Study of the Possibility of Arsenic Phytoremediation in the Soil of Sarcheshmeh Copper Complex by Native Plants

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Abstract

Arsenic is considered as a carcinogen heavy metal among the pollutant metals. In addition, it has been added into the environment due to human activities . Sarcheshmeh copper mine is a large mine site in Iran and its soil contents many heavy metals including arsenic. Using suitable plants for remediation of the polluted soils has payed more attentions in recent years.In phytoremediation plants accumulate heavy metals in their root systems and the root can be removed subseqently . In this research, plants growing around the Sarcheshmeh copper mine were examined for their ability to accumulate arsenic. Roots and shoots and soil around the root of plants, *Artemisia aucheri, Astragalus myriacanthus, Ferula oopoda, Gundelia tournefortii, and Rumex ribes* were sampled. The amounts of arsenic of the samples were measured by using ICP in Admel laboratory in Australia. The highest amount of arsenic in soil samples was 300 ppm . In the shoot of *Astragalusg myriacanthus* was 107 ppm and in its roots was 29 ppm. According to the results it is indicated that the exmined plants have high potential for accumulating arsenic.

Key words: Arsenic, Phytoremediation, Sarcheshmeh Copper Complex, Heavy metal, *Astragalus myriacanthus*

Introduction

Heavy metals are important environmental pollutants and many of them are poisonous even at low concentrations. Environmental pollution by heavy metals has accelerated since industrial evolution and it is one of the most important issues for human being (Memon *et al.,* 2001).

In many case entering heavy metals into the wastes consumed by human being has endangered the human life.Diffrent methods are applied to reduce water and soil pollutants. Most of the methods are expensive and time consuming. The conventional methods of remediation may cost from $10 to 1000 per cubic meter. Phytoextraction costs are estimated to be as low as $ 0.05 per cubic meter Cunningham [18]. Some researchers have indicated that the cost of refining each cubic meter of soil extents up to $10-100 (Watanabe, 1997). Hence selecting proper method for cleaning the envioronment is a challenge today.

Phytoremediation is a general term which is used for eliminating and degradation of fixed pollutant in the soils by the plant. Researches have shown that plants can be very effective for cleaning the polluted soils[3]. Cleaning the pollutant area by Phytoremediation has many advantages in comparison to the other method. Lower cost is the best advantage [4, 5]. Phytoremediation is classified into different categories, that phytoextraction is one category [6]. Plants which are used in this method usually have high potential of absorbing the metal pollutants without showing any poisoning symptoms in their organs. They can absorb metals much higher than they need. Sometime they can uptake the metals which they do not need. The metals are accumulated in their tissues, especially in the aerial tissues. These types of plants are called hyperaccumulators. Plants that accumulate more than 100 ppm Cd, 1000 ppm As, Co, Cu & Pb, 10000 ppm Zn &Ni are considered as hyperaccumulators[7]. These ratios are 10-500 times higher than the amounts that ordinary plants accumulate [6]. Some researchers have indicated that other indicators such as translocation factor(TF) and concentration factor(CF) are necessary to identify a plant as hyperaccumulator [6, 14]. These factors are more than 1 for hyperaccumulators, and less than 1 for ordinary plants [13].

Using the hyperaccumulator plants extracting the metal from water and soil has advantages as follow [1]:

Low cost, producing plant residues rich of metal which is recyclable, possibility of application the plants to a wide spectrum of metals radio nucleotides, minimum environmental hazardous effects, elimination of secondary air and water pollutants and general acceptance by people. It is worth noting that the best advantage of Phytoremediation is its low cost. This method cost 1000 times cheaper than other method like removing soil etc.Using various systems enhances the effectiveness of Phytoremediation [1]:

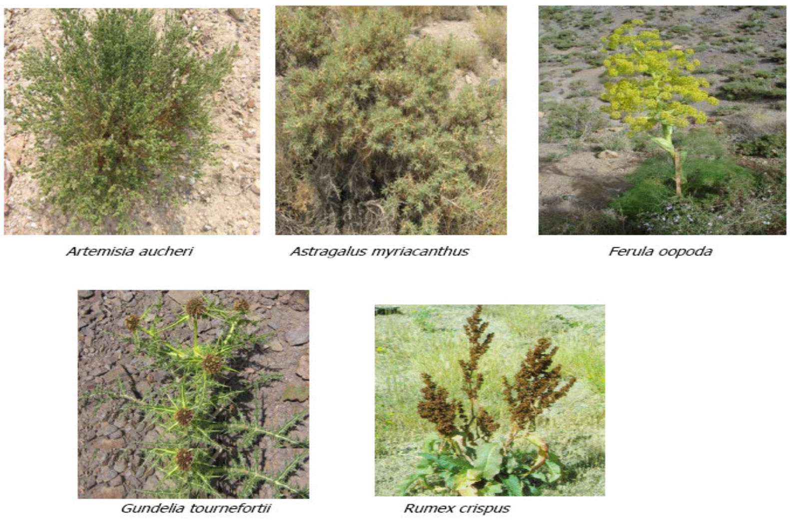
1) Selection plant species as varieties with high potential of metal accumulation.
2) Using different agricultural method such as adjusting pH and adding chelates to increase the efficiency of Phytoremediation.
3) Employing biotechnological methods to increase the ability of the plants to enhance the remediation rate of the polluted areas.

Less attention has been paid for applying Phytoremediation in Iran. Since many hyperaccumulator plants identified through the globe do not grow in the environmental condition of the pollutant areas in this country, it is necessary to identify the native accumulator plants of the polluted area in Iran.
The aim of this research was to identify the native accumulator plants among the vegetation around Sarcheshmeh Copper complex in Iran.

Methods

The study site, Sarcheshmeh copper complex, is located in south-east of Rafsanjan, Iran. The soil of the area naturally contains some heavy metals. Mining activities have also caused addition of more polluting metals into the soil surface during the last 30 years.
Plants (Figure 1) were collected from 3 sites near the furnaces of copper melting factory during the summer 2007. Five replicates of shoots & roots of each species and the soil of rhizosphere around the plants were sampled.Plants were identified according to Flora Iranica [8] and Flora of Iran [9]

Figure 1 *plants used in this study(photos from authors)*



4 grams of each soil was sieved by using 80-micro mesh and two-grams sample of replicates were poured into the plastic bags and sent to Admel laboratory in Australia where the soils were analyzed for their metal contents by using ICP with sensitivity detection of 0.5 ppm for element, As.
Each plant sample was divided into two fractions of shoot and root. The samples were washed thoroughly with distilled water tree times. Samples were dried in 50^{0} C oven for 72 hours, them they were ground and two-grams replicates of each sample were poured into the plastic bags and were sent to Admel laboratory in Australia where the plants were acid digested and analyzed for their metal contents by using ICP with sensitivity detection of 0.5 ppm for element As. Following the obtaining the results of the As content of the roots and shoots each data of the shoot was divided on the As content of the root to get translocation factors(TF). Concentration factor (CF) were also calculated by

dividing the As content of the shoots the As content of the soil samples (table2). Data were demonstrated in table-1.

Result and discussions

According to the results (table 1) total concentration of As in soil was 102.5 to 300 ppm. Arsenic amounts in the aerial parts of the plants changed from 32 ppm in *Rumex crispus* to 107 ppm in *Astragalus myriacanthus*. The range of As in roots was 7.4 in *Gundelia tournefortii* and 29 in *Astragalus myriacanthus*(table 1).

Table 1 *Arsenic amounts measured in soil, root and shoots.*

	shoot	root	soil
METHAl	As	As	As
UNITS	ppm	ppm	ppm
DETECTION	0.5	0.5	0.5
METHOD	IC3M	IC3M	IC3M
plant			
Artemisia aucheri	41.6	17.7	149
Astragalus myriacanthus	107	29	300
Ferula oopoda	38.1	6.5	102
Gundelia tournefortii	36	7.4	146
Rumex crispus	32	15.3	127.5

Arsenic pollution takes place from two natural and man made sources. The main source of this element and its entering in biological environments, is through human activities by using pesticides containing As,

The large amounts of As arrives into the atmosphere by geological process, human activities such as melting activities and fossil fuels. The amount poisonous element released is about 26000 ton per year [10]. Arsenic is a poisonous element for organism and generally for the environment and there is no evidence that show it has a biological role in the nutrition of plants. In presence of As in soils, the element is absorbed in the form of arsenite and arsenate by plants. Because of the similarity of As ion with phosphate ion it competes with phosphate and is easily absorbed by plant [11]. Nearly all of As combinations especially its organic compounds are poisonous and if arrives into food cycle and human body will cause poisonous and bad diseases [12].

Table 2 *Translocation factors(TF) and Concentration factor (CF)*

CF	TF	family	species
0.27	2.35	Asteraceae	*Artemisia aucheri*
0.35	3.68	Fabaceae	*Astragalus myriacanthus*
0.37	5.86	Apiaceae	*Ferula oopoda*
0.24	4.86	Asteraceae	*Gundelia tournefortii*
0.25	2.09	Polygonaceae	*Rumex crispus*

Conclusions

Totally the maximum amount of As in the soils is 7.5 ppm, in terrestrial plant 0.2-7 ppm, in purified water 2ppb and its amount in natural water is 50ppb. According to the results in this study, the amount of As in the soils is very high and is not permitted and is considered as environmental and biological threat. Identifying the plants that can absorb As is a very important feature. The results presented here also revealed that the plants can accumulate high amounts of As and can be employed as phytoremediators.

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