Revista de Chimie
https://revistadechimie.ro
https://doi.org/10.37358/Rev. Chim.1949

Surface Water and Groundwater Quality Evaluation in a Mining Area

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Abstract: *This paper presents a monitoring of groundwater and surface water in the mining area Tg. Ocna, by analyzing 16 physico-chemical parameters (pH, turbidity, dissolved oxygen, Pb, Ni, Cu, Fe, Mn, Zn, Cr, Mg, SO_4^{2-}, Al, NO_2^-, NO_3^-, NH_4^+), from three rivers Slanic, Trotus and Valcele, a small lake Groapa Burlacu, a fountain and three monitoring drilling wells (F11, F16 and F17). Studies on the quality of surface water and groundwater in areas near mines are important due to extraction and exploitation of salt. The samples were collected in April 2019. Following the analyzes, their results are included in the following concentration ranges: pH 7.21 to 8.46 unit. pH, turbidity 0.54 to 169 NTU, dissolved oxygen 6 to 8.59 mg/L, Pb 0.075 to 0.095 mg/L, Ni 0.026 to 1.05 mg/L, Cu 0.088 to 0.809 mg/L, NO_2^- 0.001 to 0.037 mg/L and NO_3^- 0.290 to 4.34 mg/L. The pH, turbidity and dissolved oxygen were measured in situ using portable equipment's. As for the other parameters, they were analyzed in the water laboratory from Vasile Alecsandri University of Bacau by using spectrophotometry. Some concentrations of the physico-chemical indicators of the water samples analyzed were found to be more than the water quality classes.*

Keywords: *water quality analysis, groundwater and surface water sources, mining area*

1. Introduction

Surface water and groundwater are an important water resource for different activities. Due to the urbanization, industrialization and other anthropic activities (unproper wastewater treatment and water resource management, agriculture etc), the quality of surface water and groundwaters are very affected [1-14]. Another factor that can leads to exhaustion of surface water resources may also be due to its unequal worldwide distribution. Due to these factors that lead to exhaustion of surface water resources, groundwater is used for different requirements and industry sectors [15-30]. In order, to protect the quality of groundwater against pollution, at European level, a directive was implemented in 2006, which helps them with European Commission Directive 2006/118/EC [31].

Regarding the quality of the groundwater, the physical-chemical properties monitoring can be the best methods for punctual or global quality evaluation. Besides these properties there are other parameters that can change the quality of groundwater, for example metals. The main sources of pollution with metals of the water are the untreated wastewater discharges, the industrial and mining activities, the agricultural activities etc. [32-45].

The mining exploitation, in most countries, is an important economic activity essential to supply raw materials for human activities. Within this activity, the operations used can produce large

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quantities of waste, pollution of water surface and groundwater, land degradation, evacuation of mining water which can affect the environment for a longer period [23, 32]. Also, the surface water and groundwater quality investigation in mines areas are important to maintain a proper evaluation of the water sources and the pollution incidence dynamic.

This paper presents a groundwater and surface water monitoring in the Tg. Ocna Bacau mining area, by analyzing 16 physico-chemical parameters (pH, turbidity, dissolved oxygen, Pb, Ni, Cu, Fe, Mn, Zn, Cr, Mg, SO_4^{2-}, Al, NO_2^-, NO_3^- and NH_4^+), from three rivers (Slanic, Trotus and Valcele), a small lake (Groapa Burlacu), a fountain and three monitoring drilling wells placed in the area of mining activity F11, F16 and F17.

2. Materials and methods

2.1. Study Area

The city of Targu Ocna is in the southwest of Bacau county, on the banks of the Trotus river, where it receives the waters of the Slanic and Valcele affluent. The geographical coordinates of the study area are 46.2876°N 26.6034°E. The studied area is near the Targu Ocna salt mine, which includes a salt solution section exploitation area. Since the area is located between mountains and hills, the thermal regime is a moderate one with mild winters with early spring and cool summers with an average annual temperature of 9.3°C.

Surface water and groundwater samples (Figure 1) were collected from 11 different points within the Slanic River, upstream and downstream (RSU and RSD), the Trotus River, upstream and downstream (RTU and RTD), the Valcele River, upstream and downstream (RVU and RVD), a fountain, and three drilling monitoring points (F11, F16, F17), from the city of Targu Ocna. The monitoring points were chosen for a good water quality evaluation before and after mining area.

Figure 1. Sampling points location [46]

2.2. Sampling and analysis

The collection of samples was carried out in April 2019 in 500 mL polyethylene (PET) bottles and stored at proper temperature. The equipment's used for parameters evaluations are presented in Table 1.

Physico-chemical parameters measured in-situ were *p*H, turbidity and dissolved oxygen performed by using portable WTW equipment's. The rest of parameters were evaluated in the Vasile Alecsandri

University of Bacau laboratory by using DR 3900 spectrophotometer. The standard methods for water parameters determination were: SR EN ISO 10523 for pH, SR EN ISO 5814 for dissolved oxygen and SR EN ISO 7027 for turbidity [47, 48, 49]. Regarding the analysis of rest of the parameters, were used certified methods, recommended by VIS DR 3900 spectrophotometer HACH producer.

Table 1. Evaluated parameters

Parameters	**Used equipment**
pH	pH 3210
Temperature	pH 3210
Dissolved Oxygen	Oxi 3210
Turbidity	TURB 430
Pb	DR 3900 spectrophotometer
Ni	
Cu	
Fe	
Mn	
Zn	
Cr	
Mg	
SO_4^{2-}	
Al	
NO_2^-	
NO_3^-	
NH_4^+	

3. Results and discussions

3.1. Evaluation of the parameters performed in situ

The parameters analyzed in situ were *p*H, turbidity and dissolved oxygen (Figure 2). As can be seen in Figure 2a, the samples have a *p*H value greater than 7.21 to 8.46. In the groundwater *p*H varies from 7.21 to 7.82 units *p*H and the *p*H value of the water samples from the surface water varies from 8.12 to 8.46 units *p*H. The highest *p*H values are recorded at the RSU and Groapa Burlacu sampling points (8.46 units *p*H). The lowest *p*H value is recorded at sampling point F17 having a value of 7.21 units pH. The average *p*H value in the studied area indicates that the analyzed samples are weak alkaline.

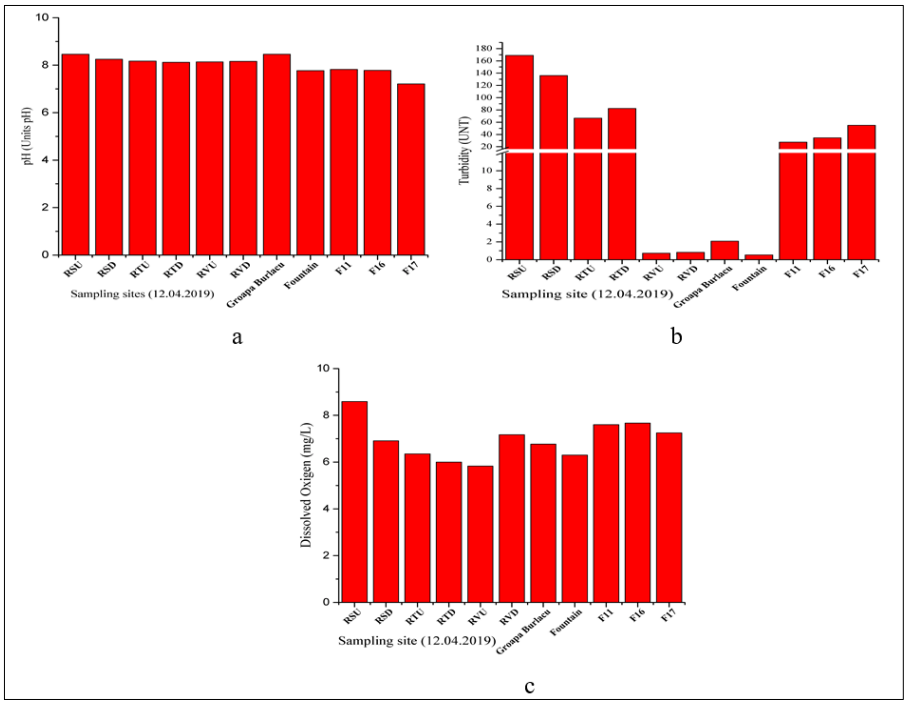

Figure 2. The values of parameters analyzed in situ:
a – pH; b – turbidity; c - dissolved oxygen

The turbidity values (Figure 2b) of groundwater varies from 0.54 to 55 NTU recorded at measurement point F17, and the values recorded within surface waters varies from 0.73 to 169 NTU. The highest values are recorded upstream for the RSU measurement point and the lowest values are recorded at the RVU measurement points and in the fountain. The high values recorded for turbidity can be a consequence of the high precipitation level from that period.

The highest values of dissolved oxygen (Figure 2c) for surface waters are recorded in the upstream of RSU and RTU, except for the sample taken from the River Valcele where the highest value is recorded downstream. The value recorded in the measuring point Groapa Burlacu was 6.77 mg/L. Regarding the measurement points taken from the groundwater, the highest values were recorded in points F16 and F11.

3.2. Evaluation of the parameters performed in laboratory

Thirteen indicators (Figures 3 and 4) Ni, NO_3^-, Cu, Fe, Mn, SO_4^{2-}, Pb, NO_2^-, Zn, Cr, NH_4^+, Al and Mg were analyzed from the samples of the groundwater and surface water in the Vasile Alecsandri University of Bacau laboratory.

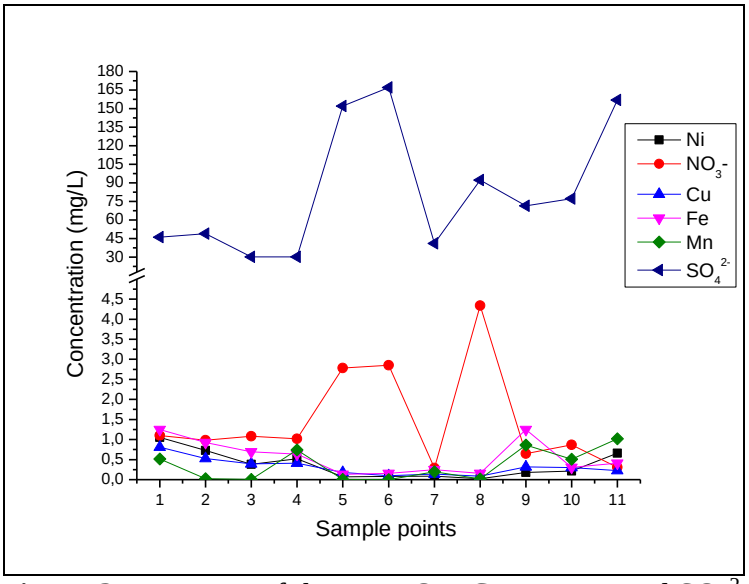

Figure 3. Variation of the Ni, NO_3^-, Cu, Fe, Mn and SO_4^{2-} parameter's evaluated in laboratory: 1 – RSU; 2 – RSD; 3 – RTU; 4 – RTD; 5 – RVU; 6 – RVD; 7 - Groapa Burlacu; 8 – Fountain; 9 - F11; 10 - F16; 11 - F17

Following the analyzes, the maximum concentrations of Fe were recorded in the RSU and F11 samples respectively 1.25 mg/L at both measured points.

The result of the analyzes regarding the concentration of Cu is in the range 0.088 mg/L to 0.809 mg/L. The maximum concentration of Cu was recorded in the RSU sample and the smallest value is present in the sample taken from the fountain.

The value of the maximum concentrations of Pb (Figure 4) was found in the samples taken from the surface waters, respectively the Groapa Burlacu with a value of 0.095 mg/L, RTD (0.092 mg/L) and RSD (0.086 mg L). Regarding the samples taken from groundwater, the concentrations of Pb present some constant values between 0.075 mg/L to 0.081 mg/L.

The small concentrations of Zn in the analyzed samples were recorded in the samples taken from the groundwater (0.001 mg/L to 0.002 mg/L). In the downstream of Slanic River (RSD) the highest value of Zn concentration recorded was 0.016 mg/L.

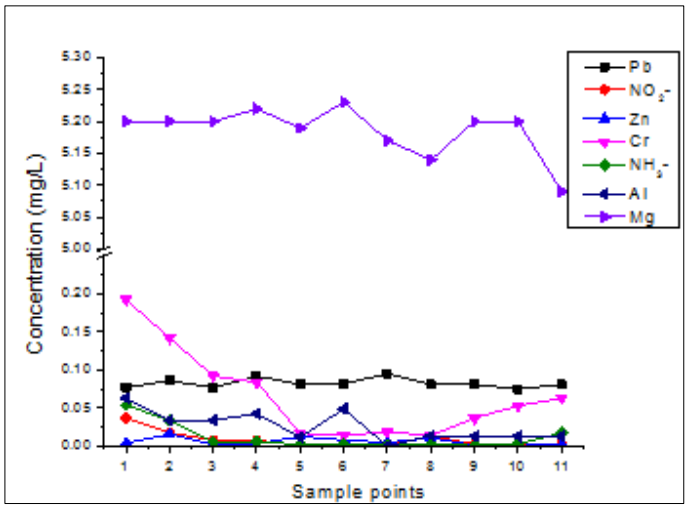

Figure 4. Variation of the Pb, NO_2^-, Zn, Cr, NH_4^+, Al and Mg parameter's evaluated in laboratory:1 – RSU; 2 – RSD; 3 – RTU; 4 – RTD; 5 – RVU; 6 – RVD;7 - Groapa Burlacu; 8 - Fountain; 9 - F11; 10 - F16; 11 - F17

The concentrations of the NO_3^- values were between 0.290 mg/L to 2.85 mg/L. The high value of the NO_2^- and NO_3^- concentration were recorded in the point RSU. This point is in the incidence of the possible waste and wastewater from near households.

The surface water analyzes results indicate high level of SO_4, 167 mg/L to 30.2 mg/L. These values indicate that the water samples are included in the II and III quality class. The samples analyzed from the sampling points RSU, RSD, RTU, RTD and Groapa Burlacu belong to quality class II, and the sampling points RVU and RVD belong to II quality class [50].

In the analyzed samples, the values of Cr concentrations for surface waters are in the range 0.014 mg/L to 0.192 mg/L. Regarding groundwater, the analyzed samples recorded values were in the range 0.014 mg/L to 0.053 mg/L.

The values for Mn in some samples analyzed are insignificant, recording values in the range 0.001 mg/L to 0.007 mg/L. For RTD measurement points, F11 and F17 the values resulting from the analyzes are in the range 0.742 mg/L to 1.02 mg/L. Following the analyzes carried out, the results on the analyzed samples indicate a concentration of Ni value between 0.026 mg/L to 0.657 mg/L, except for the RSU sample which recorded the value of 1.05 mg/L.

The concentration of Al for both samples of the surface water and groundwater as a result of the analyzes are in the range of 0.012 mg/L to 0.063 mg/L. In the water sample taken from Groapa Burlacu point the concentration of Al is zero.

Regarding the results of the concentration of Mg the resulting values are relatively constant from 5.09 mg/L to 5.23 mg/L.

4. Conclusions

The study presents a monitoring of groundwater and surface water in the mining area of Targu Ocna, Bacau county.

Following the results, the parameters that were measured for the water quality study show that the maximum *p*H value was recorded at the measuring point Groapa Burlacu indicating an alkaline pH.

Domestic activities, waste, weather conditions within the study area may influence the chemical composition of surface and groundwater within the studied area.

The present study evaluates a monitoring of the contamination level of the water sources around the studied area. The results of the analyzed indicators (Pb, Ni, Cu, Fe, Mn, Zn, Cr, Mg, SO_4^{2-}, Al, NO_2-, NO_3- and NH_4^+) in the surface and groundwaters vary from sample to sample. The highest concentrations of the analyzed indicators are found in the samples taken from the surface waters, except for the SO_4^{2-} indicator.

The metal content in the samples of surface water have been in the order Fe>Mg>Ni>Cu>Mn> Pb>Cr>Al>Zn and samples of the groundwater were of the order of Mg>Mn>Fe>Ni>Cu> Pb>Cr>Al>Zn.

The concentrations between the cations in the surface waters and the groundwater analyzed are of the order Mg>Pb>Al. The anion concentrations were of the order SO_4^{2-}>NO_3^->NO_2^- for surface and underground waters in the analyzed samples.

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Manuscript received: 17.02.2020