



Enrichment, spatial distribution of potential ecological and human health risk assessment via toxic metals in soil and surface water ingestion in the vicinity of Sewakht mines, district Chitral, Northern Pakistan

Inayat ur Rehman^{a,*}, Muhammad Ishaq^a, Liaqat Ali^b, Sardar Khan^{c,*}, Imtiaz Ahmad^a,
Imran Ud Din^b, Hameed Ullah^a

^a Institute of Chemical Sciences, University of Peshawar, Khyber Pakhtunkhwa Peshawar, 25120, Pakistan

^b National Centre of Excellence in Geology, University of Peshawar, Khyber Pakhtunkhwa Peshawar, 25120, Pakistan

^c Department of Environmental Sciences, University of Peshawar, Khyber Pakhtunkhwa, Peshawar 25120, Pakistan

ARTICLE INFO

Keywords:

Heavy metals
Soil pollution
Surface water
PERI
Chronic exposure

ABSTRACT

This study focuses on enrichment, spatial distribution, potential ecological risk index (PERI) and human health risk of various toxic metals taken via soil and surface water in the vicinity of Sewakht mines, Pakistan. The samples of soils ($n = 54$) of different fields and surface water ($n = 38$) were analyzed for toxic metals including cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), lead (Pb), nickel (Ni), zinc (Zn) and molybdenum (Mo). Soil pollution level was evaluated using pollution indices including geo-accumulation index (Igeo), contamination factor (CF), degree of contamination (CD), enrichment factor (EF) and PERI. CF showed moderate contamination of soil with Cd, Co, Fe and Mo, while Igeo values indicated moderate accumulation of Cu. For Cd, EF > 1.5 was found in agricultural soils of the study area. PERI findings presented a very high ecological risk (PERI > 380) at two sites (4%), considerable ecological risk at four sites (7.4%). Non-carcinogenic risk from exposure to Fe in soil was higher than limit (HI > 1) for both children and adults. Moreover, carcinogenic risk postured by soil contaminants i.e. Cd, Cr, Co and Ni in children was higher than their limits (except Pb), while in adults only Co posed higher risk of cancer than the limit (10^{-4}) through soil exposure. Non-carcinogenic risks in children due to Cd, Co, Mo via surface water intake were higher than their safe limits (HQ > 1), while in adults the risk order was Cr > Cd > Cu > Pb > Co > Mo. Moreover, carcinogenic risk exposure due to Co > Cd > Cr > Ni from surface water (except Pb) was higher than the tolerable limit (1×10^{-4}) both for children and adults. However, Pb concentrations in both soil and surface water exposure were not likely to cause cancer risk in the local population.

1. Introduction

Environmental contamination in different media because of anthropogenic and additionally geogenic sources greatly affects all forms of our biological community (García-Carmona et al., 2017; Singh and Kumar, 2017). Mining and agricultural activities are among the primary sources of pollution leading into contamination of environment with toxic metals. The group of metals (Cr, Ni, Pb, Cd, Cu, Hg, and Zn) and metalloids (As) with atomic density greater than 6 g/cm^3 are known as heavy metals (HMs) (Alloway and Ayres, 1997). HMs can intoxicate and retard the plant growth when reach into the soil. Moreover, they adversely affect the ecological environment (Chen et al., 2018b; Saleem et al., 2018). Due to their persistence in the environment, high toxicity, greater bioaccumulation and biomagnifications via several food webs,

HMs postured a possible risk to human beings, animals and progressively depicted a wide-ranging interest (Eqani et al., 2016; Jan et al., 2010; Yu et al., 2012). Food crops grown on metal bearing agricultural soils are reported to pose human health issues in the consumers (Boim et al., 2016; Liu et al., 2017a).

Cd is the most-probable carcinogen causing lung cancer (Zukowska and Biziuk, 2008). Pb adversely affect the central nervous system (CNS) (Kaufmann et al., 2003), cause abdominal pain, restlessness, irritability, headache, and sleeplessness, while in children under age 5 years, it might cause behavioral abnormalities and learning issues. Zn may result infertility, kidney and CNS disorders. Cu induces depression and eventually lung cancer (Sani et al., 2017). Cr is known to cause cancer and tumor of respiratory organs (Langård et al., 1980). Mo causes molybdenosis in livestock (Alloway and Ayres, 1997), while kidney

* Corresponding authors.

E-mail addresses: sigmainayat2002@gmail.com (I.u. Rehman), sardar@uop.edu.pk (S. Khan).

defects and body-weight disorders in humans (USEPA, 1993, 1998). Over doses of Ni may have hazardous effects on human-health (USEPA, 2000). Therefore, assessment of HM pollution is very essential to be carried out. Continuously expanding industrialization and mining exercises have resulted in the excessive enrichment of toxic HMs in all kinds of soils, surface water and living organisms (Iqbal et al., 2016; Kang et al., 2017; Li et al., 2013a; Salem et al., 2013).

Lithogenesis, erosion, weathering and other geological phenomena are the natural sources of pollution (Stafilov et al., 2010), while traffic emissions, agricultural, mining and industrial activities are among the anthropogenic sources (Anju and Banerjee, 2012; Gu et al., 2014). Both these origins enhanced the levels of HMs in soil, water, air and plants of the surrounding localities which eventually resulted in increased potential ecological and human health risks. Furthermore, the unnecessary assimilation of HMs pose non-cancer as well as cancer threats to the individual's health (Muhammad et al., 2011). Contrary to Aelion et al. (2008) statement that city areas are excessively polluted, the rural soils might also contain greater contents of HMs of geological and human-driven origin (application of pesticides, fertilizers and insecticides) in cultivated sites (Micó et al., 2007). Although, human health risks have been studied widely (Chen et al., 2015; Liu et al., 2017b) but most of the researchers have evaluated the probable health risks only through ingestion pathway (Hu et al., 2011; Laidlaw and Filippelli, 2008).

Thus the first point of innovation is that there is no previous data available regarding potential ecological and human health risk assessment (HRA) in the selected study area. Secondly; many researchers have considered only ingestion as the main source of exposure and no attention has been given to multiple exposure pathways (inhalation, dermal absorption of HMs and other direct ingestion).

Therefore, it is mandatory to highlight the contamination sources and find out the exposure threats to humans and their relevant ecology. For evaluating the extent of pollution, pollution index analysis (PIA) and PERI (Islam et al., 2015; Wei et al., 2015; Wu et al., 2015) have been employed globally. Nevertheless, the evaluation of cultivated/agricultural soil for contamination and the expected health hazards to which the community is susceptible adversely in the vicinity of known mineral resources (Sewakht, Chitral) is still needed.

The goals of the current research were to; 1) investigate the probable sources of toxic HMs and their dispersal in agricultural soils; 2) find-out the contamination level and PERI employing geochemical approach; 3) assess the carcinogenic and non-carcinogenic perils of HMs via multiple exposure routes of soil particles and surface water and 4) contribute to the data-record hereafter for eco-friendly efforts as well as to the effective implementation of public policies for the development of ecological/environmental sustainability in the site of interest.

2. Materials and methods

2.1. Study area

The study area, Sewakht-Chitral, (71° 46' 54.840" E, 35° 50' 30.840" N) is situated in Khyber Pakhtunkhwa (KP) Province, Pakistan (Fig. S1) having more than 1 million population (Pervez, 2014). Chitral is a subsistence-based agricultural district. Rice, wheat, maize and vegetables are among the most cultivated commodities while apple, pomegranate, peaches, persimmon, loquat and apricot are among the famous fruits. Meanwhile, the district has rich mineral resources, among the top-quality minerals in the nation. (Gamerith, 1990). The current study was primarily carried out in Awireth/ Shoghor consisting of veins of different minerals (Calkins et al., 1981). The soils of the area were mainly associated with flood plains and alluvial deposits. Comprehensive strategy has been adopted to collect samples from alluvial and agricultural fields and surface water sources to make it speculate maximum possible inherent features of minerals pollution.

2.2. Sampling and pretreatment

Soil samples (at a depth of 0–20 cm) from 54 different agricultural fields and surface water samples from 38 different sites were collected. These points were about 0.5–20 km away from mineralized zones. During the sampling period, the crops grown were wheat and rice in the area. The sampling was done in October–November when season remains dry, to avoid any geo-environmental disturbances. The soil samples were collected with the help of stainless steel auger from 3 to 5 points, within about 25–50 m² (Saleem et al., 2018). Then the collected samples were carefully coalesced to create a bulk composite, stored in zip-lock polyethylene bags for subsequent analysis. Water samples from all the available sources (including drinking water taps, irrigation channels, streams and perennial springs) were collected from the catchment areas of the mineral bearing formations. Water samples have been analyzed on spot for pH and electrical conductivity (EC). For HMs analysis of water, samples were collected in (250 ml) clean high-quality plastic bottles, acidified with 1% HNO₃ and then transported to the laboratory of NCE in Geology, University of Peshawar for analyses. All the collected samples of water were kept at 4 °C until processing and analysis. For locating the sample sites, a portable global positioning system (GPS) was used. Being air-dried, the collected soil-samples were then gently disaggregated and strained through a 0.18 mm mesh size for the removal of coarse materials, to assist its complete acid dissolution. These were then placed in oven at 60 °C for 3 h, cooled and stored in a clean high-density poly-ethylene (HDPE) bottle for further analyses.

2.3. Digestion of soil and water samples

For total metal concentrations, the soil samples were weighed (0.25 g) into clean, dry, numbered and acid-washed poly tetrafluoro ethylene (PTFE) beakers. HNO₃ (3.0 ml) followed by HClO₄ (3.0 ml) and then HF (10 ml) was added to each beaker and heated on hot plate at 180 °C for about 1–1.5 h, evaporated to dryness then allowed to cool following the procedure with some modification (Cantle, 1986). HCl (10 ml) was added to each beaker and warmed gently. At last the materials were transferred to 100 ml volumetric flask and made the volume up to the mark with double de-ionized water. All samples were analyzed very carefully and reagent blanks were also included in each batch. In case of water, 100 ml from each surface water sample was taken in a beaker and 10 ml HNO₃ (65%) was added. The contents of the beakers were evaporated at 90 °C till the volume of the water to be digested remained 40 ml, filtered in 100 ml volumetric flask and volume was made upto the mark with deionized water (APHA and AWWA, 2012). In the similar manner, the procedural blanks were prepared for the corresponding soil and surface water samples except the addition of sample portions.

2.4. Analytical procedure

The specified metals of interest (Co, Cd, Cu, Cr, Ni, Pb, Fe, Zn, Mn, and Mo) in soil and water were examined using flame atomic absorption spectrophotometer (AAS-PEA-700 Perkin Elmer, USA). Soil pH was measured (soil:water in the ratio 1:2, agitated for about an hour) using a digital pH meter (Mettler Toledo S20K) (Saleem et al., 2018). The same solution was also used for the determination of electrical conductivity (EC) and total dissolved solids (TDS) using conductometer (Jenway 470 Conductivity/TDS meter UK) (Saleem et al., 2018, 2015; Sun et al., 2013a). For determining organic matter (OM) soil samples were heated at 550 °C following weight-loss procedure (Díaz-de Alba et al., 2011). To define basic soil characteristics, soil texture was determined following method of ASTM (2007) in air dried samples.

In order to ensure quality control and assurance, standard operating procedures, reagent blanks and spiked samples recovery were implemented to check the consistency of the results.

Download English Version:

<https://daneshyari.com/en/article/8854146>

Download Persian Version:

<https://daneshyari.com/article/8854146>

[Daneshyari.com](https://daneshyari.com)