEES DURING WORK WITH CHEMICAL AND BIOLOGICAL MATERIALS

Abstract
List all chemical and biological substances that may be hazardous to workers. This includes hazardous substances used, handled, stored, produced or disposed of during work processes and any other substances workers may be exposed to. Keep the list up to date. Assess the risk from exposure to these chemical and biological substances. Sources of information include Material Safety Data Sheets (MSDS). The employer must develop and implement a system to obtain and update the required hazard information (SDSs and labels) and use it to establish safe work procedures and worker training. Monitoring (such as air sampling or personal assessment of exposure) measures exposure to contaminants in the workplace. Monitoring can help assess the risks and the adequacy of hazard controls.

Key words: Chemical materials, biological materials, employee behavior, pyramid of transition.

INTRODUCTION

Sometimes workers do not use, produce or handle chemical and biological substances directly, but are exposed to them when the substances are released into the workplace (for example, from equipment or processes such as welding, oil-drilling and servicing, sawing or grinding).
Chemicals have obvious uses and applications in chemical laboratories, in chemical production and in other chemical processes. They are also ingredients of trade name products such as paints, adhesives, photographic developers and cleaners. Workers in food processing, sewage work, laboratories, agriculture, and other occupations handle biological substances or products containing biological substances of animal, plant or microbial origin.
Develop and implement safe work procedures and processes for handling, using, transporting, storing, producing and disposing of chemical and biological substances. Integrate safety into all procedures and work processes and develop any necessary additional safe work procedures and processes.
Employers: Employers must develop, implement, and maintain a worker WHMIS education and training program. Education and training is required for workers who may be exposed to hazardous products that are produced or used at the workplace.
Workers: Workers must participate in the education and training sessions. They must also follow the safe work procedures established by their employer.
A fundamental objective of any biosafety program is the containment of potentially hazardous biological agents and toxins. The term containment describes a combination of primary and secondary barriers, facility practices and procedures, and other safety equipment, including personal protective equipment (PPE), for managing the risks associated with handling and storing hazardous biological agents and toxins in a laboratory environment. The purpose of containment is to reduce the risk of exposure to staff and the unintentional release of hazardous biological agents or toxins into the surrounding community and environment. Final determination on the combination of containment measures required to address the relevant biosafety risk present at a facility should be based on a comprehensive biosafety risk assessment. A comprehensive biosafety risk assessment is a key component of a successful biosafety program and should be part of an all-hazards risk assessment; it should be conducted on a continual basis to address evolving risks within the laboratory environment [1].

METHODS

In this research relevant articles in the fields of biological hazards. Prospects of industries that depend on biohazards and the significance of preventive health and safety measures in these industries have also been discussed here. This research follows a method approach which collected and analyzed information from research.

RESULTS

A hazard is the potential for harm. In practical terms, a hazard often is associated with a condition or activity that, if left uncontrolled, can result in an injury or illness. Identifying hazards and eliminating or controlling them as early as possible will help prevent injuries and illnesses.

It is very important to involve your employees in the hazard analysis process. They have a unique understanding of the job, and this knowledge is invaluable for finding hazards. Involving employees will help minimize oversights, ensure a quality analysis, and get workers to "buy in" to the solutions because they will share ownership in their safety and health program.

Review with your employees your worksite's history of accidents and occupational illnesses that needed treatment, losses that required repair or replacement, and any "near misses" — events in which an accident or loss did not occur, but could have. These events are indicators that the existing hazard controls (if any) may not be adequate and deserve more scrutiny.

Conduct a preliminary job review. Discuss with your employees the hazards they know exist in their current work and surroundings. Brainstorm with them for ideas to eliminate or control those hazards. If any hazards exist that pose an immediate danger to an employee's life or health, take immediate action to protect the worker. Any problems that can be corrected easily should be corrected as soon as possible. Do not wait to complete your job hazard analysis. This will demonstrate your commitment to safety and health and enable you to focus on the hazards and jobs that need more study because of their complexity. For those hazards determined to present unacceptable risks, evaluate types of hazard controls [2].

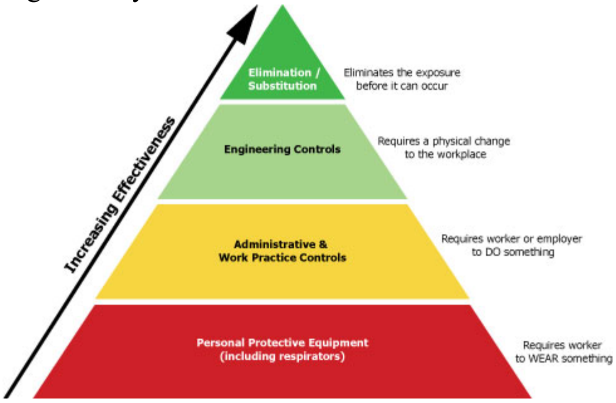
Personal protective equipment (PPE) helps protect the user's body from injury from a variety of sources (e.g., physical, electrical, heat, noise, chemical) or potential exposure to biological hazards and airborne particulate matter. PPE includes gloves, coats, gowns, shoe covers, closed-toe laboratory footwear, respirators, face shields, safety glasses, goggles, or ear plugs. PPE is usually used in combination with other biosafety controls (e.g., BSCs, centrifuge safety cups, and small animal caging systems) that contain the hazardous biological agents and toxins, animals, or materials being handled. In situations where a BSC cannot be used, PPE may become the primary barrier between personnel and the hazardous biological agents and toxins.

Risk assessment: There is no official standard approach, method, or one correct way to conduct a risk assessment, but several strategies are available, such as using a risk prioritization matrix, conducting a job hazard analysis, or simply listing the potential scenarios of what could go wrong while conducting a procedure, task, or activity. Risk assessment in veterinary diagnostic laboratories takes into account the likelihood of various risk group or BSL microorganisms being present in unknown clinical samples, plus the likelihood that routine processing of the clinical samples would expose laboratory workers to infectious agents in those samples. A risk assessment will consider the source of the clinical sample (including host species and clinical history), the suspected pathogen within a specimen with its inherent risk group characteristics, the work activity during diagnostic workup of the clinical sample in the laboratory, and the competencies and experience of the laboratory personnel.

Train your employees so they know how to safely handle chemicals and mitigate risks from working around them. A complete hazardous substances awareness program will cover such important topics as handling and storage, long-term warehousing, transport protocols and response to emergencies. It also improves supervisor and employee understanding of chemical-safety regulations and best practices and can be customized and structured according to your facility's processes.

Use all the right safety gear when handling chemicals: gloves, masks, labeled containers, etc. Personal Protective Equipment, is an important factor in chemical safety. Although it is considered the last form of defense in a complete safety program, it is essential when doing work in close proximity. Types of hazards can come in various forms, including dust, fumes, gases or liquids from such sources as batteries, pesticides, exhaust fumes, paint removers or pesticides. These can affect the respiratory system and eyes and skin, resulting in headaches, burning throat or eyes, blistering and rashes, and even long-term or permanent damage or impairment. Among the various types of approved chemical PPE are aprons, gloves, coveralls, face shields, glasses capable of chemical resistance and respiratory devices. The type of PPE used should be chosen according to the hazard type. It should also be usable by anyone, kept in working condition and used only by qualified personnel [1].

Figure 1. Pyramid of transition



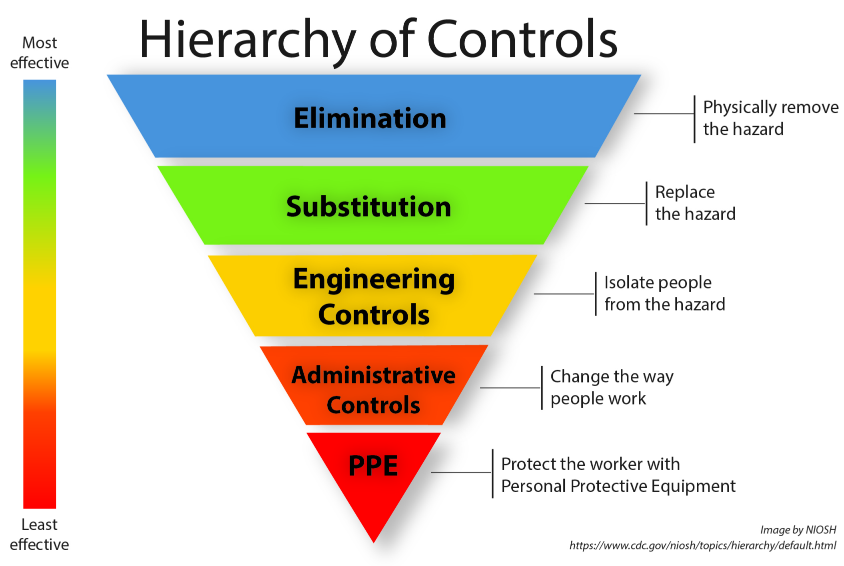
Source: Source of figure [7]

Controlling exposures to chemical hazards and toxic substances is the fundamental method of protecting workers. A hierarchy of controls is used as a means of determining how to implement feasible and effective controls.
OSHA's longstanding policy is that engineering and work practice controls must be the primary means used to reduce employee exposure to toxic chemicals, as far as feasible, and that respiratory protection is required to be used when engineering or work practice controls are infeasible or while they are being implemented.
OSHA defines these occupational risks as:
• Safety hazards. Spills, tripping hazards, unguarded machinery, improper wiring, working from heights.
• Physical hazards. Radiation, temperature extremes, exposure to extreme heat or cold.
• Chemical hazards. Toxic cleaning products, vapors, fumes, pesticides, and flammable materials.
• Biohazards. Blood and other body fluids, bacteria and viruses like Hepatitis B and C, fungi, and mold.
• Ergonomic hazards. Poorly adjusted workstations, frequent lifting, poor posture.
• Work organization hazards. Workplace violence, lack of social support, sexual harassment.
Also we can take several precautions to protect ourself from biohazards in the workplace. Some of these include:
• Treating each situation as potentially dangerous. Don't ever assume a situation involving biohazards will be fine to respond to without proper precautions.
• Washing your hands frequently with warm water and soap.
• Wearing personal protective equipment (PPE) when responding to situations involving biohazards. These can include gloves, facemasks and shields, respirators, aprons, special protective eyewear, and full body gowns or suits.
• Utilizing proper disposal methods including labeled biohazard bags or containers.
• Reporting all incidents to your supervisor [3].
Safety data sheets
A Safety Data Sheet (SDS) is a document that provides health and safety information about products, substances or chemicals that are classified as hazardous substances or dangerous goods.
SDS tell us the product (its name, ingredients and properties) who manufactured or imported it how the product can affect your health how to use and store it safely, who manufactured or imported it, how the product can affect your health, how to use and store it safely.
Employers using or storing dangerous goods or hazardous substances on their premises must ensure that: they obtain an up-to-date SDS for each of these products, their employees, contractors and emergency services personnel have access to the SDS.
Requirements of a compliant SDS
An SDS must be written in English, be legible and include:
• product identifier and chemical identity;
• manufacturer or importer details;
• emergency telephone number;

• date of preparation or last review;
• hazard identification;
• hazard statement(s) and precautionary statement(s);
• composition of the substance and information on hazardous ingredients;
• first aid measures;
• firefighting measures and accidental release measures;
• exposure control, including exposure standards, engineering controls and personal protection information;
• information relating to handling and storage, including how the substance may be safely used;
• disposal considerations;
• information relating to the physical and chemical properties of the substance;
• stability and reactivity information;
• toxicological information, including health effects

What are biological hazards?
• There are numerous agents, substances and circumstances which can constitute biological hazards in the working environment and there are different methods to determine which they are. National methods include providing for a definition of biological hazards for a classification of biological agents where certain categories are considered hazardous to human health. The latter systems are complemented with lists specifically identifying the agents or substances at issue. Such lists call for updating in line with the development of science and technology. Other national methods include listing certain agents of substances defined as hazardous [4].
Controlling exposures to hazards in the workplace is vital to protecting workers. The hierarchy of controls is a way of determining which actions will best control exposures. The hierarchy of controls has five levels of actions to reduce or remove hazards. The preferred order of action based on general effectiveness is:
• Elimination
• Substitution
• Engineering controls
• Administrative controls
• Personal protective equipment (PPE)
Using this hierarchy can lower worker exposures and reduce risk of illness or injury.

Figure 2. Inverse pyramid hierarchy of controls



Source: Source of figure [5]

Hierarchy of Controls inverted pyramid graphic representing the page's list of general effectiveness, from greatest to least.

Elimination: Elimination removes the hazard at the source. This could include changing the work process to stop using a toxic chemical, heavy object, or sharp tool. It is the preferred solution to protect workers because no exposure can occur.
Substitution: Substitution is using a safer alternative to the source of the hazard. An example is using plant-based printing inks as a substitute for solvent-based inks.
When considering a substitute, it's important to compare the potential new risks of the substitute to the original risks. This review should consider how the substitute will combine with other agents in the workplace. Effective substitutes reduce the potential for harmful effects and do not create new risks.
Elimination and substitution can be the most difficult actions to adopt into an existing process. These methods are best used at the design or development stage of a work process, place, or tool. At the development stage, elimination and substitution may be the simplest and cheapest option. Another good opportunity to use elimination and substitution is when selecting new equipment or procedures. Prevention through Design is an approach to proactively include prevention when designing work equipment, tools, operations, and spaces.
Engineering Controls: Engineering controls reduce or prevent hazards from coming into contact with workers. Engineering controls can include modifying equipment or the workspace, using protective barriers, ventilation, and more. The NIOSH Engineering Controls Database has examples of published engineering control research findings.

The most effective engineering controls: are part of the original equipment design, remove or block the hazard at the source before it comes into contact with the worker, prevent users from modifying or interfering with the control, need minimal user input for the controls to work, operate correctly without interfering with the work process or making the work process more difficult.
Engineering controls can cost more upfront than administrative controls or PPE. However, long-term operating costs tend to be lower, especially when protecting multiple workers. In addition, engineering controls can save money in other areas of the work process or facility operation.
Administrative controls establish work practices that reduce the duration, frequency, or intensity of exposure to hazards. This may include: work process training, job rotation, ensuring adequate rest breaks, limiting access to hazardous areas or machinery, adjusting line speeds
PPE is equipment worn to minimize exposure to hazards. Examples of PPE include gloves, safety glasses, hearing protection, hard hats, and respirators. When employees use PPE, employers should implement a PPE program. While elements of the PPE program depend on the work process and the identified PPE, the program should address: workplace hazards assessment, PPE selection and use, inspection and replacement of damaged or worn-out PPE, employee training, program monitoring for continued effectiveness
Employers should not rely on PPE alone to control hazards when other effective control options are available. PPE can be effective, but only when workers use it correctly and consistently. PPE might seem to be less expensive than other controls, but can be costly over time. This is especially true when used for multiple workers on a daily basis.
When other control methods are unable to reduce the hazardous exposure to safe levels, employers must provide PPE. This includes: while other controls are under development, when other controls cannot sufficiently reduce the hazardous exposure, when PPE is the only control option available
Administrative controls and PPE require significant and ongoing effort by workers and their supervisors. They are useful when employers are in the process of implementing other control methods from the hierarchy. Additionally, administrative controls and PPE are often applied to existing processes where hazards are not well controlled [5].

DISCUSSION

Recommended Practices for Safety and Health Programs, Occupational Safety and Health Administration, OSHA 3885, October 2016
To be effective, any safety and health program needs the meaningful participation of workers and their representatives. Workers have much to gain from a successful program, and the most to lose if the program fails. They also often know the most about potential hazards associated with their jobs. Successful programs tap into this knowledge base. Worker participation means that workers are involved in establishing, operating, evaluating, and improving the safety and health program. All workers at a worksite should participate, including those employed by contractors, subcontractors, and temporary

staffing agencies (see "Communication and Coordination for Host Employers, Contractors, and Staffing Agencies").

Action item 1: Encourage workers to participate in the program

By encouraging workers to participate in the program, management signals that it values their input into safety and health decisions.

How to accomplish it

• Give workers the necessary time and resources to participate in the program.
• Acknowledge and provide positive reinforcement to those who participate in the program.
• Maintain an open door policy that invites workers to talk to managers about safety and health and to make suggestions.

Action item 2: Encourage workers to report safety and health concerns

Workers are often best positioned to identify safety and health concerns and program shortcomings, such as emerging workplace hazards, unsafe conditions, close calls/near misses, and actual incidents. By encouraging reporting and following up promptly on all reports, employers can address issues before someone gets hurt or becomes ill.

How to accomplish it

• Establish a process for workers to report injuries, illnesses, close calls/near misses, hazards, and other safety and health concerns, and respond to reports promptly. Include an option for anonymous reporting to reduce fear of reprisal.6
• Report back to workers routinely and frequently about action taken in response to their concerns and suggestions.
• Emphasize that management will use reported information only to improve workplace safety and health, and that no worker will experience retaliation for bringing such information to management's attention
• Empower all workers to initiate or request a temporary suspension or shutdown of any work activity or operation they believe to be unsafe.
• Involve workers in finding solutions to reported issues.

Action item 3: Give workers access to safety and health information

Sharing relevant safety and health information with workers fosters trust and helps organizations make more informed safety and health decisions.

How to accomplish it

• Give workers the information they need to understand safety and health hazards and control measures in the workplace. Some OSHA standards require employers to make specific types of information available to workers, such as:
— Safety Data Sheets (SDSs)
— Injury and illness data (may need to be redacted and aggregated to eliminate personal identifiers)
— Results of environmental exposure monitoring conducted in the workplace (prevent disclosure of sensitive and personal information as required)
• Other useful information for workers to review can include:
— Workplace job hazard analyses
— Chemical and equipment manufacturer safety recommendations
— Workplace inspection reports
— Incident investigation reports (prevent disclosure of sensitive and personal information as required)

Action item 4: Involve workers in all aspects of the program

Including worker input at every step of program design and implementation improves your ability to identify the presence and causes of workplace hazards, creates a sense of program ownership among workers, enhances their understanding of how the program works, and helps sustain the program over time.

How to accomplish it

• Provide opportunities for workers to participate in all aspects of the program, including, but not limited to helping:
— Develop the program and set goals.
— Report hazards and develop solutions that improve safety and health.
— Analyze hazards in each step of routine and nonroutine jobs, tasks, and processes.
— Define and document safe work practices.
— Conduct site inspections.
— Develop and revise safety procedures.

— Participate in incident and close call/near miss investigations.
— Train current coworkers and new hires.
— Develop, implement, and evaluate training programs.
— Evaluate program performance and identify ways to improve it.
— Take part in exposure monitoring and medical surveillance associated with health hazards.
Action item 5: Remove barriers to participation
To participate meaningfully in the program, workers must feel that their input is welcome, their voices will be heard, and they can access reporting mechanisms. Participation will be suppressed if language, education, or skill levels in the workplace are not considered, or if workers fear retaliation or discrimination for speaking up (for example, if investigations focus on blaming individuals rather than the underlying conditions that led to the incident, or if reporting an incident or concern could jeopardize the award of incentive-based prizes, rewards, or bonuses).
How to accomplish it
• Ensure that workers from all levels of the organization can participate regardless of their skill level, education, or language.
• Provide frequent and regular feedback to show employees that their safety and health concerns are being heard and addressed.
• Authorize sufficient time and resources to facilitate worker participation; for example, hold safety and health meetings during regular working hours.
• Ensure that the program protects workers from being retaliated against for reporting injuries, illnesses, and hazards; participating in the program; or exercising their safety and health rights. Ensure that other policies and programs do not discourage worker participation.
• Post the 11(c)-fact sheet (found at www.whistleblowers.gov) in the workplace or otherwise make it available for easy access by workers [6].

CONCLUSION

Biological risks at the workplace can be prevented by maintaining good safety practices. Workers should be informed about using appropriate protective clothing and removing it at the end of the work. A safe work environment is a reasonable expectation that employees have of their employers. Employees want their employers to protect them from job hazards, but it's important that employees realize they have a role in maintaining a safe workplace as well. Safety is the business and responsibility of every employee and can be achieved through proper education, training, use of protective equipment and by following safety rules, regulations, standards, and laws. Each employee is responsible for understanding and practicing appropriate safety procedures. Employees take reasonable care of their health and safety no matter where they are or what you're doing. This is especially true in the workplace, where employees actions can affect both own safety and that of others. It's important to cooperate with their employer, make sure they receive the proper training for their job, and understand and follow company's health and safety policies. In addition to company's policies, there are generally accepted safe work practices and laws by which should also abide. The company will provide with tools to ensure employees health and safety at work. It's responsibility as an employee to use them. Observe health and safety signs, posters, warning signals, and written directions. Follow safe practices and specific guidance from Safety Data Sheets (SDS) or chemical label instructions, if the work involves hazardous materials. Use engineering controls and personal protective equipment (PPE) appropriate to work. It's also important that never interfere with or misuse anything that's been provided for health, safety or welfare.

The Level of Acceptable Risk is the warning light threshold that each employee has that establishes the level of risk an employee is willing to take or accept to perform a task or operation before he or she feels the risk is too great. Employees are the first line of defense against unsafe practices. When employees are aware of hazardous conditions or behavior, defective equipment, or other hazards, it is their responsibility to warn co-workers to keep them out of harm's way. Employees should report all unsafe acts, unsafe conditions, illnesses and injuries to the appropriate person at your company. No one knows your job or tools better than you do – if you think a job or task is unsafe, stop the work and communicate concerns with your supervisor. Employees should also consider ways to make a process or equipment safer and communicate those as well. When employees are first hired, the company will provide with adequate training for the work you are expected to perform, including the tools will need to get the job done. They will train on company safety policies and potential hazards. However, this is not where on-the-job education should end. It is up to employee, to continue to educate themself. Learn about potential hazards associated with employees work and work area, know where information on these hazards is kept for review, and use this information when needed. Make sure employees are familiar with employers company's emergency response plan and participate in emergency drills so this information is always fresh on employees mind. Participate in health and safety training when it is available, as well as monitoring programs and inspections as applicable to the work situation. Being in a state of continuing education will help you recognize when you are not qualified or adequately trained for a work task, which will prevent you from operating equipment or machinery unless you've been adequately trained.

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