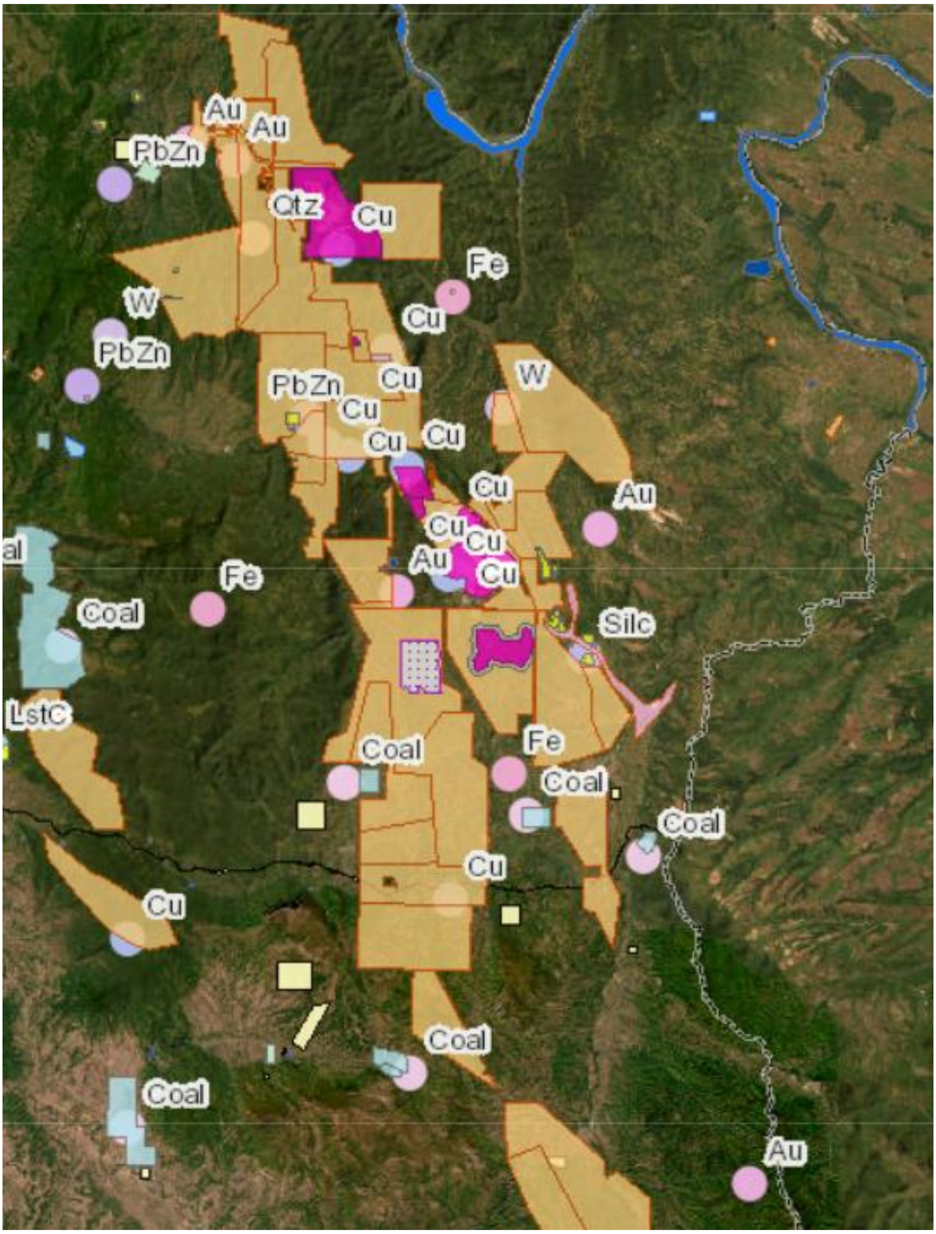
# THE ENVIRONMENT OF TIMOČKA KRAJINA




ZAJEČAR, 2024.

**On the cover: Map of exploration and exploitation fields in the Timok Region. Taken from the website of the Ministry of Mining and Energy of the Republic of Serbia https://gis.mre.gov.rs/smartPortal/Srbija**

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**ENVIRONMENTAL RESPONSE**
**TO MINING EXPANSION IN TIMOČKA KRAJINA**

# THE ENVIRONMENT OF TIMOČKA KRAJINA

**ZAJEČAR, 2024.**

# C O N T E N T

# INTRODUCTION

Since the liberation from the Ottomans, the Timok Region has been a source of both renewable and non-renewable resources. It began with the exploitation of forests in the 19th century, continued with the opening of coal mines, and then metal and non-metal mines in the 20th and 21st centuries. Geological research and the opening of new metal mines have intensified in the last two decades. It is known that mining is an activity that leads to degradation, pollution, and endangerment of the environment, ultimately affecting the quality of life and health of the local population.

In recent years, there have been significant changes in mine ownership, intensification of geological research, expansion of existing and opening of new surface mines and pits, establishment of mining waste (tailings) and flotation tailings deposits, closure of processing industry slag dumps, i.e., occupation of new areas by mining activities, relocation of entire villages, air, water, and land pollution.

The citizens' association "Za Drinking Fountains" from Zaječar, together with the "Children's Center" from this city and the Association of Young Researchers and the Civic Library "Europe" from Bor, launched the project "Environmental Response to Mining Expansion in Timočka Krajina". The main goal of the project is to contribute to the improvement of the environment in the Timok Region by raising awareness among citizens to actively participate in public policies and decision-making in the field of environmental protection and climate change in line with best practices in the European Union. One of the specific objectives is to determine the existing situation and further monitor the harmful impact of mining and urban development on the environment in the Timok Region, as well as effective supervision of the impact of public and private investments on the environment and climate. This is achieved by monitoring the results of air, groundwater, and surface water quality monitoring, establishing a database on the state and changes in the territory of Majdanpek, Bor, and Zaječar, informing the public about the state of the environment, educating, primarily children, and involving the public in the processes of drafting national and local public policy documents.

The Ministry of Mining and Energy of the Republic of Serbia has issued a series of concessions for the exploration of copper ores, precious and non-ferrous metals, and non-metallic mineral resources in Timočka Krajina. Domestic and foreign companies have exploitation rights for copper, gold, silver, coal, limestone, and quartz in mines in Majdanpek, Bor, Rgotina, Vrska Čuka, Lubnica, and Bogovina.

Intensive and numerous geological surveys are being conducted without an environmental impact assessment study. In many cases, new ore deposits are discovered, and requests for exploitation and opening of new mines are submitted, often avoiding or formally applying the legally prescribed procedures for public participation in decision-making processes in the preparation of spatial plans of special purpose, strategic and environmental impact assessments. When mining begins, citizens react, leading to conflicts between investors and the local population.

The Ministry of Mining and Energy of the Republic of Serbia has issued permits for exploration at nearly 50 locations: from the Danube in the north to Rtanj and Stara Planina in the south, Timok in the east, and Pek in the west. The search for copper, precious metals (gold and silver), as well as iron, lead, zinc, and rare metals (vanadium, molybdenum, germanium, rhenium), is prominent in most exploration fields. In addition to metals and coal, there is a significant search for non-metallic minerals (limestone, calcite, marble, quartz) in Timokčka Krajina. Exploration rights are mostly held by subsidiaries of large international mining companies.

Exploitation rights for copper and precious metals in Bor and Majdanpek belong to: Serbia ZiJin copper (a joint company of the Republic of Serbia and the Chinese company ZiJin Mining), Serbia ZiJin Mining (100% ownership by ZiJin Mining from China). The right to exploit calcite in the Potaj Čuka mine near Zagubica belongs to the Institute of Mining and Metallurgy from Bor, marble to Mat Produkt doo from Vinča, and limestone to Serbia ZiJin copper. The Timok Region is rich in quality quartz, and the right to exploit it in the mines in Rgotina and Donja Bela Reka belongs to the company Jugokaolin registered in Belgrade. Coal mines in Čitluk near Sokobanja, Bogovina, Lubnica, and Vrska Čuka are managed by the state-owned Public Enterprise for Underground Coal Exploitation Resavica.

***Table 1. Exploration and Exploitation Fields***[1]

| Location | Cadastral Number | Municipality | Mineral Type | Company |
|---|---|---|---|---|
| Brodica | 2284 | Kucevo, Golubac | Gold, Silver, Copper | Konstantin Resources doo, Belgrade |
| Voluja-Debeli Lug | 2551 | Kucevo, Majdanpek | Gold | Aurelius Exploration doo, Ljig |
| Trstenik | 2546 | Kucevo, Majdanpek | Copper, Gold | Nova Planina Resources doo, Belgrade |
| Homolje Area | 2497 | Kucevo, Majdanpek, Zagubica | Gold (Copper, Silver, Lead-Zinc, Vanadium), Quartz | Calico Metals doo, Belgrade |
| Majdanpek | Exploitation right since 1976 | Majdanpek (99%), Kucevo (1%) | Copper | Serbia ZiJin copper doo, Bor |
| Bukova Glava | 2309 | Majdanpek | Copper, Base Metals | Golden Age Resources doo, Belgrade |
| Kupinova Glava | 2455 | Kucevo, Majdanpek, Zagubica | Copper, Gold, Silver, Iron, Lead, Zinc, Vanadium | Konstantin Resources doo, Belgrade |
| Jasikovo-Durlan Potok | 2534 | Bor, Majdanpek | Copper, Gold (Silver, Molybdenum, Germanium, Rhenium) | Serbia ZiJin mining doo, Bor |

[1] Министарство рударства и енергетике, Катастар истражних и експлоатационих поља минералних сировина, https://gis.mre.gov.rs/smartPortal/Srbija, прегледано 30.11.2023

| | | | | |
|---|---|---|---|---|
| Choka Marin | Exploitation right since 2012 | Majdanpek (100%) | Copper, Gold, Silver | Serbia ZiJin copper doo, Bor |
| Potaj Chuka | 2578 | Majdanpek, Zagubica | Gold | Crni Vrh Resources doo, Belgrade |
| Potaj Chuka North | Exploitation right since 2009 | Zagubica (100%) | Calcite as carbonate raw material | Institute of Mining and Metallurgy, Bor |
| Choka Kuruga | 2378 | Majdanpek, Bor, Zagubica | Copper, Gold | Serbia ZiJin copper doo, Bor |
| Potaj Chuka | Exploitation right since 2014 | Zagubica (100%) | Marble as calcium carbonate raw material | Mat Produkt doo, Vinca |
| Choka Rakita | 2535 | Zagubica | Gold and associated metals | Crni Vrh Resources doo, Belgrade |
| Valja Strež | Exploitation right since 2005 | Zagubica (100%) | Andesite | EMS Kijevo ad, Belgrade |
| Umka | 2174 | Bor, Zagubica | Gold and associated metals | DPM Avala doo, Belgrade |
| Choka Kupjatra - East Polygon 2 | 2184 | Bor | Copper, Gold | Tilva doo, Belgrade |
| Cerovo Cementation | Exploitation right since 1991 | Bor | Copper | Serbia ZiJin copper doo, Bor |
| Cerovo North 1 | 2520 | Bor | Copper, Gold | Serbia ZiJin copper doo, Bor |
| Cerovo North 2 | 2520 | Bor | Copper, Gold | Serbia ZiJin copper doo, Bor |
| Mali Krivelj - Brezanik | 2270 | Bor | Copper, Gold | Serbia ZiJin copper doo, Bor |
| Krivelj | Exploitation right since 2006 | Bor | Limestone | Serbia ZiJin copper doo, Bor |
| Tilva Njagra | 2559 | Bor | Copper, Gold, Associated metals | Tilva doo, Belgrade |
| Veliki Krivelj | Exploitation right since 2018 | Bor | Copper | Serbia ZiJin copper doo, Bor |
| Makoviste | 2543 | Bor, Zaječar | Copper, Gold, Silver, Lead, Zinc | Golden Age Resources doo, Belgrade |

| | | | | |
|---|---|---|---|---|
| Luka | 2310 | Bor | Copper, Base Metals | Golden Age Resources doo, Belgrade |
| Northern Part of Deli Jovan | 2459 | Bor, Majdanpek, Negotin | Gold, Silver, Copper, Iron, Molybdenum | Appalachian Resources Balkan doo, Belgrade |
| Velike Poljane 1 and 2 | Exploitation right since 1982 | Zaječar | Quartz Sand | Jugo-Kaolin doo, Belgrade |
| Part and North Part of Donja Bela Reka | Exploitation right since 2019 | Bor | Quartz Sand | Jugo-Kaolin doo, Belgrade |
| Oblaci | Exploitation right since 1978 | Bor | Quartz Sand | Jugo-Kaolin doo, Belgrade |
| Branik | 2499 | Bor | Copper, Gold | Valdor Resources doo, Belgrade |
| Padina | 2151 | Bor | Copper, Gold | Valdor Resources doo, Belgrade |
| Rgotski Kamen | Exploitation right since 1960 | Bor | Limestone | Serbia ZiJin copper doo, Bor |
| Skorusa | 2401 | Bor, Bonjevac | Copper, Gold | Valdor Resources doo, Belgrade |
| Alluvium of the White River | 2389 | Bor, Zaječar | Secondary concentration of gold | Pro Ore doo, Belgrade |
| Brestovac-Metovnica | 2527 | Bor | Copper, Gold | Serbia ZiJin mining doo, Bor |
| Čukaru Peki | Exploitation right since 2020 | Bor | Copper, Gold | Serbia ZiJin mining doo, Bor |
| Nikolichevo | 2570 | Bor, Zaječar | Copper, Gold | Tilva doo, Belgrade |
| Nikolichevo East | 2182 | Zaječar | Copper, Gold | Tilva doo, Belgrade |
| Oblez | 2400 | Bor, Zaječar, Boljevac | Copper, Gold | Valdor Resources doo, Belgrade |
| Bogovina | Exploitation right since 1989 | Boljevac | Lignite | PEU, Resavica |

| | | | | |
|---|---|---|---|---|
| Bobot | 2463 | Boljevac, Bor | Copper, Gold | Southwest minerals doo, Belgrade |
| Odej Jug | 2481 | Boljevac, Zaječar | Copper, Gold | Southwest minerals doo, Belgrade |
| Lubnica | Exploitation right since 1969 | Zaječar | Lignite | PEU, Resavica |
| Gramada | 2480 | Boljevac, Zaječar, Knjazevac | Copper, Gold | Southwest minerals doo, Belgrade |
| Vrska Chuka | Exploitation right since 1968 | Zaječar | Stone Coal | PEU, Timocki rudnici |
| Kraljevica | 2492 | Zaječar | Copper, Gold | Balkan Exploration and Mining doo, Belgrade |
| Vitanovac | 2311 | Knjazevac, Sokobanja | Copper, Gold | Stara Planina Resources doo, Belgrade |

During the project implementation period, there have been significant investments in expanding existing and opening new copper mines, flotation for copper concentrate production, and increasing the capacity of metallurgical facilities.

In Majdanpek, the exploitation of ore in surface mines in the northern and southern districts has been greatly increased, flotation capacity has been doubled, and the Valja tailings pond has been exceeded.

Near Bor, a new surface mine, Cerovo 2, has been opened, the surface mine in Veliki Krivelj is expanding, a new copper flotation plant has been built, a new flotation tailings facility "Veliki Krivelj - zero field" has been formed, and a tunnel has been excavated to divert the Krivelj River into the Bor River while the bed of the Krivelj River will be dried up. Capacities of the copper smelter in Bor have been increased by 2.5 times, new electrolysis, gold refining, and power plants have been built, a plant for sulfur dioxide removal, a new sulfuric acid factory, facilities for treating metallurgical wastewater and mine process water from the pit and Cerovo have been constructed, a new flotation plant for processing metallurgical slag has been built, and the flotation tailings facility of the RTB mining part above the city level has been exceeded. Preparatory work is underway for the exploitation of copper ore in the Bor pit and the relocation of the Bor-Majdanpek railway tunnel.

The limestone mines of Kriveljski Kamen and Zagrađe 5 have been expanded for copper production, and a new lime factory has been built in Zagrađe. The Čukaru Peki mine - upper zone with pit mining has started operations, and a new flotation plant has been built for ore processing.

A filling plant has been built for the needs of the new mine to fill pit tunnels, a water intake on the Brestovac River, and numerous infrastructure facilities have been constructed.

Exploratory work is ongoing in the lower zone of the Čukaru Peki mine, accompanied by the opening of exploratory pit tunnels and high-rise wind shafts. Temporary settlements have been built for workers on almost all construction sites without spatial and urban plans.

These intensive investment activities have been accompanied by the construction of new infrastructure: power lines, electrical substations, but not road networks, so the transport of equipment and materials for these works has been carried out on existing roads, leading to their damage as well as damage to bridges.

# ANALYSIS OF PUBLIC POLICY DOCUMENTS ON AIR AND WATER QUALITY

## Analysis of Key Public Policy Documents on Air and Water Quality in the Cities of Bor and Zaječar

Within the project "Environmental Response to Mining Expansion in the Timok Region," funded by the European Union and implemented by the Association "Za Drinking Fountains," the Association of Young Researchers Bor, Civic Library "Europe" Bor, and "Children's Center" Zaječar, the analysis of existing public policy documents addressing air and water quality issues is foreseen. The analysis is based on collected documentation encompassing over a hundred documents at the international, national, and local levels of the cities of Bor and Zaječar. The documents include international plans, European directives and strategies, as well as legal regulations, strategies, programs, and plans at the national and local levels. The initial analysis was conducted separately for air and water quality issues, based on the project website's database.[2] This second analysis delves into the most important national and local documents of the cities of Bor and Zaječar in more detail, which were not covered in the first analysis because they were still in the drafting process, and some of them have not yet completed the adoption process and started implementation.

When it comes to the issue of air and water protection, important new national strategic documents that are of particular significance for the cities of Bor and Zaječar, for which the drafting process has been completed through the work of working groups, public consultations, and public debates, but which have not yet been adopted, are the INEKP[3] and the Environmental Protection Strategy of Serbia, while the Program for Adaptation to Climate Change[4] was adopted at the end of 2023.

The Integrated National Energy and Climate Plan of the Republic of Serbia for the period until 2030, with projections until 2050, has been finalized, and its adoption is expected in early 2024. The goal of developing the Integrated National Energy and Climate Plan is to align with the directions and goals of changes in the European Union and global frameworks.

The Integrated National Energy and Climate Plan of the Republic of Serbia provides an overview of the current situation in the Republic of Serbia, key policies, and appropriate measures for addressing five specific dimensions:

1. Decarbonization (greenhouse gas emissions and renewable energy),
2. Energy efficiency,
3. Energy security,
4. Internal energy market, and
5. Research, innovation, and competitiveness.

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[2] https://ekoloskiodgovor.rs/wp-content/uploads/2022/08/31.07.2022.-Pregled-prikupljanjih-podataka-o-zakonskim-i-programskim-dokumentima-javne-politike-o-vodi-i-vazduhu.pdf
[3] https://www.mre.gov.rs/tekst/sr/1094/-javne-konsultacije-i-javna-rasprava-na-predlog-uredbe-o-utvrdjivanju-inekp-a.php
[4] https://www.srbija.gov.rs/extfile/sr/757248/program-prilagodjavanja-na-izmenjene-klimatske-uslove-za-period-od-2023-do-2030_0098_cyr.zip

As part of the work on the Integrated National Energy and Climate Plan of the Republic of Serbia, a particular challenge was defining new targets in the areas of energy efficiency, renewable energy sources, and greenhouse gas emissions reduction by 2030, with a vision until 2050. The targets are set for the following priority areas: climate change and greenhouse gas emissions reduction by 2030 compared to 1990; renewable energy sources; improving energy efficiency; energy security; internal energy market; and research, innovation, and competitiveness.

In the decarbonization area, the main goal is to reduce greenhouse gas emissions by 40.3% compared to 1990. Priority is also given to climate change adaptation, which will be determined by a specific adaptation program to changing climate conditions. Circular economy and bioeconomy will be encouraged, along with significant technological changes in production processes in various industrial sectors to reduce greenhouse gas emissions. This includes modernizing technological procedures in industrial processes and increasing efficiency in preventing emissions of pollutants into the air, water, and soil in metal production and processing, chemical industry, waste management, food processing plants, etc., through the application of best available techniques (BAT) in accordance with BREF documents for specific areas of industrial production. Measures to improve waste water treatment and promote circular economy and higher levels of recycling are also included.

In the area of renewable energy sources, the main goal is to achieve a share of at least 33.6% of renewable energy sources in gross final energy consumption. This involves promoting new innovative RES technologies (installation of floating photovoltaic power plants and vertical wind turbines, promoting small wind turbines, building concentrated solar power plants, and developing advanced geothermal systems as part of innovative and demonstration pilot projects). Defined measures also include promoting electricity production for own use, supporting projects for the promotion and construction of renewable hydrogen infrastructure in all sectors of final consumption, and more.

In the area of energy efficiency, the goal is to limit final energy consumption, and in the area of energy security, the main goal is to diversify energy sources. Measures include supporting the promotion of energy efficiency and regulatory measures in the industrial sector (introduction of cogeneration systems, promoting circular economy, including the use of waste heat, and increasing digitization of industrial processes). Efforts to increase energy security aim to ensure optimal use of domestic energy sources, with a focus on increased use of renewable energy sources. Measures include improving regional electricity and gas connections, intensifying efforts for Serbia's gasification, building energy storage capacity, and more.

The Climate Change Adaptation Program for the period from 2023 to 2030 was adopted by the Government of the Republic of Serbia at a session held on December 25, 2023. The program is based on the results of scientific research on climate change in the Republic of Serbia, including an analysis of observed climate changes in the past period and scenarios of future climate changes. The impacts of climate change are analyzed in relation to particularly vulnerable sectors at the national level: health and human safety, agriculture, water management, forestry, transportation and road infrastructure, energy, urban planning and development, and biodiversity. The action plan for implementing the program covers the period from 2024 to 2026 and includes 25 measures, as well as financial, institutional, and time frames for their implementation and monitoring. Among the measures are those that envisage strengthening the capacities of local communities to, in addition to implementing numerous measures of the national program, adopt and implement local climate change adaptation plans.

The program contains four specific objectives and measures for their implementation: increasing awareness, improving knowledge and understanding of the impacts of climate change and their consequences (13 measures); establishing and strengthening capacities for systematic implementation of adaptation processes to changing climate conditions from the national to the local level (5 measures); increasing resilience to climate change of critical infrastructure and natural resources (3 measures); and improving financial support for implementing processes of adaptation to changing climate conditions (4 measures).

The development of the Environmental Protection Strategy - Green Agenda for the Republic of Serbia for the period 2024-2033, after a series of consultations and the work of a working group, entered the final stage of drafting the document in early 2024, which will be submitted for public consultation and then adopted. In the process of drafting the Strategy, the objectives of the EU Green Agenda have been integrated, in line with the Sofia Declaration signed by the Republic of Serbia in November 2020, as well as measures for further alignment with the regulations and standards of the European Union. In line with the pillars of the Green Agenda, the national environmental protection policy will focus on several key areas:

1. Climate change and emissions reduction: focusing on reducing greenhouse gas emissions and adapting to changing climate conditions, utilizing renewable energy sources, energy efficiency, and reducing dependence on fossil fuels.
2. Circular economy: focusing on industrial symbiosis, waste utilization, responsible recycling, sustainable production, innovation, eco-design, green public procurement, and efficient resource use.
3. Environmental pollution reduction: improving air, water, and soil quality, reducing industrial pollution and risk management, chemical management, reducing environmental noise, ionizing and non-ionizing radiation.
4. Biodiversity and ecosystem protection: protection and sustainable management of natural resources, including sustainable forest management and protection of protected areas and wildlife species.
5. Sustainable food systems and rural development: the impact of agriculture on the environment, food safety, sustainable food production, organic food, and the use of specific chemicals (pesticides and fertilizers).

In addition to improving the legal and institutional framework for environmental protection, the key objectives of the Strategy include strengthening a low-carbon economy, stimulating innovation and the development of "green" technologies to support green economic growth and create new green jobs, as well as actively participating in the fight against climate change.

The Strategy analyzes the achievement of environmental protection goals in the previous period, the state of the environment, and influencing factors (air, water, soil quality, industrial pollution, accident risk, chemical management, etc.), climate change (mitigation of climate change impacts, adaptation to altered climate conditions), circular economy (waste utilization), biodiversity and ecosystems (nature and biodiversity protection, forests, etc.), agriculture and rural development, state of institutional capacities and environmental financing. Based on the analysis, primary problems have been identified. For the air and water quality domain, it was identified that ambient air quality is not satisfactory, and a large number of residents are exposed to poor air quality, which can negatively affect health. Emissions from energy, transportation, industry, and agriculture sectors contribute to air pollution. Air quality monitoring is inadequate, considering the insufficient number of parameters measured and insufficient automatic stations in local government units. About 25% of surface water bodies in the Republic of Serbia have weak or poor ecological status. It is estimated that 12% of groundwater is in poor quantitative status. There is insufficient monitoring of surface and groundwater quality. Less than 15% of wastewater collected is treated. Still, a small number of industrial facilities carry out pretreatment of technological wastewater before discharging into sewage networks or other receptors.

The Strategy establishes 5 main objectives and specific goals for each of the key areas of the Strategy. The main goal for air and water is pollution reduction, with specific goals of improving air quality and enhancing water quality through integrated water management with effective pollution control. Reduction of emissions of pollutants into the air from industrial facilities will be achieved through the reconstruction of all facilities falling under the EU Industrial Emissions Directive. Specific challenges in water protection include pressures on the amount of water pumped for industrial needs and the discharge of untreated wastewater. For each of the specific goals, the Strategy identifies specific measures to be developed in the first Action Plan for the period 2024-2028. The development of the Bor City Development Plan began in 2020 with the adoption of appropriate decisions and the formation of a Coordination Committee and working groups for document preparation. During the preparation of the Bor City Development Plan, in cooperation with local self-government and civil society organizations in 2021 and 2022, special documents were prepared: Contribution to the Bor City Development Plan in the field of environmental protection[5] and Initiative for embedding certain sustainable development goals in the Bor City public policy documents in the field of the environment.[6]

For water management and air protection, the following significant goals have been defined:

- Sustainable use of mineral resources through the development of green mining concepts that promote the development of other economic sectors, infrastructure, improve quality of life, and aim to reduce negative environmental impacts.
- Improvement of air quality through cooperation and support in solving aerosol pollution problems from industrial and mining facilities, district heating facilities, and individual furnaces, optimization of traffic (bypasses, bicycle lanes, public transportation), etc.
- Established system for providing and managing healthy drinking water and water for industrial and other needs, requiring improvement of existing monitoring, construction of a clean water plant, construction of a turbidity removal plant from

[5] https://mibor.rs/wp-content/uploads/2022/03/Doprinos-Planu-razvoja-Grada-Bora-u-oblasti-zaštite-životne-sredine.pdf
[6] https://mibor.rs/wp-content/uploads/2022/02/Inicijativa-ugradivanja-COR-u-javna-dokumenta-Bora.pdf

raw water, replacement of remaining asbestos pipes in the network, improving protection of water sources.

- Established system for wastewater treatment, both municipal and industrial, introduction of continuous monitoring of watercourses and creation of a water polluters register, followed by implementation of sewage system upgrades, separation of municipal and atmospheric waters, construction of larger and smaller wastewater treatment plants, maximum closure of industrial wastewater systems through recirculation and eventual discharge into watercourses only with appropriate treatment, revitalization of degraded watercourses, reclamation of areas filled with flotation tailings, etc.

The Environmental Protection Program for the City of Bor for the period 2023-2032[7] was prepared during 2023. In early 2024, a public consultation was organized, and its adoption is expected in the first half of 2024. This document is a key local strategy covering all areas of the environment and serves as the basis for the adoption of specific local environmental protection plans in various areas, including air and water quality areas. The Program analyzes strategic international and national environmental documents relevant to local activities and defines the basic and specific goals for local community action in environmental management. Stakeholders interested in addressing environmental issues are identified, and citizens' views and priorities on environmental issues are analyzed. Based on numerous surveys, focus groups, and special analyses, it has been determined that the main environmental problems in the city of Bor are air, water, and soil pollution primarily influenced by mining and metallurgy.

Regarding the implementation of the Program, citizens are optimistic about solving the most important environmental problems, with two-thirds believing that the environmental situation will improve, particularly through historical pollution resolution due to mining, sustainable and green mining development, economic development alignment with environmental protection.

The Program provides a detailed assessment of the environmental status in all key areas (air quality, water, waste management, soil and agricultural product quality, noise, health, natural values, biodiversity, geodiversity, landscape diversity), energy efficiency and renewable energy sources, climate change, green-circular economy, citizen awareness and education, participation in decision-making, and funding sources for program implementation.

Based on the above, the Program establishes 11 specific goals. The first two specific goals of the Program are improving air quality in the Bor agglomeration and reducing harmful impacts on human health due to air pollution, and enhancing the quality of surface and groundwater, sustainable water supply, and wastewater management in the territory of the city of Bor.

The Action Plan of the Environmental Protection Program elaborates on specific goals and defines measures and tasks for their implementation. It emphasizes that the operationalization of goals and measures to address air quality issues will be realized through the existing Short-Term Action Plan for reducing air pollution in the city of Bor, as well as through the future implementation of a new Air Quality Plan for the Bor agglomeration expected to be adopted in early 2024. The most important goals and

[7] https://bor.rs/notices/gradsko-vece-grada-bora-upucuje-javni-poziv-za-ucesce-u-javnoj-raspravi-o-nacrtu-programa-zastite-zivotne-sredine-grada-bora-za-period-2023-2032-godine/

measures relate to reducing sulfur dioxide emissions from copper smelters and chemical-metallurgical plants through optimization of their operations, as well as reducing diffuse emissions of suspended particles from surface mines, landfills, and flotation tailings through land reclamation.

For the water area, the Action Plan starts from the premise that special goals and measures will be implemented in other local strategic development documents, such as the City Development Plan and the Urban Development Strategy of the city, as well as in the plans and activities of the Public Utility Company Water Supply. However, the need for a separate local water management plan should be assessed in the future period since this area is very complex and covers four special subcategories: water supply, surface water, groundwater, and wastewater treatment. Additionally, aspects of climate change adaptation in water management need to be considered. As for measures and activities related to water quality, the Action Plan of the Environmental Protection Program envisages establishing local surface water quality monitoring, regular riverbed cleaning, creating a registry of surface water polluters, informing the industry about the results of surface and groundwater quality monitoring, etc.

The new Air Quality Plan for the Bor Agglomeration for the period 2022-2030, after the completion of the public consultation on the draft of this document during 2021[8], has been amended and supplemented based on proposals and comments from the Ministry of Environmental Protection. As a result, the public consultation was extended until late 2023[9], and the document was prepared for adoption, expected to take place in early 2024.

The Bor Agglomeration (covering the area of the city of Bor) is defined by the Government of Serbia as one of the eight agglomerations in the Republic of Serbia for which air quality is specifically monitored, and there is an obligation to prepare and implement a special air quality plan. The Air Quality Plan for the Bor Agglomeration provides a detailed analysis of key pollutants (sulfur dioxide, suspended particles PM10 and PM2.5, soot, lead, arsenic, cadmium, nickel, nitrogen dioxide, carbon monoxide, ground-level ozone, benzene, and total suspended matter) as well as the main sources of air pollution, with mining and metallurgy facilities being the most significant in terms of intensity.

According to the Plan, one-third of the Bor Agglomeration's surface area (298 km2) is affected by polluted air from mining and metallurgy facilities. All settlements within a radius of less than 15 kilometers from the Copper Smelter are endangered, with 90% of the Bor Agglomeration's population living in these areas. Therefore, the protection of human health is the primary priority, with particular attention given to facilities where vulnerable groups of the population reside (children, youth, elderly, chronically ill individuals, and others with compromised health).

The Air Quality Plan for the Bor Agglomeration also provides a detailed overview of the monitoring system and network of monitoring stations for air quality monitoring. The network consists of 5 automatic monitoring stations (state network) monitoring the concentrations of sulfur dioxide, nitrogen dioxide, suspended particles PM10 and PM2.5, and carbon monoxide. There is also a local network of semi-automatic and manual stations

[8] https://bor.rs/notices/gradsko-vece-grada-bora-upucuje-javni-poziv-za-ucesce-u-javnoj-raspravi-o-nacrtu-plana-kvaliteta-vazduha-za-aglomeraciju-bor/

[9] https://bor.rs/wp-content/uploads/2023/11/PRODUZETAK-ROKA.docx

monitoring the concentrations of sulfur dioxide, soot, suspended particles, and specifically the concentrations of lead, cadmium, nickel, arsenic, copper, iron, aluminum, zinc, etc.

To reduce and control air pollution, appropriate short-term and long-term measures have been defined for each of the listed pollutants and sources of air pollution. For example, for reducing sulfur dioxide pollution, key measures include completing investments in the construction of a new Smelter and Sulfuric Acid Factory. For reducing high emissions of suspended particles from abandoned surface mines, landfills, and flotation tailings, the most important measures involve the reclamation of degraded areas (terracing, planting grass and trees). Various measures are envisaged to maintain pollutant concentrations below the limit values (related to nitrogen dioxide, carbon monoxide, ground-level ozone, and heavy metals in suspended particles) and their implementation will be overseen by the Permanent Body for Air Quality Monitoring.

In addition to these specific measures, a series of general measures are defined to improve air quality and preserve human health (enhancing air quality monitoring, establishing occupational health services, informing the population about concentrations of hazardous air pollutants, etc.), as well as measures in the field of education, raising environmental awareness, and informing citizens. Measures for institutional strengthening include strengthening relevant local community bodies, enhancing cooperation with relevant state authorities, securing financial resources for the implementation of planned measures, public participation, and monitoring the implementation of the Plan by the public, citizens, and civil society organizations.

The Development Plan of the City of Zaječar for the period 2023-2029[10] was prepared during 2022 and partly in 2023, with its adoption expected in 2024. The plan defines three main development directions: economic, social, and urban development, including environmental protection. For each of these main development directions, the existing situation was analyzed, priority goals were determined, and concrete implementation measures were specified.

In the field of environmental protection, the quality of surface waters was assessed, particularly the waters of the Black and White Timok rivers, which have a moderate to good ecological status based on microbiological and physicochemical parameters (II and III class). The waters of the Great Timok (Timok River) after the inflow of the Bor River are burdened with heavy metals from wastewater from the Bor Mining Complex. This problem takes on a transboundary context considering that the Timok River is the last tributary flowing into the Danube. In contrast, the surface waters of the Rgot Lake have a good ecological status based on microbiological parameters. Zaječar City is characterized by significant availability of groundwater, with a large number of artesian wells (31 artesian wells in public areas). Artesian groundwater is completely bacteriologically safe. Regarding air quality, Zaječar City has the status of an area with third-category air due to exceeding the tolerable values for suspended particles PM10 during the winter heating season, placing it among cities with excessive pollution and the obligation to develop an Air Quality Plan. The Air Quality Plan will determine the impact of air pollution on the environment, health risks to people, and define goals and measures for protection to ensure conditions for a healthy population.

Due to geographical characteristics (position in a valley) and unfavorable meteorological parameters (temperature inversions, humidity, wind rose), the communal environment of Zaječar is exposed to pollution during the winter heating season,

[10] http://www.Zaječar.info/plan-razvoja-grada-Zaječara-za-period-2021-2027-godina

originating from the combustion products of a large number of individual furnaces and boiler houses predominantly using solid fuels (wood and coal).

Among other priority goals, the Development Program of Zaječar City highlights the measure of urban gasification to reduce air pollution, monitoring environmental status parameters (air quality monitoring, municipal noise level, soil, surface, and groundwater, and other environmental status parameters for planning corrections in these areas), as well as the measure of remediating the degraded area with pyrite tailings in the Timok Valley after the inflow of the Bor River. The overflow of pyrite tailings from the flotation tailings of the former RTB Bor has completely destroyed alluvial land, groundwater, the Timok River after the inflow of the Bor River, as well as flora and fauna. The total area of destroyed land exceeds 700 hectares, and indirect damages continue to occur through the dispersion of dried pyrite influenced by wind to surrounding areas, leading to air pollution by transmission of suspended particles. This historical pollution needs to be addressed through remediation by the legal successor of the polluter, in accordance with the law.

The assessment of the environmental status, as well as the prioritized goals and measures in this area determined by the Zaječar City Development Plan, which need to be further specified and operationalized for successful implementation in the next period, indicate the need to promptly adopt a separate Environmental Protection Program for Zaječar City. Additionally, an assessment is needed to determine whether a separate Water Management Plan is necessary, similar to the preparation of a separate Air Quality Plan.

Based on the Decision to commence the drafting of the Air Quality Plan for the City of Zaječar for the period 2023-2031, along with the Action Plan[11], a working version of the Air Quality Plan has been developed. Organized consultations for the preparation of the draft, public hearings on the draft during May and June 2023 were held, and the final adoption of this document is expected in 2024.[12]

The Air Quality Plan for the City of Zaječar was prepared to specify and more successfully implement the goals and measures of the Zaječar City Development Plan, as well as the goals and measures of the national Air Protection Program, based on all available air monitoring data held by the Environmental Protection Office of the City Administration of Zaječar and the Institute of Public Health "Timok" Zaječar, as well as data from the Annual Reports of the Environmental Protection Agency of the Republic of Serbia. The plan includes assessments of air quality status and covers all major pollutants and main sources of air pollution that have led to contamination. It also contains, in particular: data on areas of increased pollution, data on the type and degree of pollution, data on the source of pollution, an analysis of the situation and factors that have contributed to the occurrence of exceedances, details of measures or projects applied to reduce pollution in the previous period, details of measures or projects planned for the long term, special measures aimed at protecting sensitive population groups, especially children, as well as the authorities responsible for the development and implementation of the plan.

The Air Quality Plan is adopted for the area of increased pollution present within the scope of the General Urban Plan of the City of Zaječar (which covers the urban area). This is the most densely populated area of the Zaječar territory, containing administrative, health, educational, cultural, and other institutions, as well as individual business entities.

[11] The Official Gazette of the City of Zajecar, No. 70 dated December 9, 2021.

[12] http://www.Zaječar.info/plan-kvaliteta-vazduha-grada-Zaječara-za-period-od-2023-do-2031-godine-sa-akcionim-planom.

The following parameters are monitored through monitoring within the state and local network of measurement points: sulfur dioxide, nitrogen dioxide, carbon monoxide, suspended particles PM10, soot, total deposition material, heavy metals lead, cadmium, zinc.

The zone of excessive air pollution in the territory of Zaječar is the area of the central urban core with individual industrial facilities dating from the previous period, located within the urban area. Air pollution mainly occurs in the winter heating period, primarily from individual furnaces and boiler houses, but cumulatively, pollution from traffic, emissions from industrial facilities, as well as transmission of pollution from other sources (agriculture, landfills, pyrite tailings, etc.) can be associated. The estimated size of the polluted area corresponds to the surface area of the urban area and amounts to 4152.7 hectares, or 41.527 km2.

Suspended particles PM10 are the dominant pollutant in Zaječar. Due to exceeding the annual limit value (LV is 40 $\mu g/m^3$), air quality in Zaječar is assessed as excessively polluted, i.e., the third category of air quality has been determined. Increased air pollution with suspended particles PM10 is characteristic of the colder part of the year, i.e., the heating period. Meteorological conditions for diffusion are mostly unfavorable, so high concentrations of pollutants are retained in the lower atmospheric layer. Based on monitoring results, it is evident that there is a danger of PM10 particles in the air, whose impact on health, especially on sensitive populations, needs to be determined. Poor air quality contributes to respiratory diseases, especially in children, as well as higher mortality from cardiovascular diseases, tumors, and respiratory system diseases.

The Air Quality Plan establishes goals and measures for reducing and controlling air pollution, i.e., improving air quality. The general goal is to improve air quality with parameters established by applicable legislation within permissible limit values, to protect human health and the environment. Specific goals include:

1. Reduction of air pollution from heating plants and individual furnaces and boiler houses (measures: construction of new gas heating plants, reconstruction of boiler houses, replacement of boilers and fuels in public facilities and individual households).
2. Increased energy efficiency to reduce pollution (measures: building insulation and window replacement, installation of solar panels and collectors, use of geothermal energy, replacement of public lighting).
3. Reduction of air pollution from traffic (measures: road maintenance, promotion of cycling and walking).
4. Reduction of suspended particle resuspension, including emissions from municipal waste management areas (measures: removal and remediation of illegal landfills, increased city hygiene).
5. Increased green areas (measures: afforestation of the "Kraljevica" Park forest and other public green areas, creation of a cadastre of public green areas, maintenance and improvement of public green areas).
6. Reduction of air pollution from industrial facilities (measures: updating the local registry of pollution sources, continuation of inspection supervision of emissions from industrial facilities).
7. Monitoring, education, and raising awareness of the importance of air quality and its impact on human health (measures: strengthening the capacity of the local

community to manage air quality, establishing monitoring, increasing the number of monitoring stations).

In addition to the above measures, the following are particularly highlighted: City gasification to reduce air pollution and Remediation of degraded areas with pyrite tailings (also highlighted in the Zaječar City Development Plan).

The Action Plan for the implementation of the Air Quality Plan for the City of Zaječar covers the period from 2023 to 2025 and determines the institutions and partners responsible for implementing specific goals and measures, key performance indicators, implementation deadlines, funding sources, and required resources.

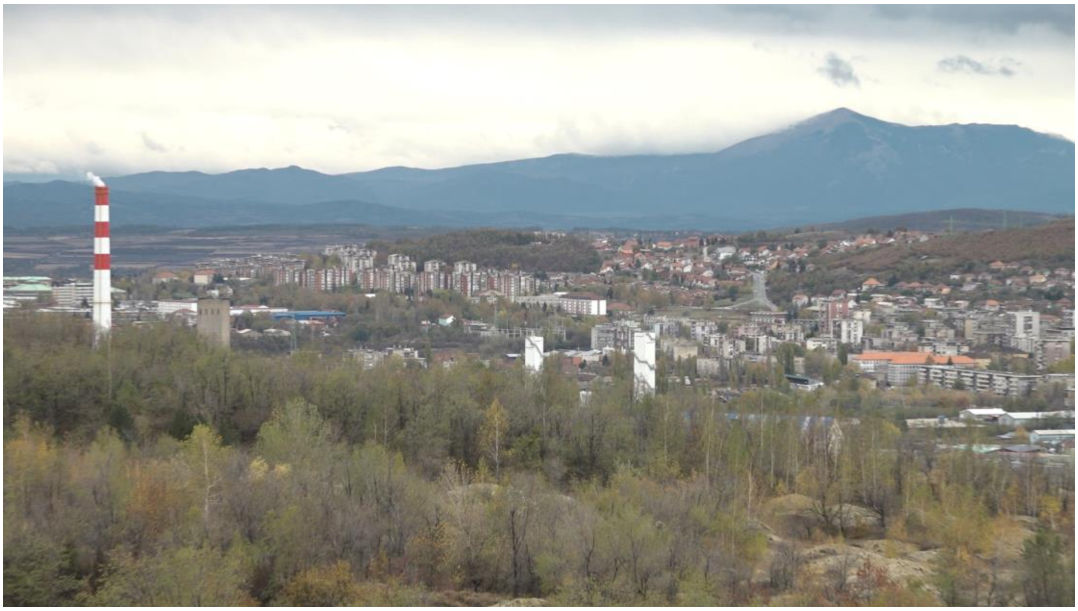
**Conclusions**

In recent years, activities regarding the creation of national and local development policies, environmental protection, and particularly air and water protection, have significantly accelerated. These policies, programs, and plans are often not adopted in hierarchical order; instead, local plans defining measures and tasks are implemented before goals are defined in national documents or higher-level local documents. For example, at the national level, the Development Plan of Serbia, Environmental Protection Strategy, and Integrated National Energy and Climate Plan are yet to be adopted, but the Air Protection Program, Water Management Plan, and Climate Adaptation Program have been adopted. Additionally, the Spatial Plan of Serbia has not been adopted yet. In the city of Bor, the City Development Plan is still being developed, while the Environmental Protection Program and a new Air Quality Program for the Bor agglomeration are being adopted, with the Short-Term Air Protection Action Plan being implemented a few years ago. In the city of Zaječar, the City Development Plan has been adopted, but the Environmental Protection Plan is not yet in place, and the development of the Air Quality Plan with an Action Plan is ongoing. In both cities, new local spatial plans or the Spatial Plan of the Timok Region have not yet been adopted. This lack of alignment requires constant monitoring and alignment of these public policies.

Neither city has yet worked on defining specific public policies for water management and protection or developed corresponding plans. The documents that have been adopted or are in the process of being developed are characterized by significant participation of all stakeholders and the public through the work of document preparation working groups, organizing early consultations and public discussions, and at the local level in the cities of Bor and Zaječar, through the functioning of permanent bodies for monitoring the state and implementation of established public policies.

**Recommendations**

It is necessary to accelerate the adoption of all national development, spatial, and environmental protection documents, as well as the final adoption of the Integrated National Energy and Climate Plan, while further improving the practice of public participation and involvement of all stakeholders in all phases of creating these documents. In Bor, it is necessary to adopt the Environmental Protection Program and the new Air Quality Program for the Bor agglomeration as soon as possible, and in Zaječar, to start the development of the Environmental Protection Program and complete the development and final adoption of the Air Quality Plan. In both cities, plans for water management and protection, as well as plans for climate change adaptation, need to be developed, and in the process of developing new spatial plans, conditions for the implementation of public environmental protection policies, especially for air and water, should be determined. It is necessary to continue the practice of working with permanent bodies for monitoring air protection policies and to establish similar bodies for water and overall environmental protection. Additionally, the practice of public participation and involvement of all stakeholders in the process of developing public policy documents and corresponding regulatory acts should be further improved.



# AIR QUALITY

## Air Qualituy in Bor

Air quality monitoring in Bor is conducted within the national and local monitoring network. In 2022, during the period when the Smelter was not operational, indicative measurements were conducted to determine the "zero states," i.e., to monitor the impact of the new Smelter, with a capacity 2.5 times greater than the old one, on air pollution.

The national monitoring network consists of automatic measuring stations in Bor (City Park and Institute of Mining and Metallurgy), in the suburban settlement of Brezonik, and in the villages of Veliki Krivelj and Slatina. All automatic measuring stations monitor sulfur dioxide concentrations, and in addition, at the measuring station in City Park, concentrations of PM10 and PM2.5 are monitored, while at the Institute, coal dust and nitrogen oxides concentrations are monitored.

Local monitoring is carried out according to the City Council Program[13]:

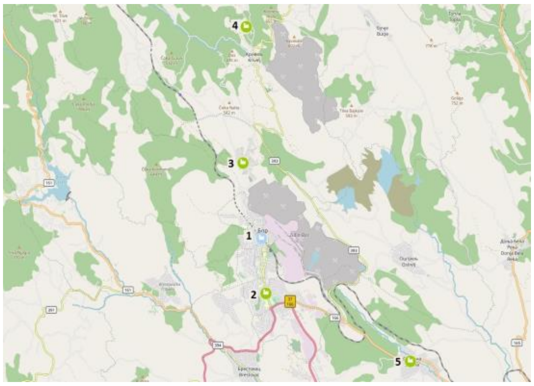


*Image 1: National Monitoring Measurement Locations*

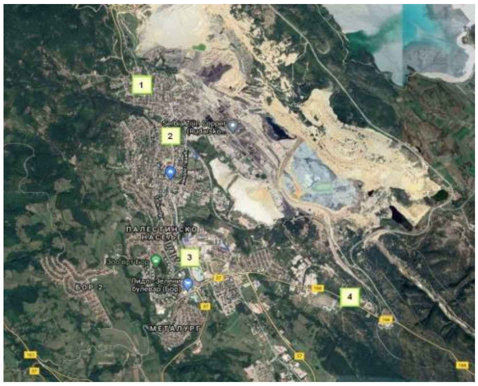


*Image 2: Local Monitoring Measurement Locations*

*Table 2: Local Air Quality Monitoring Network*

| Location | Administrative District | N-North Geo. Latitude E-East Geo. Longitude | Altitude (m) | Station Type | Pollutants | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | PAH | $SO_2$ | $PM_{10}$ | $PM_{2,5}$ | UTM |
| Technical Faculty | B | N 44º04’54” E 22º05’42” | 412 | U/I | / | + (M) | / | / | / |
| Jugopetrol | B | N 44º03’15” E 22º07’46” | 363 | PG/I | + | + (M) | + | / | / |

[13] Програм контроле квалитета ваздуха града Бора, одлука бр. 501-2006/2022- I, https://bor.rs/wp-content/uploads/2022/12/ProgramKontroleVazduha.pdf

| **Location** | **Admini strative District** | **N-North Geo. Latitude E-East Geo. Longitude** | **Altitude (m)** | **Station Type** | **Pollutants** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | **PAH** | **$SO_2$** | **$PM_{10}$** | **$PM_{2,5}$** | **UT M** |
| Brestovac (Čukaru Peki mine area) | B | N 44º59’43”<br>E 22º07’18” | 285 | PG/I | / | / | / | / | + |
| Metovnica 1 (Čukaru Peki mine area) | B | N 44º07’20”<br>E 22º08’25” | 196 | PG/I | / | / | / | / | + |
| Metovnica 2 (Čukaru Peki mine area) | B | N 43º57’20”<br>E 22º08’26" | 288 | PG/I | / | / | + (A) | + (A) | / |
| Krivelj | B | N 44º07’47”<br>E 22º05’42” | 329 | PG/I | / | / | + | / | / |
| Krivelj 2 | B | N 44º04’47”<br>E 22º05’49” | 350 | G/I | / | / | / | / | + |
| Forest Section | B | N 44º04’27”<br>E 22º05’44” | 402 | U/I | / | / | / | / | + |
| Oštrelj 1 | B | N 44º04’07"<br>E 22º09’36" | 370 | PG/I | / | + (A) | + (A) | + (A) | / |
| Oštrelj 2 | B | N 44º04’30”<br>E 22º09’56” | 325 | PG/I | / | / | / | / | + |
| Oštrelj 3 | B | N 44$^{0}$04’08”<br>E 22$^{0}$09’36” | 370 | PG/I | / | / | + | / | / |
| Hospital | B | N44º04’76”’<br>E 22º05’59” | 410 | U/I | / | / | / | / | + |
| Brezonik 1 | B | N 44$^{0}$05’53”<br>E 22$^{0}$05’30” | 430 | PG/I | / | / | + | / | / |
| Brezonik 2 | B | N 44$^{0}$05’53”<br>E 22$^{0}$05’30” | 390 | PG/I | / | / | + (A) | + (A) | / |
| Industrial Zone | B | N 44$^{0}$02’37”<br>E 22$^{0}$06’46” | 390 | PG/I | / | / | + (A) | + (A) | / |

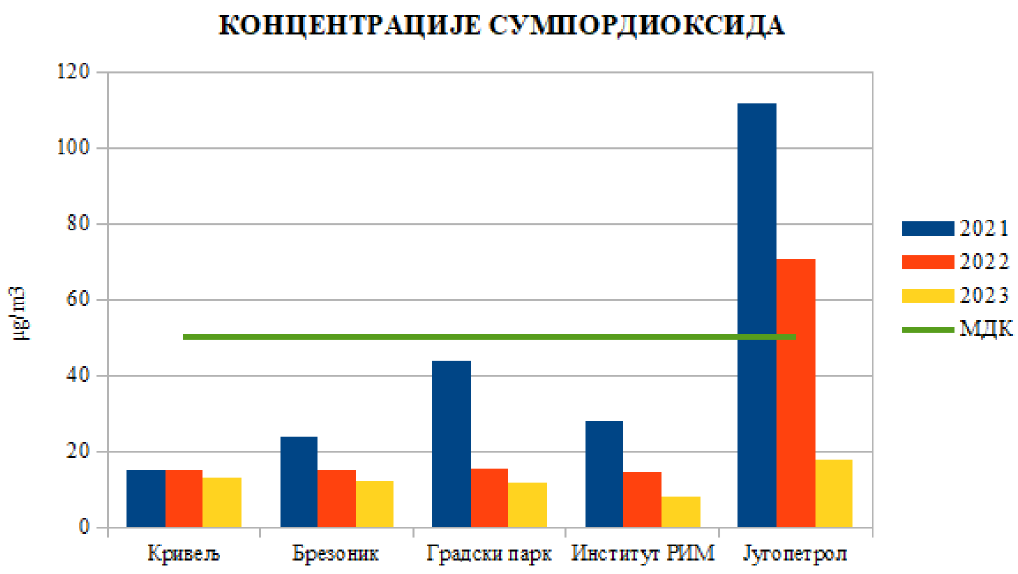
Indicative measurements were conducted from May 2022 to December 2022 at 10 measurement sites in the city and its surroundings. During the period when the Copper Smelter in Bor was not operational due to reconstruction, it was necessary to determine the level of pollutants at locations not covered by the state or local monitoring network but deemed significant. This was to assess the impact of the operation of new metallurgical facilities on air quality and human health in the Bor agglomeration during the specified period.

The Environmental Protection Agency of the Republic of Serbia prepares Annual Reports on the state of air quality in Serbia. According to the report for 2021[14], the air in Bor was classified as the third category (excessively polluted) due to exceeding the limit values of sulfur dioxide. According to the Annual Report for 2022[15], the air in the Bor agglomeration was of the third category, excessively polluted air, due to exceeding the limit value of SO2, suspended particles PM10, and lead in PM10.

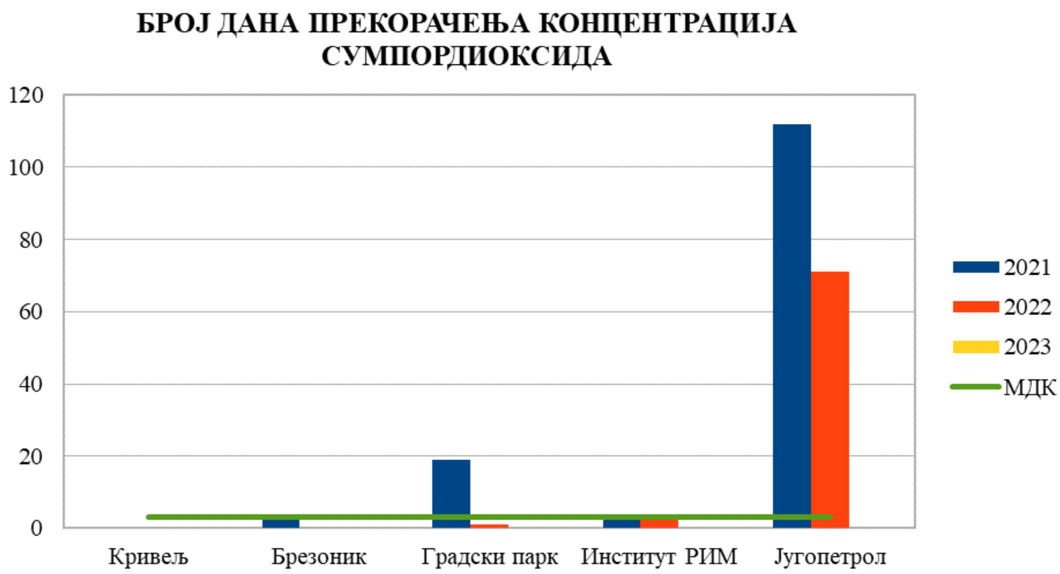
The most significant source of sulfur dioxide emissions is the Copper Smelter. High emissions of this gas lead to air pollution in the Bor agglomeration. Any change in emissions affects air quality. The cessation of the Smelter's operation in April 2022, the construction of the new Smelter, the Sulfuric Acid Factory (which uses gases rich in sulfur dioxide from the Smelter to produce acid), and the installation of desulfurization facilities resulted in a reduction in air concentration and likely resolved the sulfur dioxide pollution problem. In 2023, the boilers of the heating plant were replaced, and the type of fuel was changed. Instead of coal, compressed natural gas is now used, which contributed to the reduction of gas and dust emissions.

[14] Annual Air Quality Report in the Republic of Serbia for the year 2021, p. 9, http://www.sepa.gov.rs/download/Vazduh_2021.pdf, Reviewed 05.12. 2023

[15] Annual Air Quality Report in the Republic of Serbia for the year 2022, p. 7, http://www.sepa.gov.rs/download/Vazduh_2022.pdf, Reviewed 09.12.2023




***Graph 1: Sulfur Dioxide Concentrations at Measurement Sites in Bor, 2020 - 2023***[16]

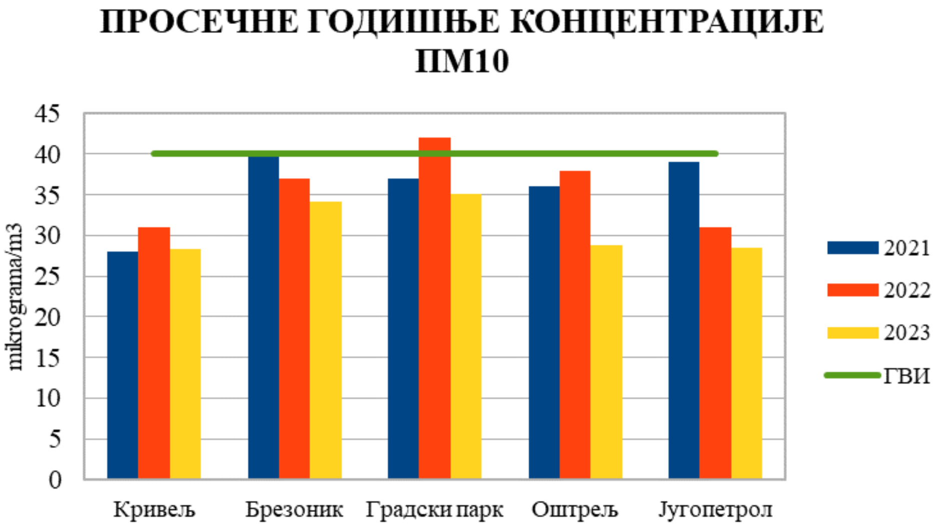



***Graph 2: Number of Days Exceeding Sulfur Dioxide Concentration at Measurement Sites in Bor from 2020 to 2023***[17]

[16] Sources: Annual Air Quality Reports from the Environmental Protection Agency of the Republic of Serbia and the Institute of Mining and Metallurgy from Bor for the years 2020, 2021, 2022, and 2023.
[17] Ibid.

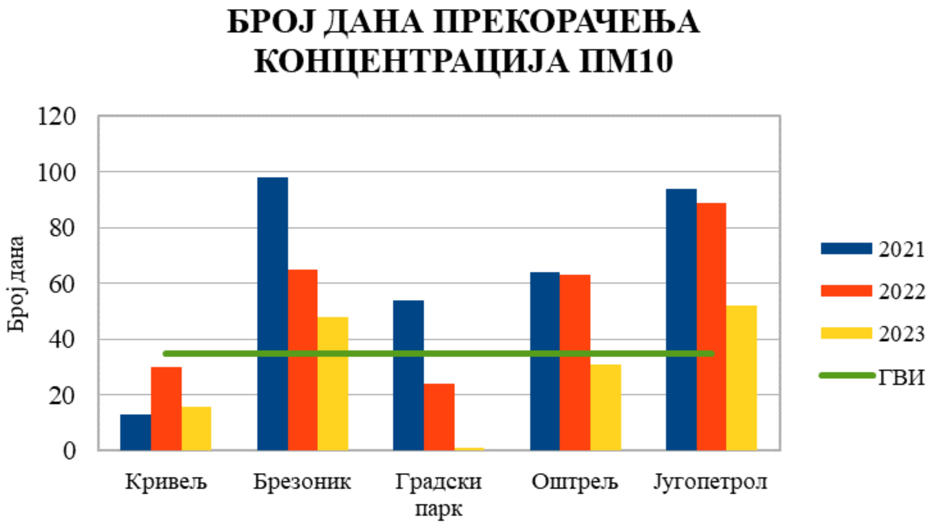
Average annual sulfur dioxide concentrations in 2020 at the Jugopetrol measurement site exceeded the average annual emission limit values by as much as 3.5 times and were above the permissible values for 112 days. At other measurement sites, average annual concentrations were within permissible limits, but the allowable daily limit values of 125µg/m3 were exceeded in the city park for 19 days and at the Institute for 4 days. High sulfur dioxide concentrations were recorded in the first three months of 2022, with average daily concentrations exceeded for 19 days at Jugopetrol and 3 days at the Institute. The Smelter was stopped in April 2022, and since then, there have been no increased concentrations. Serbia ZiJin Copper built a gas desulfurization plant for gases from the new Smelter, which started operating simultaneously with the newly constructed metallurgical units. The plant proved to be efficient because there were no exceedances of permitted sulfur dioxide concentrations after the start of the new Smelter. Continuous monitoring is necessary because the Smelter is still not operating at full capacity, and there is a risk of occasional high concentrations with each technological process disturbance.

Sources of suspended particles include surface mines, overburden dumps, flotation tailings, metallurgical plants, heating plants, power plants, and individual heating sources.




***Graph 3: Average Annual PM10 Concentrations µg/m3 for the Period 2020 - 2023***[18]

[18] Ibid.




***Graph 4: Number of Days Exceeding PM10 Concentrations for the Period 2020 - 2023*[19]**

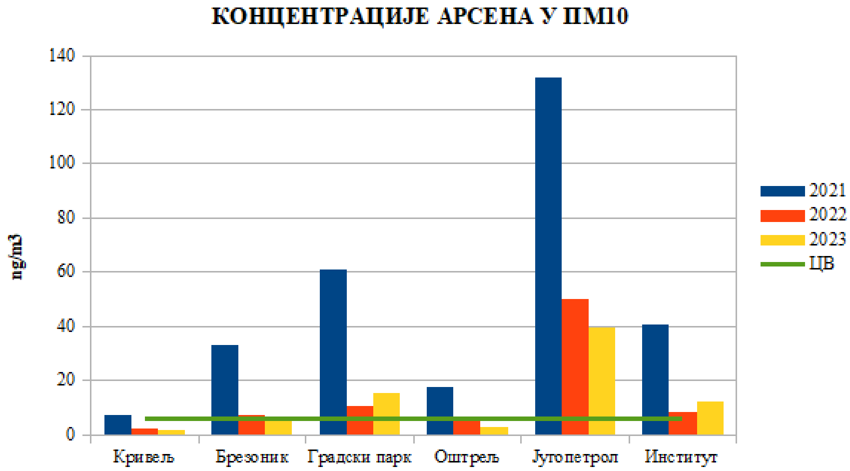
It is permitted for PM10 concentrations to exceed emission limit values for 35 days per year. At measurement sites in Brezonik (2021 - 2023), in the City Park in 2022, Ostrelj in 2021 and 2022, and at Jugopetrol for all three years, the air in Bor was classified as excessively polluted due to exceeding the average annual PM10 concentration of 42 µg/m3 in the City Park in 2022. The highest average annual concentrations of suspended particles were recorded in 2022 in the City Park. The reason for this is the proximity to the metallurgical complex where, after the shutdown of the Smelter, demolition works of old structures, which accumulated dust, and earthworks and construction of new facilities were conducted. Lower average dust concentrations were observed at the Ostrelj measurement site in 2023 compared to previous years due to the rehabilitation of a part of the flotation tailings in Veliki Krivelj.

The average annual lead concentration ranged from 5 ng/m3 in Krivelj in 2021 to 332 ng/m3 at Jugopetrol in the same year. The emission limit value throughout the year is 500 ng/m3 and it was not exceeded at any location during this observation period. The emission limit value for average daily concentrations is 1000 ng/m3 and it was exceeded every year at Jugopetrol (2021 - 32 days, 2022 - 12 days, 2023 - 2 days) as well as in 2021 at the Institute for Mining and Metallurgy for 2 days.

The greatest air quality issue in the Bor agglomeration is the constant presence of arsenic in the air. The only measurement site where concentrations did not exceed the target annual average values during the period of 2022 and 2023 was Krivelj, while in Ostrelj, the target values were not exceeded in 2023 because a part of the flotation tailings in Veliki Krivelj was rehabilitated. At all measurement sites in the city and Brezonik, arsenic concentrations were significantly above these values. The highest concentrations were recorded in 2021 when the old Smelter was operational. In that year, the arsenic concentration at the Jugopetrol measurement site was 20.4 times higher than the target value, in the City Park 12.4 times, at the Institute for Mining and Metallurgy 6.8 times, and in Brezonik 5.5 times. The lowest average annual concentrations were measured in 2022

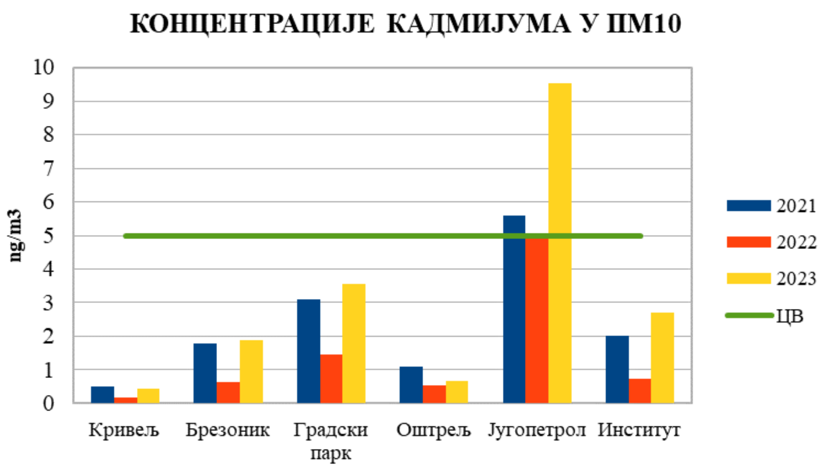
[19] Ibid.

when the Smelter was not operational for 9 months. At the beginning of the Smelter's operation in 2023, there was an increase in arsenic concentrations, and the average annual concentrations exceeded the target values, but they were lower than those in 2021.




***Graph 5: Arsenic Concentrations in PM10 (ng/m3)***[20]

The concentrations of cadmium in PM10 particles have shown a steady increase at all measurement sites in 2023 compared to the previous two years since the start of the new Smelter. In 2021, cadmium concentrations exceeded the target value only at the Jugopetrol measurement site (5.6 ng/m3), while in 2023, they are significantly higher at this measurement site, reaching 9.1 ng/m3. At other measurement sites, the average annual concentrations are lower**,** but they are steadily increasing, with high daily concentrations recorded.




***Graph 6: Average annual concentrations of cadmium in PM10 (ng/m3)***[21]

[20] Ibid.
[21] Ibid.

Graphs 5 and 6 depict the daily concentrations of arsenic and cadmium in 2023. The vertical line indicates the moment when the new smelter started operating. From May 1st to August 31st, there is a sudden and frequent increase in arsenic and cadmium concentrations at all measurement sites.

Indicative measurements were conducted at 9 measurement sites from June 1st to December 31st, 2022, during the period when the smelter was not operational, in the summer and heating seasons, aiming to determine air pollution from surface sources, traffic, and heating, and to define the "zero state" and the smelter's impact on air pollution.

Throughout the entire period of indicative measurements, no exceedances of hourly and daily limit values for semi-volatile gases were detected, nor were the targeted values for cadmium concentrations in PM10 exceeded. The only exception was the arsenic concentration in PM10 at the PU Bor measurement site, which exceeded the annual target value (for 3 days). The maximum measured average daily value of arsenic in PM10 at the PU Bor measurement site was 11.3 ng/m3.

***Table 3. Results of indicative air quality measurements when the smelter was not operational*** [22]

| Serial No. | Measurement Site | PM10 (μg/m3) | Arsenic (ng/m3) | Cadmium (ng/m3) |
|---|---|---|---|---|
| 1. | Bor Lake | 12.8 | 0.3 | Not identified |
| 2. | BrestovačkaBanja | 19.4 | 0.5 | Not identified |
| 3. | Metovnica | 26.3 | 1.2 | Not identified |
| 4. | Brestovac | 19.1 | 2.8 | 0.2 |
| 5. | Ostrelj | 20.9 | 0.7 | Not identified |
| 6. | Settlement "Petar Kočić" | 25.7 | 3.5 | 0.1 |
| 7. | Police Station Bor | 35.9 | 6.1 | 0.2 |
| 8. | Slatina | 23.3 | 3.6 | 0.1 |
| 9. | Gornjane | 34.8 | 0.5 | Not identified |

Results of regular national and local monitoring, as well as indicative measurements, have indicated that air pollution in the territory of the city of Bor mainly originates from emissions of gaseous pollutants from the Bor Copper Smelter, as well as dust from construction works and from mining waste and flotation tailings dumps.

There are citizen measurements of PM10 and PM2.5 using "Klimerko" sensors at 7 locations in the city. The results are available on certain applications.

[22] Institute of Mining and Metallurgy, Indicative Air Quality Measurements in the Bor Agglomeration, Report No. 2270/22, 2022.

## Air Quality in Zaječar

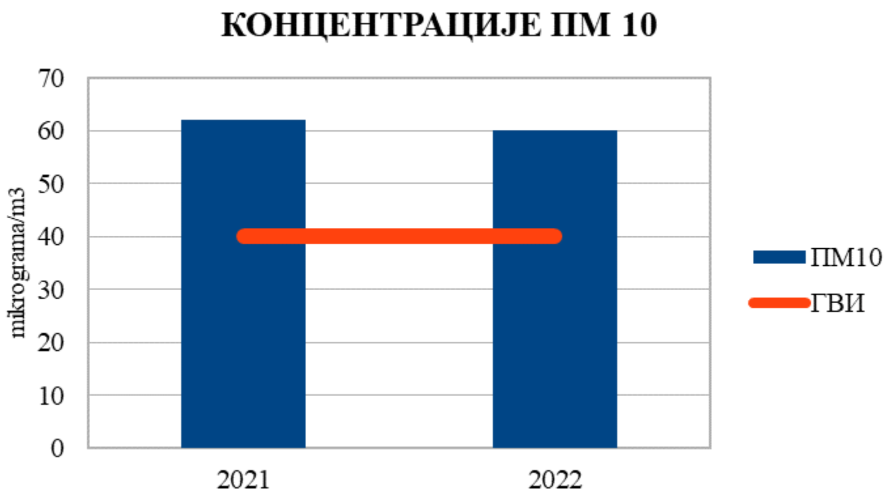
In the city of Zaječar itself, the most significant sources of air pollution are traffic, heating plants, and individual heating sources.

An automatic station of the Republic of Serbia Environmental Protection Agency, which is part of the national monitoring network, is installed in the city center. It monitors concentrations of sulfur dioxide, nitrogen oxides, and carbon monoxide.

| Year | 2021 | 2022 | 2023 |
|---|---|---|---|
| sulfur dioxide | 21,5 | 22,6 | 17,8 |
| nitrogen dioxide | 17,1 | 15,6 | 19,1 |

***Table 4: Results of sulfur dioxide and nitrogen dioxide concentration measurements in Zaječar in 2021, 2022, and 2023, in µg/m3***

The average annual gas concentrations are nearly established, and daily values did not exceed the allowed limits. At the same measurement location, the Agency manually takes samples on specific days and monitors PM10 concentrations. The Agency's assessment is that the air in Zaječar was excessively polluted in 2021 and 2022. The quality assessment for 2023 will be known by September 2024. In 2021, measurements were conducted for 310 days, and in 2022, for 285 days. The average PM10 particle concentration in 2021 was 60 µg/m3, and in 2022, it was 62 µg/m3. The allowed average concentration is 40 µg/m3, meaning that in both observed years, the concentration was 50% above the emission limit value. In both years, Zaječar ranked second in PM10 pollution, behind Valjevo. The allowed average daily emission limit value for PM10 of 50 µg/m3 was exceeded for 62 days in 2021 and 60 days in 2022.[23]




***Graph 7: PM10 Concentration in Zaječar in 2021 and 2022[24]***

[23] Environmental Protection Agency, Annual Report on Air Quality in the Republic of Serbia for the year 2021 and Annual Report on Air Quality in the Republic of Serbia for the year 2022.
[24] Ibid.

In addition to measurements conducted in the national monitoring network in Zaječar, there are 7 "Klimerko" sensors and one "SensorC" for citizen monitoring of PM10 and PM2.5 concentrations, which can be tracked through specific applications. During the implementation of the project, the association "Za česme" and the Youth Researchers Society received a donation from the "Belgrade Open School" for a sensor to monitor industrial air pollution, which tracks meteorological parameters (temperature, humidity, and air pressure) and concentrations of pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, and total organic carbon. Data processing and analysis are currently ongoing.

Rural settlements in the vicinity of Zaječar are exposed to specific sources of pollution and materials emitted from them. Nikolicevo and Gamzigradska Banja may be exposed to dust pollution from the ore landfill, pyrite from the mining and flotation tailings of the new Čukaru Peki mine. Vrazogrnac and villages downstream from the confluence of the Bor River into the Veliki Timok are exposed to dust pollution from pyrite deposits on their banks. Orchards have been planted and are sprayed with various chemical substances and protected by smoke from frost, exposing settlements in their vicinity to pollution during these activities.

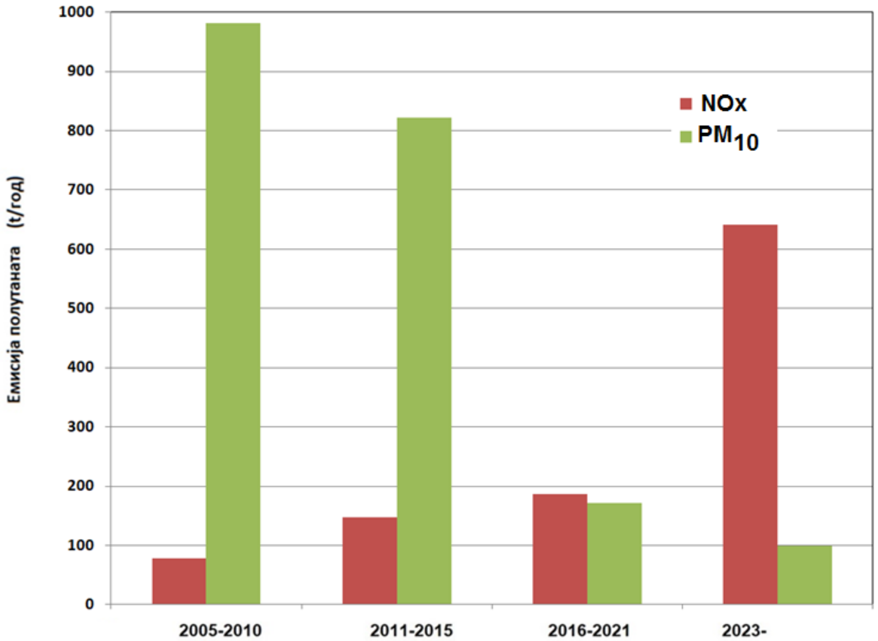
**Conclusions**

The intensive development of mining, opening of new mines, and formation of various types of mining waste landfills by occupying new areas expand pollution zones and lead to increased dust concentrations and emissions of new pollutants that were not previously present. The measures taken for reclamation are insufficient and have not yet produced significant results. The construction of new metallurgical plants with a capacity 2.5 times larger than previous ones, new sulfuric acid factories, and gas desulfurization plants has yielded results; sulfur dioxide concentrations have been significantly reduced and are below emission limits in Bor. However, with the start of operation of the new Smelter, concentrations of arsenic and heavy metals are increasing, despite the metallurgical plants not operating at full capacity. Purification of waste gases produces sludges and solid waste, the safe disposal of which has not been resolved, making them a new source of air pollution. Permits for the disposal of mining waste have not been obtained from the relevant ministry. Pollution from the power plant in Bor has been reduced by changing the fuel, but pollution from traffic has increased due to intense transportation of materials and equipment for the construction and expansion of mines.

The air quality plan for the Bor agglomeration[25] predicts an increase in gas and dust emissions from point and surface sources (which includes district heating) and changes in the contribution of point, surface, and mobile sources to emissions.

Changes in emissions of individual pollutants from point sources are presented in the following graph:

[25] Institute of Mining and Metallurgy, Draft Air Quality Plan for the Bor Agglomeration from 2023 to 2032, Bor, 2023, pp. 71-77



***Graph 8: Changes in nitrogen oxide and PM10 emissions from stationary sources in Bor[26]***

The graph shows that after the construction of the new Smelter, dust emissions will be reduced, but nitrogen oxide emissions will increase. Assessments of the contribution of different types of SOx/SO2 emissions sources to the total SOx/SO2 emissions in the Bor agglomeration are provided in graphs 9, 10, and 11.

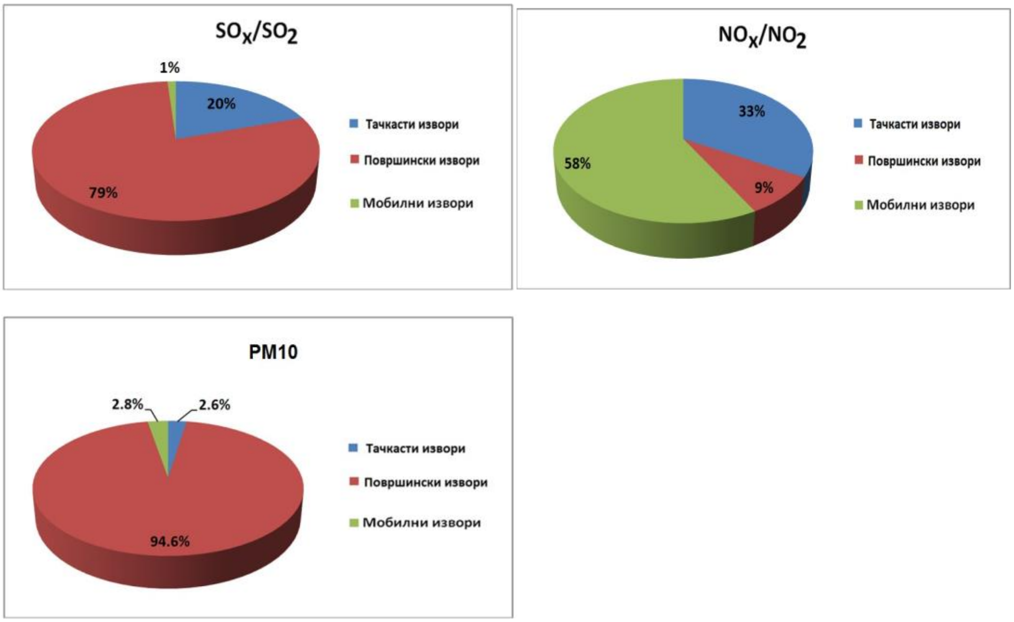
Serbia Zijin Mining plans to continue exploiting the upper zone of the Čukaru Peki mine, but the flotation plant does not have enough capacity to process the excavated ore, so it will be deposited in an open area. Approximately 30 million tons of ore containing arsenic levels of 0.3 g/t will be deposited until the construction of the new flotation plant. This will result in new dust emissions and increased arsenic concentrations in the air.

This will also be contributed to by the expansion of surface mines and flotation tailings in Veliki Krivelj, as well as the increase in the height of the RTB flotation tailings in Bor. These facilities and operations are owned by Serbia Zijin Copper.

Construction of a new flotation plant is underway at the old waste dump site between Bor and the bypass eastern highway without an environmental impact assessment study.

Preparations are intensively underway for the exploitation of ore from the "Borska River" deposits from the pit in Bor, for which ventilation shafts are being constructed in Brezonik and Bor near the hospital, which will emit waste gases and dust from the pit.

[26] Ibid.




***Graphs 9, 10, 11: Different Types of SOx/SO2 Emission Sources in the Total SOx/SO2 Emissions in the Bor Agglomeration[27]***

The preparation and necessary development of special-purpose plans for the Bor-Majdanpek mining area and for the lower zone of the Čukaru Peki mine, along with strategic environmental impact assessments, are planned. Spatial plans should reserve areas for mining development, agriculture, energy and water facilities, tourism, agriculture, and housing, while the strategic assessment determines the impact zones of mining activities.

During the transition period, Zaječar experienced significant economic, environmental, and social changes. Facilities that were major air polluters, such as crystal factories, ceramics, and machinery industries, were shut down. New non-metallic mineral mines were opened, fruit plantations were formed, and farms for domestic animals were renewed.

Such economic changes have led to significant shifts in air pollution sources. In addition to existing sources such as traffic, heating plants, and individual furnaces, new surface pollution sources have emerged - fruit plantations emitting gases from orchard burning in early spring and aerosols during intensive insecticide and fungicide protection. These activities have expanded pollution zones to previously uncontaminated settlements. The construction of the Čukaru Peki mine could threaten the settlements of Nikoličevo and Gamzigradska Banja, areas designated for tourism development.

[27] Ibid.

## Recommendations

New special-purpose spatial plans should reserve areas for mining development, solar and wind farms, water facilities, agriculture, tourism, and housing in the cities of Zaječar and Bor, as well as areas to be protected as natural preserves, internationally significant areas for biodiversity conservation, and areas significant for geodiversity. Additionally, protection of archaeological sites, cultural monuments, and traditional architecture should be included. The strategic impact assessment should consider impact zones, protection measures, remediation, reclamation, and remediation of polluted, damaged, and degraded areas.

Detailed environmental impact assessments should be conducted for all projects, with timely information and public involvement in decision-making processes.

The process of adopting air quality plans should be accelerated, short-term action plans updated, funding secured for their implementation, and consistent implementation ensured. Teams should be formed as auxiliary bodies of city assemblies to monitor the implementation of plans and programs, composed of representatives of all interested parties: executive and administrative city authorities, industry, scientific and educational institutions, and civil society organizations. Representatives of relevant ministries responsible for important decisions, plans, and permits in the fields of mining, environmental protection, industrial accident response, health, and education should be included in these teams.

Air quality monitoring plans should be adopted and regularly updated, and systems for national and local monitoring and informing the public about air quality status in real-time should be developed.

Zaječar should organize indicative air quality measurements in areas that may be affected by the new Čukaru Peki mine, in the territories of Nikoličevo and Gamzigradska Banja. These measurements should also include Vražogrnac and villages along the Veliki Timok River, which are threatened by dust from surfaces covered with pyrite tailings on the banks of the Bor and Veliki Timok rivers. Air quality monitoring should be conducted in Rgotina to assess the impact of the quartz mine on the air in this village.

Monitoring should also include monitoring the concentrations of carbon oxides and organic materials in the impact zones of large orchards in the city of Zaječar.

Based on all the mentioned indicative measurements, a program for monitoring air quality in the local and national network should be developed, with a special assessment of the need to monitor air quality in Gamzigrad, which is under UNESCO protection.

Serbia Zijin Copper and Serbia Zijin Mining should be required to prepare dispersion calculations for dust and gas emissions from their facilities into the environment, monitor emissions from their facilities, regularly inform the public about them, and designate impact zones. Serbia Zijin Copper should prepare guidelines on maximum arsenic and heavy metal content in concentrates it processes, determine control measures, and prohibit the processing of concentrates deemed "dirty" according to London Metal Exchange standards.

In Bor, the implementation of short-term action plans for air quality should continue, new air quality plans should begin in accordance with the schedule, and plans for strengthening monitoring and informing the public should be implemented in Zaječar and Bor.

Local institutions' capacities for air quality management (city administration bodies, public health institutes, scientific and professional institutions, civil society organizations) should be strengthened.

# WATER QUALITY

Mining has a significant impact on local and regional hydrological conditions. Surface mines and pits sometimes require the diversion of surface stream flows and rivers, lowering groundwater levels, directly discharging water into watercourses, leading to changes in the quality of surface and groundwater. Wastewater from ore processing plants also contaminates water bodies. Drainage waters from mines, mine waste disposal sites, and flotation tailings impoundments lead to contamination of groundwater, rivers, streams, and their surroundings. Mining and mineral processing are major consumers of freshwater, leading to the construction of water intakes, reservoirs, and sometimes freshwater is diverted from one river basin to another.

All of this occurs in the basins of the Great Timok and Pek rivers, namely in the Danube basin.

Within the project "Environmental Response to Mining Expansion in Timočka Krajina", comprehensive monitoring of surface water rivers has been implemented, including: water, sediments, radioactivity of sediments in rivers, and biomonitoring. The project included monitoring the impact of the new Čukaru Peki mine on the water quality of the Brestovačkariver and the Crni Timok river. Mines in Cerovo, Veliko Krivelj, and Bor, as well as metallurgical plants in Bor, have a significant impact on the water quality of the Krivelj river and its tributaries and the Borska river. It was very important to monitor the changes that occurred due to the opening of a new surface mine in Cerovo, the construction of ore processing plant for surface mine waters in Cerovo and Bor pit, as well as during periods when metallurgical and chemical plants were not operating and after the construction of waste water treatment plants for new facilities. All of these changes also affect the water quality in the Great Timok river. Significant attention was paid to the impact of mines, flotation, and flotation tailings on the waters of the Mali and Veliki Pek rivers, as well as the impact on the Pek river after the confluence of these rivers.

The assessment of water and sediment quality is made based on the provisions of the Water Law[28], the Regulation on Water Classification[29], and the Regulation on Limit Values of Pollutants in Surface and Groundwater and Sediment and Deadlines for Their Achievement[30].

According to the Water Classification Regulation, the Pek river is classified as class III from the source to its confluence with the Danube, the Crni Timok river from the source to Zaječar and downstream to its confluence with the Beli Timok belongs to class II, the Great Timok river to its mouth to the Danube should be class II, while the Borska river is classified as class IV watercourse.

Deadlines for achieving limit values of pollutants for surface water and sediment that are not affected by transboundary pollution, except for achieving limit values of class I, are determined in accordance with the dynamics established in water management plans, with the latest deadline for their achievement being December 31, 2032. By this deadline,

[28] Water Law, Official Gazette of the Republic of Serbia No50/21
[29] Regulation on Water Classification, Official Gazette of the Republic of Serbia No. 5/68
[30] Regulation on the Maximum Permissible Concentrations of Pollutants in Surface and Groundwater and Sediments, and Deadlines for Their Achievement, Official Gazette of the Republic of Serbia No. 50/2012

the Pek river should reach class II, Crni Timok class I, Great Timok class II, and the Borska river class III.

**Impact of mining on surface and groundwater**

The exploitation of mineral resources, their processing, and the disposal of mine waste and flotation tailings affect the quality of surface and groundwater. Mining operations in mines and pits lead to the lowering of groundwater levels. As a consequence, there are problems with water supply for the population in the vicinity of the mines, drying up of agricultural land resulting in reduced agricultural production and creating economic problems for the agricultural population.

Exploratory works, exploitation of mineral resources, and cessation of mining without applying environmental protection measures lead to contamination of groundwater and surface water. The impact of mines is not only in the phase of active exploitation but also begins with the start of exploration works and continues for a long period after the cessation of exploitation.

Figure 3 shows how surface mines contribute to the formation of acidic drainage waters and how they enter watercourses and groundwater.


***Figure 3: Primary sources and formation of acidic mine waters and pathways through which they reach surface and groundwater[31]***

[31] Younger P.L. and Wolkersdorfer C.H. (2004) Mining Impacts on the Fresh Water Environment: Technical and Managerial Guidelines for Catchment Scale Management. (The ERMITE Guidelines). Mine Water and the Environment, 23: S1 - S80

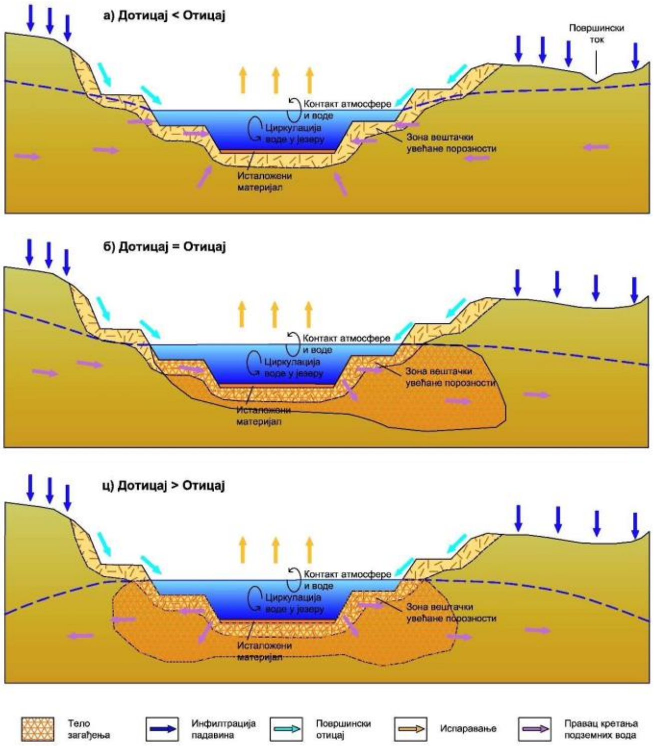



***Figure 4: Conceptual model of the impact of surface mines on groundwater and surface water.***[32]

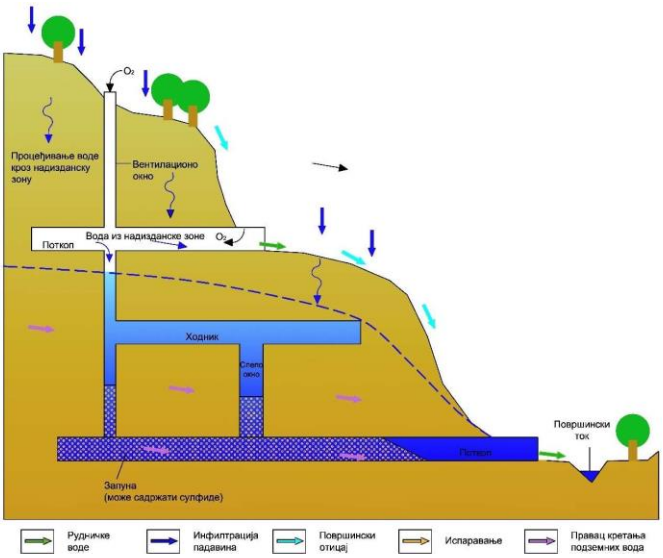



***Figure 5: Schematic representation of the formation and discharge of mine waters from abandoned pits***[33]

[32] Nebojša B. Atanacković, "Assessment of risk from pollution of water resources under the influence of abandoned mining works in the territory of Serbia," Doctoral dissertation, University of Belgrade, Belgrade, 2018.
[33] Ibid.

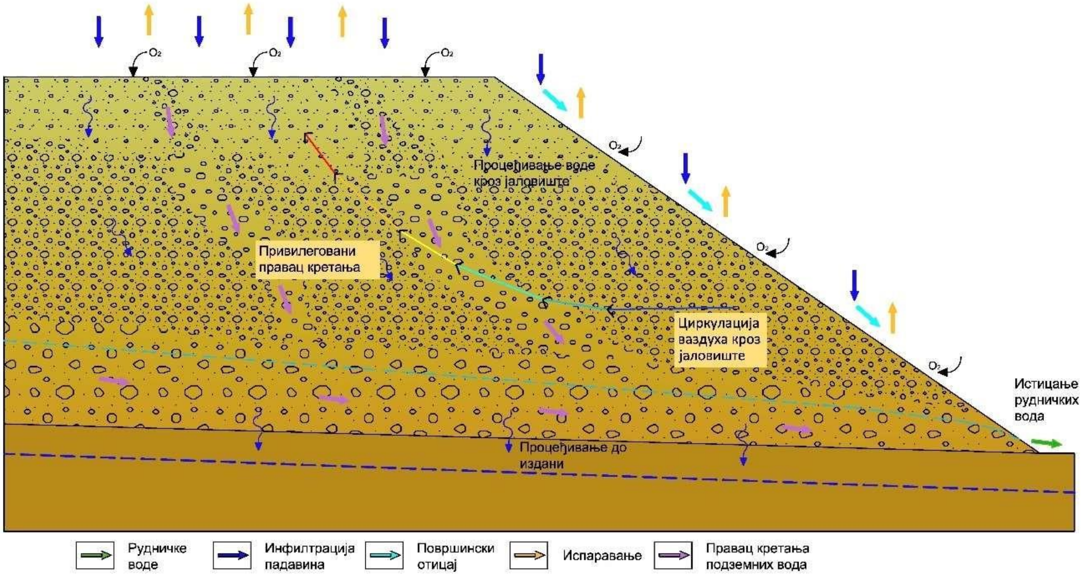



***Figure 6: Schematic representation of water and air circulation through the mine tailings facility and the formation of drainage waters***[34]

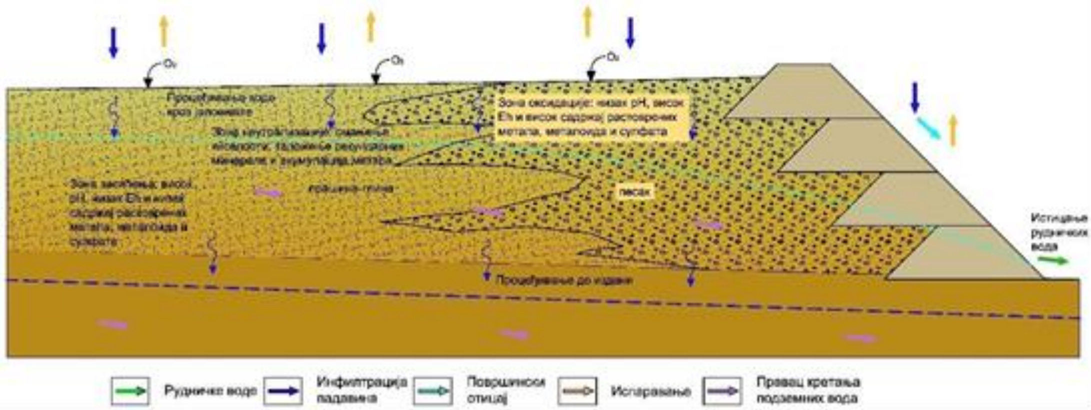



***Figure 7: Schematic representation of the formation of drainage waters from the flotation tailings facility***[35]

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[34] Amos R.T., Blowes D.W., Bailey B.L., Sego D.C., Smith L., Ritchied A.I.M. (2014) Waste-rock hydrogeology and geochemistry. Applied Geochemistry (57): 140-156., прегледано 18. 02.2024.
[35] Dold B., Fontbote L. (2001) Element cycling and secondary mineralogy in porphyry copper tailings as a function of climate, primary mineralogy, and mineral processing. J Geochem Explor 74:3–55.

Flotation tailings ponds affect the quality of surface and groundwater in various ways:

- Discharge of contaminated drainage waters - within flotation tailings ponds, the formation of acidic mine waters can occur, which, together with hazardous substances remaining from the ore flotation process, can cause long-term adverse effects on ecosystems downstream from the tailings.
- Habitat alteration - depending on the size of the mine, flotation tailings ponds can occupy a significant area, leading to changes in the morphological characteristics of the landscape and disruption of natural plant and animal habitats.
- Dam damage and tailings spills - disruption of the structural stability of dams in flotation tailings ponds, whether as a result of earthquakes, heavy rainfall, or inadequate construction and management, leads to catastrophic consequences for plant and animal life and the quality of water and soil, often resulting in direct loss of human lives.

Near Majdanpek, a deep and blind valley called Valja Fundata, formed in Jurassic karstified limestone, was utilized as a suitable site for depositing and flotation of extracted ore material and rocks. On the southern side of the Valja Fundata valley lies the valley of the Valja Mastaka stream. About 25 meters above the valley is the large opening of the Valja Fundata cave. This cave also functions as a permanent source, most likely connected to the blind valley of Valja Fundata. Aware of this fact, to prevent leakage from the tailings, mining engineers from the Majdanpek mine constructed a dam gate inside the cave, in its last accessible part. However, the problem was not solved. The first major accident occurred in 1974, after several years of tailings work, when the activation of some of the ponors of Valja Fundata at the bottom (or slopes?) allowed a path for the tailings to flow out. Released from the cave, the liquid and tailings entered the Valja Mastaka stream, reaching the Veliki Pek river at Debeli Lug. The rapid drainage of wastewater killed off the entire river fauna for several tens of kilometers, all the way to its confluence with the Danube.

Doctor Zoran O. Stevanović, in his doctoral dissertation "Leaching of Heavy Metals from Flotation Tailings"[36], using the example of the old flotation tailings in Bor, points out that due to atmospheric precipitation, leaching of flotation tailings occurs, resulting in acidic waters with high concentrations of copper, iron, zinc, arsenic, and manganese, which reach surface and groundwater, soil, and food, with long-term effects and consequences for human health and the environment.

- Due to the increased acidity of the tailings, from the surface to the bottom of the flotation tailings pond, it can be concluded that this waste material is permeable to water, which, along with increased concentrations and liberation of heavy metals, indicates ideal conditions for long-term environmental pollution due to the creation of contaminated acidic mine waters.
- The concentration of monitored toxic elements in the examined soil samples is significantly increased compared to the MAC: copper (up to 5000 mg/kg), zinc (up to 600 mg/kg), lead (up to 390 mg/kg), and arsenic (up to 280 mg/kg).

[36] Zoran O. Stevanović, "Leaching of heavy metals from flotation tailings," Doctoral dissertation, University of Belgrade, Belgrade, 2012.

- A significantly increased concentration in the sample of topsoil mixed with organic residues of nettle - Urtica Dioica, indicates the accumulation of toxic element ions after their leaching from the tailings and after the decomposition of plants that accumulated a certain amount of these elements.
- Samples of soil on the edge of the tailings also showed increased concentrations of heavy metal ions, indicating significant accumulation of these elements through adsorption via the root system of plants that come into contact with contaminated material.
- Sampled herbaceous and woody plant species, from immediate surroundings of the tailings, have absorbed and accumulated a certain amount of heavy metal ions in plant material (roots, trunk, leaves), with the highest concentrations noted for copper (up to 770 mg/kg), zinc (up to 360 mg/kg), and arsenic (up to 58 mg/kg).
- Maximum values of copper, zinc, and arsenic concentrations were measured in the roots of a one-year-old clover from the topsoil layer on the tailings site, while slightly lower concentrations, except for arsenic with significantly lower concentration, were measured in the leaves of perennial woody plants (birch and locust).
- The concentration of heavy metal ions in woody plants increases from the roots to the leaves, where it is highest.
- Copper and zinc mostly have increased concentrations in both herbaceous and woody plants, while increased accumulation of arsenic was noted in the group of herbaceous plants and birch leaves.
- Measurable concentrations of cadmium were observed only in birch from the topsoil layer on the tailings site, with the highest concentration in the trunk (2.2 mg/kg).
- Increased lead concentration was measured in the roots of a one-year-old clover from the tailings site and in birch leaves from the immediate surroundings of the tailings, while in other samples, the concentrations were below the detection limit.
- The highest concentration of manganese was measured in the reed leaves (70 mg/kg), slightly lower in birch leaves from the tailings site (58 mg/kg), while in other samples, it mostly ranged between 10-35 mg/kg.
- Based on the adsorbed amounts of heavy metals in the examined herbaceous and woody plants, it can be emphasized that copper and zinc ions have the highest mobility in the acidic environment prevailing in the observed flotation tailings, while significantly lower mobility was observed for arsenic and manganese ions.

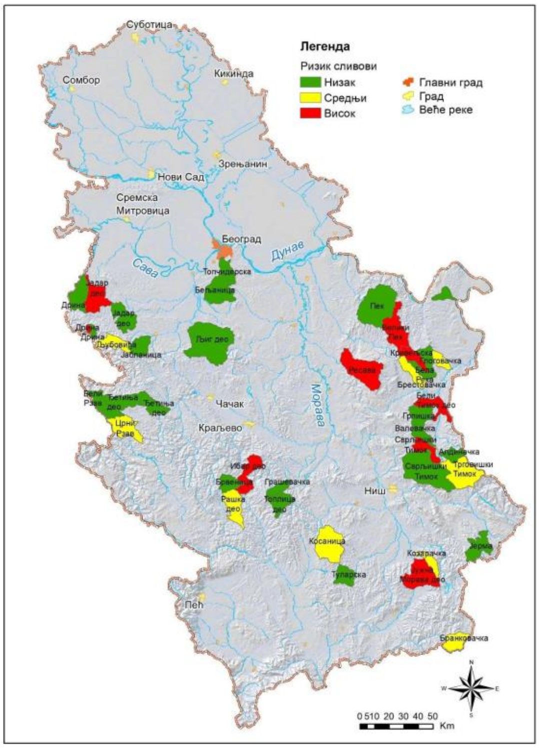



***Figure 8: Map with a preliminary assessment of the risk of water resource pollution at the level of river basins[37]***

Nebojša B. Atanacković, in his doctoral dissertation titled "Assessment of the Risk of Water Resource Pollution under the Influence of Abandoned Mining Operations in Serbia," analyzes the impact of abandoned mines on the quality of groundwater. The research covered abandoned coal, copper, and gold mines in the Timok Region. From Figure 8, it is evident that water bodies of groundwater in the vicinity of Majdanpek, Bor, and Timok are at risk. Contaminated groundwater and surface water are not only a result of current mineral exploitation but also of discharge from closed, abandoned mines. Closed mines discharging water pose a significant risk to the basins of the White and Svrljig Timok and the Pek rivers. For these basins, there are significant prospects that surface and groundwater are burdened with the presence of metals and sulfates beyond natural boundaries, as a result of the impact of abandoned mining operations. Pollution spreads downstream to the Great Timok basin and penetrates deeper into groundwater.

[37] Nebojša B. Atanacković, The cited work.

## Monitoring of Surface Waters

The water quality of this basin has been monitored in Mali Pek upstream and downstream from surface mines in Majdanpek, Veliki Pek downstream from the Valja Fundata flotation tailings facility, and Pek after the merging of these rivers.

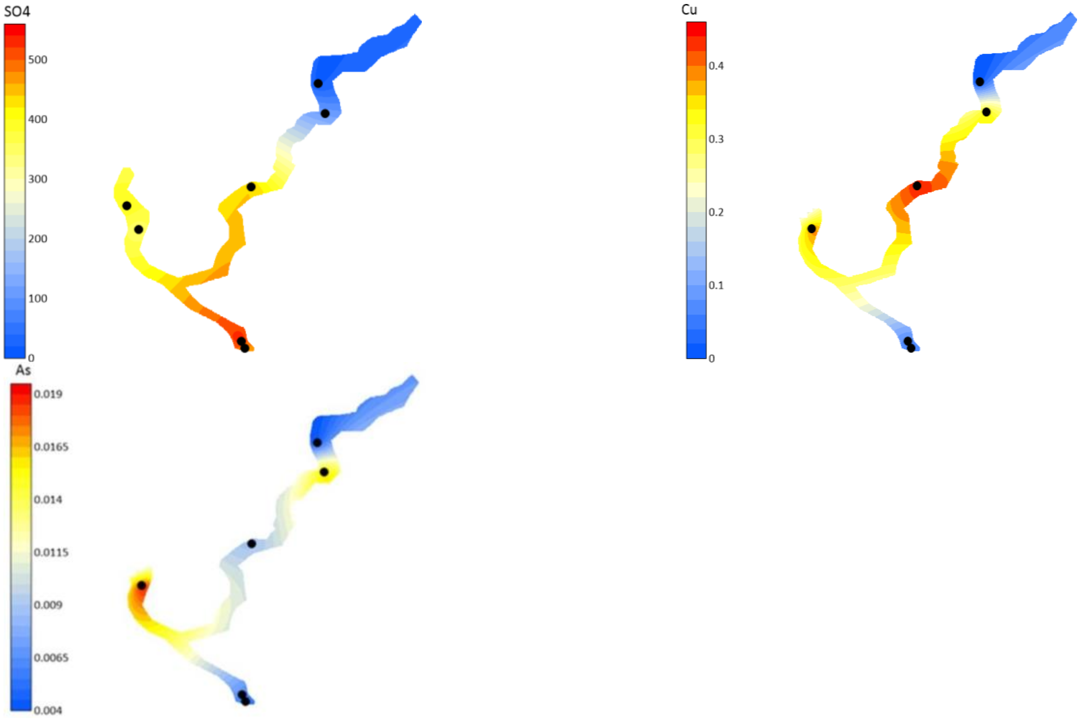
Sampling and water and sludge analysis were conducted by the Anahem laboratory from Belgrade, four times during the project on all the mentioned rivers. Measurement points were located immediately upstream from mines and downstream from surface mines, pits, and processing plants, as well as in smaller rivers before flowing into the Timok and Pek, and in them after the inflow of rivers contaminated with mining wastewater. The aim of this monitoring was to determine the impact of mining activities on the quality of surface water, as well as the intensification of these activities on the quality (pollution) of rivers.

## 1. Pek River Basin


***Images 9 and 10: Satellite imagery and depiction of water and sediment sampling points***

Water samples from the Small Pek River were collected before and after the discharge of Majdanpek sewage, upstream and downstream from the surface mines (Images 9 and 10). Sediment was sampled at the same locations, and water radioactivity was measured.

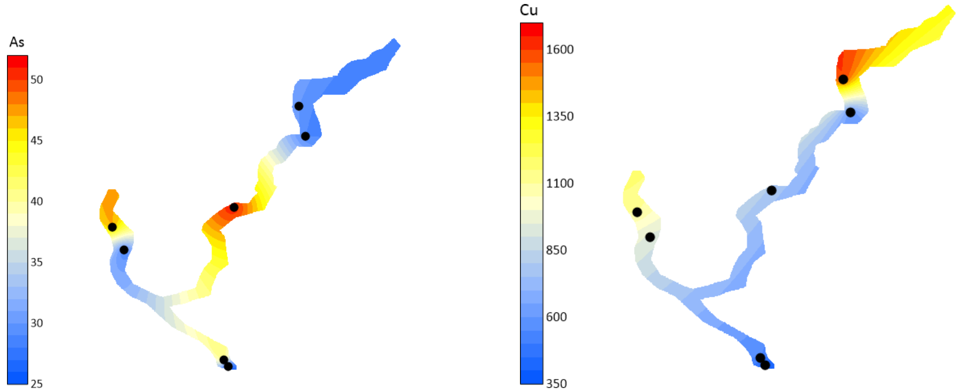
Before the discharge of sewage and upstream from the surface mines, the Small Pek River is an unpolluted watercourse. However, downstream from the mines, increased concentrations of copper, arsenic, iron, manganese, and sulfates were observed in water samples. Images 11, 12, and 13 illustrate the spatial distribution of arsenic (mg/l), copper (mg/l), and sulfates in samples from the Small and Large Pek Rivers and the Pek River after the confluence of the Small and Large Pek. The pollution level exceeds the criteria for the classification of the Pek River, which, as stipulated by regulations, belongs to Class III.




***Images 11, 12, and 13: Spatial distribution of arsenic (mg/l), copper (mg/l), and sulfates in water samples from the Small and Large Pek Rivers and the Pek River[38]***

Regarding the examination of sediment samples at the mentioned locations, the analysis showed that the concentration of copper exceeded the remediation value in all analyzed samples. Additionally, in sediment samples at the Small Pek location before the surface mine in Majdanpek, downstream from the Valja Fundata tailings pond in the Large Pek, and in the Pek River after the confluence, the concentration of arsenic exceeded the remediation value. Increased concentrations of zinc were also measured in samples from the Small Pek River after the surface mine and in the Pek River. The assessment of sediment quality, in accordance with the mentioned Regulation, indicates pollution. It is necessary to clean the sediment from the rivers and dispose of it in hazardous waste landfills. Its disposal without special protective measures is not allowed. It is essential to store it under controlled conditions with special protective measures to prevent the spread of pollutants into the environment.

[38] Anahem doo, Examination Reports No. 12051609, 12120297, 13090198 and 13120850, 2022 and 2023, Belgrade.




*Images 14 and 15: Distribution of arsenic and copper in sediments of rivers in the Pek River basin*[39]

An analysis of radionuclide content in sediments of the Small Pek, Large Pek, and Pek rivers was conducted, including 137cesium, 40potassium, 232thorium, 226radium, and 238uranium. There is an increased presence of natural radionuclides 40potassium, 232thorium, 226radium downstream from surface mines and the Valja Fundata flotation tailings pond[40], but they remain within the boundaries of the natural background.

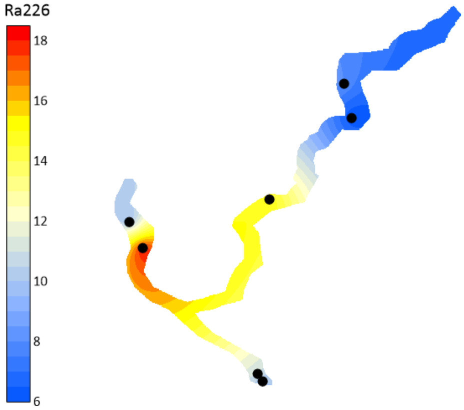



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*Image 16: Spatial distribution of radium-226 in sediments (area of Majdanpek)*

39 Ibid.
40 Ibid.

## 2. The Timok River Basin

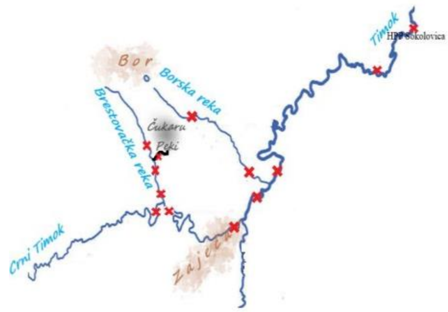




***Image 17 and 18: Satellite image and depiction of sampling points in the Veliki Timok Basin***

Special attention has been devoted to monitoring the water and sediment quality in the BrestovačkaRiver and Crni Timok to assess the impact of the new Čukaru Peki mine. In the BrestovačkaRiver basin, the exploitation of the underground mine has commenced, and an ore flotation facility has been constructed. Upstream from the point of discharge of the mine wastewater canal, a water intake facility has been built on the BrestovačkaRiver, supplying fresh industrial water to the mine and flotation facility. There is a significant demand for water in the flotation process, so a water recirculation system from the mine and flotation tailings, located in the Bor River basin, has been planned and implemented according to the environmental impact assessment study. During geological explorations, water from boreholes and underground tunnels was discharged untreated into the BrestovačkaRiver, and sedimentation is observed in the discharge canal (streambed).

All analysis results indicate that water discharged through the canal (stream) originating from the Čukaru Peki mine area contains elevated levels of sulfates, copper, lead, cadmium, nickel, and arsenic[41], not meeting the standards for the second class of watercourses.[42]

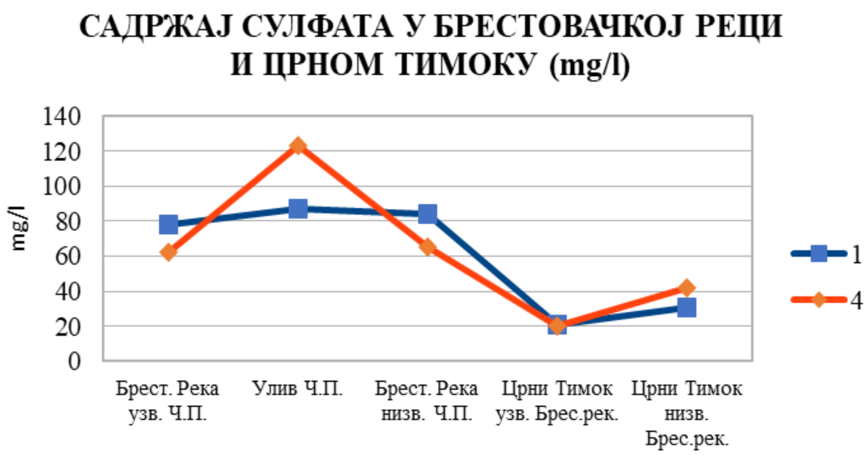
Waters outside the potentially contaminated area of the BrestovačkaRiver showed no signs of contamination. However, after the introduction of the waste canal from the Čukaru Peki mine, certain parameter values in the BrestovačkaRiver showed a slight increase compared to pre-discharge values. The results of the first water sampling of the Crni Timok River after the confluence with the BrestovačkaRiver did not show an increase in the concentration of analyzed parameters except for orthophosphates and ammonium ions. However, this condition changed during monitoring. The results of the latest water sampling indicated a slight increase in the analyzed parameter concentrations in the water of the Crni Timok River after the confluence with the BrestovačkaRiver. Sediment sampling analysis showed a high concentration of copper above the remediation value in the sample from the waste canal of the Čukaru Peki mine, as well as in the sample from the

[41] Ibid.

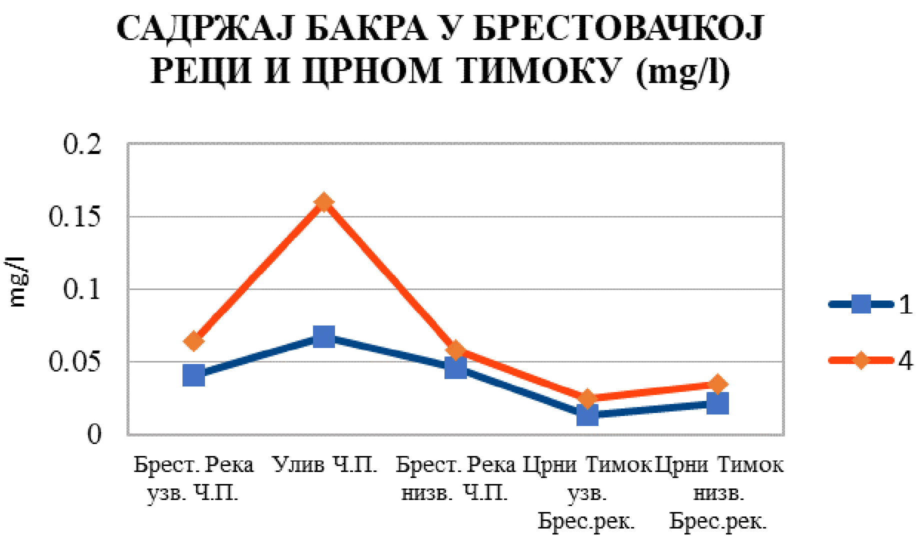
[42] Regulation on the Maximum Permissible Concentrations of Pollutants in Surface and Groundwater and Sediments, and Deadlines for Their Achievement, Official Gazette of the Republic of Serbia No. 50/2012

BrestovačkaRiver before and after the waste canal, and the sample from the Crni Timok River after the confluence with the BrestovačkaRiver. There is also an arsenic concentration above the target value in the waste canal sample.

Monitoring results indicate an increasingly significant impact of the Čukaru Peki mine on the water quality of the BrestovačkaRiver and Crni Timok. It is urgently necessary to clean up the sediments and deposit them in a hazardous waste landfill and undertake remediation of the banks of these rivers. Additionally, the Čukaru Peki mine must implement all planned measures as well as measures envisaged in the environmental impact assessment study to avoid and prevent any discharge of mine wastewater and tailings into surface and groundwater.




*Graph 12: Sulfate Content in the Waters of the BrestovačkaRiver and the Black Timok*




*Graph 13: Copper Content in the Waters of the BrestovačkaRiver and the Black Timok*

The Kriveljska and Borska rivers are among the most polluted rivers in Europe. The Kriveljska River is contaminated by mine waters from surface mines in Cerovo, and subsequently from the mine and flotation tailings of Veliki Krivelj. The Borska River is diverted into the Kriveljska River upstream from the old surface mine in Bor. Downstream from the mining-metallurgical complex in Bor, where municipal waste waters, waste waters from metallurgical and basic chemical plants, and mine drainage waters are discharged, the riverbed remains. The Borska River serves as an open collector of waste municipal and industrial waters. Downstream from the village of Slatina, new flotation tailings facilities have been built for the needs of the Čukaru Peki mine in the Grchava River valley, making this tributary also a collector of mine waste waters flowing into the Borska River.

This project aims to illustrate how all mining and metallurgical facilities affect the pollution of the Kriveljska and Borska rivers, as well as to monitor the changes resulting from the opening of the new Cerovo 2 mine, expansion of the Veliki Krivelj surface mine, formation of a new flotation tailings facility "Nulto Polje" in the Kriveljska River valley, suspension of work and construction of a new smelter and sulfuric acid plant with wastewater treatment facilities, and construction of facilities for treating mine waste waters from the Cerovo mine and Bor pit.

The Kriveljska and Borska rivers, from Bor to their confluence with the Crni Timok, are classified as poor-quality rivers and belong to Class IV water quality. Analysis of samples showed increased sulfate concentrations. The color of these water samples is brown-yellow. Analysis of heavy metal content in the samples revealed increased concentrations of arsenic, copper, iron, and manganese. Based on water samples collected before and after the confluence of the Borska River into the Veliki Timok, it can be concluded that the inflow of the Borska River leads to an increase in lead, zinc, nickel, arsenic, and cadmium concentrations. The largest detected change is in copper, iron, and manganese concentrations.

Regarding sediment quality testing, the analysis showed concentrations of arsenic, copper, and zinc above the remediation values. Lead, cadmium, and nickel content were also detected, leading to a reduction in quality assessment.

No change in the quality of the Kriveljska River was observed after the opening of the Cerovo mine and the formation of the waste disposal site in the Kraku Bugaresku pit through this monitoring. However, detailed monitoring carried out by the Bor municipal authorities revealed otherwise, which will be discussed in the section on the results of that monitoring.

The construction of wastewater treatment plants for the smelter and sulfuric acid plant and the return of these waters to circulation in the production facilities had no impact on the sulfate, arsenic, and heavy metal content in the Borska River because sediment from the riverbed dissolves in the water.

The impact of the Čukaru Peki mine tailings on the water of the Borska River was not monitored.

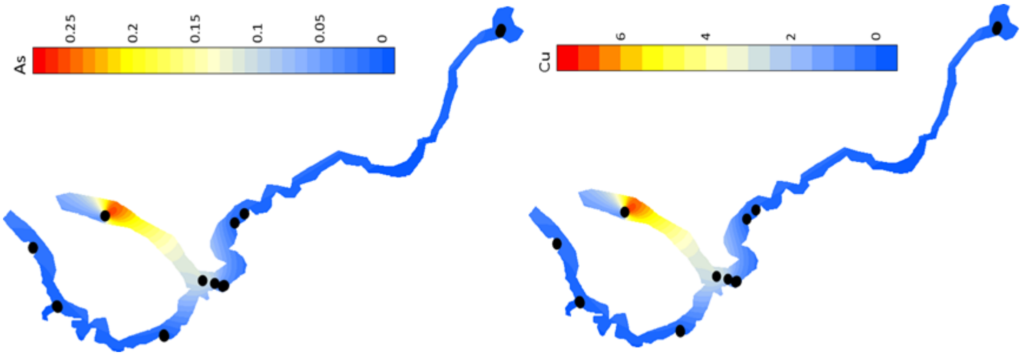



*Image 19: Spatial Distribution of Arsenic (mg/L) and Copper (mg/L) in Water Samples (Borska River - Timok)*

The dam of the Sokolovica hydroelectric power plant stops sediments in the lake, resulting in better water quality downstream of the dam.

Similar to the sediments in the rivers in Majdanpek and in the rivers downstream of the mining and metallurgical complex, there is a slight increase in the presence of natural radionuclides.

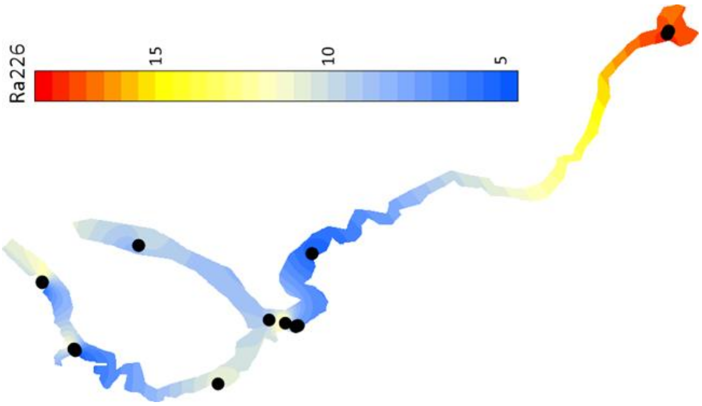



*Image 20: Spatial Distribution of Radionuclide-226 in Sediments (Borska River - Timok)*

Analysis of heavy metal content in fish from the Black and Veliki Timok rivers was also conducted. The analyses were performed on samples taken near the Gamzigrad Spa from the Black Timok and upstream and downstream of the Sokolovica hydroelectric dam on the Veliki Timok.

The highest concentrations of heavy metals in fish were observed in the lake upstream of the Sokolovica hydroelectric dam. Sediment containing numerous heavy metals and arsenic has been deposited in the lake for decades. It enters the food chain through benthic fauna and accumulates in fish. In one sample from this area, the cadmium concentration was nearly 5.5 times higher than the permissible limit. The dam has largely halted sediment transport downstream in the river. There are no fish ladders on the dam, preventing fish movement upstream, resulting in significantly lower levels of heavy metals in their organisms. The Black Timok River has better water quality and significantly lower concentrations of heavy metals in both water and sediment, resulting in much lower levels in fish compared to those from the Black Timok, especially upstream of Sokolovica. The trend of increasing pollution in the Black Timok from the waste water of the Čukaru Peki mine could lead to contamination of the river's flora and fauna.

***Table 5: Results of heavy metal content analysis in fish in 2022 (mg/kg)[43] (mg/kg)***

| **Parameter** | 2022 | | 2023 | | | MDK[44] |
|---|---|---|---|---|---|---|
| | Veliki Timok upstream of Sokolovica dam | Veliki Timok downstream of Sokolovica dam | Veliki Timok upstream of Sokolovica dam | Veliki Timok downstream of Sokolovica dam | Crni Timok – Gamzigradska banjaa | |
| Cadmium | **0,27** | <0,01 | 0.025 | 0,044 | 0.0021 | **0,05** |
| Lead | 0,058 | 0,041 | 0.089 | 0,018 | 0.0094 | **0,30** |
| Arsenic | 0,56 | <0,05 | 0,14 | 0,56 | 0.024 | |
| Copper | 5,9 | 0,71 | 5,8 | 1,9 | 0,43 | |
| Chromium | <0,1 | <0,1 | 2,1 | 1,9 | 1,9 | |
| Cobalt | 0,096 | <0,03 | 0,11 | 0,029 | 0.023 | |
| Nickel | 0,084 | <0,07 | 2,2 | 2,1 | 1,4 | |
| Iron | 20 | 25 | 74 | 27 | 22 | |
| Manganese | 4,2 | 3,1 | 11 | 4,6 | 1,3 | |
| Zinc | 22 | 23 | 42 | 32 | 12 | |
| Mercury | 0,098 | 0,15 | 0,05 | 0,039 | 0,024 | **0,50** |

[43] Anahem doo, Reports No. 12051609 and 13120850 , Belgrade, October 2022., January 2024.
[44] Regulation on the Concentrations of Certain Contaminants in Food, Official Gazette of the Republic of Serbia No. 81/2019, 126/2020, 91/2021 и 118/2021

## 3. Monitoring by the Bor City Administration

The Environmental Protection Office of the Bor City Administration conducts surface water monitoring four times a year. In the period from September to December 2023, daily monitoring of surface water pollution was carried out in the basins of the Brestovacka, Kriveljska, Borska, and Ravna rivers. The Čukaru Peki mine affects the water quality of the BrestovačkaRiver, surface copper ore mines in Cerovo and Veliki Krivelj affect the Kriveljska River, while the old surface mine and pit in Bor, as well as the metallurgical-chemical complex, affect the water quality of the Borska River. Additionally, quartz and limestone quarries affect the water in the Ravna River.

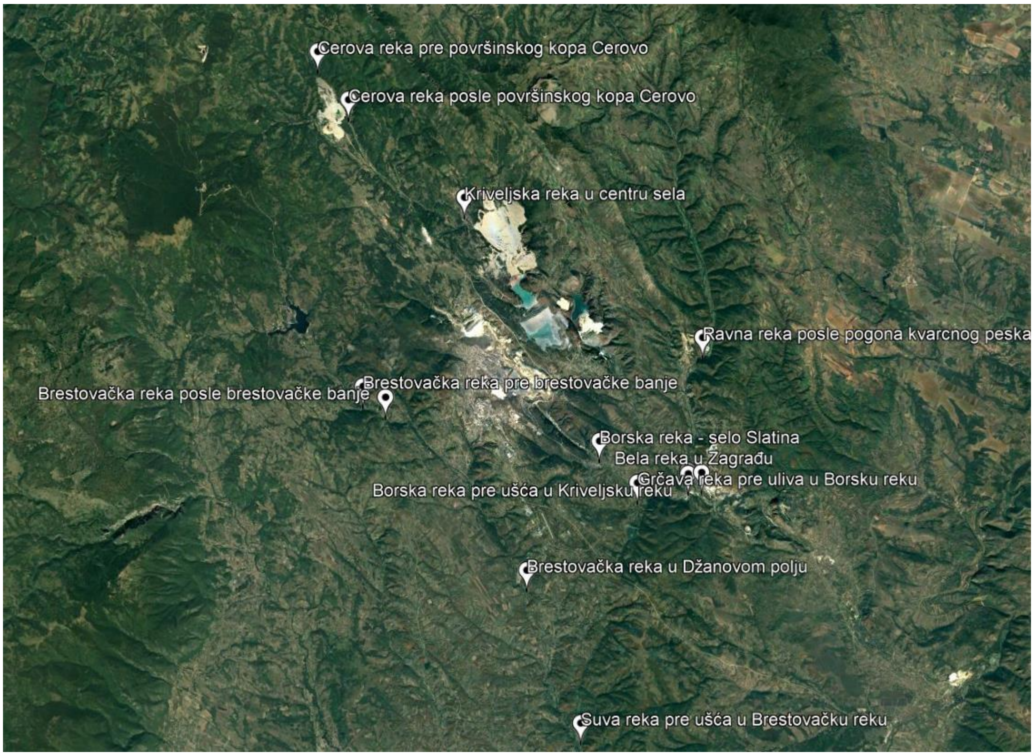



***Image 21: Sampling Locations of Surface Waters for Local Monitoring by the Bor City Administration*** [45]

The environmental status of rivers is determined in accordance with the Regulation on Limit Values of Pollutants in Surface and Groundwaters and Sediments, as well as the Deadlines for Their Achievement, and all rivers are classified into 5 categories:

**Class I -** Surface waters belonging to this class provide conditions for the functioning of ecosystems, life, and fish protection (salmonids and cyprinids) based on the limit values of quality elements and can be used for the following purposes: water supply for drinking with prior treatment of filtration and disinfection, bathing and recreation, irrigation, industrial use (process and cooling waters).

[45] Institute of Mining and Metallurgy, Surface Water Investigation Report, No. 4779/23, Bor, 2023.

**Class II -** Surface waters belonging to this class provide conditions for the functioning of ecosystems, life, and fish protection (cyprinids) based on the limit values of quality elements and can be used for the same purposes and under the same conditions as surface waters belonging to Class I.

**Class III -** Surface waters belonging to this class provide conditions for life and protection of cyprinids based on the limit values of quality elements and can be used for the following purposes: water supply for drinking with prior treatment of coagulation, flocculation, filtration, and disinfection, bathing and recreation, irrigation, industrial use (process and cooling waters).

**Class IV -** Surface waters belonging to this class can be used for the following purposes based on the limit values of quality elements: water supply for drinking with the application of a combination of the above-mentioned treatments and advanced treatment methods, irrigation, industrial use (process and cooling waters).

**Class V -** Surface waters belonging to this class cannot be used for any purpose.

The BrestovačkaRiver is of the second class throughout its course. Downstream from the Brestovačkaspa, concentrations of ammonia increase, so the water occasionally falls into the fourth class. Downstream, there is only purification, and the concentration of ammonia decreases. After the Čukaru Peki mine, near Djane's field, concentrations of arsenic increase, but the water quality still belongs to the second class. At this measuring point, there is occasional increase in sulfate concentrations characteristic of the third category of waters.

The influence of the flotation tailings from the Čukaru Peki mine is more pronounced on the waters of the Grchava River, in whose valley it is located, and which flows into the Borska River. The water in this river constantly belongs to the fourth class due to high concentrations of sulfates and phosphates.

The influence of the Cerovo surface mine is evident on the Cerova River. It flows through terrain containing copper sulfate ores, so the sulfate content in it, upstream of the mine, is high, so it can be classified as the fifth class by this criterion. Based on pH value and other parameters, it belongs to the first class of water quality. Downstream from the surface mine, there is a sudden deterioration in water quality. The pH value drops below 6, sulfate, copper, cadmium, nickel, and zinc concentrations increase, and water quality is of the fifth class.

Sulfate concentrations in the Kriveljska River in the center of the village are high, so the river is of the fourth or fifth category. From the surface mine and flotation tailings, it receives new quantities of mining water, so before flowing into the Borska River, the copper, iron, cadmium, and nickel contents are higher, and the water is of the fifth class.

The Borska River is of the fifth class throughout its course to Zagrađe due to concentrations of ammonia, sulfates, and heavy metals.

The Ravna River is of the third class after the quartz sand mine due to the presence of suspended particles.

The best overview of water quality can be shown graphically:

*Table 6: Classes of Surface Waters*

| | |
|---|---|
| **Class 1** | |
| **Class 2** | |
| **Class 3** | |
| **Class 4** | |
| **Class 5** | |

*Table 7: Classes of surface waters in the Timok basin according to the results of daily monitoring by the city administration*

| RIVER | CATEGORY |
|---|---|
| Downstream from BrestovačkaSpa | |
| Downstream from the Čukaru Peki mine | |
| | |
| Upstream from the surface mine | |
| Downstream from the surface mine | |
| From Veliki Krivelj to the confluence | |
| From Bor to Zagrađe | |
| Downstream from the quartz surface mine | |

**Groundwater**

**1. Water Quality of Fountains in Zaječar**

The association "Za Drinking Fountains" and the City of Zaječar initiated the process of legalizing artesian springs in 2018. During this time, comprehensive studies and research were conducted, which no other city in Serbia had undertaken to protect natural water as a public good. The Ministry of Mining and Energy of the Republic of Serbia issued Decision No. 31-02-022162/2021-02 on October 20, 2022, determining and certifying the reserves of groundwater from captured public springs: Zelengora, Ostrvice, Avnojska, Donja cesma Vocar, Podliv, Nedeljkova cesma, Naselje Kljuc 3, and Dve lule/Zitopromet. The water was classified as low-mineralized, hydrocarbonate-sodium type, with temperatures ranging from 14.7 to 21.9°C. The reserves were classified as category C-1 and can be used as industrial water. After objections from the Association and the city of Zaječar, the Ministry corrected the mistake with Decision No. 31-02-022162/2021-02 dated February 21, 2023, stating that the water can be used as drinking water (waters that, according to regulations, can be used for supplying the population, irrigation, technical needs of the economy, etc.).

The quality of water and its suitability for drinking at fountains in Zaječar is monitored by the Institute of Public Health "Timok" Zaječar.

***Table 8. Water Quality of Springs in Zaječar***

| Fountain | Quality Rating |
|---|---|
| Fountain Two Pipes [46] | Suitable for drinking |
| Otter Farm - Popova Beach Fountain [47] | Suitable for drinking |
| Fountain near the "Timok" Cinema [48] | Suitable for drinking |
| Fountain near "Intereks“[49] | Suitable for drinking |
| Fountain near "Jedinstvo" [50] | Suitable for drinking |
| Fountain near the "Fountain" Tavern [51] | Suitable for drinking |
| Fountain near the LJ.R. Nada Elementary School [52] | Suitable for drinking |
| Fountain near the High School Center [53] | Suitable for drinking |
| Fountain near "Triton" [54] | Suitable for drinking |
| Fountain near "Voćar" [55] | Suitable for drinking |
| Fountain near the Railway Station [56] | Suitable for drinking |
| "Louvre" Fountain [57] | Suitable for drinking |

[46] Public Health Institute "Timok", Examination Report, No.1742, Zajeačar 2023
[47] Public Health Institute "Timok", Examination Report, No.1735, Zajeačar 2023
[48] Public Health Institute "Timok", Examination Report, No.1604, Zajeačar 2023
[49] Public Health Institute "Timok", Examination Report, No.1611, Zajeačar 2023
[50] Public Health Institute "Timok", Examination Report, No.1736, Zajeačar 2023
[51] Public Health Institute "Timok", Examination Report, No.1743, Zajeačar 2023
[52] Public Health Institute "Timok", Examination Report, No.1730, Zajeačar 2023
[53] Public Health Institute "Timok", Examination Report, No.1603, Zajeačar 2023
[54] Public Health Institute "Timok", Examination Report, No.1608, Zajeačar 2023
[55] Public Health Institute "Timok", Examination Report, No.1613 Zajeačar 2023
[56] Public Health Institute "Timok", Examination Report, No.1606, Zajeačar 2023

| | |
|---|---|
| Fountain at Popova Beach - New Pipe [58] | Suitable for drinking |
| Fountain at Popova Beach - Parking [59] | Hygienically unsuitable due to color and increased iron content. Not suitable for drinking |
| Fountain at the Square [60] | Suitable for drinking |
| Fountain at the entrance to the Railway Station [61] | Suitable for drinking |
| "Ostrvce" Fountain [62] | Suitable for drinking |
| Fountain in the "Kljuc" Settlement [63] | Suitable for drinking |
| Fountain in the "Kljuc 3 - Building A6" Settlement [64] | Suitable for drinking |
| Fountain in the "Kraljevica" Settlement [65] | Suitable for drinking |
| Fountain in the "Podliv" Settlement [66] | Suitable for drinking |
| Fountain on Branko Peric Street [67] | Suitable for drinking |
| "Zelengora" Fountain [68] | Suitable for drinking |
| Zvezdanska Krivina Fountain [69] | Suitable for drinking |
| "Markova" Fountain [70] | Suitable for drinking |
| "Nedeljkova" Fountain [71] | Suitable for drinking |
| "Tackova" Fountain [72] | Suitable for drinking |

At all springs, except one, the water was suitable for drinking. At the spring at Popova Plaza, the water was not suitable for drinking due to increased iron content, which is a consequence of hydrogeological conditions. None of the springs were contaminated with bacteria and organic matter, indicating high water quality. Protecting underground water sources is essential to preserve this significant natural asset of Zaječar as a public good.

[57] Public Health Institute "Timok", Examination Report, No.1610, Zaječar 2023
[58] Public Health Institute "Timok", Examination Report, No.1734, Zaječar 2023
[59] Public Health Institute "Timok", Examination Report, No.1733, Zaječar 2023
[60] Public Health Institute "Timok", Examination Report, No.1609, Zaječar 2023
[61] Public Health Institute "Timok", Examination Report, No.1607, Zaječar 2023
[62] Public Health Institute "Timok", Examination Report, No.1925, Zaječar 2023
[63] Public Health Institute "Timok", Examination Report, No.1740, Zaječar 2023
[64] Public Health Institute "Timok", Examination Report, No.1739, Zaječar 2023
[65] Public Health Institute "Timok", Examination Report, No.1600, Zaječar 2023
[66] Public Health Institute "Timok", Examination Report, No.1737, Zaječar 2023
[67] Public Health Institute "Timok", Examination Report, No.1731, Zaječar 2023
[68] Public Health Institute "Timok", Examination Report, No.1612, Zaječar 2023
[69] Public Health Institute "Timok", Examination Report, No.1741, Zaječar 2023
[70] Public Health Institute "Timok", Examination Report, No.1602, Zaječar 2023
[71] Public Health Institute "Timok", Examination Report, No.1738, Zaječar 2023
[72] Public Health Institute "Timok", Examination Report, No.1601, Zaječar 2023

## 2. Quality of Water from Fountains in Bor

Popular public springs of medicinal mineral waters are found in BrestovačkaBanja. In the surroundings of Bor, public springs have been built in the city, villages, and recreational areas. The city administration regularly conducts monitoring of the water quality at these fountains.

*Table 9: Monitoring of Water Quality at Public Springs in the Municipality of Bor*

| Fountain | Quality Rating |
|---|---|
| Fountain in Brestovačka Spa - nerve water[73] | Suitable for drinking |
| Fountain in Brestovačka Spa - kidney water[74] | Water unfit for drinking due to increased levels of fecal streptococci, fecal coliform bacteria, and total coliform bacteria. |
| Fountain in Brestovačka Spa - stomach water[75] | Suitable for drinking |
| Fountain in Brestovačka Spa - eye water[76] | Suitable for drinking |
| Public fountain, Bor - Staro selište[77] | Suitable for drinking |
| Public fountain "Homoljska"– LC North[78] | Suitable for drinking |
| Public Fountain "Hajdučka voda"[79] | Suitable for drinking |
| Public Fountain "Metalurg"[80] | Suitable for drinking |
| Public fountains at Bor Lake - bus turnaround[81] | Unfit for drinking due to increased levels of fecal streptococci. |
| Public fountain in the weekend settlement "Savača"[82] | Unfit for drinking due to increased levels of fecal streptococci, aerobic mesophilic bacteria, fecal coliform bacteria, and Pseudomonas aeruginosa |
| Fountain in Gornjan - "Bele vode" (White Waters)[83] | Suitable for drinking |
| Fountain in Gornjan - "Krušar"[84] | Suitable for drinking |
| Fountain "Šćubej" - Slatina[85] | Unfit for drinking due to the presence of fecal streptococci and fecal coliform bacteria |
| Fountain in Brestovac[86] | Suitable for drinking |
| Fountain in Oštrelj[87] | Unfit for drinking due to the presence of fecal streptococci and fecal coliform bacteria |

[73] Public Health Institute "Timok", Examination Report, No.2941, Zaječar 2023
[74] Public Health Institute "Timok", Examination Report, No.2938, Zaječar 2023
[75] Public Health Institute "Timok", Examination Report, No.2939, Zaječar 2023
[76] Public Health Institute "Timok", Examination Report, No.2940, Zaječar 2023
[77] Public Health Institute "Timok", Examination Report, No.2933, Zaječar 2023
[78] Public Health Institute "Timok", Examination Report, No.2931, Zaječar 2023
[79] Public Health Institute "Timok", Examination Report, No.2934, Zaječar 2023
[80] Public Health Institute "Timok", Examination Report, No.2935, Zaječar 2023
[81] Public Health Institute "Timok", Examination Report, No.2936, Zaječar 2023
[82] Public Health Institute "Timok", Examination Report, No.2937, Zaječar 2023
[83] Public Health Institute "Timok", Examination Report, No.1443, Zaječar 2023
[84] Public Health Institute "Timok", Examination Report, No.1441, Zaječar 2023
[85] Public Health Institute "Timok", Examination Report, No.1448, Zaječar 2023
[86] Public Health Institute "Timok", Examination Report, No.1449, Zaječar 2023
[87] Public Health Institute "Timok", Examination Report, No.1254, Zaječar 2023

| | |
|---|---|
| Fountain in Bučje[88] | Suitable for drinking |
| Fountain in the elementary school in Gornjane[89] | Suitable for drinking |
| Fountain in Luka[90] | Unfit for drinking due to increased levels of fecal streptococci |
| Fountain in Tanda[91] | Suitable for drinking |
| Fountain in Zagrađe[92] | Unfit for drinking due to the presence of nitrates |

Out of a total of 20 monitored public fountains, water from 7 was unfit for drinking (6 due to bacteriological and one due to chemical reasons). The unfit water sources are in villages crucial for supplying water to the population during interruptions in water supply from either rural or central urban water supply systems. Of particular concern is the occasional unfitness of medicinal waters in BrestovačkaBanja, which the population heavily relies on.

[88] Public Health Institute "Timok", Examination Report, No.1255, Zaječar 2023
[89] Public Health Institute "Timok", Examination Report, No.1256, Zaječar 2023
[90] Public Health Institute "Timok", Examination Report, No.1257, Zaječar 2023
[91] Public Health Institute "Timok", Examination Report, No.1258, Zaječar 2023
[92] Public Health Institute "Timok", Examination Report, No.1447, Zaječar 2023

## Conclusions

Surface and groundwater in the Pek and Timok river basins are jeopardized by current mining activities and drainage from abandoned mines. There is no established unified monitoring system to track water quality in these basins, and local municipalities lack their own local systems. The city of Bor conducts regular monitoring of surface waters (four times a year) in rivers threatened by current mining activities but does not monitor the water quality in rivers with closed mines or where geological exploration has commenced. With the assistance of the Institute of Mining and Metallurgy, the city administration is establishing a system for daily and monthly monitoring of the Kriveljska, Borska, Brestovacka, and Ravna rivers. Reports on the monitoring results are published monthly on the city administration's website.

The rivers in the Pek basin are polluted by water from surface mines in Majdanpek and from the flotation tailings of the Velja Fundata mine. The Beli and Svrjishki Timok rivers are endangered by drainage from abandoned mines. The Crni Timok river is increasingly threatened by wastewater from the newly opened Cukaru Peki mine. The Kriveljska and Borska rivers, tributaries of the Veliki Timok, fall outside all categories due to the concentrations of sulfates, arsenic, and heavy metals.

All tributaries of the Veliki Timok are burdened with pollutants, and upon entering the Veliki Timok, they carry all their loads, causing pollution above the prescribed category. Along the courses and banks of these rivers, large amounts of sediment from mines and tailings have been deposited. It is necessary to clean the sludge and dispose of it in hazardous waste landfills to remediate river pollution.

Preliminary monitoring of the radioactivity levels of surface waters in the Pek and Veliki Timok river basins was conducted for the first time. A slight increase in the radioactivity of the sludge in them was noted after the discharge of mining and drainage waters from flotation tailings.

There is no monitoring of the quality of groundwater bodies influenced by surface mines, shafts, and mining waste disposal sites. Measurements are only carried out by owners in exploitation fields, without monitoring the impact in areas where mines may have an influence.

The biggest problems are related to the discharge of drainage water from abandoned mines and tailings ponds that have no owners. Additionally, the impact of the latest geological explorations and the discharge of water from boreholes and trenches during these activities is not monitored.

## Recommendations

At the national level, there is an urgent need to address the issue of mining water from abandoned and active mines and consistently implement the legal obligation to improve the quality of surface waters by one class by 2032.

The cities of Zaječar and Bor and the Municipality of Majdanpek should develop water quality monitoring programs in accordance with laws and establish systems for regular and timely public dissemination of results.

These local communities should insist with relevant state authorities to intensify national monitoring of water quality and implement special biomonitoring and radioactivity monitoring programs for river sediments.

Efforts should be made to incorporate provisions for sediment cleanup along the Pek and Veliki Timok rivers into national plans and programs, especially those related to spatial and urban planning, strategies, and assessments of environmental impacts of individual expansion programs of existing and new mines.

Inform and educate the public about opportunities for public inspections and involvement in the processes of drafting national and local public policy documents, especially the importance of involving the public in the processes of drafting spatial and urban plans, strategies, and impact assessments on the environment.

Continue and insist on the enactment of acts to protect artesian water in Zaječar as a public natural good and support the process of revitalization, renovation, and regulation of urban fountains as symbols of the city, and initiate the procedure to declare them as material cultural assets.

Strengthen the capacity of local communities to manage water resources and protect water sources.

It is necessary to continue the ongoing comprehensive monitoring of surface waters (water, sludge, radioactivity, biomonitoring) and expand it to monitor the quality of the Trgoviski, Svrjiški, and Beli Timok rivers, as well as groundwater throughout the Timok region around Majdanpek and in the vicinity of the Pek River.

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