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WATER QUALITY ANALYSIS FROM A MINING AREA. CASE STUDY: TARGU OCNA SALT MINE, ROMANIA

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Abstract

To resolve the water source quality problems for different water demand it is very important to establish in each zone the water sources (surface or/and groundwater) and the main source of pollution for these. By a continuous or periodical water quality monitoring, in industrial zone, can be avoided the major risks of environmental pollution and human health negative implications. The salt load and the specific salt composition, differing from natural rivers from a common area compared with surface water from a salt mining zone. The present paper aims to establish some surface and groundwater quality analysis parameters from an industrial area. The present study is focused on the Targu Ocna mining area, with salt extraction activities and the quality analyzed rivers were Trotus, Slanic, Valcica, two drilling and a fountain. In this sense, were measured 12 water quality parameters, some values were obtained in situ with portable equipment's and other parameters were determined in the research laboratory.

Key words: groundwater, mining zone, rivers, water quality

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1. Introduction

Natural water sources may contain many impurities, mineral and organic nature, dissolved or dispersed, in a higher or lower concentration, which can be carry in the of natural water course circulation. From the total global water, only 2.8% represent freshwater, of which 20% is groundwater. Surface and groundwater waters are used for industrial, agricultural and domestic uses. Groundwater is generally considered to be much cleaner than surface water. Due to this aspect the groundwater and surface water quality can be influenced and affected by the following factors: agricultural activities, domestic and industrial waste and wastewater, mining activities etc. (Barsan et al., 2014; Bellos et al., 2004; Eblin et al., 2019a; Eblin et al., 2019b; Fabian et al., 2019; Irimia et al., 2013; Misaila et al., 2019).

Typical, the mining output peaked in the eighteenth and nineteenth centuries after the industrial revolution, when demand for coal, salt, metal ores was at its highest. As a result of these activities, even if in the present the industrial activities are monitored and we have clear international regulation, there are many problems regarding the environmental pollution especially, soil and water pollution (Cochiorca et al., 2018; Cochiorca et al., 2019; Fan et al., 2010).

For each type of water sources, from an industrial area, can be establish the key parameters (according with legislative regulations) by which can be established the industrial impact during normal exploitation, in particular cases (natural disaster or

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accidents) and the pollutant retention and accumulation during time. Also, in the industrial area it is very important to establish a delimitation between natural water pollution sources and industrial pollution. This delimitation can be performed by a clear zone evaluation from geological and hydrological point of view. Regarding surface waters and lakes, at the worldwide, some research shows that their pollution has become larger, thereby causing degradation of aquatic ecosystems (degradation caused by industrial activities and human activities). The process of water pollution especially the surface is steadily increasing, the most affected are developing countries because they lack treatment facilities (Kumar Tank and Singh Chandel, 2010; Kumar Yadav et al., 2012; Kunwar et al., 2005; Massoud et al., 2006a; Massoud et al., 2006b; Untila et al., 2019).

Like surface water (in principal rivers and lakes), groundwater evaluation and monitoring are very important in special for evaluation of the possible sources of pollution. The main causes of groundwater pollution are waste from industrial and human activities, uncontrolled use, and disposal of chemical waste (Navis Karthika et al., 2018; Ouyang et al., 2006; Patil and Patil, 2011; Shrestha and Kazama, 2007). Due to the various processes that have existed over time, the water quality has undergone various modifications. Impact on water quality can be caused by different natural processes, increased exploitation of water resources and various industrial, urban and agricultural activities. The pollutants concentration from water can be influenced by groundwater flows, wastewater discharge and surface leakage (Navis Karthika et al., 2018; Ouyang et al., 2006; Patil and Patil, 2011; Shrestha and Kazama, 2007).

The present study is focused on the determination of the water quality in the mining area Targu Ocna, having as its activity the extraction of salt. For the analysis of the parameters, 10 samples of water were collected near the Salt Mine site and the Salt Solution Section (the salt mine belonging to Targu Ocna Salt mine, Bacau, Romania).

2. Case studies

In the analyzed area were establish the main water sources (surface water and groundwater) and the industrial perimeter. For the water quality analysis, ten samples of water were collected near the salt mine and from the Salt Solution Plant (included in salt mine extraction department).

2.1. Description of study area

Targu Ocna is in the South West of Bacau county (Fig. 1), with geographic coordinates of 26°37'12 " East longitude and 46°16'48 " North latitude (Stoica, 2009). From the West to the East of the city Targu Ocna, there are the flysch Carpathian and the sub-Carpathian Neogene. These two units are delimited by the Trotus and Valcica. The salt deposits in the area are found in the form of a lens in sandstone (Stoica, 2009).

The city of Targu Ocna has a wealth of underground resources, such as: salt and potassium salts, petroleum, mineral springs, construction materials. From these, the most important resources are salt. Targu Ocna salt massif Valcele it is located on the North South direction on an area of 1km and on the East West direction on an area of 600 m (Stoica, 2009). The Trotus River located near the mining area crosses the city, at 7 km from West to East and receives as affluent the Slanic River, on the right, and the Valcica River, on the left. In the drought period's, the left affluent of the Trotus River have very low debits (Stoica, 2009). In 1978, near the confluence of Slanic and Trotus, a lake with a surface of 500 m^2 and a depth of 57 m was formed. Today, the lake formed during that year does not exist being covered with the alluviums of the Slanic River.

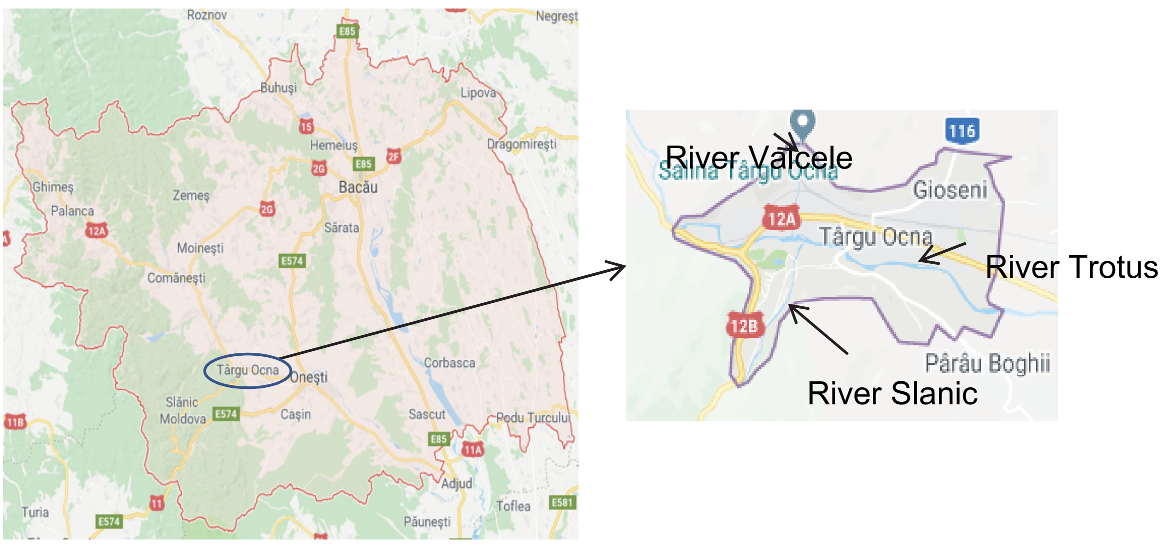

Fig. 1. Steam explosion unit

In 1986, a new lake appeared located at the edge of the "Magura" park, the lake being named by the locals "Groapa Burlacu". The formation of this lake was due to the activities of the brine wells or the existence of some old mines (Stoica, 2009).

2.2. Samples collecting and evaluation

In the present study, water samples were collected near the salt mine in Targu Ocna, from four surface water sources (Fig. 2), from upstream and downstream of the Slanic, Trotus and Valcele River and the Lake Burlacu. Groundwater samples (Fig. 2) were collected from monitoring wells and public fountain near to the mining area. Water samples were collected in containers of polyethylene terephthalate (PET) of 500 mL.

The samples were labelled according with abbreviations: RSU (Slanic River Upstream), RSD (Slanic River Downstream), RTU (Trotus River Upstream), RTD (Trotus River Downstream), RVU (Valcica River Upstream), RVD (Valcica River Downstream), LB (Lake Burlacu), DF16 (Drilling F16), DF17 (Drilling F17) and F (Fountain) (Fig. 2).

The analyzed parameters were pH, turbidity, electrical conductivity, dissolved oxygen and temperature, calcium, magnesium, alkalinity, chlorides, nitrates, sulfates and bicarbonates. Some of these parameters (turbidity, pH, electrical conductivity, dissolved oxygen and temperature) were analyzed in situ by using portable equipment (WTW devices). The other parameters were analyzing at the hydrogeology research laboratory of the DIATI department, from Polytechnic of Turin, Italy.

The parameters evaluation at the DIATI Department of Hydrogeology Research, were carried out by atomic absorption spectrophotometry method and the Mohr method. The Atomic Absorption Spectrophotometer can perform more tasks, ranging from routine analysis to research and development. The Mohr method has been developed for exact titration requirements and can perform all types of common titration. The hydrogen ions concentration reveals the acidic or basic nature of water.

3. Results and discussion

3.1. In situ evaluation of water quality parameters

The data from Table 1 shows the parameters relating to the water quality of the surface water and groundwater. From Table 1 can be observed that the maximum value of the pH was 8.81 and the minimum 7.65. Also, it can be observed that the pH values for all analyzed samples are slightly alkaline.

The results presented in the Table 1 show that all water samples that were analyzed do not show large deviations from the values that are normally recorded. They fluctuate around normal values, which means that water is not contaminated with hazardous pollutants.

The reason why the temperature varies is that the samples that were collected were from different places. It is obviously that with the increase of sampling depth, the temperature will be different. In other words, water from a fountain will never have the same temperature as a lake or river.

Fig. 2. Location of monitoring points

Table 1. Water quality parameters evaluated in situ

Measuring points	*pH*	*Turbidity UNT*	*Electrical conductivity μS/cm*	*Dissolved oxygen mg/L*	*Temperature ˚C*
RSU	8.41	3.98	1583	6.86	24.7
RSD	8.54	5.58	1868	6.53	25.1
RTU	8.81	5.31	461	7.40	23.4
RTD	8.68	5.05	905	7.01	23.6
RVU	7.74	5.23	2740	7.41	22.6
RVD	8.43	3.80	4980	7.15	24
LB	8.52	3.52	2120	5.91	26.6
F	7.65	0.92	1688	6.97	22.6
DF16	nd	nd	nd	nd	nd
DF17	nd	nd	nd	nd	nd

nd - not been determined

From the obtained data, it is observed that the value of temperature of the samples (Fig. 3) upstream and downstream for the analyzed samples within the rivers, varies between 22.6 °C to 25.1 °C, the highest value being registered at the RSD point and the lowest value being registered in the RVU. As far as the results of the analysis of samples in F and LB, the recorded temperature is 22.6 °C and respectively 26.6 °C.

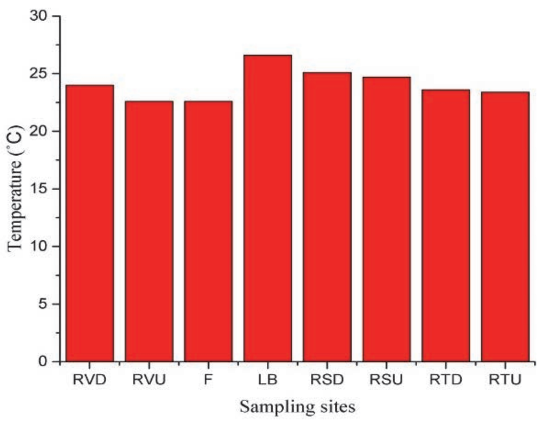

Fig. 3. The water samples temperature variation

The turbidity varies according to the sampling area, depending on the material (organic and inorganic) present in the water. The analysis results relating to the surface and groundwater, shows that the turbidity values vary from one sample to another (Table 1), so that the maximum value is registered in RSD (5.58 NTU) and the minimum F (0.92 NTU). The dissolved oxygen average value concentration was 6.9 mg/L, with a maximum value of 7.42 mg/L at the RVU sampling point and the minimum value at the LB point (5.91 mg/L).

The results on the electrical conductivity of the eight samples analyzed indicates that the maximum value was 4980 mS/cm in the RVD sampling point, and the minimum registered in the RTV (461μS/cm). In the case of RVD sample (Table 1), the conductivity is highest, because at this point where it was taken, the organic and inorganic content of the water is predominant. This aspect does not negatively influence the pH of the sample, but only the amount of matter which is present at that point is very high.

3.2. Evaluation of water quality parameters performed in situ

Fig. 4 presents the results of the water quality indicators evaluated in the laboratory. According to the recorded data, it can be seen from Fig. 4 that the calcium value is the highest, predominant at the sampling point DF 16 but significantly decreasing at the last RTU point. The highest values of chlorides and alkalinity from all samples analyzed are found in points DF17 and LB. In samples DF16, DF17 and LB the concentration of nitrates is not present.

It is important, however, that nitrates are not present in high concentration because, of their toxicity, the water in those points would have presented a high degree of danger with direct implication to the study area level of pollution. In the study, the alkalinity values in the samples taken from the two drilling were 106.309 meq L^{-1} for sample DF16 and 206.845 meq L^{-1} for DF17.

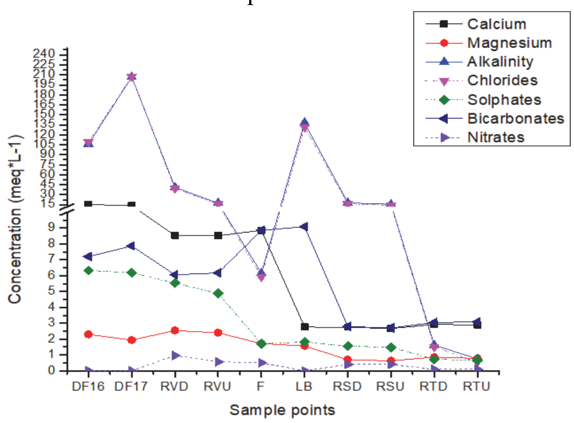

Fig. 4. Water parameters evaluated in the laboratory

The alkalinity concentration in the water samples from the Valcica river upstream and downstream evaluation reveal 41.372 $meqL^{-1}$ for RVD and 17.253 $meqL^{-1}$ for the RVU. Regarding to the chlorine concentration, the values have varied from 39.437 meq L^{-1} (for the RVD sampling point) to 16.024 meq*L^{-1} for RVU.

The alkalinity and chlorine in sampling point LB is higher than the sampling point F, with 131.339 meq L^{-1} chlorine concentration at point LB are and

5.938 meq*L^{-1} for sample point F respectively, alkalinity concentration for LB was 138.322 meq *L^{-1} and for F was 6.162 meqL^{-1}.

In the analyzed samples from points RSD and RSU (Fig. 3) it was evidenced that the alkalinity varies from 17.754 meq L^{-1} to 15.711 meq L^{-1}, and the resulting values of the chlorides varies from 16.155 meq L^{-1} to 14.134 meq L^{-1}. Also, alkalinity from RTD and RTU samples points has varied from 1.626 meq L^{-1} to 0.747 meq L^{-1} and the chlorine concentration from 1.520 meq L^{-1} to 0.560 meq L^{-1}. Generally, the alkalinity and chloride concentration were higher at RTD than at RTU, bicarbonate and calcium values varied with the other parameters, so that the bicarbonate concentration for RTD and RTU samples ranged between 3.06 meq L^{-1} and 3.087 meq L^{-1}, and for calcium 2.927 meq L^{-1} and 2.909 meq L^{-1}

4. Conclusions

In this study, the water analysis methods were used to evaluate the possible impact caused by mining activities on natural water quality.

In water, the alkalinity is mainly given by compounds of bicarbonates, carbonates, nitrates, silicates, phosphates, etc. In the analyzed samples, the alkalinity was between 0.747 meq L^{-1} and 206.845 meq L^{-1}. High content of calcium in water can cause inconvenience for different uses, such as domestic use. The calcium concentrations in the samples varied from 2,670 meq L^{-1} to 15,386 meq L^{-1} depending on the sample. The presence of chlorides in water is due to the discharge of industrial and domestic wastewater into the watercourses. The concentration of chlorine in the present study is in the range of 0.560 meq L^{-1} and 207.230 meq L^{-1}.

The high concentrations of certain parameters (alkalinity, chlorides, and bicarbonates) at sampling points are since they are located near saltwater springs (a few km away from Targu Ocna).

The evaluation of the obtained data reveals that the monitored water sources (near salt mine) do not present extreme values for the evaluated parameters. Dangerous pollutants such as nitrates and nitrates are within acceptable limits and this demonstrates from the outset that mining activities that have taken place over time in the area where the study was conducted did not cause pollution to the water sources.

The results of the water quality parameters analysis from the 8 monitoring points indicate that the maximum pH of 8.81 has been registered at the RTU sampling point, indicating an alkaline pH. The highest value of the electrical conductivity of the sample has been registered at the sampling point RVD. The chlorine concentration for all analyzed samples was in the range of 0.560 meq L^{-1} to 207.230 meqL^{-1}.

After analyzing the samples, it can be said that the mining area where the research was carried not present a negative impact on the environment and human health.

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