Bioavailability and Concentration of Heavy Metals in Soils and Plants near Irankuh mine Tailing Dams

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Extended Abstract

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Introduction

Exploitation or processing of ores is usually associated with the production of a large amount of waste materials. These materials often have a high concentration of metals which can enter the environment through weathering or erosion. It is well-known that the measurement of the total concentration of metals cannot be an adequate for evaluating the pollution status of soil. Therefore, in most studies on soil contamination, bioavailability content of metals is determined by which can predicate the fate of the metals entering into the other parts of the environment such as plants, water or human food chain. The bioavailability of metals in the soil environment is the exchangeable and absorbable metals for plants, which depends on their exchangeability and absorption by soil organisms especially plants. This is also the function of the chemical form of each element in the soil. The main purpose of the present study was to measure the total concentrations along with the bioavailable content of metals in soils and plants around the Irankuh mine tailing dams.

Area of study

The Irankuh lead and zinc mine is located 20 kilometers southwest of Isfahan. This mine is of MVT type Pb-Zn deposit which occurred mainly in limestone and dolostone of lower cretaceous age. The Irankuh mine is an open-pit mine with annual extraction of 358 thousand of PbO and ZnO. The

exploitation of mine is also associated with the production of a large amount of waste material which is piled in open dumps around the mine. The main minerals of ores are galena, sphalerite and pyrite.

Materials and methods

31 sampling sites were selected randomly for collecting agricultural soils around the tailing dams. Each soil sample is actually composite sample of four samples which are taken from a depth of 15 to 20 cm. Seven cultivated plants (*Ocimum basilicum*) were sampled from green houses in the vicinity of tailing dams. After drying and sieving, about 50g of the soils are chemically analyzed in order to determine the total concentration of the metals by the ICP-OES method. Plant samples after drying were changed to ash in the furnace at temperature > 500 C. The concentrations of metals (Zn, Pb and Cd) were then measured by Atomic Absorption Spectrometers in their stem, roots and leaves.

pH samples of soil were also determined using the EPA 9045 method. Walkley and Black method were used to measure the amount of organic matter. The cation exchange capacity (CEC) of soil samples was also determined based on EPA 9087 method. Soil texture determined using hydrometric method and then classified according to USDA classification. Diethylene Triamine Pentaacetic Acid (DTPA) extractable metals (bioavailable content) were determined using the method by Lindsay and Norvell (1978) and their concentrations in the DTPA extracts were determined by Atomic Absorption Spectrophotometer (AAS).

The metal transfer from soil to plant was calculated using the transfer factor (TF: metal content in plant divided by metal content in soil).

Results and discussion

The soil pH of the studied samples varies from 7.36 to 8.35. Cation exchange capacity (CEC) of soil samples was estimated to be in the range of 4 to 22.2 Meq/100 g. Also, the amount of organic matter in the studied soil samples varies from 0.17 to 3.43%. The relative high levels of soil organic matter are probably due to addition of organic manure to soil through agricultural activity. The total concentration of these three matls are

significantly higher than their corresponding values in the crust implying that the mining activity and tailing dams greatly elevated the concentration of these metals in soils. Statistically, there is a significant positive correlation among Zn, Pb and Cd (at confidence level of 0.01) indicating that their potential source is the same or having similar geochemical behavior in the soil. The soil clay content showed a significant correlation at the level of 0.05 with Zn, Cd and Pb. This indicates that clay fraction plays a significant role in absorption of these metals in soil. According to the results of single extraction (DTPA method), the proportion of available content for Cd is higher than that of Zn and Pb. Cadmium is often characterized by its high mobility in soil media. Based on the correlation coefficients at the confidence level of 0.01, it is also observed that the increase in total concentration of Cd increased its bioavailability content in the soil consequently increase the availability of other elements in the soil. Therefore, it can be inferred that the availability of Cd in the soils of the study area is likely to be increased in the presence of Zn and Pb because in sites where the total concentration of Pb and Zn is high, the content of Cd availability has also elevated.

Based on the comparison of the average concentration of the metals in different parts of the plants, the concentration of metals is ordered as follows stem> leaf> root, which indicates the high root capacity for the accumulation of metals. The average transfer factor (TF) for Cd is obtained much higher than those of Zn and Pb. There is also a negative significantly correlation between the concentrations of Cd in the aerial parts of the plants and its bioavailability concentration in the soil. Also, there is positive and significant correlation between Zn and Cd for all three different parts and its bioavailability concentration in the soil. In the case of Pb, a significant correlation is observed between stem and root parts. This means that Cd and Zn after being absorbed by the root, are more likely being uptake by the plants due to high mobility of zinc. However due to less mobility of Pb, it is seemingly entered into the plant aerial parts after absorption by the root.

Conclusion

The concentration and degree of contamination of the studied soils is very high in terms of total Pb, Zn and Cd concentrations in agricultural soils around the Irankuh mine. The increased heavy metal contents in soils can be attributed to mining activity and tailing dams near cultivated lands. The measurement of the bioavailable content of these metals indicates that the Cd has the highest availability as compared to Zn and Pb. The average concentration of Pb and Cd in different parts of plant which is higher than the permissible limits, implying that the transfer of the available metal part (especially Cd) from the contaminated soil into the plant. Based on the calculated health risk assessment index in this study, it can generally be concluded that the gradual accumulation of these metals, especially in aerial parts of basil might have health hazards for local consumers.

Keywords: Soil, Heavy metals, Bioavailability, Vegetables, Irankuh mine.

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