Study on the mining influenced water and a possibility to extract copper metal from tailings deposition in Bor, Serbia

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Abstract

Bor area is one of the important copper mining areas in Serbia. Mine drainage water and wastewater from the mine area may be affecting surrounding areas. The study has two purposes. One is to clarify environmental impacts caused by mine drainage water from overburden and wastewater from mining facilities, and another is to propose a possibility to extract copper metals from the tailings deposited. Investigations on the water were carried out in the region from the Bor mining area through Timok River to the Danube in August 2011. As a result, water quality along the river and a technical possibility on copper extraction from the tailing is confirmed.

Key words: copper mine, mine drainage, tailing, copper extraction, Serbia, Bor mine

Introduction

Bor mining complex is located 230km south-east of Beograd, Serbia. There are two major mines and copper smelter/refinery. The Bor underground mine has a history of more than 100 years, and Bor open-pit mining started in 1923. A total amount of approximately 100 million tons of ore and 170 million tons of waste were mined from the open-pit. There are other smaller mines, such as Veliki Krivelj open-pit mine and Cerovo open-pit mine. Waste dumps, low grade ore dumps and tailing deposition are distributed in surrounding areas. The mining influenced water including waste water from the smelter is flowing into the Krivelj river and Bor river down to the Danube, which is causing strong concern to the environmental situation not only the Serbia government and municipal people but also international organizations.

Methods

Mining influenced water investigation

Investigation was carried out in the region from the Bor mining area through Timok River to the Danube from August 10 - 24, in 2011. Surveys and sampling were carried out at 20 sites in total. Samples collected at each site were solutions for chemical analyses of cation and anion (mine drainage water, wastewater and river water), residues of the solution trapped on a 0.45 micro meter filter and sediments on the riverbed. Mine drainage water from the Bor mine and overburden, wastewater from the smelter and municipal water from Bor City were collected around the Bor mine. Other samples in this study were river water collected from Bor River, Veliki Krivelj River, Bela River, Timok River and the Danube.

Metal recovery

Basic studies for metal recovery from old flotation tailing deposits to find out optimal conditions on acid leaching, solvent extraction and electrolysis tests were carried out. Also continuous tests were conducted based on the obtained results, and an examination for final scaling up was performed.

Results

Mining influenced water investigation

Water in the Bor mining area that has an impact on the environment is divided into four types: mine drainage water flowing out from the Bor underground mine and overburden, wastewater from the smelter, municipal water from Bor City, and mine drainage water-bearing river water. Acidic waters related to the mining activity in the Bor mining area are water of P-11 (Robule Lake), P-3 (mine drainage water from the underground of the Bor mine), P-2 (Saraka Stream, overburden), P-6-1 (wastewater from the smelter) and P-6-2 (overburden south of Bor City) in the Bor mining area (fig. 1).

Water from the smelter (P-6-1) has low pH, high copper content and large flow rate (fig. 2). Loss of copper through wastewater from the smelter is estimated to be over 1,000 g/min. The water from the smelter also has a large environmental impact on the river system from Bor River to Bela River because of the low pH value, high copper content, and large flow rate.

Flow rate and pH value of river water in the Bor mining area range from 5,900 to 58,000 L/min and from 3.6 to 8.2, respectively (fig. 3). The pH value of river water of Veliki Krivelj River at P-10 (approximately 13 km downstream from the Veliki Krivelj open pit) became acidic from 6.7 on August 14 to 3.6 on August 22, suggesting that the pH value of Veliki Krivelj River at P-10 changed according to the development plan for exploitation at the open pit.

Copper content in water flowing out from the mine drainage water and wastewater ranges from 11.5 to 138 ppm. The range of copper content of river water of the Bor mining area is 0.1 to 31.1 ppm.

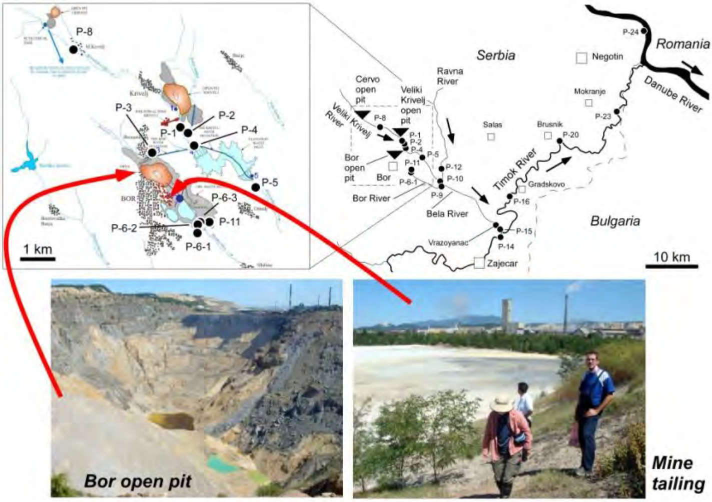

Figure 1 *Map showing the river system and sampling sites from the Bor mining area to the Danube*

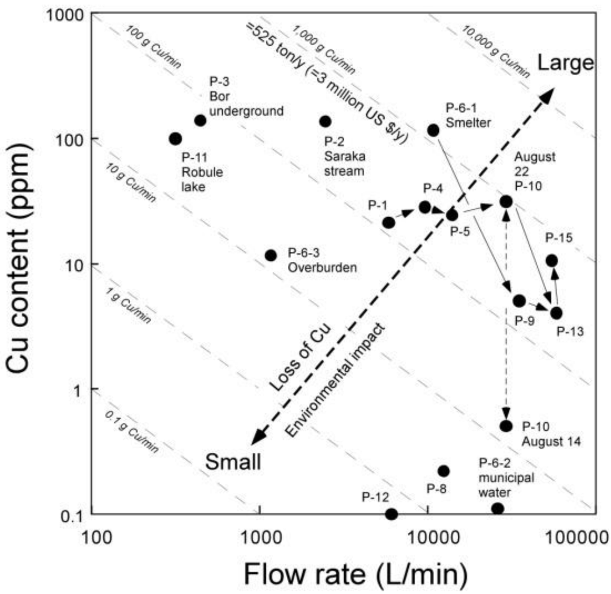

Figure 2 *Relations between flow rate and copper content of mine drainage water, wastewater and river water in the Bor mining area.*

Water having both large flow rate and high Cu concentration is wastewater from the smelter (P-6-1) and mine drainage water from overburden (P-2) (fig. 2). The river water at P-1, P-4, P-5 and P-10 (sampling sites along Veliki Krivelj River) also has a large flow rate and high Cu content. Copper content of river water at P-4, P-5 and P-10 along Veliki Krivelj River shows variation from 31.1 to 22.6 ppm except for 0.5 ppm at P-10 on August 14 (fig. 4).

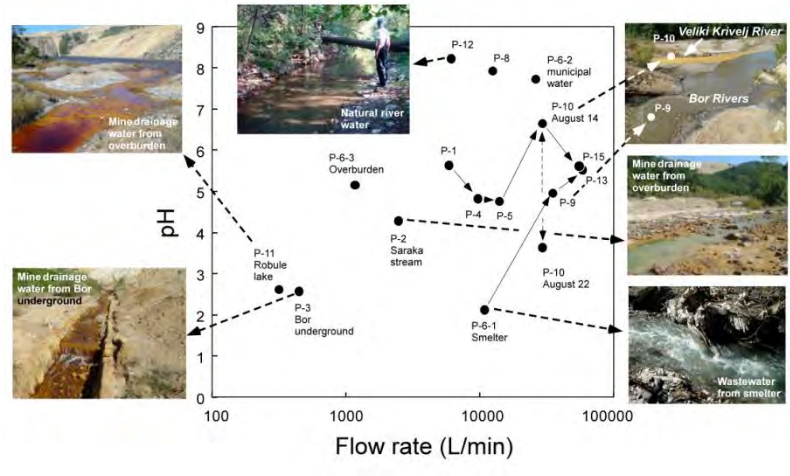

Figure 3 *Relations between pH and flow rate of mine drainage water, wastewater and river water in the Bor mining area.*

Copper content of the river water of Timok River (Gradskovo (P-16), Brusnik (P-20) and Mokranje (P-23)) ranges from 0.15 ppm to 0.08 ppm, suggesting that the environmental impact of copper in mine drainage water is small in Timok River. Copper content of river water of the Danube was 0.11 ppm. This study confirmed the presence of mine tailings from the Bor mine along the banks of Timok River near Brusnik (P-20) and Mokranje (P-23). Copper contents of river water of Timok River at P-20 and P-23 were close to or below the Serbia water quality-based limitation. The effect of copper dissolution from mine tailings along the banks of Timok River is estimated to be small.

Metal recovery

The compositions of deeply-placed sample are shown in Table 1.The leaching test was conducted by using deeply-placed tailing samples. The condition is as follows: leaching solution pH=1 (H_2SO_4), pulp density 400g/L, temperature 50°C, leaching time 4 hours. Table 2 shows the results of the leaching test. The results show that the copper recovery rates are approximately 60%.

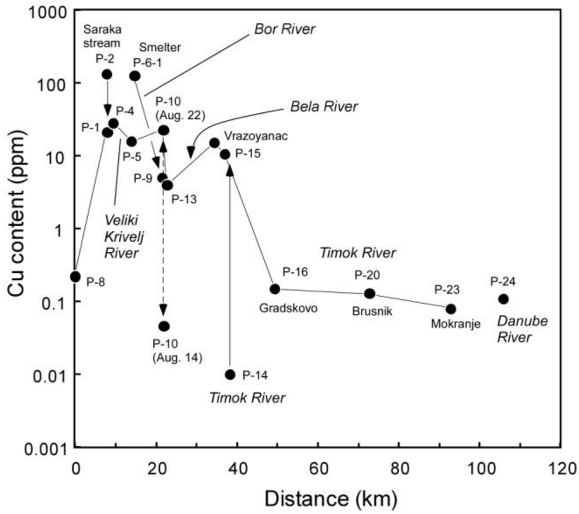

Figure 4 *Variation of copper content in river water from the Bor mining area to the Danube.*

Investigation on the effect of leaching temperature on copper leaching found that the rise in temperature leads to little increase of the copper recovery. In addition, investigation on the effect of addition of oxidant on copper leaching found that the addition of the oxidant does not lead to increase in copper recovery.

Table 1 *Composition of deeply-placed sample (14m deep, wt%)*

	B-1	B-2	B-3	B-4
Cu : total	0.46	0.44	0.39	0.58
Cu : oxide	0.27	0.27	0.27	0.27
Fe	10.18	10.94	6.37	17.28
S	9.7	11.08	7.50	18.58

Table 2 *Results of leaching test*

	B-1	B-2	B-3	B-4
Cu recovery (%)	56.17	59.85	67.28	45.62
Fe recovery (%)	7.70	9.60	11.20	3.40
pH start/end	1/1.34	1/1.30	1/1.20	1/1.06

Conclusions

- The copper content of river water in the lower reach of Timok River was lower than that of the water quality standard in August 2011, suggesting that the impact of mine drainage water from the Bor mining area on the environment is small and that the effect on the quality of river water of the Danube was also small in August 2011.

- River water from the Bor mining area to a point (P-15) of the lower reach of Bela River (approximately 25 km) contains high copper contents.
- Positive results were obtained by copper metal extraction experiments from the flotation tailing.
- It is considered that the copper recovery and extraction from mine drainage, tailing, overburden and waste water will be possible measures to reduce the environmental impact and to cover the cost for reclamation.

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