MINING AND METALLURGY
INSTITUTE BOR

and

TEHNICAL FACULTY BOR,
UNIVERSITY OF BELGRADE

IOC2024

International October Conference

55th International October Conference on Mining and Metallurgy

PROCEEDINGS

Editor:
Ana Kostov

15 – 17 October 2024
Hotel "Đerdap" Kladovo, Serbia

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MONITORING THE pH VALUE AND ELECTRICAL CONDUCTIVITY IN THE RIVERS OF THE BOR AREA

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Abstract

The impact of copper mining and metallurgy activities on the quality of surface water in the Bor Area during the period September 2019 – September 2021 has been taken into consideration in this paper. The pH value and electrical conductivity were monitored through the eight sampling campaigns. The pH values during each sampling campaign were low for the acid mine drainage, metallurgical wastewater, and water from the Bor River and Bela River. The pH values for the rivers without the impact of mining and metallurgical activities had the neutral values. Electrical conductivity for metallurgical wastewater had a value higher than the maximum value of the instrument.

Keywords: pH value, electrical conductivity, surface water, copper mining

1. INTRODUCTION

The mineral reserve in the territories of Eastern Serbia has resulted in the mining of some minerals, and production of their primary products has increased severalfold in the past few decades. Copper ore deposits occur as the porphyry copper and massive sulfide types, predominantly in the East Serbian sector of the Carpatho-Balkanides (the Bor metallogenic zone).

The mine water generated from the Bor mine flows into the Bor River. The Bor River and Krivelj River form the Bela River, a tributary of the Timok River which flows into the Danube River. The characteristics of discharged mining water include a high content of suspended substances, such as copper and other heavy metals, and low pH. Therefore, the Danube River is constantly threatened, since it is the final recipient of water contaminated with large quantities of arsenic, heavy metals, and sulfates [1].

This paper presents the results of pH and electrical conductivity at the nine measuring points, six from the surface water rivers and three samples from the mine and industrial wastewaters. Samples were taken during the eight sampling campaigns, in the period September 2019 to September 2021, in the Bor Area.

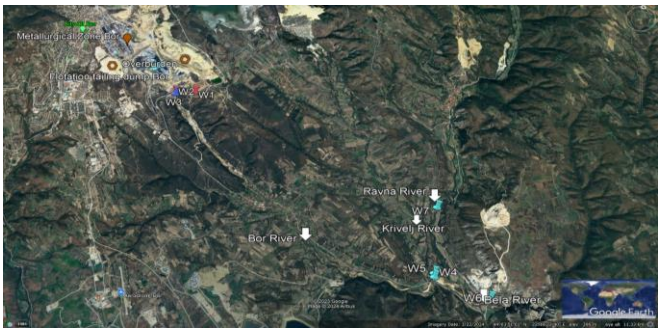
The pH value is a quantitative measure of the acidity or basicity of aqueous or other liquid solutions. The pH is usually measured with a pH meter, which translates into the

pH readings of difference in the electromotive force (electrical potential or voltage) between the suitable electrodes placed in the solution to be tested [2].

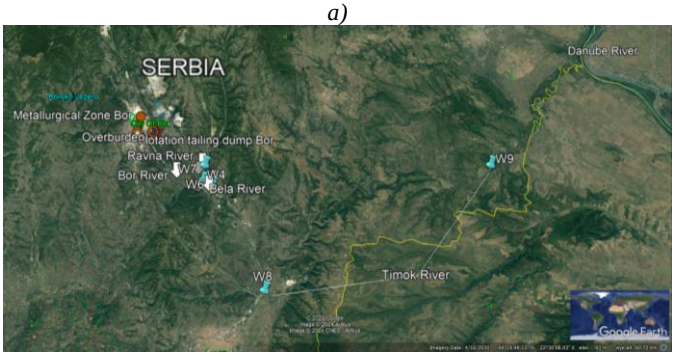
Electrical conductivity is the ability of water to conduct electricity, and it depends on the amount and type of dissolved substances, salts, minerals, chemicals, etc. Substances that are dissolved in water consist of positive and negative ions that conduct the electricity in water. An increased value of the electrical conductivity of water can indicate its pollution.

2 STUDY AREA

The nine locations, chosen to take samples, are aimed to define the pH value and electrical conductivity (EC) of those samples. Figure 1 shows all locations that are directly affected by the mining and metallurgical activities (a), and all locations where the water sampling was performed (b) [3].



a)



b)

Figure 1. *Water sampling locations: a) locations under a direct impact of the mining and metallurgy activities, b) all sampling locations.*
Coordinates: W1 - AMD from overburden (N: 04880494, E: 07591486), W2 - AMD from flotation tailings (N: 04880366, E: 07591043), W3 - industrial wastewater (N: 04880342, E: 07591076), W4 – the Bor River (N: 04877524, E: 07594505), W5 – the Krivelj River (N: 04876932, E:07597572), W6 – the Bela River (N: 04876866, E:07597572), W7 – the Ravna River (N: 04876953, E: 07597650), W8 – the Timok River (out of the impact of the mining and metallurgy activities from study area) (N: 04867539, E: 07605955) and W9 – the Timok River after confluence with the Bela River (N: 04884420, E: 07625930)

The Bor River is formed from the untreated municipal wastewater, AMD from overburden deposited near the village of Oštrelj (W1), AMD from the flotation tailing dumps that are not in operation (W2), and metallurgical wastewater (W3), also discarded without previous treatment. Sampling of the Bor River (W4) is carried out at the point near the confluence with the Krivelj River (W5). The sampling of the surface water from the Krivelj River was done at the place where there is a significant impact of all wastewater from the study area (mine, drainage, flotation). The Bela River (W6) was sampled after merging the Bor, Krivelj and Ravna rivers (W7). Two sampling points were selected in the Timok River, before (W8) and after (W9) the confluence with the Bela River [3]. The coordinates of the sampling locations were measured with a GPS device (Global Positioning System) and are shown in Figure 1.

2.1 Sampling Procedure

Water samples (AMD, industrial wastewater, water from rivers) were sampled by the hand tools according to the standard sampling methods, and interpretations were recorded on the lists for water sample collection and testing. The details included all the information necessary to assist in data interpretation and repeatability of sampling. At the site, a portion of water sample from a plastic container was poured into a vessel for the pH and electrical conductivity measuring.

2.2 Samples Characterization

Methods prescribed by the relevant international and European standards were used to measure the pH and electrical conductivity. For certain constituents and physical values, an immediate analysis in the field is required. At the sampling site, a part of a water sample from a plastic container was poured into a vessel to measure the pH and electrical conductivity. The vessels for pH and electrical conductivity measuring were also three times rinsed with a water sample before performing the measure. All field measurement instruments are calibrated before starting sampling and once again after completing all of the sampling. Electrical conductivity and pH are measured on the field for a duration of 10 min. Electrical conductivity is measured with the EC1387, CHEMLAND, and pH with WTW 7310, Ino Lab [3].

3 RESULTS AND DISCUSSION

According to the Serbian Regulation on categorization the watercourses, the observed rivers are categorized into the III and IV categories. The pH value should be in the range of 6.5 to 8.5 for both categories. The maximum value of electrical conductivity (μS/cm) for the III-category rivers is 1500, while for the IV-category rivers, it is 3000 [4, 5].

3.1 pH Values

Based on the displayed pH values in the eight sampling campaigns, the conclusion is that the wastewater W1, W2, W3, and surface water W4 and W6 have increased acidity. The wastewater from locations W1 and W2 is AMD, and the water from location W3 is the industrial metallurgical wastewater, it is understandable to expect such pH

values. The low pH values are also characteristic of the Bor River (W4), which is created by mixing the W1, W2, and W3 with the municipal wastewater from the town of Bor. The lowest pH value of the Bor River was measured in the V sampling campaign (2.29), which is also characterized by the lowest pH value at location W3 (1.49). The above data once again confirmed the dominant impact of metallurgical wastewater on the pH of the Bor River.

The Bela Reka (W6), which originates from the confluence of the Bor River (W4), Krivelj Reka (W5), and Ravna River (W7), is also characterized by the low pH values compared to the pH values of surface water from locations W5, W7, W8, and W9. Although the Krivelj River (W5) is characterized by the pH in the range of 6.53-7.7 when it joins the Bor River, whose pH value is in the range of 2.29-3.36, the pH value of the newly formed Bela River (W6) drops and ranges between 2.82-3.9, which confirms the impact of metallurgical wastewater on the pH value of the Bela River.

The pH values of surface water that are not under the impact of the mining and metallurgical activities are within the MAC values (6.5 - 8.5). The pH values, measured during the realized campaigns, are shown in Figure 2.

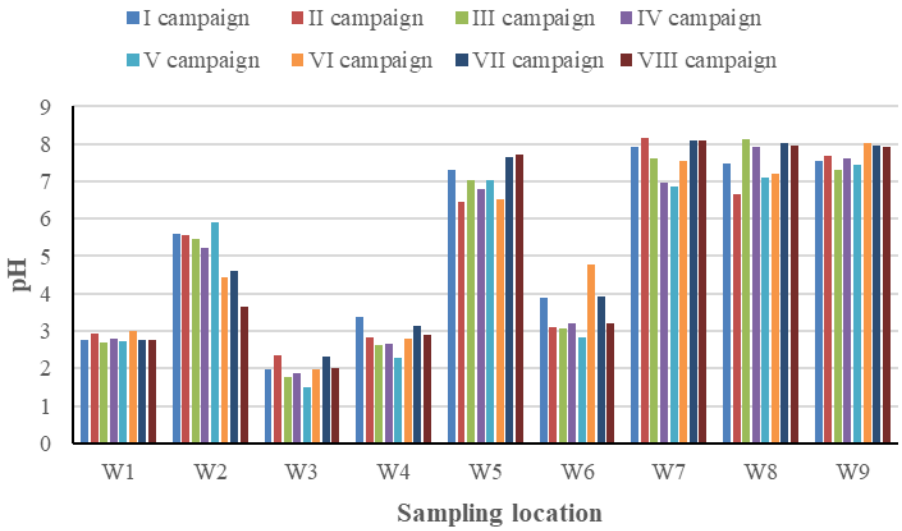


Figure 2. *The pH values in the realized sampling campaigns and sampling locations*

3.2 Electrical Conductivity

The measured values of electrical conductivity during the implemented sampling campaigns are shown in Figure 3.

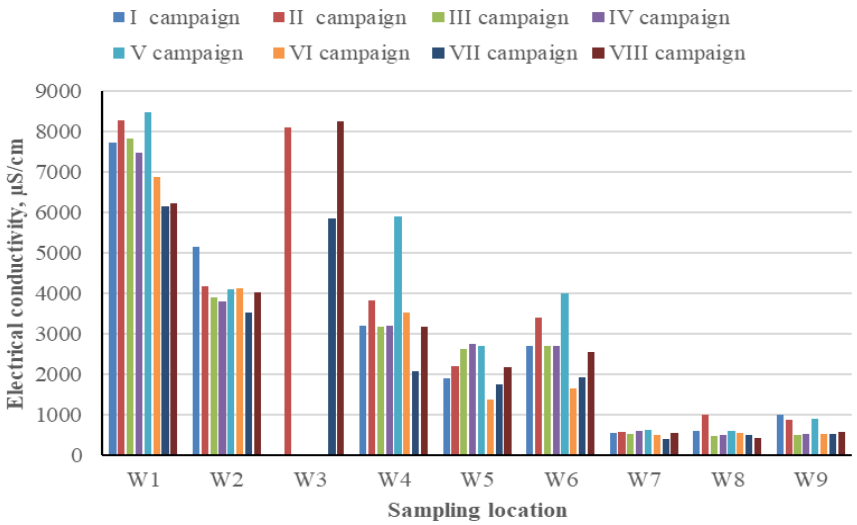


Figure 3. *Values of electrical conductivity in the realized sampling campaigns*

The electrical conductivity values of wastewater from locations W1, W2, and W3 were very high and ranged from 3500 µS/cm to above 8000 µS/cm indicating the presence of high concentrations of Cu, As, Ni, Cd, and Pb ions in the studied wastewater. The electrical conductivity of water in the sample W3 in the five campaigns was above the upper sensitivity limit of the instrument (19990 µS/cm), confirming the high concentrations of metal ions in this water.

Surface water, under a direct impact of the mining and metallurgical activities (W4, W5, and W6) are characterized by the slightly lower electrical conductivity values, but are still higher than 1500 µS/cm, which is the upper limit for the class III according to Serbian legislation. The characteristic of the surface water from locations W7 and W8 is that the values are below 1000 µS/cm, [4, 5].

The electrical conductivity of the Timok River (W9) during certain sampling campaigns was higher than that of water from the sites W7 and W8, which confirmed the impact of the Bela River (W5) on the value of electrical conductivity of the Timok River (W9) after joining the Timok River (W8) out of impact the mining and metallurgical activities from the study area and Bela River (W5).

4. CONCLUSION

The pH values, during each sampling campaign, were low for the acid mine drainage, metallurgical wastewater, Bor River, and Bela River. The rivers, without the impact of the mining and metallurgical activities, had the neutral pH values.

Electrical conductivity of the metallurgical wastewater had a value that was higher than the instrument maximum value in almost all sampling campaigns.

The characteristic of the Timok River (W8), which flows through the area that is out of impact the mining and metallurgy activities, is that the concentration of each monitored parameter was lower than the MAC value.

This work represents one of the broadest investigations of the pH and electrical conductivity values in wastewater, produced by the mining and metallurgical activities in the surface water of rivers in the Bor Area.

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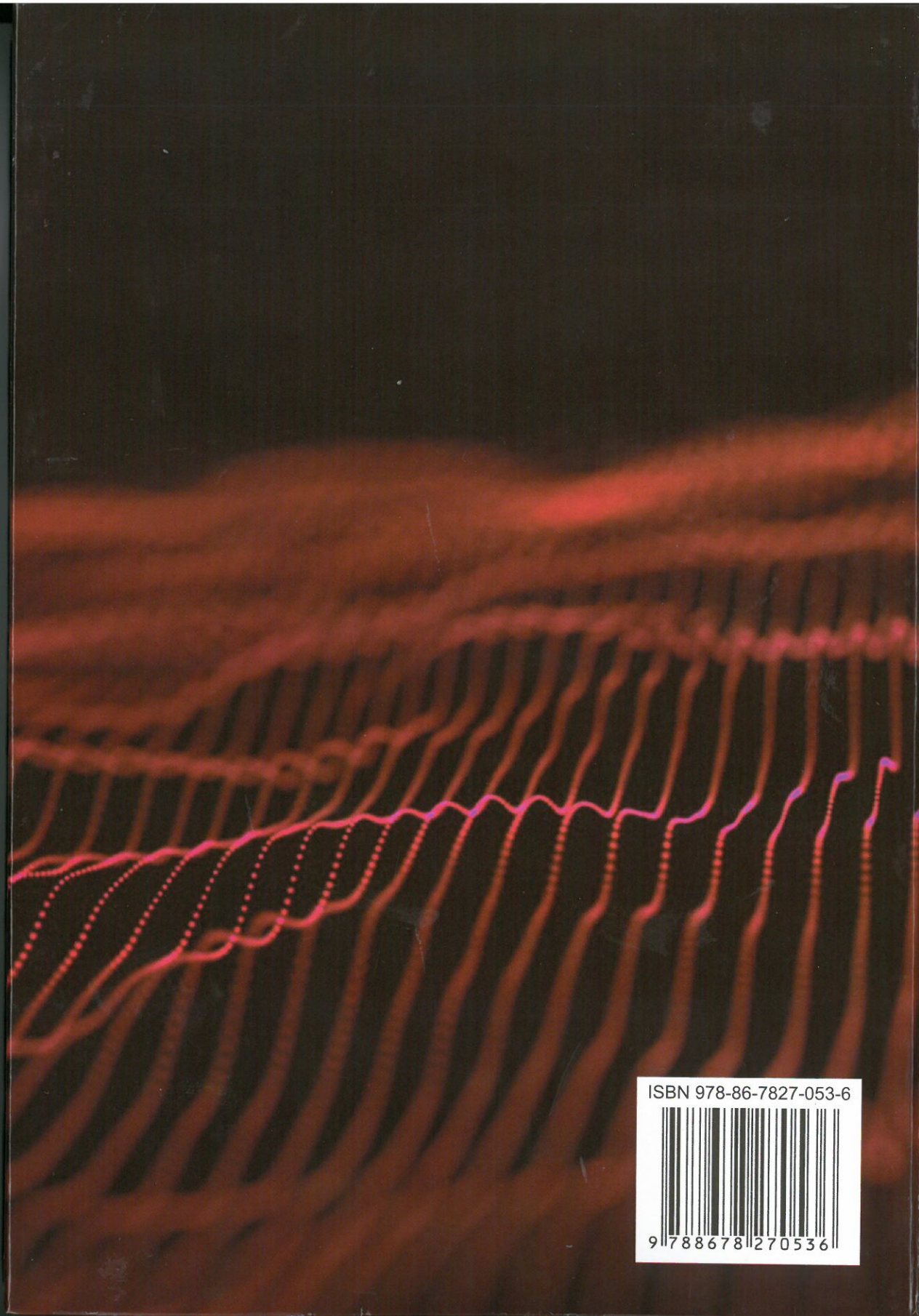
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