Verica S. Jovanović[1]
Institute of Public Health of Serbia
"Milan Jovanović Batut"
Belgrade (Serbia)

Igor L. Dragićević[2]
Public Health Institute of Šabac
Šabac (Serbia)

UDC 338.23:622(497.11)
502.175
Review scientific article
Received: 17.12.2024.
Accepted: 24.12.2024.
doi: 10.5937/napredak5-55502

The Public Health Importance of Monitoring Surface Water, Soil, Air, Biological Monitoring and Sustainable Mining

Abstract: Modern technological advancements in mining involve the implementation of environmental standards and protective measures that significantly contribute to preserving natural resources and preventing potentially harmful impacts on the environment. These advancements enable early identification and minimisation of risks. The mining industry plays a vital role in the economic development of society while simultaneously adhering to strategies for environmental preservation and public health protection. This is achieved through modern methods for monitoring environmental parameters and population health. Mining and geological exploration may lead to the presence of potentially toxic elements (PTEs), which in certain concentrations across various environmental media pose challenges to both the environment and human health. Environmental monitoring is a crucial strategy for achieving sustainable mining. Sustainable mining development through effective monitoring of water, soil, air, and biological indicators in mining areas ensures the preservation of ecological balance and public health in regions where mineral exploitation occurs.

Keywords: mining, monitoring, surface water, soil, air, bio-monitoring

Foreword

Mining represents a key industrial sector that significantly contributes to the development of society, the economy, and technology. The extraction of minerals and metals provides essential resources for numerous industries, including construction, electronic equipment production, transportation, and renewable energy sources. This sector also drives technological innovations and infrastructural

[1] verica_jovanovic@batut.org.rs ; https://orcid.org/0000-0002-9650-0709
[2] igordragicevic@yahoo.com ; https://orcid.org/0000-0003-4895-3399

development, promoting societal modernisation. Given the importance of preserving natural resources and protecting the environment, mining activities are conducted following the most advanced regulations and measures to ensure sustainability. These include environmental protection strategies, public health safeguards, and occupational safety and health measures for workers in the industry. Relevant institutions and various sectors, including multiple ministries, actively contribute to integrating environmentally responsible practices at all stages of mining processes. This approach seeks to balance economic growth with the preservation of natural ecosystems, ensuring the long-term protection of public health and the environment. Thanks to such initiatives, mining remains indispensable for sustainable economic and technological progress while necessitating continuous environmental monitoring.

The public health aspect of mining pertains to identifying, monitoring, and managing health risks associated with mining activities to preserve both the environment and human health. This includes assessing the impact of mining processes on the quality of surface water, soil, and air through integrated monitoring systems. Broadly speaking, monitoring is essential across many disciplines, from environmental protection and industry to healthcare and public policy, as it enables decision-making based on reliable data. Monitoring is defined as the continuous process of overseeing, observing, and collecting data about a particular process or condition to draw relevant conclusions (Knežević et al., 2015). Some of the approaches to controlling the environmental impact of mining, relevant to public health, include comprehensive environmental monitoring, soil monitoring, water monitoring, air monitoring, and biological monitoring.

Environmental monitoring in a broader sense refers to a systematic process of collecting and analysing data on selected parameters characterising the state of the environment to detect changes in a timely manner, support decision-making, and prevent adverse environmental impacts (Ehlers & Kastler, 2009; European Commission [EC], 2003). In the Republic of Serbia, public health significance is prioritised through monitoring parameters such as water, soil, and air quality, as well as biological monitoring. When planning environmental monitoring and selecting parameters, it is necessary to consider environmental characteristics and potential hazards, including their sources, spread, changes, and potential recipients. During ore extraction, especially of metallic ores, one anticipated hazard is the release of metals and metalloids classified as potentially toxic elements (PTEs). Monitoring methods and parameters for PTEs depend primarily on the medium (soil, water, air, or biological material) where these pollutants are tracked. Continuous exchange of substances occurs between water, sediments, soil, air, and living organisms, requiring each of these media to be included in the monitoring plan (Nieder, 2024).

Monitoring the quality of water, soil, and air in mining areas is an important element of public health strategies, which affect the preservation of the environment and public health within a multidisciplinary approach to monitoring risk factors for human health. In addition to the aforementioned types of monitoring, biological monitoring stands out as an additional method significant for assessing the cumulative potential impact of risks originating from mining processes on the environment and potential effects on human health.

The aim of this paper is to examine the key elements and methods of environmental monitoring (surface water, air, soil) with the goal of preserving public health in Serbia, including potential methods of biological monitoring in mining areas and their application in assessing risks to human health.

> The public health aspect of mining pertains to identifying, monitoring, and managing health risks associated with mining activities to preserve both the environment and human health.

Regulations governing the environmental monitoring process in the context of mining activities

The environmental monitoring process in the Republic of Serbia, in the context of mining activities, is regulated by a series of laws, by-laws, and regulations aligned with international standards and European Union (EU) directives. Key regulations include the Law on Environmental Protection (Official Gazette of RS, no 135/04, 36/09, 36/09 – other law, 72/09 – other law, 43/11 – CC, 14/16, 76/18, 95/18 – other law, 94/24 – other law), which defines obligations for monitoring air, water, soil, and biodiversity quality, as well as procedures for environmental impact assessments and strategic environmental assessments. The Law on Mining and Geological Exploration (Official Gazette of RS, no 101/15, 95/18 – other law, and 40/21) mandates environmental oversight and remediation during and after the exploitation of mineral resources, along with the preparation of environmental impact studies. The Law on Water (Official Gazette of RS, no 30/10, 93/12, 101/16, 95/18, 95/18 – other law) regulates the protection and sustainable use of water resources, including the regular monitoring of surface and groundwater quality near mining facilities.

The Environmental Impact Assessment Law (Official Gazette of RS, no 94/24) prescribes procedures for assessing the environmental impact of projects, including the use of public hearings, conclusions from expert panels, and continuous monitoring during project implementation. The Waste Management Law (Official Gazette of RS, no 36/09, 88/10, 14/16, 95/18 – other law, and 35/23) regulates the management of mining waste and the monitoring of potential pollution from tailings and other waste materials.

The Republic of Serbia aligns its regulations in this field with EU directives, enabling the application of the highest environmental protection standards in the mining sector. Key institutions overseeing the implementation of monitoring include the Environmental Protection Agency, the Ministry of Environmental Protection, and the Environmental Protection Inspection, as mandated by Serbian regulations.

The implementation of legal provisions in the field of monitoring contributes to reducing the potential negative impact of mining activities on the environment and public health, enables the timely identification and elimination of potential risks, and supports sustainable development and the protection of natural resources.

The Public Health Law of the Republic of Serbia (Official Gazette of RS, no 15/16) defines the preservation of public health and the application of all environmental monitoring strategies as a key obligation of the state to ensure its protection.

Elements of environmental monitoring

Environmental monitoring is based on tracking specified parameters, which can be qualitative or, more commonly, quantitative. In environmental monitoring, chemical, physico-chemical, and biological parameters are most frequently tracked. Predefined parameters can be measured or determined in situ or by sampling followed by subsequent analysis. Depending on the nature of the parameters, their values can be measured continuously or intermittently (Ruppen, 2021). The monitoring plan must define the geographical area where monitoring is conducted, the parameters being tracked and the medium (environment), the plan and method for direct measurement or sampling, the conditions for storage and transportation of samples, sample processing, sample analysis, the plan for data processing, the plan for data analysis, and the method of presenting and disseminating results.

In the environmental monitoring process, it is essential to provide and plan the development of standard protocols for each monitoring phase, train personnel conducting the monitoring, ensure logistical conditions for monitoring implementation, and obtain appropriate accreditation and certification for institutions carrying out the monitoring (EC, 2003; Modoi, 2014).

Monitoring of surface water, soil, and air

These types of monitoring are essential for the preservation of public health. Protecting public health involves safeguarding the environment as well as maintaining the health of the population. Precisely defining the area under investigation and its characteristics is crucial for the effective implementation of these monitoring activities (Loredo et al., 2010). Defining the geographical area requires knowledge of its size and exact location. For surface water monitoring, it is also necessary to map the entire watershed, including the tributaries of water bodies located in mining areas (Wei et al., 2018). Additionally, it is essential to determine the position of water body segments relative to the sites/areas of ore extraction and processing, as well as waste disposal, and to define which sections are upstream and which are downstream of these locations (Modoi, 2014; Jiménez-Oyola et al., 2023; Ruppen et al., 2021).

For professionally conducted water monitoring, it is crucial to understand the composition and structure of rocks, soil, and tailings, primarily due to their potential interaction with surface waters. Tailings are by-products of mining processes, specifically ore extraction and processing, in the form of liquid sludge or suspensions. It is important to note that the chemical composition of suspended particles depends on the composition of the ore, rocks, and soil, as well as the chemicals used during ore processing. For this reason, the properties of tailings will depend on their composition, acidity, salinity, particle size distribution, solid matter content, and consistency (Gorakhki & Bareither, 2016; Wang et al., 2014). Responsible management of waste generated during ore extraction is an integral part of the mining process. Proper waste management during ore extraction is a highly significant preventive measure in environmental protection and an imperative practice for sustainable mining.

It should also be emphasised that the description of the characteristics of the mining area includes climatological data, primarily the average annual temperature, precipitation amount, and seasonal distribution of precipitation (Loredo et al., 2010). The amount of precipitation affects biogeochemical processes in the soil, and during prolonged dry periods, it can lead to a decrease in soil acidity and further mobilisation of potentially toxic elements (PTE), causing them to transition into water (Modoi et al., 2014). A significant parameter for effectively conducting water monitoring is the flow rate in running waters, which is also closely related to climatic parameters (Nordstrom, 2011).

In monitoring the quality of surface waters in mining areas, the concentration of substances of interest for a specific type of mine is primarily monitored. The defined parameters are tracked intermittently, through water sampling and subsequent analysis of samples. Additionally, parameters such as pH and electrical conductivity are monitored in situ, through direct measurements, which can be either intermittent or continuous by setting up appropriate sensors and automatic data logging systems (Ruppen et al., 2021). For the surface water monitoring process, it is essential to define the exact sampling locations (sampling network), the time and frequency of sampling (sampling schedule), as well as quality control of sampling (Behmel et al., 2016; Jiang et al., 2020).

When preparing a soil monitoring plan, the soil type should be determined based on particle size (sand, silt, or clay), which represents the first step in the analysis. Additionally, monitoring the soil pH is extremely important, along with examining the chemical composition, including the content of organic matter, which significantly influences the soil properties in soil monitoring. Special attention should be given to the content and forms of elements such as aluminium (Al), iron (Fe), and manganese (Mn), as their oxides often serve as centres for the co-precipitation of other elements, which can indicate their behaviour in the soil (Rinklebe et al., 2019). It is important to know that the toxicity, mobility, and biological availability of potentially toxic elements (PTEs) are influenced by their form, or speciation, which depends on biogeochemical processes in the soil that, in addition to pH, are affected by numerous parameters, including some elements resulting from microbial activity (Frohne et al., 2014; Ponting et al., 2021).

According to Rinklebe and colleagues, when planning sampling, in addition to defining the location and time, it is essential to understand the soil profile and define the depth from which the sample is taken (Rinklebe et al., 2019). Additionally, Nieder and Benbi note that the concentrations of elements in soil particles are in constant equilibrium with the water present in the soil pores, making them available to living organisms (Nieder & Benbi, 2023). Due to this dynamic of potentially toxic elements (PTEs) between the soil and water, it is necessary to map the hydrological characteristics of the area and record potentially flooded areas (Ponting et al., 2021). According to available literature, innovations in soil monitoring are driven by the rapid development of sensors and their application. However, sampling and subsequent sample analysis are still the methods that are routinely applied.

The main challenges related to the mining industry concern mining waste dumps that can impact the environment. Due to their chemical nature, which includes a lack of nutrients and a high concentration of metals and metalloids, mining waste dumps (landfills) can potentially have a negative impact on the environment, making safety measures in waste management processes extremely important. One of the effects of mining activities is soil degradation, which is particularly evident near mining sites (Ali et al., 2021). In these areas, the soil may potentially be contaminated with heavy metals and metalloids, so such phenomena must be prevented. Modern methods of mining waste disposal include fraction separation, as well as thickening, dewatering, and compacting tailings (waste), which can reduce the potential environmental impacts of mining waste (Furnell et al., 2022; Onifade et al., 2024).

According to the Air Protection Act (Official Gazette of the RS, no 36/09, 10/13, and 26/21 – amended law), in order to ensure effective air quality management, an integrated system is established for monitoring and controlling pollution levels, as well as for maintaining a database on air quality, known as air quality monitoring.

Air quality monitoring is one of the key instruments whose application contributes to the protection of public health and the environment. This practice is especially important in mining areas where industrial activities can significantly affect the concentration of pollutants in the air. The air quality monitoring system establishes a national and local network of measuring stations and/or measurement points for fixed air quality measurements. Mining activities are among the most significant human activities that can contribute to dust and aerosol emissions, depending on the type of mine, covering large areas globally, and involving the presence of potentially toxic elements (PTE) (Csavina et al., 2012). The significance of air monitoring lies in the timely detection of increased concentrations of pollutants, which enables quick interventions and the implementation of measures to protect the population. It is particularly important to emphasise that regular air quality monitoring allows for the assessment of long-term trends, thereby contributing to strategic planning and improving public health in Serbia.

Biological monitoring and mining

Biological monitoring is a method of tracking the concentration of specific parameters and is an important approach for assessing the impact of pollutants, such as potentially toxic metals and metalloids, on human health and the environment in mining areas. Mining activities often lead to the release of potentially toxic elements (PTEs), such as arsenic (As), cadmium (Cd), lead (Pb), as well as silver (Ag), mercury (Hg), and zinc (Zn) (Rakete et al., 2021). The use of biological monitoring allows for the identification of the presence of metals and metalloids and the assessment of the level of exposure of living organisms.

Biological monitoring is the continuous, long-term, or periodic tracking and assessment of biological and ecological changes (parameters) using specific methodological approaches (Hirvonen, 2008). Additionally, biological monitoring is the use of living organisms as bio-indicators of changes in the environment over space and time. The term "bio-indicators" was first introduced by Clements in 1920 to refer to organisms whose presence in a specific habitat indicates the ecological conditions of that habitat. For methodological reasons, biological monitoring is divided into different categories depending on the type of environment in which changes are monitored, including: air monitoring (where lichens and mosses are used as bio-indicators); aquatic environment monitoring (with bio-indicators such as algae, bacteria, fish, and other organisms indicating changes in water quality); and soil monitoring (where plants, i.e., vegetation, are used as bio-indicators) (Metcalfe, 1989).

Also, occasionally and most often of a project-based nature, analyses of biological samples in the human population are conducted. For such methods, special consent from the subjects or the existence of legal regulations is required. In these cases, based on the analysis of biological samples such as blood, urine, hair, or saliva in the human population, it is possible to track the cumulative impact of these contaminants on the health of the population, as well as on ecosystems in the immediate vicinity of mining areas (Molina-Villalba et al., 2015; Rakete et al., 2021).

According to Nagajyoti, heavy metals and metalloids present in the soil cannot be degraded due to their persistence and stability, but instead bio-accumulate, gradually entering plants, animals, and humans through the air, water, and food chain (Nagajyoti, 2010). Arsenic, cadmium, hexavalent chromium, copper, lead, methyl mercury, nickel, and zinc are heavy metals that have the ability to bio-accumulate (U.S. Environmental Protection Agency [EPA], 2000). Additionally, according to the data from the Environmental Protection Agency (EPA), the bio-accumulation process is accompanied by bio-magnification, where concentrations of harmful substances increase as they move up the food chain, with predators at the top of the chain being most at risk due to consuming large amounts of contaminated organisms (EPA, 2021). Bio-magnification factors represent the ratio of metal concentration in the predator's body compared to its prey, clearly tracking how metals move through the food chain and increase in concentration in the predator's organism (Ciesielski et al., 2006).

Today, in the Republic of Serbia, in accordance with regulations, the aforementioned types of monitoring in mining areas are key protective strategies for the preservation of the environment and public health as a whole.

In the context of surface waters and soils in mining regions, biological monitoring is used to identify pollution sources and assess their long-term effects (Costa & Teixeira, 2014). Specific organisms, such as fish, plants, and microorganisms, known as bio-indicators, enable early recognition of pollution in water and the presence of pollutants, which helps in assessing its consequences on the stability of ecosystems (Cakaj et al., 2024; Chovanec et al., 2003).

Biological monitoring is also, though very rarely, used to assess the exposure of the local population, particularly in areas where mining activities are conducted, which can potentially lead to increased concentrations of PTEs in the environment, in order to assess health risks for both mine workers and the local population (Michalak & Chojnacka, 2014). The use of biological monitoring in mining areas contributes to a better understanding of the ecological and health risks associated with potentially toxic elements, thus enabling more effective environmental monitoring (EPA, 2022). Such application of the monitoring is carried out sporadically.

Sustainable development of mining and measures for environmental protection and public health

According to the literature, from a public health analysis perspective, there are two basic methods of ore extraction: surface and underground.

Surface mining, according to the literature, provides greater efficiency and safety, but it can potentially disrupt environmental balances. Underground mining is more environmentally acceptable (Sahu et al., 2015).

Considering the facts mentioned so far regarding monitoring in various media, most authors define sustainable mining or sustainable development of mining as a practice that achieves a balance between economic, ecological, and social factors (Laurence, 2011). It is concluded that sustainable mining development involves achieving a balance between economic viability, technical feasibility, environmental responsibility, and social impact, with a focus on integrating the concept of sustainability into decision-making strategies (Pavan Kumar, 2014). Minimising environmental impact at all stages of the mine's life cycle is crucial for supporting sustainable mining development, which is achieved through effective environmental management (Hilson & Murck, 2000). According to Laurence, safety in mining is achieved through responsible risk management, efficient monitoring and reporting systems, continuous education, training, and capacity-building of the workforce employed in mining, as well as equipment and work processes (Laurence, 2005). All of these activities represent measures that contribute to the protection of the environment and public health, thereby ensuring the long-term sustainability of mining projects.

Before the start of mining operations, the first and most significant measure is conducting an environmental impact assessment study, which is applied to projects in industries such as mining, energy, transport, tourism, agriculture, forestry, water management, waste management, public services, as well as projects in protected natural and cultural heritage areas. According to the Law on Environmental Impact Assessment (Official Gazette of RS, no 135/04 and 36/09), the environmental impact assessment study analyses the quality of the environment, sensitivity in a particular area, the impacts of existing and planned activities, and measures to prevent harmful effects on the environment and human health. Before opening a mine, the practice is that the company initiating the opening and operation of the mine is obliged to ensure that the study will thoroughly address and present all potential cumulative impacts of the project on the environment. More importantly, for each detected potential impact, it is necessary to explicitly list measures for its minimisation, as well as monitoring plans for various media. Monitoring both the environment and the health of the population represents key aspects of sustainable mining, where regular implementation and continuity must be ensured to timely identify and minimise potential negative impacts on the environment and human health.

Improving safety and sustainability in mining – modern practices

In recent years, global attention in mining has been focused on improving the legal frameworks that regulate safety in the mining sector. This progress is the result of collaboration between governments and international organisations, which are aware of the need for a modern approach to addressing new challenges and reducing the negative impacts of mining activities on the environment and human health.

The International Council on Mining and Metals (ICMM) represents one of the important initiatives and brings together leading global companies in the mining and metallurgy sectors. Their set of core business principles promotes responsible mining practices, environmental sustainability, and worker safety (International Council on Mining & Metals [ICMM], 2024). In recent years, the global trend has been the improvement of legislation in the mining sector. It has been noted that many countries at the national level are improving legislation to address local specifics and challenges within the mining industry.

In practice, companies in the mining sector implement various measures to ensure a safe working environment. This includes quality training programs to educate workers about the risks of mining work and protective and preventive measures, the application of modern technologies for automation and monitoring of working conditions in mines, as well as the use of personal protective equipment (Arbak, 2015; Agboola et al., 2020; Kursunoglu et al., 2022). In addition, creating effective emergency response plans and continuously monitoring the health of workers helps with prevention and timely treatment when necessary. A very important feature of responsible business practices in mining is also improving community awareness. Involving the local community in decision-making processes is also of great importance, and such actions by companies managing mines build trust and foster opportunities for cooperation between companies and communities.

Following the development of mining, as well as methods for monitoring various environmental parameters, the continuous advancement of technologies applied in this industry, and the integration of advanced technologies such as artificial intelligence and robotics, collectively reduce the level of worker exposure to hazards and optimise safety standards (Hyder et al., 2019). At the same time, the global trend towards sustainable practices in mining requires a reduction in potentially negative environmental impacts (Gorman & Dzombak, 2018). In light of the increasing demand for resources, the mining industry will have obligations to balance the sustainability of this sector, the protection of worker health, and market needs.

Conclusion

Responsible management of mining activities, particularly in the context of potential projects being implemented worldwide, as well as within the territory of the Republic of Serbia, requires a comprehensive approach that includes the application of the latest sustainable technological solutions in mining, the implementation of environmental protection measures, and transparent participation of all stakeholders in achieving responsible management of mining activities. A comprehensive approach involves the application of modern technologies, the improvement of regulations, and the strengthening of cooperation between states and companies operating in this industry. This approach is key to achieving responsible mining that is safe for workers, the population, and the environment. The application of best available techniques for waste management, water treatment, and control of GHG emissions in mining areas enables the minimisation of their potentially negative impact on the environment and public health. Continuous environmental monitoring and the involvement of local communities in monitoring information related to mining operations contribute to improving public awareness of the technologies applied and safety measures.

The integration of multi-sectoral cooperation between state institutions, scientific organisations, the civil sector, and local governments contributes to more efficient solutions to challenges or unforeseen events related to mining, while adhering to domestic and European standards in mining and environmental protection. In addition to technical measures, raising the level of awareness and consciousness among the population, as well as informing employees in this industry, plays a significant role in achieving the sustainability of mining and the preservation of natural resources and a safe environment.

References

Agboola, O., Babatunde, D. E., Isaac Fayomi, O. S., Sadiku, E. R., Popoola, P., Moropeng, L., Yahaya, A., & Mamudu, O. A. (2020). A review on the impact of mining operation: Monitoring, assessment and management. *Results in Engineering*, 8, 100181. doi.org/10.1016/j.rineng.2020.100181

Ali, B., Loubna, B., & Leila, B. (2021). Impacts of mining activities on soil properties: case studies from Morocco mine sites. *Soil Science Annual*, 71 (4), 395–407. doi.org/10.37501/soilsa/133011

Arbak, P. (2015). Precautions for the Prevention of Mine Accidents and Related Respiratory Emergencies. *Turkish Thoracic Journal / Türk Toraks Dergisi*, 16 (1), 25–26. doi.org/10.5152/ttd.2015.007

Behmel, S., Damour, M., Ludwig, R., & Rodriguez, M. J. (2016). Water quality monitoring strategies - A review and future perspectives. *The Science of the total environment*, 571, 1312–1329. doi.org/10.1016/j.scitotenv.2016.06.235

Cakaj, A., Drzewiecka, K., Hanć, A., Lisiak-Zielińska, M., Ciszewska, L., & Drapikowska, M. (2024). Plants as effective bioindicators for heavy metal pollution monitoring. *Environmental Research*, 256, 119222. doi.org/10.1016/j.envres.2024.119222

Chovanec, A., Hofer, R., & Schiemer, F. (2003). Chapter 18 Fish as bioindicators. *Trace Metals and Other Contaminants in the Environment*, 639–676. doi.org/10.1016/s0927-5215(03)80148-0

Ciesielski, T., Pastukhov, M. V., Fodor, P., Bertenyi, Z., Namieśnik, J., & Szefer, P. (2006). Relationships and bioaccumulation of chemical elements in the Baikal seal (Phoca sibirica). *Environmental Pollution*, 139 (2), 372–384. doi.org/10.1016/j.envpol.2004.12.040

Costa, C., Teixeira, J. P. (2014). Biomonitoring. *Encyclopedia of Toxicology*. doi.org/10.1016/B978-0-12-386454-3.01000-9

Csavina, J., Field, J., Taylor, M. P., Gao, S., Landázuri, A., Betterton, E. A., & Sáez, A. E. (2012). A review on the importance of metals and metalloids in atmospheric dust and aerosol from mining operations. *Science of the Total Environment*, 433, 58–73. doi.org/10.1016/j.scitotenv.2012.06.013

Ehlers, M., Kastler, T. (2009). Environmental monitoring. In: J. H. Bullinger (ed.), *Technology Guide*. Berlin, Heidelberg: Springer. doi.org/10.1007/978-3-540-88546-7_71

European Commision. (2003). Integrated Pollution Prevention and Control (IPPC) Reference Document on the General Principles of Monitoring. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-03/superseded_mon_bref_0703.pdf

Frohne, T., Rinklebe, J., & Diaz-Bone, R. A. (2014). Contamination of Floodplain Soils along the Wupper River, Germany, with As, Co, Cu, Ni, Sb, and Zn and the Impact of Pre-definite Redox Variations on the Mobility of These Elements. *Soil and Sediment Contamination: An International Journal*, 23 (7), 779–799. doi.org/10.1080/15320383.2014.872597

Furnell, E., Bilaniuk, K., Goldbaum, M., Shoaib, M., Wani, O., Tian, X., Chen, Z., Boucher, D., & Bobicki E.R. (2022). Dewatered and Stacked Mine Tailings: A Review. *ACS ES & T Engineering*, 2 (5), 728–745. doi.org/1021/acsestengg.1c00480

Gorakhki, M. R. H., & Bareither, C. A. (2016). Effects of Salinity on the Geotechnical Characterization of Fine-Grained Soils and Mine Tailings. *Geotechnical Testing Journal*, 39 (1), 45–58. doi.org/10.1520/GTJ20140283

Gorman, M. R., & Dzombak, D. A. (2018). A review of sustainable mining and resource management: Transitioning from the life cycle of the mine to the life cycle of the mineral. *Resources, Conservation and Recycling*, 137, 281–291. doi.org/10.1016/j.resconrec.2018.06.001

Hilson, G., & Murck, B. (2000). Sustainable development in the mining industry: clarifying the corporate perspective. *Resources* Policy, 26 (4), 227–238. doi.org/10.1016/s0301-4207(00)00041-6

Hirvonen, A. (2008). *Biomonitoring*. Springer EBooks, 355–58. doi.org/10.1007/978-3-540-47648-1_643

Hyder, Z., Siau, K., & Nah, F. (2019). Artificial Intelligence, Machine Learning, and Autonomous Technologies in Mining Industry. *Journal of Database Management*, 30 (2), 67–79. doi.org/10.4018/jdm.2019040104

International Council on Mining & Metals. (2024). Mining principles: Performance expectations for environmental, social and governance practices. Available at: https://pimcore.icmm.com/website/publications/pdfs/mining-principles/mining-principles.pdf?cb=59962

Jiménez-Oyola, S., Valverde-Armas, P.E., Romero-Crespo, P. et al. (2023). Heavy metal(loid)s contamination in water and sediments in a mining area in Ecuador: a comprehensive assessment for drinking water quality and human health risk. *Environ Geochem Health*, 45, 4929–4949. doi.org/10.1007/s10653-023-01546-3

Jiang, J., Tang, S., Han, D., Fu, G., Solomatine, D., & Zheng, Y. A. (2020). Comprehensive review on the design and optimization of surface water quality monitoring networks. *Environmental Modelling & Software*, 132, 104792

Knežević, D., Nišić, D., Cvjetić, A., Ranđelović, D., Sekulić, Z. (2015). *Monitoring in the environment - Selected chapters*. Beograd: Univerzitet u Beogradu – Rudarsko geološki fakultet. [In Serbian]

Kursunoglu, N., Onder, S., & Onder, M. (2022). Evaluation of Personal Protective Equipment Usage Habit of Mining Employees Using Structural Equation Modeling. *Safety and Health at Work*, 13 (2). doi.org/10.1016/j.shaw.2022.03.004

Laurence, D. (2005). Safety rules and regulations on mine sites – The problem and a solution. *Journal of Safety Research*, 36(1), 39–50. doi.org/10.1016/j.jsr.2004.11.004

Laurence, D. (2011). Establishing a sustainable mining operation: an overview. *Journal of Cleaner Production*, 19 (2–3), 278–284. doi.org/10.1016/j.jclepro.2010.08.019

Loredo, J., Petit-Domínguez, M. D., Ordóñez, A., Galán M. P., Fernández-Martínez, R., Alvarez, R., & Rucandio M. I. (2010). Surface water monitoring in the mercury mining district of Asturias (Spain). *Journal of Hazardous Materials*, 176, 323–332. doi.org/10.1016/j.jhazmat.2009.11.031

Metcalfe, J. L. (1989). Biological water quality assessment of running waters based on macroinvertebrate communities: History and present status in Europe. *Environmental Pollution*, 60 (1–2), 101–139. doi.org/10.1016/0269-7491(89)90223-6

Michalak, I., Chojnacka, K. (2014). Effluent Biomonitoring. *Encyclopedia of Toxicology*. doi.org/10.1016/B978-0-12-386454-3.01008-3

Modoi, O-C., Roba, C., Török Z., & Ozunu A. (2014). Environmental risks due to heavy metal pollution of water resulted from mining wastes in northwest Romania. *Environmental Engineering and Management Journal*, 13 (9), 2325–2336. http://omicron.ch.tuiasi.ro/EEMJ/

Molina-Villalba, I., Lacasaña, M., Rodríguez-Barranco, M., Hernández, A. F., Gonzalez-Alzaga, B., Aguilar-Garduño, C., & Gil, F. (2015). Biomonitoring of arsenic, cadmium, lead, manganese and mercury in urine and hair of children living near mining and industrial areas. *Chemosphere*, 124, 83–91. doi.org/10.1016/j.chemosphere.2014.11.016

Nagajyoti, P. C., Lee, K. D., & Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: a review. *Environmental Chemistry Letters*, 8 (3), 199–216. doi.org/10.1007/s10311-010-0297-8

Nieder, R., & Benbi, D. (2024). Potentially toxic elements in the environment – a review of sources, sinks, pathways and mitigation measures. *Reviews on Environmental Health*, 39 (3), 561–575. doi.org/10.1515/reveh-2022-0161

Nordstrom, D.K. (2011). Hydrogeochemical processes governing the origin, transport and fate of major and trace elements from mine wastes and mineralized rock to surface water. Applied Geochemistry, 26, 1777–179. doi.org/10.1016/j.apgeochem.2011.06.002

Onifade, M., Zvarivadza, T., Adebisi, J. A., Said, K. O., Dayo-Olupona, O., Lawal, A. I., & Khandelwal, M. (2004). Advancing toward sustainability: The emergence of green mining technologies and practices. *Green and Smart Mining Engineering*, 1 (2), 157–174. doi.org/10.1016/j.gsme.2024.05.005

Pavan Kumar, N. (2014). Review on Sustainable Mining Practices. International Research. *Journal of Earth Sciences*, 2 (10), 26–29. Available at: https://www.isca.me/EARTH_SCI/Archive/v2/i10/4.ISCA-IRJES-2014-030.pdf

Ponting, J., Kelly, T.J., Verhoef, A., Watts, M.J., Sizmur, T. (2021). The impact of increased flooding occurrence on the mobility of potentially toxic elements in floodplain soil – A review. *Science of The Total Environment*, 754, 142040

Rakete, S., Moonga, G., Wahl, A.-M., Mambrey, V., Shoko, D., Moyo, D., Muteti-Fana, S., Tobollik, M., Steckling-Muschack, N., & Bose-O’Reilly, S. (2021). Biomonitoring of arsenic, cadmium and lead in two artisanal and small-scale gold mining areas in Zimbabwe. *Environmental Science and Pollution Research*. doi.org/10.1007/s11356-021-15940-w

Rinklebe, J., Antoniadis, V., Shaheen, S. M., Rosche, O., & Altermann, M. (2019). Health risk assessment of potentially toxic elements in soils along the Central Elbe River, Germany. *Environment international*, 126, 76–88. doi.org/10.1016/j.envint.2019.02.011

Ruppen, D., Chituri Owen, A., Meck Maideyi, L., Pfenninge,r N., & Wehrli, B. (2021). Community-Based Monitoring Detects Sources and Risks of Mining-Related Water Pollution in Zimbabwe. *Frontiers in Environmental Science*, 9, 754540. doi.org/10.3389/fenvs.2021.754540

Sahu, H. B., Prakash, N., & Jayanthu, S. (2015). Underground Mining for Meeting Environmental Concerns – A Strategic Approach for Sustainable Mining in Future. *Procedia Earth and Planetary Science*, 11, 232–241. doi.org/10.1016/j.proeps.2015.06.030

U.S. Environmental Protection Agency. (2000, February). Bioaccumulation testing and interpretation for the purpose of sediment quality assessment: Status and needs (Table 4-2). Available at: https://archive.epa.gov/water/archive/polwaste/web/pdf/bioaccum.pdf

U. S. Environmental Protection Agency. (2021). Toxics in the food web. Available at: https://www.epa.gov/salish-sea/toxics-food-web

U.S. Environmental Protection Agency. (2022). Introduction to biomonitoring topics. Available at: https://www.epa.gov/system/files/documents/2022-10/biomonitoring_intro.pdf

Wang, C., Harbottle, D., Liu, Q., & Xu, Z. (2014). Current state of fine mineral tailings treatment: A critical review on theory and practice. *Minerals Engineering*, 58, 113–131. doi.org/10.1016/j.mineng.2014.01.018

Wei, W., Ma, R., Sun, Z., Zhou, A., Bu, J., Long, X., & Liu, Y. (2018). Effects of Mining Activities on the Release of Heavy Metals (HMs) in a Typical Mountain Headwater Region, the Qinghai-Tibet Plateau in China*. International journal of environmental research and public health*, 15 (9): 1987. doi.org/10.3390/ijerph15091987