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Investigating the Absorption Behavior of Plants Selected from Darreh-Zereshk Copper Mine for Phytoremediation purposes

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Abstract: The purpose of this research was to study various plant species and to model the absorption behavior thereof in relation to the various elements in and around of Darreh Zereshk Copper Mine to find the most suitable indigenous species for phytoremediation study. The goal is reducing the impacts and environmental pollution of the pollutant elements. For this purpose, 36 plant samples (including 17 different species) and 32 soil samples (in two different size fractions) were taken. After preparation and application of different digestion methods, the samples were analyzed by atomic absorption method for copper, iron and lead elements. By using four different solvent extraction methods, the absorption behavior of the plants was modeled and the best method was identified as extracted by organic solvent EDTA. This solvent could better detect the absorption behavior of the plants and distinguish contaminated areas from virgin and non-contaminated areas. The soil with smaller size fraction is more enriched of the metals and the copper presented in this fraction is absorbed by the solvent at higher concentrations. This suggests that the fine particles of the soil scavenged a higher content of metal by absorption property. By calculating the bioconcentration factor, the absorption behavior of different plant species was compared in contaminated and non-contaminated areas, and accordingly, the species of “Hertia Angustifolia” , “Glycyrrhiza Globra” and “Euphorbia” were identified as accumulator species and “Tamarix”, “Alhagi”, “Astragalus” and”Artemisia Sieberi Besser” determined as hyper-excluder species. “Hertia Angustifolia” species has a fairly good abundance in the region, therefore it can be introduced and used as an indigenous indicator species for the purpose of phytoremediation.

Keywords: Solvent extraction, Biological absorption, Phytoremediation, Hertia angustifolia plant, Darreh–Zereshk copper mine.

INTRODUCTION

In the past few decades, soil contamination caused by mining activity has increased. Heavy metals such as Pb, Hg, Cd and As are the main causes of the contamination. In parallel, high concentrations of Zn, Cu, Ni and Cr in soil, can cause toxication in plants (as the main part of the ecosystem) and consequently in animals and human being.

Phytoremediation is one of the bioremediation techniques which is more stable and easier to perform rather than the other remediation techniques [1,2]. Phytoremediation has some other advantages: – soil structure will not be destroyed; – contaminant element(s) will maintain in the soil (contaminant propagation will be limited); – contaminating element(s) will be extracted from the soil and – phytoremediation is 10 times cheaper than the other remediation techniques [3-6].

Although phytoremediation has introduced in 1983, it was discussed from 300 years ago [7]. Previous studies revealed that spinach, garden cress and carrot can respectively extract and collect Cd, Cr and Pb from contaminated soils [8-10]. Iranian researchers have worked on phytoremediation of contaminated soils by heavy metals and have noticed that sun flower can extract Pb and Cd [11,12]. Moreover, E. prostrate species was introduced as a hyperaccumulator species for Pb [13]. Another study has concentrated on an iron ore mine waste stockpile and L. Chyrsopogon zizanioides species was introduced as a good accumulator for Fe, Mn, Zn, Cu, Al, Cr, Ni and Pb [14].

The present study is focused on absorption behaviour of different domestic plants of Darreh-Zereshk copper mine area. The goal is to identify indicator and accumulator species for possible future phytoremediation plans.

METHODS

In order to investigate absorption behavior of plants, it is necessary to take plant and related soil samples [15]. The best times for plants sampling are those that plant metabolism is stable; e.g. end of Spring and Autumn [16]. Sampling at the Darreh-Zereshk area was carried out at 19 stations (32 samples in two different size fractions from B-horizon of the soils and 36 plant samples from 17 different species) at June 2016. The location of the samples was designed in the way that covers both contaminated and intact areas. Prepared plant samples were analyzed for Cu, Fe and Pb using Atomic Absorption Spectrometry (AAS) with a detection limit of 0.05 ppm. Soil samples were prepared using DTPA, EDTA, Ammonium Citrate and Sodium Nitrate metal extraction methods, and analyzed with the same device as plant samples.

FINDINGS AND ARGUMENT

Statistical distribution of copper concentrations in plants shows a bimodal behavior which can be interpreted as two types of plants behavior for copper accumulation. It is found that EDTA extraction method is more accurate in delineating contaminated and intact areas. Also, the highest correlation coefficient between copper at soil and plant is obtained by EDTA method. Therefore, this method is more relevant to be used when we need to model the biological absorption behavior of copper in plants. These results are also the same for Fe in the soils and plants.

Using spider diagrams of Cu contents in the soil and plants, it is found that EDTA and DTPA methods are useful to extract Cu in both soil and plants but Ammonium Citrate and Sodium Nitrate could not be able to extract copper from plant samples.

Studying Bioconcentration Factors (BCFs) is also revealed that EDTA method is the best choice to model the accumulation behavior of plants. Moreover, because of high values of BCFs for Hertia angustifolia DC., Euphorbia L. and Glycyrrhiza globra, it is found that these species are acting as accumulator of copper at the study area. Because of deeper roots of Glycyrrhiza globra and abundance of Hertia angustifolia DC. in the area, these two species are introduced as good choices for practical phytoremediation. It is notable that Juncos acutus also showed high accumulation values but it is not common in the area and consequently, can not be considered as a good choice for phytoremediation.

CONCLUSIONS

Although at the Darreh-Zereshk area the vegetation density is low [17], there are 17 different plant species. Biological absorption behaviour of these species were investigated by comparing metal contents at the plant and the regarding soil, both for contaminated and intact areas. It is found that EDTA metal extraction method is the most accurate method to model the accumulation behaviour of plants of the Darreh-Zereshk area.

A positive relationship between Fe and Cu, both for contaminated and intact areas and also for plants and soil samples is discovered. It could happen due to concentration of Fe by copper mineralization processes (e.g. oxidation of pyrite). This relationship is not observed for Pb. Therefore, studying Fe contents can lead to delineate contaminated and intact zones in a similar but unknown area.

In the other hand, studying Bioconcentration Factors (BCFs) revealed that Hertia angustifolia DC., as a domestic accumulator species with deep root, is the best nominee for phytoremediation at the Darreh-Zereshk area.

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