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Research Article

Evaluating Waters in Jeiroud Phosphate Mine Area and the Effects of Mine on Jeiroud River Water

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Abstract

This study examined the quality of waters in Jeiroud Phosphate Mine area and its effect on changing Jeiroud River water properties. Among the requirements of this study the followings can be implied: the accompaniment of heavy metals and nutrient elements in phosphate mineral, the proximity of mine to Jeiroud River providing a part of Latian Dam water, the location of this mine near Jeiroud Village, and the necessity of maintaining health and virginity of the area. To specify mineral area water qualities, underground waters of mine and river area were sampled. Then, parameters such as BOD5, COD, TDS, heavy metals, and nutrient elements are measured. Underground and river waters type was set using stiff diagram. River water samples were measured and analyzed before and after mine area. Results showed that most parameters in the river water changed when passing through mine area. High concentration of Antimony, Vanadium, Uranium elements are seen in the river water. It must be considered in various usages and their entrance into the river must be prevented.

Keywords: *Jeiroud Phosphate Mine, water evaluation, Jeiroud River*

Introduction

Mining is one of the requirements of societies. Preparing raw materials for various industries is impossible without mining. Any type of mining activity can bring about a variety of environmental effects. In this study, regarding the coexistence of phosphates and heavy metals as well as nutrient elements, the proximity of mine with Jajroud River and the location of mine which is one of Tehran people's touristic areas, waters in the mineral area are evaluated and the effect of mine on Jeiroud River is shown. It must be noted that Jajrud River supplying Latian Dam water has various branches. One of these branches flowing through mine site is called as Jeiroud River. This part of Jajrud River is located near Jeiroud Mine. Hence, any kind of mining activity directly affects the river. For instance, the mine sank in 2006. A part of sliding waste and minerals entered into the river and a part unstably accumulated near the river. As a result, any stimulus like river water raise can enter these materials into the water.

The mineral area is located 45Km from Northern Tehran, in Central Alborz heights (E51°,28',40" and N35°,59',43") and near Jeiroud Village in Latian Dam basin which provides a part of water for Tehran people (Figure 1). Latian Dam basin height ranges between 1500 and 4000m and %80 of its area has high over 2500m. The mine is also located in high area. Regarding weather, this basin is mainly affected by Mediterranean air mass and then air front between Siberian and Mediterranean area. Hence, less than %5 of annual precipitation happens in dry season (summer). Average annual precipitation is about 700mm (B. Rahmani, 2009).

Figure 1 Jeiroud Mine is located on the map

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The area under study is located in Central Alborz geological unit. It is composed of a set of faulted and trusted anticlines and synclines. The area was exposed to Mosha-Fasham thrust. In addition, several sub-faults are also seen around the mine. They have shifted the direction of mineral layers. They can also be the path through which mine drainage can enter into underground water and river water. Various formations have outcrops in the area such as Barut, Zagun, Lalun, Mila, Jeiroud, Mubarak, dorud, Ruteh, and Nasan formations from Precambrian and Paleozoic Era; Elika, Shemshak, Delichai, Lar, and Tizkuh from Mesozoic Era; Fajan, Ziarat, and Karaj formations from Cenozoic Era; and finally Quaternary sediments and deposits including old and new alluvial thrusts in the rivers bank most of which are located on gardens and farmlands. Formations having outcrops in mineral area are illustrated in Figure 2.

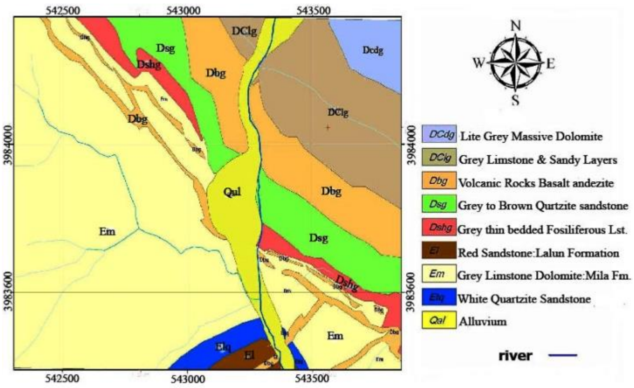

Figure 2 Geological map of mineral area modified from (V. Rasuli, 1995)

Phosphate rock contains highly measured phosphate minerals for mining. Mostly, sources containing over %20 of P2O5 are mined. The main mineral in this rock is apatite existing in form of fluoroapatite (FA). Phosphate sediments which can be mined are divided into three types: 1- phosphorites, 2- carbonatites and alkali igneous rocks, and 3- Guano sediments (B.G. Lottermoser, 2007). Jeiroud ore is of phosphorite type and most its mineral contents consist of fluoroapatite. Impurities are in terms of physical inclusions (e.g. sand, quarts, iron oxides, organic materials, and carbonates) or crystal substitution inside phosphate minerals. Ions replaced with calcium and fluorine include CO3, Sr, Mg, SO4, Na, and also rare elements (like U, Th, REE, Y, Cd, and Zn) (I. Jarvis et al, 1994; P.M. Rutherford et al, 1994).

Rare heavy metals or metalloids (like Zn, V, Se, Sb, Ni, Mo, Cu, Cd, and As) show high enrichment in phosphorites with organic materials. This enrichment is resulted from the absorption or participation of these elements in organic materials or sulfates (Rutherford et al, 1994). Based on (R.A. Gulbrandsen, 1966) studies, the frequency of rare elements in phosphatites emanates from their coexistence in apatite net. Accordingly, separating these elements from phosphates can lead to the pollution of the area water resources.

Jeiroud Phosphate Mine was exploited in 1993. Its definite reserve is 1500000T. Annually, 8000T ore is mined (M. H. Karimpour and S. Sa'adat, 2005). Four tunnels have been bored so far to access and transport this mineral. These tunnels are totally 850m. The mineral is transported to Parchin; the only manufacturer of phosphoric acid in Iran. Then, it can be used for producing chemical fertilizer, drinks, conserving food, making match, and producing aflame bullets (B. Rahmani, 2009).

Materials and Methods

Here, after data collection, the review of reports from the area as well as sources of phosphate mining environmental effects, the mineral area was visited. Then, water was sampled and examined, and results were analyzed.

Five stations were selected to examine waters heavy metals, BOD5, and COD. Three separate samples were taken from each station based on the tests. To determine the amount of soluble cations and anions, five stations were selected and sampling was done in each. Places of sampling are shown in Figure 3 prepared by GIS AR. All sampling dishes were made of polyethylene. They were first pickled and then cleaned using distilled water. They were again depleted and filled by sampling water in triplet. Samples were prepared from deep and traverse parts in the middle of the river as well as non-turbulent areas of water. In preparing mine drainage, attempts were made to prevent from the entrance of air bubbles and hand contact.

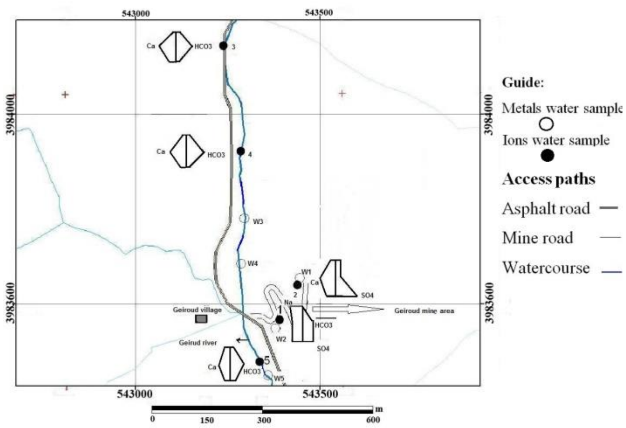

Figure 3 Waters sampling place (filled circles show cation-anion samples and hallow circles show heavy metals samples), type of waters, Jeiroud Mine, River, and Village are seen on map (adopted from ((Tehran Geological Survey, 2002) and (Tehran Topography Map, 2004))

Heavy metals in water samples were measured using ICP method in Geological Agency laboratory by Varian 735-ES. BOD5 and COD were measured in the

Chemistry Laboratory of Environment Protection Organization. Soluble cations and anions were evaluated in the laboratory of Soil Protection and Watershed Management Research Center of Agricultural Jihad.

Result and Discussion

We will discuss the results in three parts including the examination of soluble cations and anions, COD and BOD5, and heavy metals.

To have an overview of the conditions of waters in the area, stiff diagram of waters was prepared using Aquachem (Figure 3). Based on diagrams, waters in mineral area approach sulfate type. This is explained by the coexistence of sulfide minerals and phosphates of Jeiroud. River water also approaches bicarbonate type. It is resulted from dolomitic and limy formations in the river bed. As seen, the mine has smaller bicarbonate-calcium arm in the river water after passing through mineral area. It can be resulted from the formation of phosphoric and sulfuric acids.

Dissolved materials form due to the solubility of solids, liquids, and gases in water. Dissolved materials may be organic or non-organic. They can produce color, poison, and bad odor. Some of them are toxic and even induce cancer. Total Dissolved Solids (TDS) can be weighed and determined by evaporation and after being filtered. Based on the table, samples 1, 2, 3, and 4 had desirable amount. Yet, since these values were above the amount in the river, this parameter increases after the river passes through mineral area (Figure 4).

Total Hardness (TH) refers to the amount of ambivalent cations existing in water. It is measured based on calcium carbonate (mg/l). These cations include Ca, Mg, St, Fe, and Mn. The main factors of hardness are Ca^{+2} and Mg^{+2}. Hence, hardness is shown in form of total Ca and Mg ions. Total hardness is the sum of temporary hardness (calcium and magnesium carbonates) and permanent hardness (calcium and magnesium sulfates). Among the consequences of water hardness, the followings can be mentioned: sedimentation, soap consumption increase, water quality reduction (regarding water potability). Desirable potable water hardness is 15unit, yet up to 500unit is also acceptable (H. Amirbeigi, 2003).

As seen in Table 1, water hardness of new echelon drainage (Sample 1) is above permissible level. Its entrance into the river can increase this parameter in river water. Figure 4 illustrates TH diagram.

Sulfate (SO^{-2}_4) increases dissolved solids in water. But, it is not practically justifiable. It combines with calcium and produce calcium sulfate precipitation. According to WHO, its recommended amount in potable water is 250mg/l (H. Amirbeigi, 2003). Based on Table 1, samples 1 and 2 contain amounts of sulfate beyond the recommended level. This is also seen in the diagram of the area water type. In Figure 4, sulfate diagram shows that the amount of river sulfate has increased after river passed through mineral area.

Nitratic nitrogen (NO_3^{-2}) is the most oxidized form of nitrogen. American Environment Temporary Standards for Potable Water has limited the amount of nitrate to 45mg due to its serious and sometimes fatal effects on children. According to WHO, its recommended amount in potable water is 50mg/l. The permissible amount for being released in ground waters and absorbent well is respectively 50mg/l and 10mg/l (A. Abrishamchi et al, 2006). Based on Table 1, samples contain amounts of nitrate below the permissible level for being released into ground waters. In Figure 4, nitrate diagram shows that the amount of river sulfate has increased after river passed through mineral area.

Chemical tests like BOD5 and COD are carried out to examine the hazard of marine living environment and water pollution. Any substance in the watercourse can be oxidized by biological or chemical method. It reduces oxygen in the environment. Both qualities are used for calculating lack of oxygen in aquatic environment. Both are related to water pollution. BOD5 test shows oxygen requirement for decomposing organic substances. COD test shows the need for biological oxygen as well as oxygen required for the chemical oxidation of organic materials. Both BOD5 and COD amounts are below the recommended level in samples. As a result, there is no problem regarding the lack of oxygen in waters of the area. At first, this results in a paradox concerning the existence of phosphate mine. Yet, based on the examinations, phosphates of the area were of flouroapatite with very low solubility (H. Helalat, and M. Bolurchi, 1994). Then, it does not lead to serious overfeeding conditions in the river. However, based on Figure 4, the river water shows increase in phosphor content after passing through mineral area (B. Rahmani, 2009).

As mentioned earlier, a variety of heavy metals and radioactive substances can be substituted in phosphates structure. To examine the concentration of these metals in mineral area and their effect on river, samples were prepared from mineral area as well as upstream and downstream parts of the river and analyzed.

Antimony is among heavy metals shows enrichment in the area under study. According to EPA, its recommended amount in potable water is 6ppb. All waters in the mineral area contain high amounts of antimony. To show the effect of mine on the river water, antimony changes diagram is drawn in Figure 4. As seen, the amount of this element has increased after passing through the mineral area (after Sample W4).

Vanadium is the next element of heavy metals surveyed in this study. The average level of this element in potable water is 0.43μg/l (G.H. Illing, 1995). The water samples of mineral area contain values higher than this level. To examine the effect of mine on the river water, vanadium changes diagram is drawn in Figure 4. As seen, the amount of this element has increased after passing through the mineral area.

Regarding the replacement of radioactive substances in phosphates, uranium content of water resources was also examined.

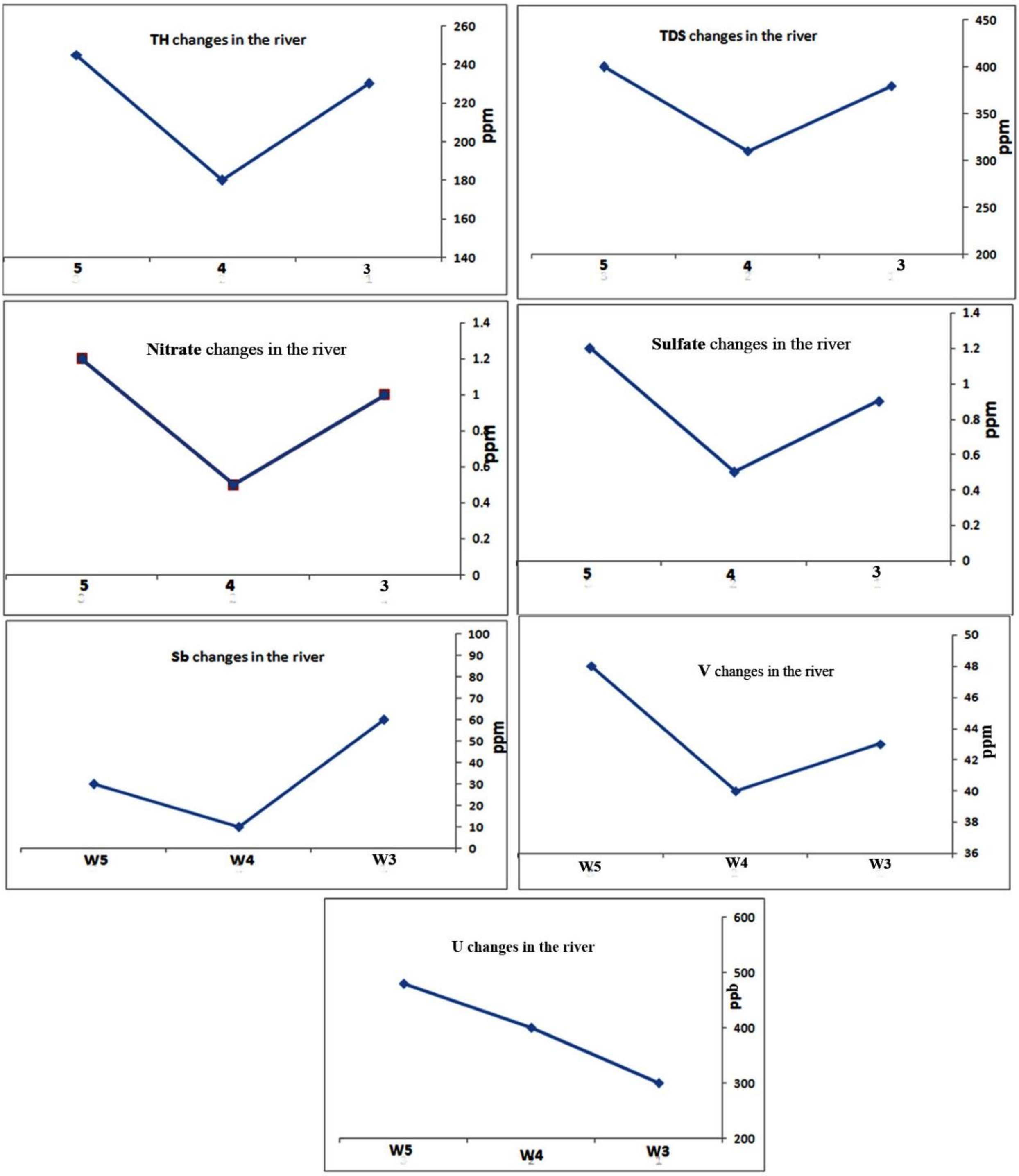

Figure 4 Various parameters changes related to river when passing through mineral area (the river enters into mineral area after sample 4)

Table 1 Water samples cations and anions analysis results

P	**NO_3^-**	TH	**TDS**	**SO_4^{2-}**	**CO_3^{2-}**	**pH**	**EC**	
ppm	Mg/l	ppm	ppm	Mg/l	Mg/l	Mg/l	ms	**Sample**
-	5.04	850	1288.4	13.7	**-**	7.16	1.12	1
0.15	3.64	425	1.67	6.94	**-**	7.12	0.99	2
0.08	2.24	2.25	389.2	0.96	0.8	8.05	0.37	3
0.11	2.8	175	317.8	0.65	0.8	8.05	0.38	4
0.15	3.39	235	391.1	1.17	1	7.95	0.42	5

Table 2 BOD5-value of the samples and permissible level

Sample No.	W1	W2	W3	W4	W5
BOD5 mg/l	1	2	3	3	2
permissible level for being released into ground waters	30	30	30	30	30

Table 3 COD-value of samples and permissible level

Sample No.	W1	W2	W3	W4	W5
COD mg/l	13	43.8	49	49	6
permissible level for being released into ground waters	60	60	60	60	60

All samples contain amounts higher than the permissible level. According to EPA, its recommended amount in potable water is 30ppb. Hence, waters of the area are contaminated by uranium. This must be considered in applications. To examine the effect of mine on the river water, uranium changes diagram is drawn in Figure 4. As seen, the amount of this parameter has increased after passing through the mineral area.

Results

The examination of dissolved anions and cations show that the type of mineral area waters is Ca-So4 and the river water type is Ca-HCO3. Hence, waters in the mine area can be corrosive, and the river water can have temporary hardness and sedimentation. Parameters such as temporary hardness and total dissolved solids in the river have increased in the proximity of the mine. These factors can affect quality of waters in terms of various usages. Based on the examination of BOD5 and COD, the river water shows higher amounts of them after passing through the mineral area. On the other hand, the water is more polluted.

Uranium, antimony, and vanadium have higher concentration in the waters of the area. The effect of mineral area on the river also shows that the amounts of these elements have increased after the river passed through mineral area. Since most trees in the mineral area are not fruit trees and only flower is cultivated near the area, these elements cannot be transferred by nutrients. Regarding the fact that Jeiroud Village residents seasonally live in the area, it seems that it does not considerably affect their health. Yet, it is probably dangerous for miners.

Since all parameters and elements examined in river waters have increased after the passage of the river through mineral area, it is suggested that the accumulation of mineral substances and wastes in the area is prevented. It is also proposed that the contact between these materials and the river is avoided by operations like building separation wall and vegetation.

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