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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

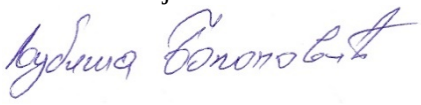
We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović



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AIR QUALITY MEASUREMENTS IN THE BOR CITY DURING THE RECONSTRUCTION OF THE COPPER SMELTER BOR IN 2022

Viša Tasić[1], Tatjana Apostolovski-Trujić[1], Bojan Radović[1], Nevena Ristić[1], Tamara Urošević[1], Vladan Kamenović[1], Zvonko Damnjanović[2]

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Abstract

Industrial activities in Bor, especially those related to the operation of the copper smelter, have caused a number of negative impacts on the environment in the region (including air, water, and soil) and have caused serious concern about the effects they have on human health. The Government of the Republic of Serbia invested significant funds in the construction of a new copper smelter in Bor which began operating in 2016. The new copper smelter uses flash-smelting technology, so the emissions of waste gases from metallurgical plants are of different intensities and compositions than before. In the meantime, the mining and smelting basin of Bor goes through an ownership transformation in 2018. ZiJin, one of the world's leading mining companies in the production of copper and precious metals, became a strategic partner. The Serbia ZiJin Bor Copper launched a number of projects to increase mining and metallurgical production in Bor. The capacities of the copper smelter in Bor are being expanded during 2022-2023 by about 2.5 times and a new sulfuric acid factory and a new electrolysis plant is being built. The start of operation of the expanded facilities in the copper smelter is expected in the middle of 2023. This paper presents the results of air quality measurements in the city of Bor in the time period when the copper smelter in Bor is not working, due to reconstruction (June - December 2022). These measurements aimed to determine the level of air pollution at locations not part of the state or local air quality monitoring network. These measurements are of great importance because many people live in those areas. The obtained results will serve as a basis for future air quality monitoring when the copper smelter in Bor starts to operate again.

Keywords: *copper smelter, air pollution, suspended particles, arsenic*

1. INTRODUCTION

The copper ore has been mined and processed on the territory of the city of Bor (Serbia) for more than a century. The operations of the copper ore excavation and processing have caused a number of negative impacts on the environment in the region (including air, water, and soil) and have caused serious concern about the effects they have on human health [1,2,3]. Air quality monitoring in the city of Bor has been systematically carried out since the seventies of the last century. Since 2005, automatic methods of measuring sulfur dioxide concentrations have been applied at several measuring points in the city [4,5,6]. The smelting technology in the copper smelter in Bor was changed in 2016, so the concentrations of sulfur dioxide that have been recorded since then are significantly lower than during the period of operation of the copper smelter with the old smelting technology. Despite the changed copper smelting technology, the concentration of SO_2 and carcinogenic elements, especially arsenic, in the suspended particles of the PM_{10} fraction is still higher than prescribed by law at certain measuring points in the city [7,8,9].

ZiJin, one of the world's leading mining companies in the production of copper and precious metals, became the majority owner of the copper smelter and mine in Bor in 2018 [10]. The Serbia ZiJin Bor Copper company launched a number of projects to increase mining and metallurgical production in Bor. The capacities of the copper smelter in Bor are being expanded during 2022-2023 by about 2.5 times and a new sulfuric acid factory and a new electrolysis plant are being

built. The start of operation of the expanded facilities in the copper smelter is expected in the middle of 2023. During the reconstruction period (from June 2022 to March 2023), the copper smelter in Bor was not operated, so this period was used for air pollution monitoring with an aim to better understand the impact of the smelter's operation on air pollution in Bor.

2. EXPERIMENTAL

Based on the analysis of the concentrations of air pollutants measured at the existing measuring points in the city of Bor from 2016 up to 2022, as well as the possible impact of the new mining and metallurgical facilities on the air quality, additional measurement locations were selected. So, those locations are not part of the national or local air quality monitoring network. This was done in order to better assess the impact of the operation of the Bor copper smelter on air quality and human health at those locations too.

Figure 1 - Map of the agglomeration of Bor with measurement points marked (1. Bor Lake, 2. Brestovacka Spa, 3. Metovnica, 4. Brestovac, 5. Oštrelj, 6. Industrial zone, 7. Slatinsko naselje, 8. Police headquarters, 9. Slatina, 10. Gornjane, KR- Krivelj, BR- Brezonik, TP - Town Park, IN- Institute MMI, SL- Slatina) [11]

At each of additional measuring point (marked with numbers 1-10 in Figure 1), sampling of suspended particles (PM_{10}) was carried out for 10 consecutive days (June 2022 - December 2022). Daily PM_{10} samples were collected with reference sampler Sven/Leckel LVS3[12] on Whatman QM-A quartz filters with a diameter of 47 mm. Sampling and determination of the mass concentration of suspended particles PM_{10} were performed in accordance with the standard SRPS EN12341:2015 [13]. Further preparation of samples for chemical analysis was carried out in accordance with the SRPS EN14902:2008 [14]. The content of chemical elements in the PM_{10} samples was determined using ICP MS (Agilent model 7700) [15]. The detection limits of this device for As, Pb, Cd, and Ni were 0.1, 0.5, 0.02, and 0.7 ng/m^3, respectively. The control of the applied procedures was carried out using the reference material [16]. Simultaneously with gravimetric measurements, continuous measurements of mass concentrations of gaseous pollutants SO_2, NO_x, NO_2, NO, CO, and O_3 were carried out using Teledyne automatic gas analyzers [17] installed in a mobile measuring station.

3. RESULTS AND DISCUSSION

The measurement results presented in Table 1 show that there was no exceedance of the daily limit values for gaseous pollutants, nor was there an exceedance of the limit value for the average daily concentration of lead in suspended particles of the PM_{10} fraction. There was no overshooting of

target values for annual concentrations of cadmium and nickel in PM_{10}. The concentration of arsenic in PM_{10} at measuring point 8 (PU Bor) was above the target annual value for 3 out of 10 measurement days. The maximum measured mean daily value of arsenic concentration in PM_{10} at this measuring point was 11.3 ng/m^3. We believe that surface emissions of suspended particles inside the copper smelter Bor (road dust, construction works) are the dominant source of As detected in PM_{10} at this measuring point.

Table 1 - Results of air quality monitoring (measuring points marked from 1-10 in Figure 1). Mean daily concentrations of PM_{10}, chemical elements in PM_{10}, SO_2, NOx, NO_2, NO, CO, and O_3 (AMS -Automatic Moniring Station)

		Measuring point									
	Unit	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
PM_{10}	µg/m^3	12.8	19.4	26.3	19.1	20.9	44.2	25.7	35.9	23.3	34.8
As	ng/m^3	0.3	0.5	1.2	1.8	0.7	4.2	3.5	6.1	3.5	0.5
Cd	ng/m^3	0.0	0.1	0.0	0.1	0.1	0.4	0.1	0.2	0.1	0.1
Pb	ng/m^3	0.5	1.7	3.9	4.2	2.6	19.6	47.6	10.9	4.2	3.5
Ni	ng/m^3	1.9	1.3	2.9	3.5	2.4	4.2	3.9	0.9	3.8	0.8
Al	ng/m^3	2.4	38.8	289.2	230.0	306.6	565.2	582.2	268.2	244.0	237.7
Sb	ng/m^3	0.0	0.1	0.1	0.3	0.1	0.7	1.0	0.5	1.1	0.4
Zn	ng/m^3	10.0	29.7	3.8	18.1	24.0	47.8	23.5	11.8	45.1	10.5
Cu	ng/m^3	1.2	5.8	8.2	33.5	41.4	73.1	106.1	5.4	27.3	4.6
Co	ng/m^3	0.0	0.1	0.3	0.1	0.1	0.3	0.3	0.1	0.2	0.1
Mn	ng/m^3	0.4	2.2	6.2	6.1	6.1	21.5	11.8	6.8	6.4	6.0
Cr	ng/m^3	5.0	1.8	7.0	4.6	6.2	8.1	6.5	0.2	7.6	0.2
Fe	ng/m^3	4.4	65.3	241.2	156.2	253.5	706.9	440.5	209.6	212.1	186.0
Se	ng/m^3	1.8	2.3	2.0	2.2	2.0	1.8	16.5	2.2	2.3	2.0
Sr	ng/m^3	0.5	1.2	1.3	1.9	2.4	4.6	5.2	0.7	1.7	0.6
Mo	ng/m^3	0.5	0.6	1.2	1.1	1.0	0.5	1.3	0.6	1.0	0.5
Ag	ng/m^3	0.5	0.6	1.8	2.0	1.8	0.4	5.1	2.0	1.8	1.8
Sn	ng/m^3	0.5	0.6	0.6	4.2	1.7	0.6	1.2	0.5	0.6	0.5
Ba	ng/m^3	1.5	2.6	2.8	2.0	14.9	11.8	11.8	2.7	5.8	2.3
Ca	ng/m^3	158.0	289.9	403.4	348.3	785.8	1177.2	1302.1	90.1	565.4	82.7
K	ng/m^3	71.7	168.6	133.5	108.3	151.7	271.6	273.0	317.5	149.6	284.1
Mg	ng/m^3	36.3	37.1	80.8	69.7	110.5	146.5	158.3	22.5	76.5	20.9
Na	ng/m^3	248.2	258.4	48.1	136.2	274.8	231.3	712.7	11.3	146.5	10.3
S	ng/m^3	181.3	520.3	1112.2	344.6	569.4	1358.0	659.1	579.9	867.6	520.7
AMS SO_2	µg/m^3	9.3	7.3	21.0	4.4	6.1	8.0	8.0	15.9	21.4	5.3
AMS NOx	µg/m^3	8.0	6.5	7.9	10.0	9.9	19.6	16.5	25.7	14.2	12.2
AMS NO_2	µg/m^3	4.6	3.6	4.1	6.7	6.4	12.8	12.9	11.0	8.7	8.0
AMS NO	µg/m^3	3.0	1.8	2.4	2.4	2.3	4.4	2.5	9.7	3.5	2.9
AMS CO	mg/m^3	0.2	0.3	0.2	0.2	0.2	0.7	0.2	0.6	0.4	0.5
AMS O_3	µg/m^3	66.1	72.6	94.7	93.0	91.8	57.6	87.1	68.0	88.0	67.6

4. CONCLUSION

This paper presents the results of air quality measurements at an additional 10 locations in the Bor agglomeration in the period June - December 2022, at a time when the copper smelter in Bor was not operating. Based on a complete insight into the results of air quality measurements in the Bor agglomeration in 2022 [11,18], it can be concluded that, in the period when the copper smelter was in operation, a dominant share in the levels of SO_2, as well as the concentrations of As, Cd, and Pb in PM_{10} originates from emissions of gaseous pollutants from a copper smelter Bor.

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