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TREATISE ON ASSESSMENT OF RISK ON AQUATIC ECOSYSTEM OF THE RIVER JADAR OWING TO EXPLOITATION OF BORON AND LITHIUM IN THE PROJECT „JADAR“

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Abstract

Risk assessment of the aquatic ecosystem of the River Jadar is based on the composition and amount of wastewater that is to be processed and released into the stream. This study aimed to assess the effects of untreated wastewater on aquatic ecosystem components, presumably fishes, by simulating the accident. Methodology relied exclusively on the published documents that investors, “Rio Tinto" and “Rio Sava Exploration” d.o.o., issued about the boron and lithium mine in the Jadar region of Serbia as the only source of the publicly available data about concentration of mineral contents in underground water. Results revealed that concentrations of boron in a range of 3.43-12058.83 mg l^{-1} and those of lithium in a range of 0.70-2452.50 mg l^{-1} in a stream water of the River Jadar would pose a great risk to aquatic ecosystem in any lapse in proper processing of wastewater at either average low-, medium-, or high-water levels. Such high contents would inevitably cause toxic, genotoxic and other pathological effects on aquatic organisms. Records published on the relevant *in vitro* models reveal that if the concentration of boron and lithium in the stream water would exceed safe concentrations, the ecosystem would be seriously harmed, especially for the fish that are most sensitive to metal pollution. Due to a lack of actual referent in-field data, it is difficult to predict either the extent of harmful effects on downstream sections, or the period the ecosystem would need to recover from high levels of pollution.

Key words: Jadar region, wastewaters, water pollution, hazard, lithium, boron

INTRODUCTION

Jadarite, a lithium sodium borosilicate mineral, was discovered in 2004. It was found southeast of the city of Loznica in western Serbia (Figure 1) and named after Jadar, the toponym of that area. Project “Jadar” was created to produce battery-grade lithium carbonate (Li_2CO_3), a critical mineral used in large-scale batteries for electric vehicles and storing energy. In addition, Project “Jadar” is expected to produce plenty of borates (BO_3^-) and sodium carbonate (Na_2CO_3) as by-products, owing to their high contents in the mineral rock deposits and underground water. Borates are essential for the development of renewable energy equipment such as solar panels and wind turbines (Rio Tinto, 2021). The proposed project includes an underground mine with associated infrastructure and equipment and a beneficiation chemical processing plant to produce battery-grade lithium carbonate, expected to operate no earlier than 2027. The exploitation period of this mine is expected to be at least 40 years, during which 2.3 x 10^6 t of Li_2CO_3 would be produced.

As reported in Anonymous (2021a), the contents of boron (B) (2404.7 mg l^{-1} and 2865.9 mg l^{-1}) and lithium (Li) (273.5 mg l^{-1} and 269.5 mg l^{-1}) in underground water sampled from exploration drills at depths of 482 m; as well as the contents of 4600 mg l^{-1} of B and 1200 mg l^{-1} of Li in underground water sampled from the deep piezometers were very high. The exploitation of the mine would lead to that water becoming wastewater. During the exploitation period, 0.038 m^3 s^{-1} of underground water is expected to enter into the mine corridors. That wastewater will have to be pumped out to the surface for safety reasons (Anonymous, 2021a). The same source (Anonymous, 2021a) stated that during most of the exploitation period, the inflow of underground water into the mining corridors is expected to be in a range of 0.02 m^3 s^{-1} (if the spent, i.e., exhausted corridors would be filled after their exploitation period) to 0.1 m^3 s^{-1} (if they would be left hollow, i.e., unfilled).

Various literature sources report different discharges in the River Jadar. Ivković *et al.* (2012) reported the absolute maximum discharge of 192 m^3 s^{-1} in June 2001, with an average annual discharge of 8.21 m^3 s^{-1} and an average high water level discharge of 105.4 m^3 s^{-1}. Josimović and Nenković-Riznić (2019) reported an absolute maximum discharge of 219 m^3 s^{-1} in May 2014 and of an average annual discharge of 7.79 m^3 s^{-1}, as well as the minimal discharge of 0.03 m^3 s^{-1} recorded in October 2012. In Anonymous (2021b), the reported average discharge was 6.8 m^3 s^{-1}, whereas the minimal one in summer droughts dropped down to 0.12 m^3 s^{-1}. The lasting water levels and discharges associated with them in the River Jadar drainage area throughout the 1990 - 2010 period are available in Ivković *et al.* (2012).

During the period of exploitation, the reported capacity of wastewater treatment facilities would be in a range of 0.145 to 0.290 m^3 s^{-1}, with the maximum of treated wastewater of 0.23 – 0.53 m^3 s^{-1} that would be emitted into the River Jadar. Thus, during most of the exploitation period, the amount of wastewater that would be emitted to the River Jadar as a local recipient would be 0.25 m^3 s^{-1} (Anonymous, 2021b).

The fish fauna in the area of concern of Project „Jadar" is available from **a** couple of sources, e.g., Marić *et al.* (2003) and Anonymous (2021a). Both sources reported the fish fauna typical for the streams small-to-medium in size flowing through valleys at low altitudes, with moderate slope and current velocity. In the fish fauna of those streams, the composition of fish communities may vary slightly, but in general, it consists of chub *Squalius cephalus* (Linnaeus, 1758), spirlin *Alburnoides bipunctatus* (Bloch, 1782), common *Barbus barbus* (Linnaeus, 1758) and Balkan barbel *B. balcanicus* Kotlík, Tsigenopoulos, Ráb & Berrebi, 2002, nase *Chondrostoma nasus* (Linnaeus, 1758), stone loach *Barbatula barbatula* (Linnaeus, 1758) and Balkan *Cobitis elongata* Heckel & Kner, 1858 and Danube loach *C. elongatoides* Băcescu & Mayer, 1969, with few other occasional fish species.

Although there are reports that B could be considered an essential micronutrient in the content below 2 mg l^{-1}, in greater concentration it reveals a variety of toxic effects indifferent to pH or dH (water hardness) values. Regarding toxicity, the water contains chlorides (Cl^-) in an amount of 4058 mg l^{-1} which might even enhance the toxic effect of B on the aquatic organisms, depending on the species. (ANZG, 2021). The intake of B is either through passive diffusion or active transport at lesser concentrations. In the cell, the toxin inhibits the mitochondrial enzymes. The amount of B in the water that revealed the chronic toxic effect for particular aquatic organisms was from 1.8 mg l^{-1} – 14 mg l^{-1} for fish, to 2.4 mg l^{-1} – 29 mg l^{-1} for shrimps, to 15 mg l^{-1} – 56 mg l^{-1} for amphibians (ANZG, 2021). The lowest amount that is considered harmless for aquatic organisms is 1 mg l^{-1}, though experimental reports revealed that some of them sustained for a longer period at a concentration of up to 10 mg l^{-1}. The most sensitive organism reported was flathead minnow (*Pimephales promelas)*, revealing clear signs of intoxication at concentrations below 13 mg l^{-1} (Eisler, 1990; Soucek *et al*., 2011). Experiments of the 24 – 48 hours of exposure of zebrafish (*Danio rerio)* to boric acid and borax in concentrations 1 mg l^{-1} – 64 mg l^{-1} revealed the prominent genotoxic effect on erythrocytes as assessed using the comet assay (Gülsoy *et al*., 2015). In concentrations range of B from 10^2mg l^{-1} to 10^3mg l^{-1}, the direct effects, e.g., edema, inflammations, parenchymatic tissues' degeneration, and histopathological changes were recorded on rainbow trout (*Oncorhynchus mykiss)* muscles, kidneys and gills (Topal *et al*., 2016).

As for the toxicity of Li in the aquatic environment, the experiment on juvenile rainbow trout exposed to Li concentration of 1 mg l^{-1} revealed its great bioavailability (Tkatcheva *et al*., 2015). The fast intake of Li into the organism increased its content in the blood serum in eight hours and in the brain in two days since the beginning of exposure. The value of Li content in the brain reached that in the blood serum in the next four days, which illustrated the easy passage of Li through the blood-brain barrier. Simultaneously, the concentration of electrolytes (e.g., Na^+, Ca^{2+}, Mg^{2+}, K^+ and NH_4^+) were remarkably reduced in the blood serum and the brain, which tremendously affected the functioning and survival of fishes. The assumed mechanism of the effect of Li is in changing a level of the arachnoid fatty acid in the brain that participates in the active transport through the brain cells' membrane and thus acts as a mood stabilizer (Tkatcheva *et al*., 2015).

In considering the impact of mining activities on flora and fauna (Anonymous, 2021a), the lethal effect was assumed only on fishes. The lesser impact on aquatic invertebrates was expected to come from wastewaters and the modification of river channel's structure (e.g., siltation of deposits), excluding the channelization and change of the water flow direction themselves. Mere harmful effects on the aquatic ecosystem; air and soil pollution; and habitat disturbance caused by mining and other associated activities were factors considered possibly deteriorating on amphibians, aquatic reptiles, and mammals.

The circumstances of the Jadar Mine Project were disputable shortly after its beginning. There is yet to be a detailed report on the foreseen effects on the aquatic environment of the River Jadar, expected from the operation of the mine. Wastewaters consisting only of natural underground waters would be extracted from the mine corridors and they would be released into the River Jadar. This study aimed to assess the effects of untreated wastewater on aquatic ecosystem components, presumably fishes; by simulating the accident in the most realistic and conservative way that might occur due to any possible reason.

MATERIALS AND METHODS

The whole research was undertaken in 2021, when the documents that contain data about the concentration of the B and Li in underground water obtained by deep drills, were published by mine investor, the Rio Tinto company and became publicly available. Owing to either scarcity, variety, or even the contradiction of particular data in the available literature sources, the approach applied is as conservative as possible. That was accomplished both by presuming the least possible effect of wastewaters and by looking for the mean (instead of either maximal or minimal) values of parameters in concern, e.g., the depth of horizons of underground water samplings and the concentration levels of Li and B in those wastewaters which will be pumped out of mine corridors. To ensure unbiased assessment of effects on the aquatic ecosystem (primarily fishes), the data on the average discharges in the River Jadar and the foreseen recipient of wastewaters were taken for periods of high--, medium, and low-water levels available in the literature. The available literature doesn't present the values of Li and B contents in the surface, i.e., the stream water of the River Jadar. Our starting presumption about this was that those values are sufficiently low to make any harmful effect to aquatic organisms of the River Jadar, since such an event was never reported there. Therefore, we took into consideration only the contents of B and Li in underground water that would be released as untreated wastewater into the River Jadar. We did not account for the release of wastewaters that might happen from the mine's tailings site. For the amount of underground water afflux into the mine corridors and thereby the discharge of wastewaters into the River Jadar during the most of the exploitation period, we have chosen to operate with the two values given in Anonymous (2021a).

In order to take samples from the section of the River Jadar in the area where the project „Jadar" is to be realized, a fish sampling by electrofishing was accomplished by wading, on August 11, 2021. The fish sampling was taken with the backpack-battery-powered electrofishing gear using AquaTech device IG200/1 (input 12 V per maximum 15A DC, output 500 V, and frequency 65 P s^{-1}). Three locations were sampled (Figure 1): Lopatara in the Krivajica village area (N 44°26'10.36''; E 19°26'43.80''); in the Draginac village area (N 44°30'19.07''; E 19°24'44.76''); and Kozjak in the Gornji Dobrić village area (N 44°34'51.16''; E 19°18'02.0'').

Figure 1. Sampling locations on the River Jadar (1, Lopatara; 2, Draginac; 3, Kozjak).

Each sampling stretch was approximately 100 m in length, across the whole width of the river, at low water level and discharge; in all types of habitat (e.g., glide, pool, riffle, undercut bank, little cascades, etc.); and at very high air (30-35 ^{o}C) and stream water temperatures. All sampled fish were immediately, in the nearest shadow identified down to the species level, quickly measured for their standard length (*SL*) and mass. This was accomplished using the field-use adjusted ruler of up to the nearest 0.5 cm of precision and the digital scale up to the 1 g of precision. The fish were returned alive to the stream.

Calculation of the expected B and Li contents in a stream water of the River Jadar (C_S) at each of three average discharges (D_s) and of two wastewaters' discharges (D_w) was accomplished using the formula:

$$C_s=D_W/D_S*C_W$$

where $\frac{D_W}{D_S}$ D_W/D_S denotes the dilution rate and C_W denotes B and Li contents in wastewaters.

RESULTS

The value for average discharge in the River Jadar of 7.6 m^3 s^{-1} was obtained from three available and only slightly different records. Similarly, the average minimal discharge of 0.075 m^3 $s^{-1}$was generated in the same way. To establish conservativity and an unbiased approach, the average maximal discharge value of 105.4 $m^3 s^{-1}$ was used, despite higher values that would likely make an assessment more favorable for aquatic environments.

The one value we operated with for the afflux of underground waters that might be the wastewater during most of the exploitation period was 0.1 $m^3 s^{-1}$, considering that the literature source stated that filling of the exhausted mine corridors and consequent decrease in afflux of underground waters will occur after the period of mine's exploitation. The second value of 0.25 $m^3 s^{-1}$ we used is also given as a discharge of wastewater that would be released into the River Jadar.

The values for concentration of B were 2404.7 mg l^{-1} and 2865.9 mg l^{-1}, and for those of Li were 273.5 mg l^{-1} and 269.5 mg l^{-1} in the underground water samples from the depths of 482 m. In the samples from deep piezometers, the values of 4600 mg l^{-1} and 1200 mg l^{-1} for B and Li, respectively were reported in underground water. From the data, we used the average values of 3617.65 mg l^{-1} and 735.75 65 mg l^{-1}, respectively as measures of B and Li contents that would contain the water that would be extracted from the mine's corridors during the exploitation period.

Table 1. Concentrations of B (in mg l^{-1}) in the River Jadar at average low water level, average mid water level and average high water level discharges, in wastewaters' discharges of 0.1 $m^3 s^{-1}$ and 0.25 $m^3 s^{-1}$.

River Jadar		**Wastewaters' discharges** ($m^3 s^{-1}$)	
Water level	**Average discharges ($m^3 s^{-1}$)**	0.1	0.25
Minimal	0.07	4823.53	12058.83
Mid	7.60	47.60	119.00
High	105.40	3.43	8.58

The analysis accomplished on the data from relevant documents about the mining of Li and B in the River Jadar valley revealed that in 0.1 $m^3 s^{-1}$ of wastewaters' discharge the concentration of B would be in a range of 3.43 mg l^{-1} to 4823 mg l^{-1} (Table 1) and that of Li would be in a range of 0.70 mg l^{-1} do 981 mg l^{-1} (Table 2). In 0.25 $m^3 s^{-1}$ of wastewaters' discharge, the concentration of B would be in a range of 8.58 mg l^{-1} to 12059 mg l^{-1} [1] (Table 1) and that of Li in a range of 1.74 mg l^{-1} to 2452.5 mg l^{-1} (Table 2).

Table 2. Concentrations of Li (in mg l^{-1}) in the River Jadar at average low water level, average mid water level and average high water level discharges, in wastewaters' amounts of 0.1 $m^3 s^{-1}$ and 0.25 $m^3 s^{-1}$.

River Jadar		**Wastewaters' discharges** ($m^3 s^{-1}$)	
Water level	**Average discharges** ($m^3 s^{-1}$)	0.1	0.25
Minimal	0.07	981.00	2452.50
Mid	7.60	9.68	24.20
High	105.40	0.70	1.75

In all three fish samples the faunistic composition was very similar (Table 3), consisting in total of eight fish species from two families, minnows (fam. Cyprinidae) and loaches (fam. Cobitidae) expected for that type of stream. Majority of fish were in the size classes below 10 cm *SL*; only few chub and common barbel were up to 20 cm in *SL*, whereas all nase were 15-19 cm in *SL*.

Table 3. Structure of fish samples in the River Jadar at three localities presented in the upstream-downstream order, situated close to the mining site of the project „Jadar".

Species	**Localities**		
	Draginac	Lopatara (Krivajica)	Kozjak (Dobrić)
FAMILIA CYPRINIDAE			
Nase *Chondrostoma nasus*	6		
Common barbel *Barbus barbus*	10	6	18
Chub *Squalius cephalus*	13	11	6
Spirlin *Alburnoides bipunctatus*	18	8	7
Bitterling *Rhodeus sericeus*	4		7
Roach *Rutilus rutilus*			1
Gudgeon *Gobio obtusirostris*			3
FAMILIA COBITIDAE			
Danube loach *Cobitis elongatoides*			1

DISCUSSION

All data of B and Li used in this assessment originated from the literature sources published by the investor, the „Rio Tinto" company and by „Rio Sava", their affiliate in Serbia. In addition, the relevant records for the River Jadar water discharges and various types of harmful effects of B and Li on aquatic organisms, primarily fishes, were taken from available scientific literature.

The concentration values for B and Li estimated in the River Jadar after the release of wastewaters (originating from extracted and untreated underground water) were high. There is an estimation reported in Anonymous (2021b) based on underground water influx and low filtration coefficients claiming that watering of the Jadar site deposits is weak, especially when the size and features of the mine are in concern. The prominent feature of underground waters from the horizons of the depth between 375 m and 613 m is their high total salinity of 15 g l^{-1}. It makes them convenient only for industrial use, i.e., obtaining 1.3 x 10^4 of salt that would be precipitated as a by-product annually. The planned location for releasing the treated wastewaters' discharge is at the Veliko selo area, a 1.5 km away from the mine itself.

We used the value of 0.25 m^3 s^{-1} for the wastewater discharge during the exploitation period (JCWI, 2019; in Anonymous, 2021a), instead of the value about ten times lower, occurring in the Anonymous (2021b), because we considered the literature source referring the former value more relevant. Likewise, it should be noted that the amount of wastewater is expected to increase up to about 50 times in relation to the initial one in the first year of mine operation (we used the maximal value). In addition, it is stated that the contents of B and Li in the wastewater will increase with the depth of horizons where mine corridors are going to be built. It is expected to progressively add to the harmful, especially the toxic effects of B and Li on fish - from initial weaker, chronic, to subsequent sublethal and lethal effects. In all the reports we used it is not entirely clear which wastewaters will be treated. Either it's all of the wastewater, including also the pumped underground waters influxing into the mine corridors, or only the wastewaters coming from the extraction of B and Li using predominantly sulphuric acid (H_2SO_4) in processing of the jadarite mineral. Any accident at the solid tailings dumping site would release its dissolved content in the recipient aquatic ecosystem, making it impossible to intervene or sanitize such high contents of B and Li (Tables 1 and 2). The common toxic effect in those circumstances would be devastating, regardless of the period of the year or the immediate meteorological, hydrological, and idioecological conditions in the River Jadar ecosystem.

Statements claiming that there would be no additional risk from solid tailings deposits as concentrations of microelements like the heavy metals from jadarite mineral processing will be similar to those occurring in soil elsewhere (Anonymous, 2021b) are questionable. The composition of soil and rocks at the depths of over 375 m near the largest deposits of jadarite are pretty different compared to that of soil at the surface (Anonymous 2021a) and depositing such large amount of tailings would spread the single spot of potential pollution to the surrounding area and surface waters there. As for the water quality, the investor stated that their wastewater treatment facilities of ultra-filtration, double reverse osmosis and ion exchange technologies worth $40 million would process wastewaters up to the quality class II reported for River Jadar. The investor's claims of water discharges being about 300 times and five times greater in the River Jadar during the high and low water level periods respectively, compared to the expected discharge of the released wastewaters, could not annul such high concentration values of B and Li in wastewaters if they were released untreated for any reason (e.g., failure in power supply, in wastewater treatment facilities, etc.). Investors stated that daily release of treated wastewaters into the River Jadar would be about 70% lesser than the amount of communal wastewaters released from the city of Loznica into the River Drina (Anonymous, 2021b). The relevance of this statement is questionable having in mind the size, i.e., the discharge of both recipient waters, the character of pollution here in concern and the resilience, i.e., the self-purification capability of two ecosystems (rivers Drina and Jadar) against these two completely different kinds of pollution. Opposite to the findings herewith presented, the investor's assessment reporting only the moderate impact of mine's underground waters on the environment at such high values of B and Li contents in them seems diminutive and unrealistic, especially when the risk from accidents is in question.

A single incident of the wastewater treatment facility malfunctioning, the herewith assessed concentrations of B (Table 1) and Li (Table 2) that would amount much over 1 mg l^{-1} in the River Jadar would likely have either toxic, genotoxic, or histopathological effects on fish, as well as on other animals in the aquatic ecosystem. This statement could be taken cautiously only for Li content at high water level and great average stream water discharge in the River Jadar (Table 2), although even that concentration in a range of 0.7 – 1.75 mg l^{-1} in a longer period might have the effect of chronic intoxication. Not only would this affect rainbow trout, a coldwater species more sensitive to pollution (Tkatcheva *et al.*, 2015; Topal *et al.*, 2016), but the levels of pollution with B and Li assessed in this research would affect both zebrafish and flathead minnow that are more tolerant species (Eisler, 1990; Gülsoy *et al*., 2015). Although nothing is known at the moment about the tolerance of native fish species in the River Jadar to increased concentration of B and Li in natural aquatic ecosystems, their general ecology and native dispersal imply the similarity to other fish species in that regard. The sampling that we accomplished in August 2021 on three localities on the River Jadar revealed the composition of fish fauna very similar to that given in previous reports (Marić *et al.*, 2003; Anonymous, 2021a). The only difference was particular fish species missing from this sample, e.g., lamprey *Eudontomyzon* sp., bleak *Alburnus alburnus*, Danube barbel *Barbus balcanicus,* Balkan loach *Cobitis elongata*, Balkan spined loach *Sabanejewia balcanica* and streber *Zingel streber*. The species missing in the reports at the moment of sampling is likely owing to seasonal circumstances, e.g., the high air and water temperatures, very low water level, low discharge and oxygen content, and either their stillness, or gradual retreat in the cooler nearby tributaries during those harsh conditions occurring in that period. The fish community structure we assessed then and species recorded in such middle-rithron fish communities from the foothill areas in other similar streams in the River Sava drainage area (Simonović *et al*., 2015), are most comparable to the ones in the foothill mid-western streams and ponds of North America containing flathead minnow. The harsh summer conditions might also roughly correspond to the natural environment of the tropical zebrafish, the second common model fish species, as well. Therefore, their tolerance on B content reported in the literature might also be relevant in considering the effect on those native fish species in the River Jadar. The simultaneous spill of Cl^- and HCO_3^- might in certain amounts add to the harmful effects, especially at medium and low stream water discharges and levels that dominate in the River Jadar throughout the year (Ivković *et al*., 2012). This implies that the pollution risk for the majority of aquatic animal species would occur at any level of pollution with the mine's wastewaters spill. Although all aquatic species would then be equally threatened from the ecosystem point-of-view; particularly strictly protected fish species (Anonymous, 2010), e.g., brook lamprey *Eudontomyzon* sp. (Anonymous, 2021a) and streber *Zingel streber* (Marić *et al.,* 2003) would be under the especially serious threat, owing to their still, sedentary way of life in the specific habitats. They would be strongly limited in avoiding the pollution wave, or escaping downstream in front of it. Even the more vagile fish species like nase, chub, and spirlin could not cope with it effectively, so the harm for fish stock would most likely result in fish kill, while the River Jadar's ecosystem would be heavily polluted, facing a long recovery period. The massive fish kill will likely be accompanied, to some extent, with the death of other aquatic biota, whose carcasses would decompose swiftly, especially at high water temperatures, causing the great consumption of oxygen and its depletion in the stream water. The additional intoxication from ammonium that would come from decomposed organic material would augment the initial lethal effect on the remaining aquatic organisms, despite their better tolerance to the original pollution from B and Li. It is also difficult in this way to estimate the distance at which the intensity of pollution would decrease sufficiently to drop either below the lethal, or chronic toxic levels. Likewise, nothing is currently known about the capacity of the River Jadar's ecosystem for recovery from this type of pollution.

CONCLUSIONS

The risk that mining of the mineral jadarite in the Jadar Region of the Western Serbia poses to the River Jadar as a main recipient of treated underground waters is very high. High contents of B and Li in underground water would strongly affect the ecosystem of the River Jadar regardless of whether the untreated water was released at low-, medium-, or high-water levels and discharges. The concentrations of B and Li that would then occur in water of the River Jadar would greatly exceed the limits considered harmless for species in the fish community of the River Jadar and most likely cause serious fish kill, as well as death of other aquatic organisms. Owing to their sedentary way of life, the most susceptible will be brook lamprey and streber that are declared as strictly protected species in the national legislation. The massive death of aquatic organisms and decomposition of their carcasses will deplete oxygen in stream water and increase the ammonium content, which will additionally augment the initial lethal effect. The downstream extent of pollution, as well as the lasting recovery period for the ecosystem is difficult to predict.

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STUDIJA O PROCJENI RIZIKA PO VODENI EKOSISTEM RIJEKE JADAR U ODNOSU NA USLOVE EKSPLOATACIJE BORA I LITIJUMA U PROJEKTU „JADAR“

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Sažetak

Procjena rizika po vodeni ekosistem rijeke Jadar zasnovana je na sastavu i količini otpadnih voda koje treba da budu prečišćavane i upuštane u rijeku. Studija ima za cilj da procijeni efekte neprečišćenih otpadnih voda na vodeni ekosistem, posebno ribe, simulacijom akcidenta. Metodologija se oslanja isključivo na objavljene dokumente koje su o rudiku bora i litijuma u regionu Jadra u Srbiji izdali investitori, “Rio Tinto” i “Rio Sava Exploration” d.o.o. kao jedine javno dostupne podatke o koncentracijama sadržaja minerala u podzemnim vodama. Rezultati su pokazali da bi koncentracije bora u opsegu od 3.43-12058.83 mg l^{-1} i litijuma u opsegu od 0.70-2452.50 mg l^{-1} u vodi rijeke Jadra predstavljale veliki rizik po vodeni ekosistem pri bilo kom prekidu prerade otpadnih voda i pri prosječnom niskom, i po prosječnom srednjem i prosječno visokom nivou vode rijeke. Tako visoki sadržaji imali bi neizbježno toksični, genotoksični i druge patološke efekte na vodene organizme. Podaci objavljeni na relevantnim *in vitro* modelima pokazuju da bi ekosistem bi bio ozbiljno oštećen, posebno ribe kao najosjetljivije na zagađenje metalima, ako bi koncentracije bora i litijuma u vodi rijeke premašile za njih bezbjedne vrijednosti. Zbog nepostojanja stvarnih referentnih podataka sa terena, teško je predvidjeti bilo prostiranje štetnih efekata na nizvodne dijelove rijeke ili period koji bi bio potreban ekosistemu da se oporavi od visokih nivoa zagađenja.

Ključne riječi: region Jadra, otpadne vode, zagađenje vode, rizik, litijum, bor