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Comparing heavy metal accumulation abilities in *Artemisia aucheri* and *Astragalus gummifer* in Darreh Zereshk region, Taft

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Abstract

Treatment of soils contaminated with heavy metals using plant species is a method which has been widely used in the past. This method, which is known as phytoremediation, has been applied for pollution treatment using different plant species worldwide. The method has been used for remediation of various types of pollutants in laboratory, pilot and industrial scales. The aim of this study was to compare the capability of heavy metal accumulation in *Artemisia aucheri* and *Astragalus gummifer* in the Darre Zereshk deserts located in Taft, Iran. Plant and soil samples were collected from eight stations. After acid digestion, concentration of heavy metals was measured in plant tissues and rhizosphere soil using an ICP-OES instrument. The bioconcentration factors (BCF) and translocation factors (TF) were calculated for each plant species. The BCF and TF in *A. aucheri* were higher than in *A. gummifer*. Therefore, it is suggested that *A. aucheri* has higher capabilities in removing metals from polluted soils and hence is a better option for phytoremediation purposes.

Keywords: Bioconcentration; Heavy metals; *A. aucheri*; *A. gummifer*

1. Introduction

Soil pollution by heavy metals is a serious and growing problem. Human activity and the entrance of heavy metals into the environment have resulted in soil pollution in many areas. Therefore, the intensity of pollution in the soils is or will be higher than the normal range (Nazemi and Khosravi, 2010). Heavy metals are mainly deposited in the surface layer of soil. In the long term, metal uptake by plants and accumulation in different organs occurs with increasing concentration in soil (Yargholi *et al.,* 2009). In general, heavy metal pollution is a concern because of these metals' characteristics such as non-biodegradability, bioconcentration ability and harmful effects on live organisms; they are considered very dangerous pollutants in the environment (Dayani *et al.*, 2009; Davari *et al.,* 2010).

Several studies have been conducted on the ability of plants to absorb and accumulate heavy metals. Franco-Hernandez *et al.,* (2010) studied heavy metals' concentration in plants growing on heavily contaminated tailings in central Mexico. The objective of this study was to measure metal concentrations in plant tissues, and to estimate their potential for re-vegetating metal-contaminated soils. Based on the results, the ratio between the metal concentrations in shoots versus

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those in roots was often more than 1. Nine species of the plants at the mine spoil belonged to the family Asteraceae (Compositae).

Azad Shahraki *et al.* (2007) investigated the *A. aucheri* as a heavy metal marker plant in rangelands surrounding the Sarcheshmeh copper complex. Ghotbi Ravandi *et al.*, (2008) investigated the use of native plants to remove heavy metals from Sarcheshme mineral area. Based on their findings, *Onosma stenosiphon* had the highest concentration of Pb and Cu in its tissues. In addition, the largest amount of Zn was measured in the species of the genus *Malva*. Panahi (2013) studied native plants' capabilities in phytoremediation of heavy metals from soils around a landfill in Karaj. She found that *H. pilifera* and *A. sieberi* were appropriate for refining lead from contaminated soils.

The aim of this research was to determine the concentration of the heavy metals arsenic (As), copper (Cu), lead (Pb) and zinc (Zn) in *A. aucheri* and *A. gummifer* and to compare their ability in removing metals from the surrounding rangelands of Darreh Zereshk copper mine.

2. Material and methods

The study area was located in Darreh Zereshk copper mine (53º 45' to 53º 54' East longitude and 31º 29' to 31º 36' North latitude). This region is located 45 kilometres southwest of Taft, on the road to Yazd-Shiraz, and 10 kilometres from the Ali Abad copper mine. Darreh Zereshk copper deposit is located on one of the active tectonic zones in central Iran and the western border of Shirkooh Granite (National Iranian Copper Industries Company, 2011).

The stratified random sampling method was applied to rangelands of the study area, which was divided into eight sections. Ten samples of each species were collected from each region and six soil samples were collected from each region (0-30 cm depth of soil).

The concentration of heavy metals in soil and plant samples was measured by dry acid digestion. The ash of each plant sample was digested in 10 ml aqua regia (1 HNO_3; 3 HCl) on the hot plate. All samples were made up to volume with 1% HNO_3 to 25 ml (Demirezen and Aksoy, 2004). One gram of each dry soil sample was left at room temperature in 3.5 ml of HNO_3 and 10.5 ml of HCl for 16 h. It was then heated at 130 ºC for 2 h and quickly filtered and diluted with 0.5 % HNO_3 to 50 ml (Sola *et al.*, 2004). Determination of the metals in all samples was carried out with an ICP-OES instrument.

The bioconcentration factor (BCF) and translocation factor (TF) were calculated using the following formulas (Martinez-Sanchez *et al.*, 2012):

$$BCF = C_{root}/TC_{soil} \quad (1)$$

$$TF = C_{shoot}/C_{root} \quad (2)$$

Where C is the metal concentration and TC is the total metal concentration.

3. Results

- Bioconcentration factor (BCF): for all studied metals, *A. aucheri* showed higher values compared to *A. gummifer*. In *A. aucheri*, BCF of copper was the highest and BCF of lead was the lowest. In *A. gummifer*, BCFs of copper and lead were the highest and lowest, respectively (Table 1).

Table 1. Heavy metal bioconcentration factor from soil to root of *A. aucheri* and *A. gummifer*

	Artemisia aucheri			*Astragalus gummifer*		
Heavy metal	Soil	Root	BCF	Soil	Root	BCF
Arsenic	23.62	5.42	0.23	101.18	7.60	0.08
Copper	39.24	9.87	0.25	44.04	4.10	0.09
Lead	54.18	1.95	0.04	667.54	12.82	0.02
Zinc	126.69	24.14	0.19	234.55	18.95	0.08

- Translocation factor (TF): for all the investigated metals (except copper), *A. aucheri* showed greater values compared with *A. gummifer*. In *A. aucheri*, TF of lead had the highest amount and TF of copper had the lowest. In *A. gummifer*, TFs of copper and lead had the highest and lowest amounts, respectively (Table 2).

Table 2. Heavy metal translocation factor from root to shoot of *A. aucheri* and *A. gummifer*

	Artemisia aucheri			*Astragalus gummifer*		
Heavy metal	Root	Shoot	TF	Root	Shoot	TF
Arsenic	5.42	17.84	3.29	15.29	5.94	0.39
Copper	9.41	8.55	0.91	4.31	4	0.93
Lead	1.81	7.24	4	18	3.70	0.21
Zinc	23.88	40.45	1.69	18.64	15.76	0.85

4. Discussion

Based on the results, the calculated values for both factors of most of the elements were greater in *A. aucheri* than in *A. gummifer*. The uptake and accumulation of pollutants varies from plant to plant and also from species to species within a genus (Fischerova *et al.*, 2006). The accumulation of trace elements is influenced by the life-stage of the plants. In general, adult plants have higher foliar concentration of many trace elements than young saplings (Dominguez *et al.,* 2008). Solubility of the elements and microbial activity play an important role in the accumulation process (Santos-Jallath *et al.*, 2012).

Bioconcentration factor was lower than 1, for all the metals in both species. A bioconcentration factor value higher than 1 shows that the plant could act as a hyperaccumulator of trace elements (Martinez-Sanchez *et al.*, 2012). However, the translocation factor was higher than 1 for all the metals (except copper) in *A. aucheri* and for Mn and Si in *A. gummifer*. Hyperaccumulators could be characterized by a shoot-to-root metal concentration ratio (TF) of more than 1, whereas non-hyperaccumulator plants usually have greater metal concentrations in the roots than in the shoots (Martinez-Sanchez *et al.*, 2012).

In this study, *A. aucheri* was a more appropriate option for selection as a hyperaccumulator plant compared with *A. gummifer*. This species can be used for environmental operations such as phytoremediation if the area is contaminated in the future. According to Franco-Hernandez *et al.* (2010), the ratio of metal concentrations in the shoot to metal concentrations in the root was often greater than 1. Furthermore, of the selected plants at the mine spoil, nine species belonged to the family Asteraceae. This might indicate that species of Asteraceae are more tolerant to heavy metals in soil than other families (Franco-Hernandez *et al.,* 2010). Artemisia also belongs to this family. Based on the results of Azad Shahraki *et al.,* (2007), the significant accumulation of heavy metals in *A. aucheri* was observed in rangelands surrounding the Sarcheshmeh copper complex. Indeed, according to Panahi (2012), *Artemisia sieberi* is an appropriate species for treatment of soil pollution with lead.

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