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Assessment of Contaminations Caused by Mining Activities Using Stream Sediment Geochemical Studies

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Abstract: Exploration and exploitation of mineral deposits could increase heavy metal contents in the environment around the deposits. In mining areas, water flow facilitates dispersion of the metal contamination. Thus, due to the toxic effect of heavy metals on environment and human, it is important to recognize sources of the contamination for the possible fixing of such problems. In this study to investigate the contaminations caused by heavy metals, element contents of Cr, Co, Ni, Cu, Zn, Cd, Pb, and As in 911 stream sediment samples, which were taken from Baft area, Kerman province, were used. Pollution load index, Ecological risk index, Geo-accumulation index, Contamination Factor, and Modify Contamination Degree were applied to delineate contaminated areas. Outcome demonstrated that there are moderate to intense contamination of Zn, Cd, Pb, Cr, Ni, and As in some parts of the area. Inspection of upstream of the contaminated samples illustrated that sources of the contamination are mainly mining and anthropogenic activities. Due to the proximity of the pollution sources to residential areas and its negative effect on the catchment watershed and basins, continuous monitoring of the pollution, caused by mineral activity, is recommended to modulate the negative influence of the contamination.

Keywords: Mining environment, Heavy metals, Stream sediments, Mineral activities, Baft area.

INTRODUCTION

Neglecting the destructive effects of mining activities on the environment results in the exhumation of heavy metals in the environment cycle in such areas [1].The pollutants in addition to environmental degradation is a threat to the health of animals and humans [2]. In this regard, mining of minerals in rock formations that are rich in trace elements exposes them to the outer environment, where they get into contact with oxygen and water, accelerating their movement into rivers and streams. In areas where streams are available, these pollutants may appear several kilometers downstream [3]. Therefore, in assessing the contamination of the area and determining the extent of its pollution holes, the geochemical studies of the stream sediments play a key role.

In this study, in order to assess the quality of sediments caused by mining activities in Baft area, Kerman province, and to evaluate the pollution of Cr, Co, Ni, Cu, Zn, Cd, Pb, and As metals, single and integrated sediment quality indices such as pollution load index, ecological risk index, geo-accumulation index, contamination factor, and modify contamination degree as well as Pearson correlation matrix were used. Finally, the contaminated areas were identified and the relationship between pollution and geological factors and anthropogenic activities was investigated.

METHODS

Study area

The study area, 1:100,000 scale Baft quadrangle map, is situated in the southern part of the Urumieh-Dokhtar Volcanic Belt of ran, which is a magmatic arc. In this paper a dataset of 911 stream sediment samples was applied.

Pollution indices

Pollution load index (PLI) was calculated for all analyzed elements using the following equation:

$$PLI = \sqrt[n]{CF_1 CF_2 CF_3 \cdots CF_n} \quad (1)$$

where, n is the number of elements and CF=$C_{element}/C_{background}$. Contaminant factor (CF) is used for monitoring and evaluating pollution for a single element .Contamination assessment is made as follows: if PLI > 1 = polluted and PLI value < 1 = unpolluted [4].

The geo-accumulation index (Igeo) was calculated using the formula:

$$I_{geo} = Log_2\left(\frac{C_x}{1.5\,B_x}\right) \quad (2)$$

where C_x is the concentration of the element in sediment, B_x is the geochemical background value, and 1.5 is a correction factor due to changes that may occur in lithology [3].

Ecological risk index (RI) was calculated using the formula:

$$RI = \sum_{m=1}^{n} T_m \frac{C_m}{C_b} \quad (3)$$

where, n is the number of element contents (in this situation have been taken into account 7 elements: Cr, Ni, Cu, Pb, Zn, Cd and As) and T_m is the response coefficient for the toxicity of each element (Cd=30, As=10, Cr = 2, Zn = 1, and 5 for Pb, Cu and Ni) [4].The results are interpreted as follows: RI < 300 low to moderate; between 300 and 600 high; and RI > 600 extremely high. Cm is the m minor element content in the sample and C_b represents the background value of the element m [1].

FINDINGS AND ARGUMENT

Statistical Parameters

Analysis of the statistical parameters of Cr, Co, Ni, Cu, Zn, Cd, Pb and As in the study area showed that the elements have often highly skewned and abnormal distributions. Since the elements in the sediment have different mineralogical and lithology properties, the Median Absolute Deviation (MAD) method was used to determine the background of each element [4].

Pollution assessment

The concentration of the elements are very relevant to the geological settings and characteristics of the region under study. Alteration and transportation are processes that play important role in the mobility and sedimentation of the materials along the hydrographic basin. Increasing the concentration of heavy metals in the river sediments could be due to the deposited metals of the materials being carried.

Correlation coefficients between the Contamination Factor index and Pearson correlation test were used to statistically interpret the relationship between heavy metal contamination and their origin. The results showed that the correlation between Pb – Zn, Cd – Pb, Cd-Zn, and the Ni-Cr is, respectivelly, 0.98, 0.99, 0.98, and 0.53, indicating a positive relationship between Pb-Zn-Cd and Ni-Cr elements, perhaps because of the same pollution source. In this paper, contamination level of each element was analyzed by the contribution of the determined background values for each of the elements using the sediment pollution indices. To assess the total pollution of Cr, Co, Ni, Cu, Zn, Cd, Pb and As in each sample, the environmental risk index was used. Accordingly, ten samples were recognized contaminated based on the environmental risk index. Figure 1 shows the contaminated areas and the location of contaminated specimens based on the environmental risk indicator.

Recommend to detailed reviews

The methods proposed and applied in this paper accurately determined contaminated areas. Therefore, further investigation can be focused on these identified areas in detail, including higher sampling density of the waters to measure PH and EH, as well as taking the plant samples to identify and treat the main sources of pollution.

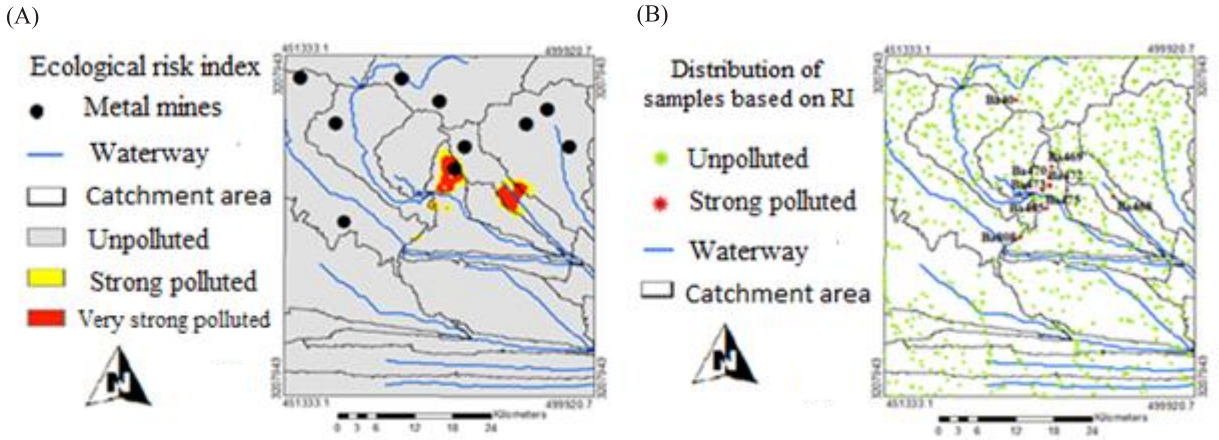

Figure 1. A: Separation of pollution holes based on Ecological risk index, B: Distribution of the sample based on the Ecological risk index

CONCLUSIONS

Entering heavy metals into soils and their ensuing stabilization in the environment result in changes in the quality of the soils during times. Although some heavy metals are nutrients for plants, their excessive content in agricultural soil may be irreversible dangers for animals and human being that is due to their adverse impact on the quality of products such as food, drinking water and subsoil waterways.

Topographical relief in and around the chromium mine in the study area of this paper provides wide spread of pollution caused by the mine activity. As a result, due to the landscape, the reason for the chromium and nickel contamination is anthropogenic factor. Due to the high contamination rate of chromium and nickel in this area and its proximity to current water and native habitats, it is necessary to control the extraction and processing processes of ore deposits in a more-safe way.

This study found that Pb-Zn-Cd elements cause very severe contamination. The contamination of these elements in several sampling sites has been proven. Concentrations of these elements are in a region known as Shahkouh, which itself is a massive Batolithic massif, including Laleh Zaar copper mine, Qanat Marwan lead mine and Talkhechaar iron mine. Due to the outcrops and face of the ore in these mines, it can be concluded that these mines play a very significant role in the spread of contamination in the region. High pollution in the Shah Kouh mining area that can affect the catchments and watersheds of Baft, Orzuiyeh and Rabor makes it necessary to continuous monitoring of the pollution to modulate the negative influence of the contamination.

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