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RESEARCH PAPER

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Evaluation of Cu in soil and number of plant species around a Sarcheshmeh copper deposit in Kerman province

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Abstract

Evaluate the accumulation of toxic elements in soils and plants are very important and necessary for the health and life of humans and other animals in the environment. However, when present in excess quantities, Cu is also highly toxic to plant growth potentially causing damage resulting in complete inhibition of growth. The aim of this study is evaluation of Cu in soil and number of plant species around a Sarcheshmeh copper deposit and identifying the copper accumulator plants. 4 locations (at a distance of 200-800m from the mine) were selected for sampling Soil physical and chemical characteristics of different locations were determined. Plant samples were collected from each location. Copper concentrations were determined by atomic absorption. Plant species were identified using the Flora Iranica. The results indicate soil of study area contaminated with copper. There was significant difference between total Cu concentration and soluble concentration in four stations. The highest and lowest amount of copper absorption has been found in *Epilobium Hirsutum* and *Salsola kali* respectively.

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Introduction

Major component of inorganic contaminates are heavy metals. They present a different problem than organic contaminants. Soil microorganisms can degrade organic contaminants, while metals need immobilization or physical removal. Although many metals are essential, all metals are toxic at higher concentrations, because they cause oxidative stress by formation of free radicals. Another reason why metals may be toxic is that they can replace essential metals in pigments or enzymes disrupting their function (Alloway, 1990). Heavy metal contamination is caused by various sources, such as industrial processes, manufacturing, disposal of industrial and domestic refuse, and agricultural practices. Mining and mineral processing, particularly metal mines have an important role in the destruction and environmental pollution. Some heavy metals, such as copper, zinc and nickel are necessary as micronutrients for plant growth and absorbed by the roots from the soil (Berrow, 1991). Phytoremediation is one of the promising methods for reclamation of soils contaminated with toxic metals by using hyperaccumulator plants (Ghosh & Singh, 2005). Baker and Brooks (1989) have defined metal hyperaccumulator as plants that contain more than or up to 0.1% i.e. more than (1000 mg/g) of copper, cadmium, chromium, lead, nickel cobalt or 1% (>10,000 mg/g) of zinc or manganese in the dry matter.

Copper is an essential plant micronutrient, required for the protein components of several enzymes (Marschner 1995). However, when present in excess quantities, Cu is also highly toxic to plant growth potentially causing damage resulting in complete inhibition of growth. This accumulation of toxic Cu concentrations has been observed on both naturally 'polluted' soils and on anthropogenically polluted soils. Sarcheshmeh Copper deposit is located 65 km southwest of Kerman City, southeastern Iran. It has been causing heavy metal contamination in surface soils during the years of its activity. Due to unsuitable soil conditions in the contaminated areas, establishment and plant growth is a problem. Therefore, the identification of plant species to tolerate extreme environmental conditions and have the ability to accumulate heavy metals, increase the efficiency of phytoremediation methods. Study of vegetation cover around the copper deposit and determination of copper concentration in them can be useful in identifying the copper accumulator plants. There is little information about trace elements in the soil of Iran. For example the study of Ghaderian and ghotbi on the concentrations of Cu, Zn, Pb and Ni in the soils and plants in Sarcheshmeh (2005), Chehregani *et al.*, 2009 in Angouran mine. The presence of high levels of metals in soils exerts a selection pressure on plant populations leading to the evolution of a specific local flora of metal-tolerant species.

The aim of this study is evaluation of Cu in soil and number of plant species around a Sarcheshmeh copper deposit and identifying the copper accumulator plants.

Materials and methods

Study Area

Sarcheshmeh copper deposit is located in the 65 km southwest of Kerman, Iran. This area is situated at "20 '52 ° 55 E longitude and" 40 '56 ° 29 N latitude at altitude of 2620 m above sea level. The climatic information was obtained from the nearest meteorological station. Climate of this area is arid and cold. The lowest and highest extreme temperatures are –15° C and 32° C. Annual precipitation is 550mm. The average relative humidity is 38%.

Plant sampling

In this area, 4 locations (at a distance of 200-800m from the mine) were selected for sampling. Soil samples were collected from depth of 0-20 cm around the mine. Soil physical and chemical characteristics of different locations, including pH, electrical conductivity (EC), some elements were determined and presented in Table 1. Plant samples (roots and shoots) were collected from each location. Plant species were identified using the Flora Iranica (Rechinger, 1963).

Analysis and Evaluation of copper in plant samples

After separating the roots and shoots, plants were washed with distilled water and were placed in the oven at 80°C for 48 hours. Plant samples were ground and extracted with nitric acid and H_2O_2. Copper concentrations were determined by atomic absorption.

One-way ANOVA method was conducted to analyze the obtained data using SPSS, and a Duncan test was administered to compare the means.

Results and discussion

Soil characteristics

Some characteristics of soil sample at the sampling locations are presented in Table 1. Due to the presence of pyrite, the soil of the region is in form of mildly acidic to neutral. In table 2 total and soluble copper concentrations in soil is shown. Minimum and maximum total concentration of Cu was 850 and 600 (μg/ g) belong to the third and forth station.

Cu concentrations in plant species

The concept of using plants to clean up contaminated environments is not new. About 300 years ago, plants were proposed for use in the treatment of wastewater (Hartman, 1975). Byers reported that plants of the genus *Astragalus* were capable of accumulating up to 0.6 % selenium in dry shoot biomass. One decade later, Minguzzi and Vergnano (1948) identified plants able to accumulate up to 1% Ni in shoots. More recently, Rascio (1977) reported tolerance and high Zn accumulation in shoots of *Thlaspi caerulescens*. Despite subsequent reports claiming identification of Co, Cu, and Mn hyperaccumulators, the existence of plants hyperaccumulating metals other than Cd, Ni, Se, and Zn has been questioned and requires additional confirmation (Salt *et al.*, 1995).

Many metals such as Zn, Mn, Ni, and Cu are essential micronutrients. In common nonaccumulator plants, accumulation of these micronutrients does not exceed their metabolic needs (<10ppm). In contrast, metal hyperaccumulator plants can accumulate exceptionally high amounts of metals (in the thousands of ppm) (Boyd and Martens, 1994; Pollard and Baker, 1997).Copper is a trace element essential to life, yet, at high doses it can be toxic to humans. At very low concentrations it is biocidal on algae, mosses and other microorganisms. Copper is not biodegradable, It accumulates in the environment and eventually reaches hazardous concentrations levels (Robert-Sainte, 2009). Over-accumulation theory of using plants to remove metals from contaminated soils was represented Utsunamyia (1980) and Chaney (1983).

Plants in this area are as metallophytes plants (ie plants that grow on metalliferous soils), but none as pure (true) metallophytes. Plants in this area are considered psudometalophytes (ie plants that grow on metalliferous soils and natural soils). These plants are grown in natural soils but have a few genes for resistance to heavy metals (Ryser, 2006).

The results indicate soil of study area contaminated with copper. There was significant difference between total Cu concentration and soluble concentration in four stations. According to this study, the number of resistant plants to some metals was recognized. *Epilobium Hirsutum, Polypogan fugax* and *Chenopodium album* were found to accumulate copper. They can be used in the refinement of copper from the soil or water. Also, the water plants like *Urtica urens* and *Mentha longifolia* with the relatively high concentration of copper in their leaves can be used to eliminate water pollution (Table 3).

Table 1. The general characteristics of soil.

Stations	Depth (Cm)	pH	CEC (meq/100g)	Clay (%)	Silt (%)	Sand (%)	Organic matter
1	0-20	7.7	19/7☐	6	30	64	0/14
2	0-20	7/94☐	22/9	23	35	42	0/23
3	0-20	6/32☐	20	18	33	49	0/21
4	0-20	6/56	20/5	19	35	46	0/25

Table 2. Total and soluble copper concentrations in soil.

Stations	1(800m)	2 (600m)	3(400m)	4 (200m)
Total concentration (μg / g)	90± 1.7[d]	150±2.8[c]	600±12[b]	850±5.6[a]
soluble concentration (μg / g)	0.28±0.01[c]	0.31±0.007[b]	1.9±0.05[a]	2.1±0.03[a]

Table 3. List of studied species and Cu concentration.

No.	species	Family	Cu concentration in plant (μg/g)
1	*Artemisia aucheri*	Asteraceae	950
2	*Astragalus myriacanthus*	Fabaceae	1200
3	*Cardaria draba*	Brassicaseae	82
4	*Chenopodium album*	Chenopodiaceae	1040
5	*Cynedon ductylon*	Poaceae	1000
6	*Epilobium Hirsutum*	Onagraceae	4012
7	*Glycyrrhizia glabra*	Fabaceae	635
8	*Juncus effuses*	Juncaceae	985
9	*Marrubium crassidens*	Lamiaceae	924
10	*Mentha longifolia*	Lamiaceae	650
11	*Phragmites australis*	Poaceae	825
12	*Polypogan fugax*	Poaceae	1580
13	*Rheum ribes*	Polygonaceae	685
14	*Salsola kali*	Amaranthaceae	28
15	*Solanum nigrum*	Solanaceae	30
16	*Urtica urens*	Urticaceae	952
17	*Verbascum songaricum*	Scrophulariaceae	1130

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