Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 19, No. 4, p. 47-52, 2021
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Heavy metal contamination of soil and water due to chromite mining in Tehsil Khanozai, District Pishin, Balochistan, Pakistan

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Article published on October 26, 2021

Key words: Soil, Water, Mining, pH, Electrical conductivity, Salinity, Heavy metals

Abstract

Heavy metals are not a biodegradable element, so they are on the rise due to widespread anthropogenic effects. The depletion of heavy metals and unsustainable assets increase the natural cost of mining. The current research was conducted in Khanozai District during the 2018 and 2019. The environmental and communal effects of both surface and underground mining were studied to determine heavy metals in water and soil samples. The heavy metal such as iron, copper, manganese, chromium and lead were examined through using Atomic Absorption Spectrophotometer. The results show that the lead, manganese, chromium and iron content in the water has been found to exceed the WHO recommended limit while the copper values have been recorded below. Normal salinity and pH were recorded for all water samples, while electrical conductivity was reported for all water samples within WHO limits. For all soil samples pH and salinity were recorded lower while the values of electricity conductivity were fluctuated. The results demonstrate that Khanozai is highly contaminated by heavy metal due to extensive activities of mining.

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Introduction

Metals and metalloids include cadmium, lead, copper, chromium, manganese, mercury, arsenic, zincs and iron are important metals. Most of them are function as micronutrition and are required by cattle, plants and humans. However excess intake of these metal is lethal (Simeonov, 2010; Alloway, 2013; Silva *et al.*, 2014). The pollution of soil, air and water can increase the concentration of heavy metals on terrestrial and in marine ecosystem (Gianguido *et al.*, 2015). Hence, heavy metal pollution has become a common issue in the developing world due to illegal mining (Kaushik *et al.*, 2009; Zhang *et al.*, 2015).

The use of pesticides in agriculture, manufacturing industry and mining, as well as natural or anthropogenic activities is a major contributor to heavy metal emissions. Anthropogenic activities have increased heavy metal pollution to the environment, a situation that has been exacerbated in recent decades, especially as a result of the Industrial Revolution (Hui *et al.*, 2014; Zhang *et al.*, 2015). In most developing countries such as China, China, Pakistan, Bangladesh and India, industrial development without enforcing environmental laws has caused horrendous pollution by dumping citizens and industrial waste into rivers (Suthar *et al.*, 2010; Islam *et al.*, 2015; Waseem *et al.*, 2014; Zhang *et al.*, 2015).

Mining is not considered environmentally friendly as it is a major source of heavy metal production (Adamu *et al.*, 2014; Guan *et al.*, 2014). Miners are at higher risk of exposure to heavy metals because they either breathe directly or through indirect means. It is not difficult for miners to work without exposing heavy metal during mining (Zhuang *et al.*, 2014). Environmental and habitat challenges to metal mining, their significance cannot be ignored within society as they are the construction blocks of the society. In Khanozai the largest chromite deposits are found, the main source rock of Chromite is Dunite and is either partly or completely serpentinite in some instances (Khan *et al.*, 2007; Simeonov, 2010). Triassic to recent sedimentary rocks in the area. Calvary and limestone, sandstone and conglomerate are the sedimentary rocks (Khan *et al.*, 2010).

The main purpose of this study was to determine the concentration of heavy metals and specific physicochemical parameters. The parameters in this work include pH, electrical conductivity and water salinity in mining areas. Five heavy metals including PB, MN, Q, CR and Fe were studied during this study.

Materials and methods

Description of study area

The current study was performed at the Tehsil Karezat, the union council of Khanozai of Pishin District (Fig. 1). Study sites include Yaru, Khushab, Mughutian, Lumran and Mulazai form part of the Karezat quadrangle, as well as many residential areas such as Balozai, Dilsora, Bostan, Khanozai, Khushab, Salahabad, Kili Umerzai, Sagi, Torakhola, Pashi, China, Gural, Murgha, Mangalabad and Dilsora. Tehsil Khanozai is located 70 km east to Quetta. The Pishin District comprising of 7,874km and its population is around 80 million. Horticulture and mining are the main business sources in this region. The climate is favors for fun summer and in winter severely frozen snow. Precipitation is erratic, and hurricanes affect the local area during winter. The Northern Reach of Khanozai falls between 30°36'54.16 " and the East Longitudes of 67°20'52.47".

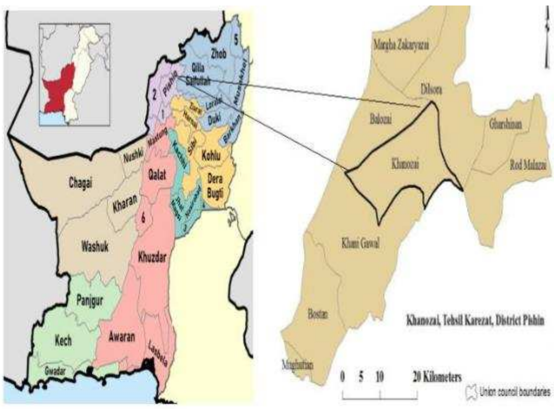

Fig. 1. Showing the study site, Khanozai, Pishin District, Balochistan province.

Sample collection

About 39 samples were collected from 12 Khanozai locations, which include Balozai, Dilsora, Gural China, khushab, Khanozai, Kili Umerzai, Mangalabad, Murgha, Pashi, Sagi, Salahabad, and

Torakhola. The following are the most widely reported samples. Samples from the dispersed areas from surrounding chromite mines were obtained. In December (2016), sampling was finished. For the analysis of water quality measurements, 100 mL polythene bottles were used. Soil samples were collected in water and air resistant plastic bags. While, collecting samples, 1% nitric acid was added for sustaining the samples quality. Each sample was packed at 4 C using polythene containers and added few ice packs to restrict the changes in the physicochemical properties of metals. The water tanks were cleaned three times with distilled water before collecting water samples.

Water samples treatment

Water samples were taken in 12 separate tubes and three samples from deep underground wells. About 12 samples from 12 separate karezes (underground channels) and one sample from local dam were collected for surface About 100 mL of water was filtered and then acidified by adding 1 mL of concentrated HNO_3.

Soil samples treatment

Soil samples were taken from a depth of 0-30 cm, collected from 13 different mining areas in the study area. The samples were processed, labeled, and properly sealed in water/air-powered plastic containers. Soil samples were then placed on glass sheets and dried in the air until the moisture was removed. The solution was heated in a hot plate at 90°C in a foaming cupboard for 45 minutes. The temperature was eventually raised to 150°C and the sample was moving to the destination of complete evaporation of the deep vapor and yellow shaded substance. Finally, concentrated 5 mL HNO_3 was used until the amount of soil sample decreased to 10 ml (Emmanuel *et al.*, 2018).

Sample analysis

Different parameters such as pH, saltiness and electrical conductivity were performed for collected samples. The soil and water samples were used to estimate the selective heavy metals including Cr, Fe, Pb, Mn and Cu using Polarized Zeeman Flame (Mass Spectrophotometer, Hitachi-Z-5000).

Result and discussion

The present studies were carried out to detect heavy metal and to assess the physical and chemical parameters of a total of 13 samples taken from Pishin District of Balochistan. To study the physical parameters, water temperature and color were manually studied while the chemical parameters include pH, dissolved oxygen content (DOC), alkalinity, salinity and electrical conductivity (EC) were tested for each sample (Table 1).

Table 1. Physio-chemical parameters of soil, surface water and ground water.

SN	Soil			Surface water			Ground water		
	pH	Salinity	EC	pH	Salinity	EC	pH	Salinity	EC
1	7.12	0.04	931	7.61	0.13	547	8.28	0.48	693
2	6.93	0.22	419	7.14	0.28	632	7.31	0.23	789
3	6.45	0.02	718	6.92	0.36	698	7.21	0.49	788
4	7.44	0.03	648	6.12	0.98	784	7.84	0.26	845
5	5.35	0.09	720	7.46	0.58	724	8.32	0.16	621
6	7.86	0.39	785	7.88	0.78	846	6.95	0.39	672
7	6.36	0.06	121	7.98	0.49	716	7.61	0.18	768
8	7.31	0.10	194	7.73	0.54	945	7.85	0.34	912
9	5.25	0.04	647	7.13	0.32	952	8.15	0.85	835
10	6.55	0.03	656	8.25	0.46	841	7.25	0.92	763
11	6.85	0.05	833	8.28	0.18	698	7.45	0.41	789
12	6.75	0.03	657	7.47	0.36	874	7.49	0.58	937
13	7.21	0.08	780	7.10	0.35	730	7.24	0.67	867
WHO	6.5-8.5	20-200	400-600	6.5-8.5	20-200	400-600	6.5-8.5	20-200	400-600

* Number of samples taken for soil, surface water and ground water.

** WHO standard values

Table 2. Heavy mental concentration estimated from the samples taken from A. soil, B. surface water and C. and ground water.

SN	Chromium			Iron			Manganese			Copper			Lead		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	2.72	0.50	0.48	1.59	1.78	0.06	3.1	0.08	0.10	0.95	0.08	0.029	0.36	0.019	0.022
2	1.29	0.23	0.29	1.28	0.84	0.14	2.6	0.09	0.22	0.63	0.09	0.039	0.29	0.009	0.015
3	1.53	0.21	0.37	1.27	0.18	0.09	2.3	0.07	0.17	0.67	0.05	0.050	0.22	0.028	0.056
4	1.94	0.14	0.29	1.17	0.40	0.03	2.2	0.12	0.21	0.58	1.02	0.019	0.27	0.009	0.029
5	1.06	0.51	0.17	1.13	0.22	0.27	2.1	0.16	0.20	0.69	0.06	0.069	0.30	0.016	0.049
6	1.38	0.49	0.50	1.19	0.25	0.13	2.5	0.15	0.19	0.74	1.01	0.048	0.21	0.039	0.046
7	0.71	0.36	0.49	9.47	0.92	0.30	1.3	0.09	0.16	0.63	0.05	0.049	0.26	0.028	0.039
8	1.05	0.29	0.38	8.72	0.57	0.14	1.5	0.14	0.20	0.44	1.09	0.037	0.24	0.050	0.047
9	1.72	0.48	0.11	1.16	0.10	0.03	1.7	0.08	0.19	0.64	0.09	0.043	0.23	0.019	0.033
10	1.24	0.43	0.29	1.28	0.21	0.50	1.7	0.17	0.26	0.57	0.08	0.046	0.19	0.027	0.050
11	0.32	0.17	0.49	6.92	0.52	0.11	1.25	0.18	0.22	0.60	1.03	0.038	0.17	0.039	0.039
12	0.49	0.25	0.50	6.75	0.44	0.12	1.64	0.19	0.19	0.72	1.04	0.027	0.18	0.028	0.040
13	0.66	0.18	0.11	2.40	0.57	0.23	1.38	0.15	0.18	1.05	0.09	0.019	0.21	0.029	0.033
WHO		Cr = 0.5			Fe = 0.5			Mn = 0.5			Cu = 1.0			Pb = 0.01	

** WHO standard values.

The pH for water samples is found to be in accordance with WHO standards, except for samples number five and six where the pH was slightly lower. The pH for the remaining samples was not found to be in line with WHO standard. Salinity for samples were found to be below the recommended level. The EC falls in the normal range (i.e., 400-600µS/cm) except for two samples taken from surface water.

Four major heavy metal were detected during the research including Chromium (Cr), Iron (Fe), Manganese (Mn), Copper (Cu) and Lead (Pb). For soil samples Cr, Fe, and Pb values were recorded higher than WHO standards while most of the Cu values found in normal range. For water sample (surface and ground) most of the values of heavy metal were found normal except for lead which were recorded higher than standard values. These findings are in consist of previously reported work (Simeonov, 2010; Alloway, 2013; Gautam *et al.*, 2014; Silva *et al.*, 2014; Zhuang *et al.*, 2014).

We collected all the data around chromium mines. Chromium is a heavy metal, which can have harmful effects on both living and non-living ingredients on exposure. The chromite mining industry is a major contributor to heavy metals such as zinc, arsenic, copper, cadmium, iron and mercury and has a significant impact on changing environmental conditions. This heavy metal is polluting the environment, soil physiology and water chemistry, and is constantly affecting the health of the residents and miners in our target areas. This heavy metal tends to be in the air for a long-time during chromite mining and polluting environments and health hazards (Dhakate *et al.*, 2008; Asrari, 2014).

Despite its industrial use, Chromite mining has many physical, chemical and environmental effects on water, air, and soil. Surface and ground water both are affected by change in pH, increase in dissolved solids, and variation in hardness, and conductivity of water. Same results are also obtained in this study which are consistent with previous reports (Gautam *et al.*, 2014).

However, heavy metals may mix with underground water and can find some space for its occupation after the isolation of minerals from water such as chromite, barite and plum from the rocks and soil. These heavy metals are then consumed by plant, animals and humans as a result it effects it affects their health (Andráš *et al.*, 2013; Zhuang *et al.*, 2014).

In developing countries where mining is done without complying with environmental legislation, this type of contamination is more rapidly occurs. Pakistan, which is a developing country, is producing many minerals such as charcoal, magnesite, iron, chromite, barite, copper, bauxite, and others (Mebrahtu & Zerabruk, 2011), however production of excessive concentration of heavy metals is neglected or not properly addressed.

Conclusion

This study provides a basis for further analysis by measuring and comparing the pollution rate and WHO standards with the impact of extensive mining of chromite on land and water in Khanozai district. It is recommended that WHO standards are important to study the water chemistry and soil physiology if contaminated by heavy metal.

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