ASSESSING THE POTENTIAL EFFECTS OF MINING OPERATIONS AT RUPICE MINE ON THE WATER QUALITY AND ECOLOGICAL STATE OF THE BUKOVICA RIVER: AN EMPIRICAL INVESTIGATION

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ABSRACT
As result of an empirical investigation of numerous ecological and environmental factors, with special focus on spatial, hydrogeological and hydrological conditions, it is demonstrated that there is no possibility of influence of ore exploitation activities on the Rupice mine site to the water supply Bukovica and no impacts on water quality and/or quantity of Bukovica river. In those terms, conducted additional multifield research with exact field methods assessing the potential effects from mining activities to surrounding hydrological system, especially river Bukovica basin and water supply "Bukovica".

Keywords: ecological impact, environmental impact, physio-chemical and biological factors, hydrogeology, hydrological, mining impact, Bukovica river basin

1. INTRODUCTION

The polymetallic mine site Rupice near Vares has been explored for more than 3 years by various methods of geological research with aim of determining reserves and quality of lead, zinc and barite ores. Same time, many environmental analyses and research about biodiversity, water quality and quantity, soil, air quality, noise and weather and clime are conducted for better understanding the nature of area. Within the conducted research, hydrogeological surveys had a significant role for determining hydrogeological and hydrological conditions of the area. [1]

The geology in the area of Vareš is naturally enriched with metals, so there is present tradition of metal exploitation in this area for centuries. [2]

The area of mine is in a mountainous area with elevations from 900 to 1276 m above sea level. It is a terrain that includes eastern slopes of the Lipnica mountain, which is followed by the Zvijezda mountain on the east. The slopes are very steep and slightly rounded at the peaks, and the ravines are very distincted in the longitudinal slope and cross section.

2. AREA OF RESEARCH

Previous geological and hydrogeological surveys were conducted within the approved exploration areas according to the decisions of the Federal Ministry of Energy, Mining and Industry. By the decision of Federal Ministry of Energy, Mining and Industry, UPI No. 06-18-381/14 basic research area Rupice-Juraševac-Brestić was determined and subsequently the

decision UPI No. 06-18-86/19 dated 04.03.2019 was issued for expanded research area Rupice – Borovica (Figure 1).

Following documentation is done:

- Exploitation permit for underground works on complex ore of lead, zinc and barite with the content of accompanying mineral components in the exploitation field Rupice-Juraševac-Brestić, Municipality Vareš, Federal Ministry of Energy, Mining and Industry, UPI No: 06-14-1-334/21, July 2021.
- The main project for the collection, treatment and release of polluted water precipitation generated during the execution of works on the exploitation of complex ore of lead, zinc and barite with the content of associated mineral components at the Rupice.
- Decision on water consent for the main project of collection, treatment, and discharge of precipitation-polluted water - Rupice for sanitary and fecal water.
- Decision on water consent for the main project of collection, treatment and discharge of polluted storm water -Rupice for mine water, No: UP-1/21-2-40-543-7/21, December 2021
- Decision on the use of the water system Sastavci, No: 02/03-19-5-692-1/22, June 2022.
- Updated study of environmental impact assessment of underground exploitation complex ore body of barite and following mineral components in deposit Rupice, Municipality Vareš: Rudarski Institut d.d. Tuzla, October 2020.
- Environmental and social impact assessment, Wardel Armstrong, November 2021.

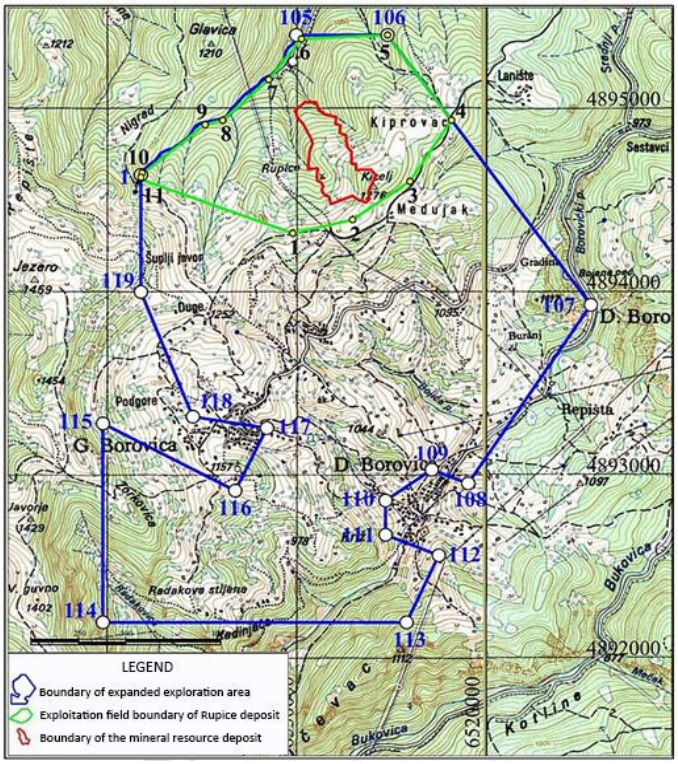

Figure 1. Topographic map of research area (blue) with a marked exploitation field (green)

Within zone of approved research area, basic and extended, there are no settlements and in the immediate and wider environment are traditional mountain settlements of Gornja and Donja Borovica, Pogar and others. [3]

Exploration works (monitoring points) are located in the Borovica basin (6 monitoring points) and in the Vrući potok basin (3 monitoring points). The exploration area for additional

hydrogeological research is conditioned by nature and scope of given impacts research of mining works in the lead, zinc and barite mine "Rupice" on quality and quantity of water in the Bukovica basin and water supply for water supply of town Kakanj "Bukovica" (Figure 2).

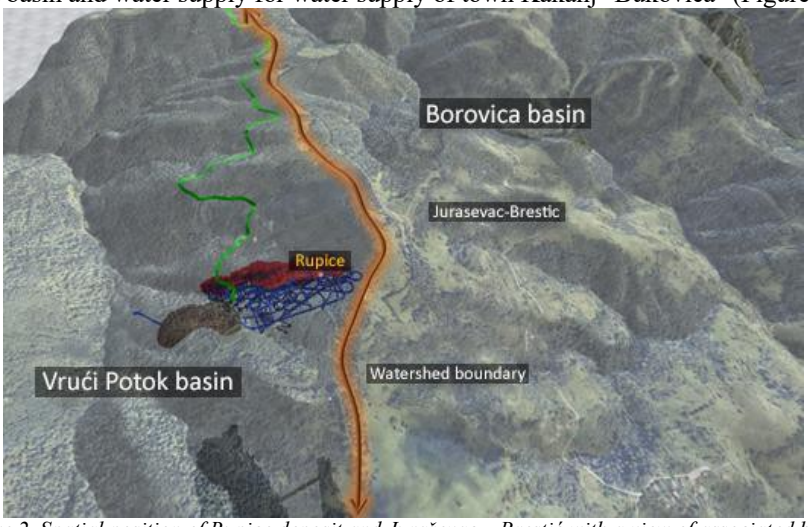

Figure 2. Spatial position of Rupice deposit and Juraševac – Brestić with a view of associated basins

3. METHODOLOGY OF HYDROGEOLOGY RESEARCH

In the hydrogeological term, a high level of knowledge of hydrogeological relations in deposit itself has been achieved. These studies analyzed scope and intensity of impact of all pollutants as well as future exploitation on the surrounding hydrological system and sources of public water supply.

Conducted hydrogeological research in the area of "Rupice" can be divided into phases:

- phase of hydrogeological research within framework of general geological research for the opening of deposits, construction of exploratory drillholes and hydrogeological facilities (drillholes and piezometers)
- phase of additional hydrogeological research and performance of tracer experiments (two tracer experiments through well REW-4 and excavation R-1).
- phase of interpretation of results (Study on possible impacts of pollution on the surrounding hydrological system and water supply Bukovica.

3.1. Hydrogeology mapping

As part of implementation of the Hydrogeological Research Project, hydrogeological mapping (registration of hg occurrences, reambulation and compilation of existing maps) was performed as an extension of existing hydrogeological map to the exploitation field. [4]

Hydrogeological mapping in the subject area was a very complex task due to configuration of terrain, which is reason why part of data was taken from previous detailed hydrogeological maps that contained a sufficient number of details.

Simultaneously with the mapping, an analysis of aerial photographs, hydrometeorological data and other geological documentation was performed, and a “Detailed hydrogeological map of the exploitation field 1: 2500” is created.

3.2. Tracing experiment

Tracing experiments are standard in hydrogeological research and are very different in terms of hydrogeological environment in which they are performed, applied marker (tracers), number of tracers, intervals and lengths of observation time and other parameters.

The experiment was performed using a tracer (marker) which was added into water flow (in this case drillhole REW-4 or the excavation R-1). Sodium-fluorescein (dye) was used as a tracer. The beginning of the experiment was registered through the Report.
Sodium fluorescein does not affect chemical composition of water, living beings in water and is not harmful to human health if they come into contact with colored water. Due to possible visual effect of temporary intensive staining, the surrounding population was informed about experiment performance. The realization of first phase of dyeing experiment was carried out in the following phases

1. Preparation and procurement of material resources for the experiment.
2. Preparation of tracer solution in the laboratory/base.
3. Tracers (dye) adding into the REW-4 drillhole i.e excavation R-1 in the field.
4. Observation of color occurrence and sampling of 9 points, at given intervals.
5. Laboratory analysis of samples by fluorescence spectroscope, in diffuse light.

Injecting tracer into REW-4 drillhole ie excavation R-1 was performed by Mr. Nermin Taletović, Mr. Goran Prajo and Mr. Aldin Džinić. After tracer adding was completed, all contaminated used equipment, utensils and personal protective equipment were collected and incinerated, and executors did not directly participate in further course of sampling and monitoring occurrence of tracers.

- Water supply pipeline was provided from main reservoir to the REW-4 drillhole ie excavation R-1 with water inflow adjusted to 0.15 l/s for REW-4 and 0.10 l/s for R-1.
- NPV (ground water level) was measured in the drillhole REW-4.
- After continuous water supply to the drillhole/escavation has been provided, area is visibly marked and secured against unauthorized access or tampering of supply pipe.

Continuity of inflow is controlled at least twice a day.
Sampling and monitoring of dyeing occurrence was performed on 9 monitoring locations. Having in mind importance of protection of the surrounding hydrological system and water springs of public water supply, monitoring/observation period was extended to a total of 30 days with variable sampling intervals, as follows:

- first 2 (two) days - every 3 hours
- next 5 (five) days - every 6 hours
- next 3 (three) weeks - every 12 hours

The sampling procedure itself is maximally simplified for more practical implementation and is reduced to the following:

- Previously each sampling point is adapted for concentrated discharge of clean water and possibility of pouring into a smaller container or directly into a bottle/test tube. Sampling points are marked with visible markings.
- Water samples were taken at scheduled time in a 0.3 l test tube/bottle and properly labeled each bottle with exact time and location of sampling. The possible presence of tracer in the water was visually observed.
- Water samples were delivered and deposited in the base/laboratory for analysis of the existence and intensity of dyeing.

4. EXPERIMENT RESULTS WITH INTERPRETATION

Experiment had two phases. First phase during hydrological minimum, and second phase during hydrological maximum, the tracer was added into the REW-4 drillhole on 16.11.2021 at 9:00 h (am), while the tracer was added into the R-1 excavation on 15th March 2022. at 9:00 h (am).
All activities and obtained results were recorded in working documentation and presented in the Report of conducted research. [5]
At none of monitoring points (9 points) there was no appearance of visual water coloration, which could be claimed to be the appearance of sodium fluorescein as a tracer.

Considering total amount of such substances in tested samples, it can be seen that values range from 0 ppb to 117 ppb, and from 0 ppm to 0.117 ppm, respectively.
Below are diagrams showing these concentrations. The concentration is expressed in ppb (µg/l). (1 ppm = 1000 ppb). Concentration values are indicated on the ordinate and sampling dates are indicated on the abscissa (Figure 3).

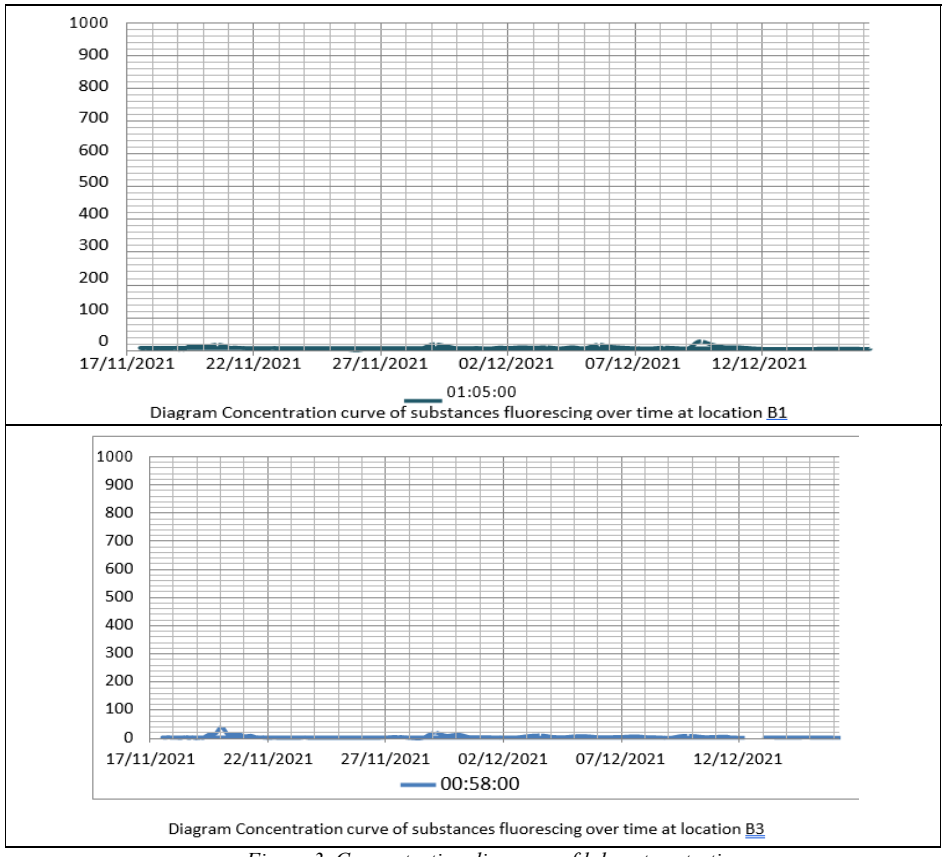

Figure 3. Concentration diagrams of laboratory testing

Based on laboratory tests, the attached diagrams show how concentration of fluorescent substances in samples changes over time. In none of samples the appearance of green colour visually was observed, which indicates appearance of significant concentrations of fluorescein, which was documented in the records during sampling.
If we correlate the periods with intense precipitation (meteorological station "Rupice"), snow melting and other activities that led to an increase in suspended particles, with the movements of groundwater level at the nearest monitoring location of adding tracer (piezometer BRP-1) and recorded concentrations on monitoring location VP-1, we can determine that above changes in suspended particles in the samples have an impact on the measured values of fluorescein concentrations (Figure 4).
Conducted field trials of groundwater flow tracing, despite extended duration of observations (2 times per month), did not show transfer of tracer (Sodium fluorescein) from the point of entry (REW-1 and R-1) to Borovica stream or Bukovica basin. The appearance of visual dyeing was not observed at any of the monitoring points (9 points), which could be reliably claimed to be sodium fluorescein as a tracer.

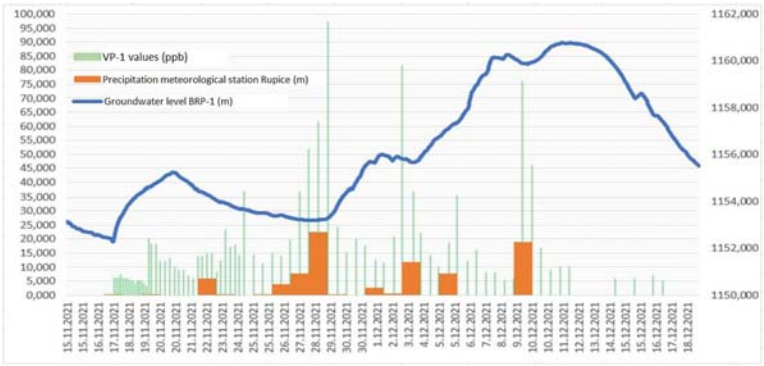

Figure 4. Correlation of quantitative precipitation (MS Rupice), groundwater level on BRP-1 and measured values of concentrations on monitoring location VP-1 during first phase

6. CONCLUSION

Conducted field trials of groundwater flow tracing, despite extended duration of observations (2 times per month), did not show transfer of tracer (Sodium fluorescein) from the point of entry (REW-1 and R-1) to Borovica stream or Bukovica basin. The appearance of visual dyeing was not observed at any of the monitoring points (9 points), which could be reliably claimed to be sodium fluorescein as a tracer.

There is no any of key hydrogeological factors of transference and transport of pollution by groundwater filtration indicatesreal possibility of transport of probable pollutants from mining area of exploitation at Rupice deposit to surrounding water supply facilities (Gornja Borovica, Radakovica, Bijele Vode, Dragovici, Kopljari, Mijakovici, etc.).

Between Rupice exploitation area and water supply "Bukovica", which is located as a "Tyrolean intervention" in Bukovica, there is a multiple hydrogeological barrier of clastic flysch sediments of undivided Jurassic-Cretaceous formation (J, K), which prevents horizontal filtration of groundwater in Rupice deposit exploitation area towards lower course of Bukovica and in area of water supply "Bukovica".

The established regular monitoring of groundwater and surface water quality of whole surrounding hydrological system by Adriatic Metals BH, which has been conducted continuously since May 2020, should maintain a permanent character and be an indicator of water quality permanently during exploitation of deposit. Any indicative changes in any of the quality parameters should be investigated and appropriate measures taken. Monitoring was updated and extended to a new three locations on river Bukovica. Physico-chemical analysis of water quality is performed by licensed laboratories, on many parameters.

7. REFERENCES

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