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CONTEMPORARY PROBLEMS OF OCCUPATIONAL SAFETY AND HEALTH IN THE DOMAIN OF CHEMICAL POLLUTION

Abstract: *Chemical pollution in the workplace is not just a concern; it's a serious threat to workers' health, causing both acute and chronic diseases. The key issues at hand include exposure to hazardous chemicals, insufficient exposure monitoring, and improper use of protective equipment. Industrial solvents, fumes, dust substances, and particulate matter significantly increase the risk of cancer, neurological disorders, and diseases of the respiratory system, particularly in the construction, chemical, pharmaceutical, and agricultural industries. Many companies are not conducting regular air quality measurements or biological monitoring of employees, and existing legal regulations often do not address new chemical risks. This lack of control and inadequate training results in the improper use of personal protective equipment (PPE), leading to an increase in occupational diseases such as asthma, chronic obstructive pulmonary disease (COPD), dermatitis, and chemical poisoning. It's clear that better regulations are urgently needed to address these issues. New research indicates the potential health risks of nanoparticles, particularly in the electronics industry. While there are international standards (OSHA, EU REACH, ILO), their implementation is inconsistent, inspections are infrequent, and sanctions are lenient. To address these issues, urgent action is needed in the form of improved regulation, stricter control, and enhanced worker education.*

Keywords: chemical pollution, occupational diseases, nanoparticles, workplace safety

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INTRODUCTION

Chemicals are integral to almost all aspects of modern society and are indispensable in numerous industries worldwide. Their application is diverse and multi-useful — from the production of medicines and disinfectants to the increase of yields in agriculture and the development of high technology. In many cases, chemicals contribute to better human health, more efficient production, and improved quality of life. As the second largest in the world among production branches, the chemical industry records constant growth, and every year, an increasing number of new substances are introduced into circulation (K. Singh et al., 2011; Xie et al., 2023). Although economically beneficial, this trend brings significant challenges — many of these chemicals have dangerous properties that can endanger human health and cause serious environmental consequences.

Exposure to hazardous chemicals can cause acute effects such as poisoning, irritation, and burns, but also long-term consequences, including cancer, neurological disorders, and endocrine system disorders (Alagan et al., 2023; Ghosh et al., 2022; Proshad et al., 2017; Thompson et al., 2017). A particular challenge is posed by chemicals that degrade slowly, tend to bioaccumulate, and spread through waterways and air, causing permanent damage to ecosystems.

Despite the benefits of chemicals, their irresponsible development, application, and disposal can cause irreparable consequences for health and nature. Industrial accidents, inadequate storage, non-compliance with regulations, and weak controls often lead to catastrophic consequences in local communities and globally (Palacios et al., 2021). More than one billion workers worldwide are annually exposed to hazardous chemical substances in the workplace, including pollutants, dust, fumes, and gases (International Labour Organization, n.d.). Unlike the general population, workers are often exposed to higher concentrations of these substances for more extended periods, which increases the likelihood of developing illnesses and injuries.

According to United Nations data from 2018, every 30 seconds, a worker dies due to exposure to chemicals at work (International Labour Organization, n.d.). These

deaths most often occur because of serious diseases such as cancer, systemic poisoning, and respiratory diseases, but also as a result of explosions and fires caused by chemicals. In addition to deaths, the number of non-fatal but serious injuries that lead to disability and chronic diseases, such as occupational asthma, dermatitis, and neurological disorders, is enormous.

The importance of the cumulative effects of long-term exposure is often overlooked — workers develop symptoms only after years of working in a contaminated environment, when the health damage is already irreversible. Many chemicals do not leave immediate traces, further complicating the timely diagnosis and treatment of diseases.

Chemical pollution in the workplace is a growing global problem with serious consequences for occupational safety and health. Exposure to hazardous substances such as industrial solvents, gases, dust particles, and fumes is associated with many acute and chronic health problems. Despite international standards and growing awareness, many workplaces are still characterized by inadequate risk assessment, weak enforcement of safety measures, and insufficient regulation. This paper aims to investigate the contemporary challenges associated with chemical pollution in the working environment, examine their impact on workers' health, with special reference to Serbia, and propose measures to improve the current situation.

Chemical exposure and health risks

Workers in various industries, especially construction, chemical, pharmaceutical, agricultural, and electronics, are exposed to various chemical agents. These agents include solvents, pesticides, heavy metals, acids, bases, aerosols, and other toxic substances used in everyday industrial processes.

The mode of exposure may include:

- Inhalation of toxic fumes – for example, workers who use solvents or solders in confined spaces are often exposed to harmful fumes that irritate the respiratory tract and cause headaches, dizziness, and even loss of consciousness (J. Singh et al., 2021).
- Contact with irritating substances - there is direct contact with chemicals that cause burns, allergic reactions, and dermatological problems (Rustemeyer et al., 2012).
- Absorption through the skin - many chemicals can pass through the epidermis and enter the bloodstream, causing systemic effects such as liver, kidney, or nervous system damage (Anderson & Meade, 2014).

Long-term exposure can result in chronic diseases such as:

- Chronic obstructive pulmonary disease (COPD) (Elonheimo et al., 2022).
- Asthma caused by the workplace (Ha et al., 2021).
- Dermatitis (allergic or irritant).
- Neurological disorders - due to exposure to heavy metals such as lead, mercury or manganese (Koszewicz et al., 2021).
- Cancerous diseases - associated with work in refineries, paint, and rubber industries (Boniol et al., 2016).

A special challenge is the increasingly frequent use of nanomaterials, especially in electronics, pharmaceuticals, cosmetics and nanotechnology. Due to their dimensions of less than 100 nm, nanoparticles can penetrate biological barriers that larger particles cannot cross (Baranowska-Wójcik et al., 2020). This includes:

- Penetration through the alveolar-pulmonary barrier and reaching the bloodstream,
- Accumulation in organs such as the liver, kidneys, and brain,
- Induction of oxidative stress, inflammation, and changes in cellular DNA.

Due to their size, nanoparticles often pass unnoticed through conventional filtration systems, and currently, valid regulations do not always include specific guidelines for their detection and control. The insufficiently investigated long-term effect of exposure to nanoparticles requires urgent interdisciplinary research and adaptation of rules to cover this new risk category in the working environment.

Weaknesses in supervision and regulation

Globally, regulations related to chemical safety at work lag behind technological developments. Although many countries have adopted laws and regulations such as OSHA (Occupational Safety and Health Administration) in the United States, REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) regulations in the European Union, and International Labor Organization (ILO) guidelines, their implementation is uneven, especially in developing countries. There are serious deficiencies in inspection systems, a lack of trained personnel, and limited resources for law enforcement. REACH is a comprehensive regulation of the European Union that entered into force in 2007 (Imaizumi, 2016). This regulation aims to ensure a high level of protection of human health and the environment through better and earlier identification of the properties of chemical substances. According to REACH, manufacturers and importers are obliged to register the chemicals they produce or import in quantities greater than one ton per year, and they are obliged to provide information on their properties and safe use. Although REACH represents one of the most advanced legal frameworks in the world, there are often delays in risk assessment and slow updating of the list of prohibited and restricted substances.

In Serbia, although there are basic legal acts that regulate safety and health at work, the application of these regulations is often formal and ineffective. It is problematic that monitoring of exposure to chemical

agents is rarely carried out, and biological monitoring is almost non-existent in practice. There is a lack of specialized laboratories for the analysis of toxic substances and personnel with expert knowledge in industrial toxicology and chemical safety. A particular challenge is the lack of up-to-date and comprehensive databases on chemicals used in industry and their effects on health.

Inspection services are insufficiently equipped with personnel and technology, and companies often do not feel obliged to comply with the regulations because the penalties are mild and rarely applied. In addition, there is insufficient synergy between regulatory bodies, scientific research institutions, and health institutions, which makes it challenging to coordinate and adopt effective policies.

Improvement actions

At the global level, an additional challenge is the slow reaction of legislation to the emergence of new materials and technologies, especially in the field of nanotechnology. Although more and more attention is directed to the potential risks of nanoparticles, regulations that would precisely define their use and worker protection criteria are still in their infancy.

To solve the problem, urgent reforms are needed, including:

- Improving legal regulations, especially about new chemical agents and nanomaterials.
- Introduction of mandatory and continuous workers' education on risks and protective measures.
- Regular implementation of air monitoring and biological analyses.
- Investments in quality personal protective equipment and improvement of working conditions.
- Strengthen inspection services and introduce stricter sanctions for non-compliance with safety regulations.
- Improving cooperation between institutions, including inspection services, academic institutions, and the health sector.
- Develop national databases on chemical substances and standardize risk assessment procedures.

Problems with personal protective equipment

One of the key problems in protecting workers' health from chemical pollution is improper use and inadequate availability of personal protective equipment (PPE). In many work environments, PPE is not standardized or adapted to the specific risks of the workplace. Poor quality equipment is often used without the necessary certificates, which do not provide adequate protection against chemicals, especially gases, vapours, and nanoparticles.

Workers are often not trained to properly use PPE - masks are not appropriately sealed, gloves are not changed regularly, and protective clothing is not resistant to chemicals with which employees come into contact. In addition, employers sometimes neglect the obligation to provide the appropriate equipment and to replace it after a specific period of use. This practice leads to a false sense of security among workers, who believe they are protected while chronic exposure to hazardous substances occurs.

In more advanced industrial systems, despite the availability of high-quality PPE, the problem is poor supervision of its proper use. Also, the efficiency of the equipment is rarely analyzed about specific chemical risks. Insufficient education and the absence of a safety culture contribute to the systemic neglect of preventive measures.

The need for regulatory reform and education

Solving the problem of chemical pollution requires strengthening the legal framework and enforcement mechanisms. It is necessary to harmonize the legislation with modern challenges, including the risks of nanoparticles and the mandatory toxicological assessment of all industrial chemicals.

Mandatory and regular education of employees must become a standard, with a special focus on small business entities in Serbia. Modernization of the health surveillance system, using digital tools for exposure monitoring and early warning, would enable a more effective response. In parallel, investing in engineering measures such as improving ventilation and local extraction of harmful substances is necessary.

International cooperation also plays an important role. Serbia should strengthen the exchange of data and experience with the EU and neighboring countries to encourage harmonizing standards and improve the efficiency of inspection and preventive mechanisms.

Current global trends

World trends in regulating chemical pollution in the working environment increasingly tend towards a proactive approach that includes the precautionary principle, the integration of risk evaluation in all stages of the industrial process, and comprehensive databases available to regulators and the public. The increased use of digital tools for monitoring chemical substances, including exposure simulation software and digital registries, allows for more accurate risk assessments and better surveillance efficiency. There are a growing number of "green chemistry" programs that encourage the replacement of hazardous chemicals with safer alternatives.

CONCLUSION

Chemical pollution in the workplace remains a key occupational safety and health challenge. Although there have been efforts to improve regulations and standards, there are still serious deficiencies in supervision, workers' training, and the implementation of protection measures. Especially in Serbia, where

institutional capacities are limited, there is an urgent need for comprehensive reforms.

To effectively protect employees' health, it is necessary to improve laws, strengthen control mechanisms, invest in education and technology, and encourage the cooperation of all actors in the occupational safety and health system. Only with such an integrated approach can the number of occupational diseases be reduced and a healthier and safer working environment ensured.

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