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Trace element concentration in soils and plants in the vicinity of Miduk copper mine

Farid Moore, Sharareh Dehghani* and Behnam Keshavarzi

Department of Earth Sciences, College of Sciences, Shiraz University, Shiraz, Iran

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Introduction

High concentrations of metals are usually encountered in surface soil and vegetation in areas affected by mining activity (Liu et al., 2006). Different distribution of elements in chemical fractions result in different bioavailability; therefore knowledge of the total content of an element in soil is not a sufficient criterion to estimate the environmental implications of trace metal presence (Maiz et al., 2000).

Sequential extraction analysis gives information on the element distribution among different phases of soil. Several schemes of sequential extraction are used for the determination of commonly distinguished metal species, which are in general: (1) easily exchangeable or water soluble; (2) specifically sorbed; e.g., by carbonates or phosphates; (3) organically bound; (4) occluded by Fe-Mn oxides and hydroxides; and (5) structurally bound in minerals or residual (Kabata-Pendias and Mukherjee, 2007). The main objectives of this study are: (1) to describe the distribution pattern of elements in rocks and soils of the Miduk area; (2) to assess the fractionation of elements in soil and the mining impact on the mobility of trace elements; (3) to investigate the uptake of analyzed elements by selected indigenous plant species.

Materials and Methods

In this study, 32 soil samples at two depths (0-5 cm and 15-20 cm), were analyzed for total concentration of 45 elements. In order to assess the possible bioaccumulation of the elements, the roots and the overground parts of 3 plant species (*Astragalus-Fabaceae, Acanthophyllum -Caryophyllaceae, Artemisia -Asteraceae*) were also collected and analyzed.

Enrichment factors (EFs) were calculated to assess whether the concentrations observed represent background or contaminated levels. The Tessier *et al*. method (Tessier et al., 1979) was chosen for sequential extraction of 6 subsoil samples. Correlation analysis was used to examine the relationship between the analyzed elements in soil. The plant's ability to take up chemical elements from growth media was evaluated by calculating transfer factor (TF) (Kabata-Pendias and Pendias, 2001).

Results

Topsoil samples displayed higher mean levels of Mo, Cd, Se, Fe, As, Pb, Cu and Zn compared to subsoil samples. Generally, Cu is accumulated in the upper few centimeters of the soil, but in deeper soil layers it has a tendency to be absorbed by organic compounds and oxy-hydroxides of Mn and Fe (Kabata-Pendias and Mukherjee, 2007). The total mean concentrations of Cu (201.19 mg kg^{-1}), As (26.90 mg kg^{-1}) and Pb (83.87 mg kg^{-1}) are higher than those recorded for natural uncontaminated soils worldwide (Kabata-Pendias and Pendias, 2001).

The strongest correlation (higher than 0.80) is observed in samples taken from two depths for Zn and Pb, Zn and Cd, Cr and Ni, and Ni and Mg. The geochemical behavior of Pb and Zn is known to be similar in most natural processes (Reinmann and Caritat, 1998).

Element concentrations in the roots and leaves of plants differ considerably between the three analyzed plant genuses. Element concentrations in *Astragalus* genus are higher than *Artemisia* and *Acanthophyllum*, expect for Pb and Cd, which displayed the highest concentration in *Artemisia*. *Astragalus* is the most contaminated species

*Corresponding author's email: Sh.Dehghani@Shirazu.ac.ir

among the collected plants. The lowest concentration for all elements is found in the leaves of Acanthophyllum species. The results probably demonstrate the influence of the plant's genetics on element uptake.

The following decreasing order shows median transfer factor in plants with little differences between the three plant species: Cd>Mo>Cu>As>Mg>Mn>Pb>Fe>Ni>Ag>Co> Cr.

The results of sequential extraction analysis showed that more than 54.01% of extracted Cu is bound to Fe-Mn oxides fraction, followed by the organic matter and residual fractions. The hydrous oxides of Fe and Mn control Cu fixation in soil (Davies, 1997).

Arsenic and chromium mostly remained in the residue of the sequential extraction process. The high Pb concentration in the residual and Fe-Mn oxides fractions indicated that the soil may be considered unpolluted by lead.

Discussion

Among the measured elements, soil contamination is mostly observed for Cu, Pb, and As. The soil of the study area is also significantly polluted by lead, especially in the old mining areas. The high concentrations of Mg, Se, and Cd extracted into the first three fractions of sequential extraction showed that the metals could be easily mobilized upon changes in ionic strength or decrease in pH and redox potential.

Artemisia leaves are significantly contaminated by Cu. Arsenic and copper also accumulate in *Astragalus* leaves. The consumption of *Artemisia* and *Astragalus* leaves can constitute an exposure risk, especially for small domestic animals. Miduk inhabitants consume *Artemisia* leaves for treatment of digestive upsets. It is suggested to keep this area inaccessible to domestic animals and preferably to collect plants from distant areas.

Obviously, systematic monitoring during mining should be instituted, and continuous environmental surveys should be performed to prevent future pollution problems.

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