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Assessment of Arsenic Pollution in Water from Talvar River, Kurdestan Province, Iran

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***Abstract*— Toxic elements like heavy metals are natural constituents of the earth's crust and a number of these elements are biologically essential at trace levels and play an important role in human health. Arsenic is a ubiquitous element in the environment, which is found in trace amounts in rocks, water, soils, and plants and even in air. It is concentrated in many ore deposit types, and may cause environmental hazards due to unwanted delivery of this element and other associated elements (Zn, Ni, Mn and Sb) in the environment. Talvar river basin located in NW Iran, is a significant mineralized zone and the most famous and important As-Au mine in Iran is located here. This paper attempts to document the concentration of arsenic in surface waters. Water samples collected from Talvar stream indicate high content of as which ranges from 0.001 to 0.286 mg/l^{-1} in water samples. The anomalously high background of trace metals in the area and its exposure to weathering is considered to be the main sources of heavy metal pollution in the studied area.**

Keywords*— Heavy metals, Arsenic, Talvar River, Kurdestan Province, Iran

I. Introduction

Two main sources of heavy metals in soils can be considered: (i) the natural pedo-geochemical background, which represents the heavy metal concentration inherited from the parent rock and (ii) anthropogenic contamination, which can be directed via wastes, animal manure, compost, sewage sludge, or diffuse via aerosol deposition. The exploitation of mineral deposits and mining activities are often associated with environmental impacts, including an increase in heavy metal contamination. The abandoned mines are areas where metal pollution can occur and large amounts of heavy metals are released. Once released into the environment, the heavy metals have a potentially negative impact on sediment and water for many decades after the mine closure [1-5]. Numerous studies have demonstrated elevated levels of heavy metals in and around metalliferous mines due to discharge and dispersion of mine wastes into the surrounding environment [6-11].

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Heavy metals may also pose a potential health risk to people from natural pedogenic sources. Natural processes such as rock weathering play a noticeable role in the enrichment of water/sediments with heavy metals [12-13]. However, there is no information on the impact of pedogenic as well as mining activities on the surrounding environment of the studied area, especially on water systems. Considering these facts, the present study focuses on the level of Arsenic mainly in the water samples from Talvar River. To achieve this, the geochemical data of the Talvar water basin is considered.

Arsenic is not a metal but a metalloid. High concentration of arsenic causes health problems including skin lesions, skin cancer, internal cancers (bladder, kidney, and lung), neurological effects, hypertension and cardiovascular disease, pulmonary disease, peripheral vascular disease, and diabetes mellitus [14-16]. The environmental impacts of arsenic and related elements result from the fact that they are mobilized under natural conditions. Weathering can increase the concentrations of toxic elements downstream from the pedogenic as well as anthropogenic sources and it can release elements to the environment. [17-19].

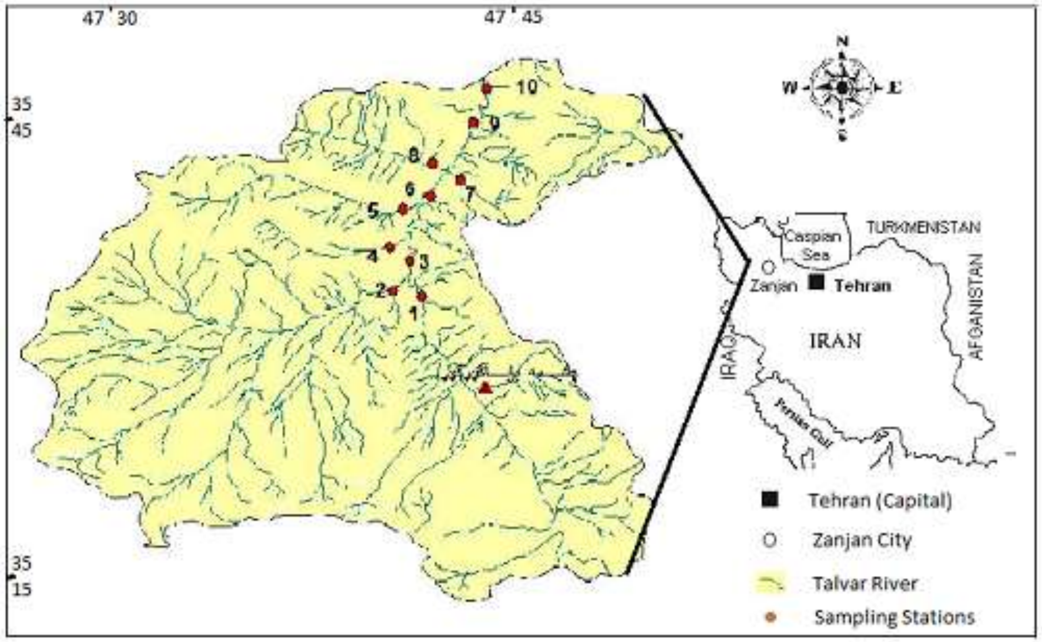
> The most important source of potentially toxic elements in the area could be related to pedo-geochemical sources, especially from black shales and other ore bearing rocks within the river basin. The signif-ycant correlation between concentrations of the studied metal in all stations further proves its relation to the chemistry of source minerals.

II. Study area

Talvar river basin (6560 km^2) is located about 400 km west of Tehran, in the northern part of the Sanandaj-Sirjan Zone, Kurdistan province, between 35º 16' E, 35º 47' E and 47º 25' N, 47º 54' N. The river originates from southern parts of the basin, flows northward while many big and small tributaries join the main stream. At the northern border of the basin Talvar dam is constructed across the river which collects its water for drinking and agricultural purposes.

The studied area has a semi-arid climate with moderate summers and very cold winters with an average annual temperature of about 9° C. Annual precipitation is about 327 mm, falling mostly as snow.

The general geology of the area has exerted an environmental influence on the water compositions of the Talvar River. Thus, a brief description of geology of the area



and the types of minerals present in the deposits is provided. The Talvar basin is a polymetallic massive sulphide ore deposit, hosted by a succession of volcano-sedimentary complexes which are a part of the Sanandaj-Sirjan volcanic belt. This major volcanic belt possesses numerous massive sulphide deposits. From the economic viewpoint, this area is very significant with respect to its mineral potential and proven reserves of copper ore. Various rock types are present and crop out in the area, ranging in age from Precambrian to Recent. Frequent faults and fractures are involved in ore mineralization. The ore mineralogy defining the type of heavy metals consists of sulfide and nonsulfide minerals. Nickel and cobalt arsenide's are also common constituents of the ore body. The mineralogy and chemical compositions of these minerals could be considered the principal sources of high concentrations of some heavy metals including As in river water/sediments, causing possible environmental pollution.

III. Sampling

Water samples were collected from 10 stations along the Talvar River and its tributaries (Fig 1). Samplings were performed during two periods (Dry/Wet seasons) in 2014, which assured stable conditions. Physical properties of water samples, notably; Temperature (T), Turbidity, pH, Dissolved Oxygen (DO) and Electrical Conductivity (EC) were immediately measured at sampling stations using a portable digital pH meter (HACH HQ 40D). The 2100 portable turbidimeter (HACH) was also used for determination of turbidity of water samples in the field. Results for both wet/dry seasons were compared with WHO guidelines and are given in brief in Table 1.

River water samples were collected in 100 ml polyethylene bottles and a few drops of concentrated ultra-pure HNO_3 were added to the samples to reach pH < 2 to prevent loss of metals and bacterial and fungal growth [20]. In laboratory Samples were filtered through 0.45 µm filters. To ensure the removal of organic impurities from the samples and thus preventing interference in analysis, the samples were preserved and digested with concentrated nitric acid.

Table 1 Physical properties of water samples collected from wet/dry seasons (Averages)

Season	T	pH	DO	EC	Turbidity
Avg. in wet season	10.50	7.7	8.7	888	4.16
Avg. in dry season	13.62	7.9	8.1	1338	3.07
WHO Guidelines	-	*6.5-8*	-	*1500*	*5.00*

IV. Preparation of Samples

The concentrations of Arsenic in the samples were determined using Atomic Absorption Spectroscopy (Varian 220Z) using hydride generation technique. Atomic absorption spectrometry with hydride generation (HG-AAS) is a commonly used method to analyze Arsenic due to the method's high sensitivity and selectivity. All the chemicals used in this research were analytical grade chemicals and were used as received. Arsenic atomic absorption calibration standards were prepared from 1000 ppm Merck titrisol solution. The positions of sampling stations were recorded using a Ground Positioning System (GPS). Table 2 demonstrates the geographic position of the sampling stations and the concentration of As in both dry/wet seasons.

V. Results and discussion

Arsenic concentration in surface water within the Talvar river basin ranges from 0.001 mg/l^{-1} (sample 8 in both dry/wet seasons), to 0.286 mg/l^{-1} (sample 6 in wet season). Ninety percent of As concentration in river bodies is above the WHO standard of 0.01 mg/l^{-1} [21]. Arsenic pollution in these areas are traced to pedogenic pollution especially hot spring waters.

In dry season correlation analysis show a close relationship between the couples As/Zn, As/Ni, As/Mn, As/Sb, As/Turbidity and in Wet season this behavior change to As/Zn, As/Mn, As/Sb and As/EC. Therefore, close correlation between As and other parameters specially turbidity and EC confirm that Arsenic source is totally of pedo-geochemical source leached from the upper soil layers with raining. Noteworthy in wet season the average amount of As is higher than dry season.

VI. Conclusion

The most important source of potentially toxic elements in the area could be related to pedo-geochemical sources, especially from black shales and other ore bearing rocks within the river basin. The significant correlation between concentrations of the studied metal in all stations further proves its relation to the chemistry of source minerals. Elements released into water systems, are transported as dissolved and particulate and bed load phase. In the natural conditions, the mineral's containing toxic elements are relatively stable but once weathering has taken place, the minerals are broken down due to exposure to oxygen and water (Ogola et al., 2002).

High concentration of As in Shaliabad (sample 1) was a stimulus to trace the sources of elements in areas not affected by mining activity, and in fact in distant areas. This resulted in the conclusion that hot spring waters are also an important source of arsenic in this area, which demands further investigation but are probably related to Tertiary and Quaternary hydrothermal activity in this region. Samples from stations 1, 3 and 6 show very high As values of 0.222, 0.242 and 0.275 mg/l^{-1} respectively. There is a general decreasing trend in element concentrations with distance from hot spring waters. Sharp decrease in some samples is related to simple dilution by cleaner tributaries (such as stations 4, 5 and 8).

In conclusion, it may be said that surface waters in the Talvar river basin area is contaminated with As and the abnormal concentration of As is mainly due to pedogenic sources. Construction of Talvar dam on the river which aims to supply drinking and agricultural water may pose a serious health hazard for hundreds of inhabitants in the area.

Table 2 Geographic position of the sampling stations and the concentration of Arsenic in samples

Station Cod	Station Name	Longitude	Latitude	Debi m^3/s	Arsenic *Dry season*	Arsenic *Wet season*	Arsenic Avg. mg/l^{-1}
1	Shaliabad	47° 46′ 38″	35° 28′ 23″	3.05	0.195	0.250	0.222
2	Abdolabad	47° 46′ 28″	35° 28′ 48″	2.43	0.132	0.162	0.147
3	Cheraghabad	47° 46′ 48″	35° 30′ 47″	5.60	0.176	0.246	0.242
4	Hosseinabad	47° 46′ 17″	35° 32′ 45″	0.98	0.011	0.015	0.013
5	Jorvandi	47° 47′ 24″	35° 35′ 52″	1.35	0.025	0.031	0.028
6	Gojekand	47° 47′ 26″	35° 35′ 29″	6.15	0.264	0.286	0.275
7	Chaman	47° 50′ 40″	35° 39′ 30″	1.00	0.055	0.110	0.082
8	Ozondarreh	47° 50′ 14″	35° 39′ 47″	1.36	0.001	0.001	0.001
9	Chehelamiran	47° 53′ 05″	35° 44′ 08″	6.75	0.099	0.160	0.129
10	Rezaabad	47° 54′ 12″	35° 44′ 54″	6.75	0.093	0.120	0.106

References

[1] D. C. Adriano, Trace Elements in Terrestrial Environments, 2nd ed., Springer-Verlag, New York, 2001.

[2] J. S. Ogola, W.V. Mitullah, M.A. Omula, "Impact of gold mining on the environment and human health: a case study in the Migori Gold Belt, Kenya," Environ. Geochem. Health, 24: 141–158, 2002.

[3] H.B. Bradl, Heavy Metals in the Environment: Origin, Interaction and Remediation, Elsevier Academic Press, London, 2005.

[4] M.C. Navarro, C. Perez-Sirvent, M.J. Martinez-Sanchez, J. Vidal, P.J. Tovar, and J. Bech, "Abandoned mine sites as a source of contamination by heavy metals: A case study in semi-arid zone" J. Geoch. Explor., 96, 183–193, 2008.

[5] F. Ghazban, A.H. Parizanganeh, A.A. Zamani, and B. Taghilou, "Assessment of Heavy Metal Pollution inWater and Sediments from the Ghalechay River, Baychebagh Copper Mine Area, Iran," Soil and Sediment Contamination, 24:1–19, 2015.

[6] B.G. Lottermoser, P.M. Ashley, D.C. Lawie, "Environmental geochemistry of the Gulf Creek copper mine area, North-Eastern New South Wales, Australia" Environ. Geol., 39:67–74, 1999.

[7] M. Astrom, and K. Nylund, "Impact of historical metal works on the concentrations of major and trace elements in sediments: A case study in Finland" Appl. Geochem,. 15, 807–817, 2000.

[8] J. Lee, H. Chon, and K. Kim, "Human risk assessment of As, Cd, Cu and Zn in the abandoned metal mine site" Environ. Geochem. Health., 27, 185–191, 2005.

[9] V. Milu, J. L. Leroy, and C. Peiffert, "Water contamination downstream from a copper mine in the Apuseni Mountains Romania" Environ. Geol., 42, 773–782, 2002.

[10] J.M. Park, J.S. Lee, J.U. Lee, H. T. Chon, and M.C. Jung, "Microbial effects on geochemical behavior of arsenic in As-contaminated sediments" J. Geochem. Explor. 88, 134–138, 2006.
[11] S, Yajam, P. Montero, J.H. Scarrow, J. Ghalamghash, S.M.H. Razavi, and F. Bea, "The spatial and compositional evolution of the Late Jurassic Ghorveh-Dehgolan plutons of the Zagros Orogen, Iran: SHRIMP zircon U-Pb and Sr and Nd isotope evidence" Geologica Acta, Vol. 13, Nº 1, 25-43, 2005.
[12] U. Forstner, and G.T.W. Wittmann, Metal Pollution in Aquatic Environment, 2nd ed., Springer-Verlag, Berlin, 1983.
[13] J. O. Nriagu, "A global assessment of natural sources of atmospheric trace metals" Nature 338, 47–49, 1989.
[14] C. Hopenhayn-Rich, M. L. Biggs, A.H. Smith, "Lung and kidney cancer mortality associated with arsenic in drinking water in Cordoba, Argentina" Int. J. Epidemiology, 27:561–569, 1998.
[15] M.D.R. Islam, R. Salminen, P.W. Lahermo, "Arsenic and other toxic elemental concentration of groundwater, surface water and soil in Bangladesh and its possible effects on human health" Environ. Geochem. Health, 22:33–53, 2000.
[16] A. H. Smith, E. O. Lingas, R. Rahman, "Contamination of drinking water by arsenic in Bangladesh: a public health emergency" Bulletin of the World Health Organization 78(9): 1093–1103, 2000.
[17] E.A. Munroe, V.T. McLemore, P. Kyle, "Waste rock pile characterization, heterogeneity, and geochemical anomalies in the Hillsboro Mining District, Sierra County, New Mexico" J. Geochem. Explor., 67:391–405, 1999.
[18] S.A. Banwart, M.E. Malmstro¨m, "Hydrochemical modelling for preliminary assessment of minewater pollution" J. Geochem. Explor., 74:73–97, 2001.
[19] S. Modabberi, F. Moore, "Environmental geochemistry of Zarshuran Au-As deposit, NW Iran" Environ. Geol., 46: 796-807, 2004.
[20] A.A. Zamani, M.R. Yaftian, and A.H. Parizanganeh, "Multivariate statistical assessment of heavy metal sources of ground water around a lead zinc plant in Iran" Iranian J. Environ. Health Sci. Eng., 9, 1–10, 2012.
[21] WHO, Guidelines for Drinking Water Quality: Vol. 2. World Health Organization, Geneva, 1993.

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