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THE IMPACT OF POLLUTED WASTEWATER ON WATER QUALITY OF THE BOR RIVER AND SURROUNDING GROUNDWATER**

Abstract

Due to the immediate vicinity of the mining and industrial facilities, the water pollution in the Bor River is extremely high. Sources of the Bor River pollution are active and inactive mining operations (surface and underground), flotation tailing dumps, waste rock dumps from the open pit, waste water generated in the process of copper ore processing and municipal wastewater.

The Bor River basin has an area of approximately 61.0 km². Maximum length of the river flow is about 10.0 km with an altitude difference of 160 m. The Bor River belongs to the basin of the Bela River, the basin of the River Timok or the Danube basin. In its course, it runs through the village of Slatina, connecting downstream of the village with the Krivelj River and Ravna River forming the Bela River. The Bela River, downstream from the village of Vražogrnac flows into the River Veliki Timok, which empties into the Danube [1] [2].

Wastewater from the mining and industrial facilities are still discharged directly into the river, so the water pollution in the river has also a large impact on the ground water pollution, especially in the area of the village of Slatina, located downstream from the town of Bor.

In addition to the waste water, discharged into the Bor River, the major threat to the environment is also a large amount of flotation tailings, located on the coast of this river, which, due to the frequent accidents, occurred in the Bor Flotation Plant during the last century, was directly discharged into the Bor River [3].

This paper work gives a detailed overview of the quality of surface and groundwater both of the Bor River and water polluting of this river.

Keywords: Bor River, waste water, underground water, pollution

INTRODUCTION

Due to the immediate vicinity of the mining and industrial facilities, the water pollution in the Bor River is extremely high. Sources of the Bor River pollution are active and inactive mining operations

(surface and underground), flotation tailing dumps, waste rock dumps from the open pit, waste water generated in the process of copper ore processing and municipal wastewater (Figure 1) [4] [5].

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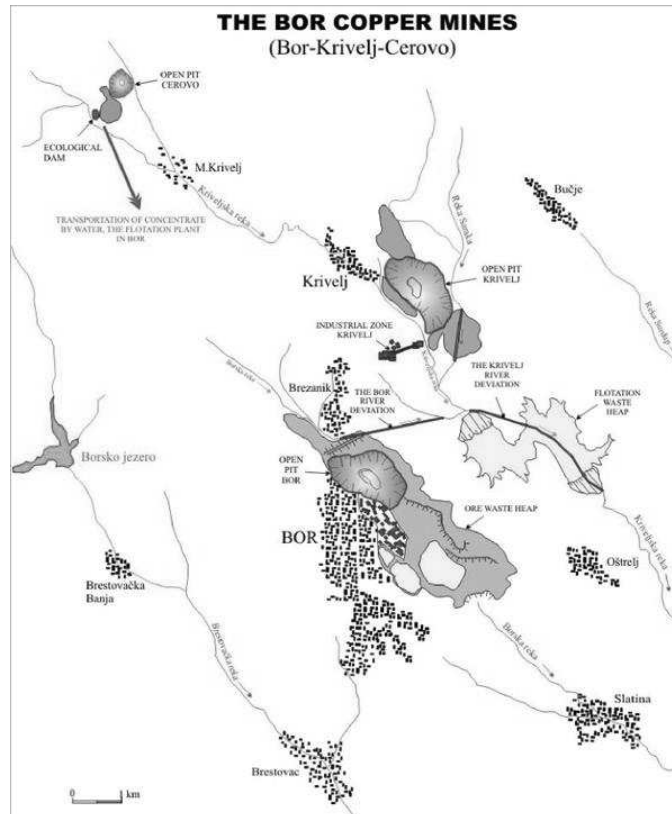


Figure 1 Waste water generated in RBB Bor and TIR complex

In addition to the waste water, discharged into the Bor River, the major threat to the environment is also a large amount of flotation tailings, located on the coast of this river, which, due to the frequent accidents, occurred in the Bor Flotation Plant during the last century, was directly discharged into the Bor River [3].

THE IMPACT OF POLLUTED WASTEWATER

The Bor River basin has an area of approximately 61.0 km². Maximum length of the river flow is about 10.0 km with an altitude difference of 160 m. The Bor River belongs to the basin of the Bela River, the basin of the River Timok or the Danube

basin. In its course, it runs through the village of Slatina, connecting downstream of the village with the Krivelj River and Ravna River forming the Bela River. The Bela River, downstream from the village of Vražogrnac flows into the River Veliki Timok, which empties into the Danube [1].

Waste water from mining and industrial facilities is still discharged directly into the river, so the water pollution in the river has also a large impact on the ground water pollution, especially in the area of the village of Slatina, located downstream from the town of Bor [4][5], (Figure 1).

Such pollution has a very large negative impact on the health of residents of the village of Slatina since the coastal of the Bor River is used for different purposes [4] [5], (Figure 2).

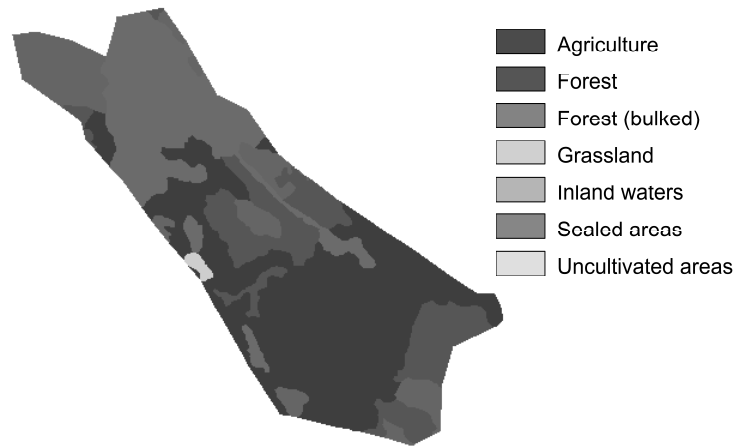


Figure 2 The use of land in the catchment area of the Bor River

Proportions of the land use are listed in Table 1.

Table 1 Proportions of the catchment area of the Bor River

Land use [%]	
Cereals, fodder plants	Cereals, fodder plants
Grassland	Grassland
Forest (very bulked)	Forest (very bulked)
Forest (medium)	Forest (medium)
Sealed areas	Sealed areas

In the period from February to June 2011, a continuous sampling of water samples from the Bor River was carried

out twice a month. Tables 2 and 2a present some of the results of water analyses from the Bor River.

Tables 2 and 2a Results of physical-chemical testing the samples from the location of the Bor River

Sampling spot	T (°C) air	T (°C) water	Color/smell	Electrical conductivity $\mu\text{S}/\text{cm}$	pH	Cu mg/dm^3	Pb mg/dm^3	Zn mg/dm^3
Bor River	17.2	17.6	muddy/without	1472	5.00	16.9	0.23	2.9

Sampling spot	Cd (mg/dm^3)	Ni (mg/dm^3)	Cr (mg/dm^3)	Se (mg/dm^3)	As (mg/dm^3)	Fe-total (mg/dm^3)	Susp.matters (mg/dm^3)	SO ₄ ⁻² (mg/dm^3)
Bor River	<0.1	0.37	<0.1	<0.2	<0.1	36.9	899.0	1204.3

Testing Also, in the same period, water samples were taken twice a month from piezometers in the coastal of the Bor Ri-

ver. Tables 3 and 3a present some of the results of water analyses from this piezometer.

Tables 3 and 3a Results of physical-chemical testing the samples of ground water

Sampling Spot	T (°C) air	T (°C) water	Color/smell	Electrical conductivity $\mu\text{S/cm}$	pH	Cu mg/dm^3	Pb mg/dm^3	Zn mg/dm^3
P4	20	16.0	muddy/ without	1777	5.21	5.1	<0.1	2.9

Sampling spot	Cd (mg/dm^3)	Ni (mg/dm^3)	Cr (mg/dm^3)	Se (mg/dm^3)	As (mg/dm^3)	Fe-total (mg/dm^3)	Susp.matters (mg/dm^3)	SO ₄ ⁻² (mg/dm^3)
P4	<0.1	0.37	<0.1	<0.2	<0.1	36.9	899.0	1204.3

CONCLUSION

In the Republic of Serbia, the protection of surface water is according to the legislation which made the water classification into four classes according to the level of pollution and use. The limit values of elements are given in the Official Gazette of the Republic of Serbia No. 31/82 (Chemical Quality Parameters).

Surface water within the Bor River cannot be classified (according to their composition) neither in the class IV and they fall into the water with high levels of potentially toxic elements (heavy metals) according to the level of maximum allowable concentration.

Such pollution has a very large negative impact on the health of residents of the village of Slatina, located downstream from the town of Bor and industrial complexes which pollute the Bor River, and which flows through the village itself.

The favorable copper prices on the world market have also affected the copper production in Bor that grows from year to year. Also, the pollution level in the Bor River increases with increased production. In order to reduce the level of pollution in the Bor River, it is necessary as soon as possible to access the modern methods of remediation both of polluted industrial water and coastal contaminated land.

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UTICAJ ZAGAĐENIH OTPADNIH VODA NA KVALITET VODE BORSKE REKE I OKOLNIH PODZEMNIH VODA**

Izvod

Usled neposredne blizine rudničkih i industrijskih objekata zagađenost vode u Borskoj reci je izuzetno visoka. Izvore zagađenja Borske reke predstavljaju aktivni i neaktivni rudarski radovi (površinski i podzemni), flotacijska jalovišta, odlagališta kopovske jalovine, otpadne vode nastale u procesu prerade rude bakra i komunalne otpadne vode.

Sliv Borske reke je površine oko 61,0 km². Maksimalna dužina toka je oko 10.0 km sa visinskom razlikom od 160 m. Borska reka pripada slivu Bele Reka, slivu reke Timok, odnosno slivu Dunava. U svom toku protiče kroz selo Slatinu, spajajući se nizvodno od sela sa Kriveljskom rekom i Ravnom rekon formirajući Belu reku. Bela reka se nizvodno od sela Vražognac uliva u reku Veliki Timok, koji se uliva u reku Dunav [1] [2].

Otpadne vode iz rudničkih i industrijskih objekata se još uvek ispuštaju direktno u reku, tako da zagađenje vode u reci ima velikog uticaja i na zagađenje podzemnih voda, pogotovo u oblasti sela Slatina koje se nalazi nizvodno od grada Bora.

Pored otpadnih voda koje se ispuštaju u Borsku reku veliku opasnost po životnu sredinu predstavlja i velika količina flotacijske jalovine koja se nalazi u priobalju ove reke, koja je usled čestih akcidentnih situacija koja su se dešavala u Borskoj flotaciji tokom prošlog veka ispuštana direktno u Borsku reku [3].

Ovaj rad daje detaljan prikaz kvaliteta površinskih i podzemnih voda Borske reke i voda koje ovu reku zagađuju.

Ključne reči: Borska reka, otpadne vode, podzemne vode, zagađenje

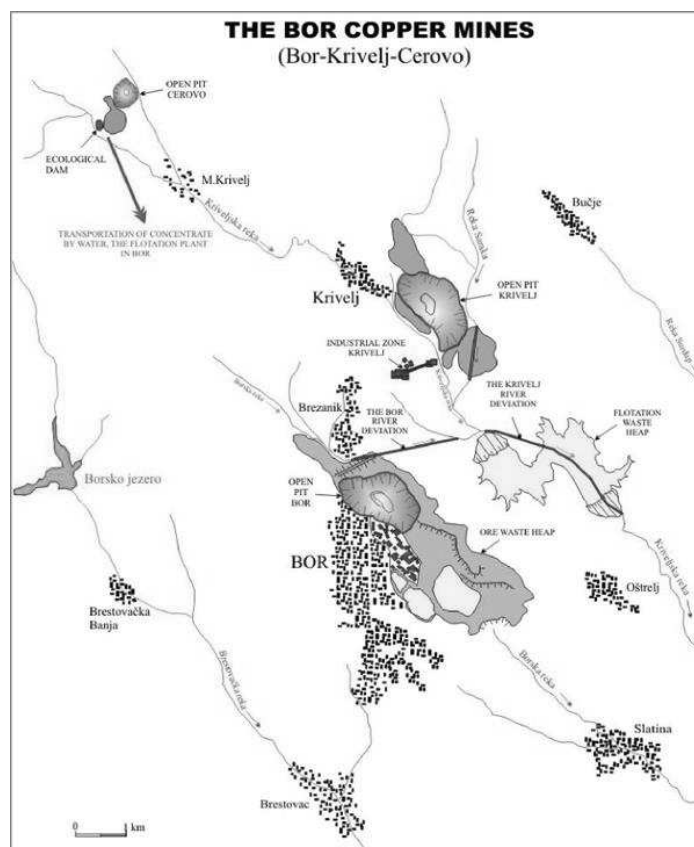
UVOD

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šinski i podzemni), flotacijska jalovišta, odlagališta kopovske jalovine, otpadne vode nastale u procesu prerade rude bakra i komunalne otpadne vode (slika 1) [4] [5].

* Institut za rudarstvo i metalurgiju Bor

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Sl. 1. Otpadne vode nastale u RBB Bor i TIR kompleksu

Pored otpadnih voda koje se ispuštaju u Borsku reku veliku opasnost po životnu sredinu predstavlja i velika količina flotacijske jalovine koja se nalazi u priobalju ove reke, koja je usled čestih akcidentnih situacija koja su se dešavala u Borskoj flotaciji tokom prošlog veka ispuštana direktno u Borsku reku [3].

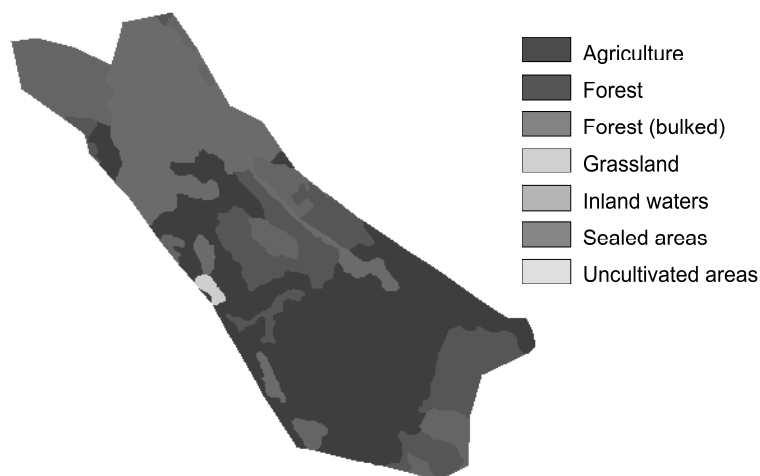
UTICAJ ZAGAĐENIH OTPADNIH VODA

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protiče kroz selo Slatinu, spajajući se nizvodno od sela sa Kriveljskom rekom i Ravnom rekon formirajući Belu reku. Bela reka se nizvodno od sela Vražogrnac uliva u reku Veliki Timok, koji se uliva u reku Dunav [1].

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Ovakvo zagađenje ima izuzetno veliki negativan uticaj na zdravlje stanovnika sela Slatina obzirom da se priobalje Borske reke koristi u različite namene [4] [5], (slika 2).



Sl. 2. Upotreba zemljišta u slivu Borske reke

Procentualni udeo pojedinih vrsta upotrebe zemljišta u slivu Borske reke navedeni su u tabeli 1.

Tabela 1. Proporcija u slivu Borske reke

Upotreba zemljišta [%]	
Žitarice, krmno bilje	43,83
Livade	1,70
Šume (vrlo prostrane)	12,77
Šume (srednje)	19,15
Zatvorene oblasti	22,55

U periodu od februara do juna meseca 2011. godine je vršeno kontinualno uzimanje uzoraka vode iz Borske reke, uzorkovanje je vršeno dva puta mesečno. U tabelama 2 i 2a su prikazani neki od rezultata analiza vode iz Borske reke.

Tabela 2 i 2a. Rezultati fizičko hemijskih ispitivanja uzoraka vode iz Borske reke

Mesto uzorkovanja	T (°C) vazduha	T (°C) vode	Boja/miris	El.provod. $\mu\text{S/cm}$	pH	Cu (mg/dm ³)	Pb (mg/dm ³)	Zn (mg/dm ³)
Borska reka	17.2	17.6	Mutna/bez	1472	5.00	16.9	0.23	2.9

Mesto uzorkovanja	Cd (mg/dm ³)	Ni (mg/dm ³)	Cr (mg/dm ³)	Se (mg/dm ³)	As (mg/dm ³)	Fe-total (mg/dm ³)	Sus.mater. (mg/dm ³)	SO ₄ ⁻² (mg/dm ³)
Borska reka	<0.1	0.37	<0.1	<0.2	<0.1	36.9	899.0	1204.3

Takođe u istom periodu, dva puta mesečno je vršeno i uzimanje uzoraka vode iz pizometra izrađenog u priobalju Borske reke. U tabelama 3 i 3a su prikazani neki od rezultata analiza vode iz ovog pizometra.

Tabela 3 i 3a. Rezultati fizičko hemijskih ispitivanja uzoraka podzemne vode

Mesto uzorkovanja	T (°C) vazduha	T (°C) vode	Boja/miris	El.provod. $\mu\text{S/cm}$	pH	Cu (mg/dm ³)	Pb (mg/dm ³)	Zn (mg/dm ³)
Borska reka	20	16.0	Mutna/bez	1777	5.21	5.1	<0.1	2.9

Mesto uzorkovanja	Cd (mg/dm ³)	Ni (mg/dm ³)	Cr (mg/dm ³)	Se (mg/dm ³)	As (mg/dm ³)	Fe-total (mg/dm ³)	Sus.mater. (mg/dm ³)	SO ₄ ⁻² (mg/dm ³)
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ZAKLJUČAK

U republici Srbiji, zaštita površinskih voda vrši se zakonskom regulativom, koja se zasniva na klasifikaciji voda na četiri klase prema nivou zagađenosti i upotrebi. Granične vrednosti elemenata date su u Službenom listu Republike Srbije br. 31/82 (parametrihemijskog kvaliteta).

Na osnovu ovog pravilnika površinske vode Borske reke po svom sastavu ne mogu da se svrstaju ni u IV klasu i spadaju u vode sa visokim sadržajem y potencijalno toksičnih elemenata (teški metali) prema nivou maksimalno dozvoljene koncentracije.

Ovakvo zagađenje ima izuzetno veliki negativan uticaj po zdravlje stanovnika sela Slatina koje se nalazi nizvodno od grada Bora i industrijskih kompleksa koj zagađuju Borsku reku, a koja protiče kroz samo selo.

Povoljno kretanje cene bakra na svetskom tržištu je uticalo i na proizvodnju bakra u Boru koja raste iz godine u godinu. Takođe sa povećanjem proizvodnje raste i nivo zagađenja u Borskoj reci.

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