

STATE OF AIR QUALITY IN THE CITY OF BOR IN 2024

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Abstract

In 2024, the air quality in the city of Bor was classified as Category III, indicating polluted air, according to the Mining and Metallurgy Institute (MMI) Bor annual report. While the Krivelj and Metovnica measuring points recorded Category I air quality, signifying clean or slightly polluted air, the Oštrelj and Brezonik sites experienced excessive levels of PM₁₀, exceeding the daily limit value for more than 35 days. Despite meeting other air quality parameters, these sites were classified as Category III. The Institute site reported arsenic (As) concentrations in PM₁₀ samples that exceeded the annual target value (6.8 ng/m³ compared to 6 ng/m³). Similarly, the Town Park site showed elevated levels of arsenic and cadmium (Cd) in PM₁₀, with concentrations of 16.8 ng/m³ and 9.5 ng/m³, respectively, surpassing the target annual values. The Jugopetrol site was notably affected, with 77 days of PM₁₀ concentrations exceeding the daily limit, arsenic concentrations of 42.0 ng/m³, and cadmium concentrations of 19.8 ng/m³, both significantly above their respective target values. The overall air quality assessment for the Bor agglomeration in 2024 was determined based on the most polluted measuring site, resulting in a Category III classification, indicating polluted air. This highlights the need for continued monitoring and mitigation efforts to improve air quality in the region. The air quality in the city of Bor in 2024 is worse compared to 2023 due to higher concentrations of Cd in PM₁₀ samples measured at the Jugopetrol and Town Park monitoring sites, as well as a greater number of days exceeding the daily limit value for PM₁₀ concentrations. If domestic copper concentrates do not contain Cd in significant percentages the question arises: What kind of imported concentrates are being smelted in the Bor copper smelter in 2023 and 2024 to cause such high Cd concentrations in PM₁₀ samples?

Keywords: air quality, monitoring, suspended particles, arsenic, cadmium

1. INTRODUCTION

Air pollution refers to the presence of chemicals, particles, or biological materials that cause harm or discomfort to humans and other living organisms, or that threaten the natural environment in the atmosphere [1]. Air pollution occurs when gases and microscopic dust particles (PM₁₀ and PM_{2.5}) and soot are released into the atmosphere, altering the natural balance and concentration of the fundamental components of air. In some cases, these particles enter the atmosphere through natural processes, such as emissions from wildfires. However, more frequently, they are introduced as a result of human activities. Until 2016, outdated copper concentrate smelting technology was used at the copper smelter in Bor, leading to environmental pollution. Elevated concentrations of sulfur dioxide, exceeding the legally prescribed hourly and daily limits, were frequently detected at all air quality monitoring stations in Bor. Since 2016, the flash smelting technology has been employed at the Bor copper smelter [2, 3, 4], with all waste gases from the flash furnace being processed at a sulfuric acid plant. This study analyzes air quality in Bor during 2024 by comparing the air quality data with that obtained in 2023.

2. EXPERIMENTAL

Ambient air quality monitoring in Bor and its suburban settlements was conducted to obtain data necessary to properly select measures to protect and improve human health and preserve the environment. The Mining and Metallurgy Institute Bor holds an accreditation certificate that confirms that, during 2023 and 2024, the organization met the requirements of the ISO/IEC 17025:2017 standard for performing air quality monitoring according to the ambient air monitoring program for the city of Bor and its suburban settlements. This paper presents the results from the annual air quality monitoring reports for Bor in 2023 and 2024 [5].

3. RESULTS AND DISCUSSION

Table 1 presents the average annual concentrations of SO₂ in Bor in 2023 and 2024 [5]. Based on the data from Table 1, at most monitoring stations, the annual mean SO₂ concentrations in 2024 are approximately the same or slightly higher than those recorded in 2023. During 2024, three exceedances of the average daily limit value for SO₂ concentration (125 µg/m³) were recorded at the Jugopetrol monitoring station, while in 2023, no exceedances of the daily limit value for SO₂ concentration were observed at any monitoring station [5].

Table 1 - Mean annual concentrations of sulfur dioxide (µg/m³) in Bor in 2023 and 2024 (Technical Faculty - TF, Town Park - TP, Institute - IN, Jugopetrol - JP, Brezonik - BR, Slatina - SL, Krivelj - KR, Annual Limit Value - LV)

Year	TF SO ₂	TP SO ₂	IN SO ₂	JP SO ₂	BR SO ₂	SL SO ₂	KR SO ₂
2023	8.8	11.6	8.1	17.9	12.1	11.1	12.4
2024	11.6	11.0	16.0	26.3	11.2	11.5	12.7
LV	50						

The average annual concentrations of PM₁₀ at monitoring sites in Bor for the years 2023 and 2024 are presented in Table 2. Throughout 2023, no exceedances of the annual limit value for PM₁₀ concentrations were recorded at any monitoring site. However, exceedances in the number of days (more than 35 days) during which the average daily PM₁₀ concentration exceeded the daily limit value (50 µg/m³) were observed at the following monitoring sites: JP (52 days) and BR (48 days) [5]. In 2024, exceedances in the number of days (more than 35 days) with average daily PM₁₀ concentrations above the daily limit value were recorded at the following monitoring sites: BR (86 days), JP (77 days), and OS (75 days) [5]. Across all monitoring sites, an increase in the number of days exceeding the daily PM₁₀ limit in 2024 compared to 2023 is evident [5].

Table 2 - Mean annual concentrations of PM₁₀ (µg/m³) in Bor in 2023 and 2024 (Town Park - TP, Institute - IN, Jugopetrol - JP, Krivelj - KR, Brezonik - BR, Oštrelj - OS, Industrial zone - IZ, Metovnica - ME, Annual Limit Value - LV)

Year	PM ₁₀ _TP	PM ₁₀ _IN	PM ₁₀ _JP	PM ₁₀ _KR	PM ₁₀ _BR	PM ₁₀ _OS	PM ₁₀ _IZ	PM ₁₀ _ME
2023	23.4	33.8	35.1	28.5	34.2	28.8		
2024	32.5	30.7	37.0	26.8	39.6	36.7	32.8	22.6
LV	40							

Table 3 shows the annual concentrations of arsenic in PM₁₀ samples in Bor, by measuring points, in 2023 and 2024. During 2024, the annual target value for arsenic concentration in PM₁₀ (6 ng/m³) was exceeded at TP, IN, JP, and IZ measuring sites. Extremely high concentrations of arsenic in PM₁₀ samples were detected at the measuring points JP and IZ because they are located in the dominant wind direction, which carries pollution from the copper smelter to these sites.

Table 3 - Mean annual concentrations of arsenic in PM₁₀ (µg/m³) in Bor in 2023 and 2024 (Town Park - TP, Institute - IN, Jugopetrol - JP, Krivelj - KR, Brezonik - BR, Oštrelj - OS, Industrial zone - IZ, Metovnica - ME, Annual Target Value - ATV)

Year	As_TP	As_IN	As_JP	As_KR	As_BR	As_OS	As_IZ	As_ME
2023	15.4	12.2	39.8	1.7	6.6	3.1		
2024	16.8	6.8	42.0	1.4	5.6	3.3	15.1	2.3
ATV	6							

Table 4 shows the annual concentrations of cadmium in PM₁₀ samples in Bor by measuring point in 2023 and 2024. From the results given in Table 4, an increase in the annual values of cadmium concentrations in PM₁₀ samples can be observed at all measuring points in 2024 compared to 2023. During 2024, the annual target value for the concentration of cadmium in PM₁₀ samples was exceeded at the measuring points TP, JP and IZ.

Table 4 - Mean annual concentrations of cadmium in PM₁₀ (µg/m³) in Bor in 2023 and 2024 (Town Park - TP, Institute - IN, Jugopetrol - JP, Krivelj - KR, Brezonik - BR, Oštrelj - OS, Industrial zone - IZ, Metovnica - ME, Annual Target Value - ATV)

Year	Cd_TP	Cd_IN	Cd_JP	Cd_KR	Cd_BR	Cd_OS	Cd_IZ	Cd_ME
2023	3.1	2.0	5.6	0.5	1.8	1.1		
2024	9.5	3.9	19.8	0.7	2.7	1.4	8.0	0.7
ATV	5							

During the reconstruction of the copper smelter (2021-2022), when the copper smelter was out of operation, high concentrations of As and Cd in PM₁₀ were not detected at any measuring point in Bor [5]. Therefore, it is concluded that high concentrations of As and Cd in PM₁₀ samples were detected during 2024 at the measuring site of JP, originating from the copper smelter; that is, they are the result of the processing of copper concentrate with an increased content of As and Cd. This means that the percentage values of these carcinogenic elements in the copper concentrate in some periods were higher to the values predicted in the environmental impact assessment study of the project: Increasing the capacity of the copper smelter within the "Serbia Zijin Copper" DOO Complex [3]. For this reason, it is necessary to implement additional measures to regularly control the composition of the concentrates processed in the copper smelter in Bor and harmonize them with the prescribed values in the study [3] to bring the content of carcinogenic elements in the suspended particles of the PM₁₀ fraction to the values provided by law, at all measuring points in Bor.

In 2024, 14 days were recorded with exceeding the daily limit value for the concentration of Pb in PM₁₀ samples at the measuring site JP, while in 2023, an exceedance was recorded for 2 days. The above results indicate an increase in the processing of imported copper concentrates in the copper smelter in Bor because there is no Pb in domestic copper concentrates. In 2024, there was no exceedance of the target value for Ni concentration in PM₁₀ at any measuring point.

4. CONCLUSION

This paper analyzes the air quality in the city of Bor in 2024. Despite the reconstruction of the copper smelter, the problem of the emission of high concentrations of carcinogenic elements in PM₁₀ samples persists. The air quality in Bor in 2024 is worse compared to 2023 due to higher concentrations of Cd in PM₁₀ samples measured at the Jugopetrol and Town Park monitoring sites, followed by a higher number of days exceeding the daily limit value for PM₁₀ concentrations.

So that, it is necessary to apply additional measures to reduce these emissions to the values provided by law, which relate to the regular control of the composition of the copper concentrate processed in the copper smelter in Bor and harmonization with the prescribed values for the percentage composition of carcinogenic elements in the copper concentrate provided for in the Study on the Impact Assessment on project environment: Increasing the capacity of the copper smelter within the "Serbia Zijin Copper" DOO Complex [3].

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