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The Role of the Plants for the Removal of Heavy Metals around Industrial Plant

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ABSTRACT

Due to increasing population and increasing organic and inorganic contaminants, it is essential to provide a reliable, low cost, and relatively quick method for removing contamination without any undesirable side effects for the environment. Phytoremediation is an appropriate way in this regard. This study aimed to determine the heavy metal accumulation capacity around the Iralko aluminum factory, located in Markazi (Iran) using plant Artemisia sieberi. This study employs a "factorial experiment" with completely randomized design under greenhouse conditions. It conducted four treatment plants, 3Repeat and 4 treatments of heavy metals (zinc, nickel and chromium) in control, which were 2.5,5 and 10 times more than average concentration of elements in soil to evaluate the phytoremediation methods and compare the estimated absorption in refining metals-contaminated soils. In this study the average concentration of Zink in soil is 107 mg/kg and the bioavailability is 0.4mg/kg which is more than other two metals. After analysis of plant tissues, results shows that the Zink has the highest concentration with 37.05% in leaves and then 37% in the stem of the plant. Considering the morphology terms and resistance to water shortages this plant is more efficient in absorption of zinc than absorption of Cr and Ni from the soil around the Iralko factory.
Key Words: phytoremediation, Iralko, Artemisia sieberi

INTRODUCTION

All the heavy metals at high concentrations have strong toxic effects and are regarded as environmental pollutants .Environmental pollution with heavy metals is a global disaster that is related to human activities such as mining, smelting, electroplating, energy and fuel production, power transmission, intensive agriculture, sludge dumping, and melting operations [17]. All the heavy metals at high concentrations have strong toxic effects and are regarded as environmental pollutants [26]. Sawidis (2008) showed that heavy metals have toxic effect on the pollen growth and pollen tube growth and cause to be a range of strong morphological abnormalities, characterized by uneven or aberrant growth, including apical branching or swelling at the tip of the pollen tube. Numerous efforts have been undertaken recently to find methods of removing heavy metals from soil, such as phyto-remediation [2].[17].[16].For chemically polluted lands, vegetation plays an increasingly important ecological and sanitary role [2].Proper management of plants in such areas may significantly contribute to restoring the natural environment. Perhaps, not surprisingly, phytoremediation was initially proposed as an environmental cleanup technology for the remediation of metal-contaminated soil[7].[19].The identification of metal hyperaccumulators, plants capable of accumulating extra-ordinary high metal levels, demonstrates that plants have the genetic potential to clean up contaminated soil. Phytoremediation has recently become a subject of public and scientific interest and a topic of many recent research [28].[17].[16].The ability of selecting species of plants, which are either resistant to heavy metals, or can accumulate great amounts of them, would certainly facilitate reclamation of contaminated areas [6]. The study conducted by Kumar Maiti and Jaiswal (2007) showed that natural vegetation removed Mn by phytoextraction mechan- isms while other metals like Zn, Cu, Pb and Ni were removed by rhizo filtration mechanisms. Ike reported that the bacterial symbiosis will be useful in phytoremediation of heavy metals[18]. Muneer showed that the isolated yeast can be exploited for bioremediation of chromium-containing wastes, since they seem to have the potential to accumulate the toxic metals from the environment[25]. Phytoremediation is a cost-effective technology for environ- mental cleaning if native plants were applied in each polluted areas. We need new and variable accumulator plants for phytoremediation in different climates, so new studies are still necessary to find new accumulator plants for using in different conditions.

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MATERIALS AND METHODS

In Iralko, the imported alumina (aluminum oxide) is carried into the factory, after the Hall-Heroult process and other process it turns into aluminum and in casting process forms ingots, and then it is carried out of the factory. Study area in dominant wind direction with angle 75 between 500 to 1500 meters from chimneys. Screen3 software was chosen for this purpose .Also an area of approximately 2000 square meter at a distance of approximately 1100 meters as the study area were selected. The reason of this selection was the possibility of presentation of heavy metals in more concentration in this area. In soil sampling from Arak lands around the Iralko complex, All samples were taken from 0-25 cm soil depth. For this purpose a tube of stainless steel was used with diameter approximately 4 m and 1m in length, equipped with a piston for soil extraction. To obtain comprehensive information about the soil contamination, samples were taken from 11 land area totally, providing 2 or 3 samples from each land area, and then samples were mixed.

All samples were dried at a temperature of 70 "C. After separating of about 5 g under 63 microns particles, they were powdered in agate mortar [13].Digestion method was carried out using HNO3, HCL, HF, HCLO4. Digestion temperature was 125 º C using sand bath[14][15]. Artemisia sieberi was Plant Species Studied and experiments were performed on this invasive plant grown in normal conditions and also in the study area. Was choose it because this plant was resistant to both contamination and drought conditions, and also because it's morphological conditions. The study area was fencing and it had suitable conditions for protecting this plant. After consultation and considering the nature of study and variety of its factors, blocks were selected from area completely random. The experiment was performed in study area with 4 treatment and 3 repeat. Treatments include different concentrations of the elements Cr, Ni, Zn, which has presented in used statistical design (Figure 1).

To add elements Nickel, Chromium and zinc to the study soils, zinc nitrate Zn (No3) $2.6H_2O$, Nickel sulfate ($NiSo_4$, $6H_2O$), atomic mass 263 and Ammonium dichromate (NH4) Cr_2O_7, atomic mass 252, respectively were used. Contaminating was done in 3 steps to achieve the desired concentration. Then by components analysis, different amounts of available elements were recognized.

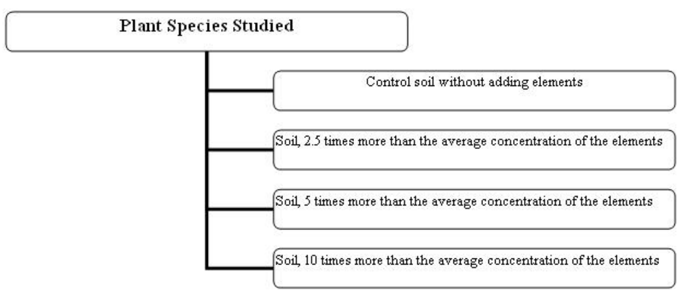
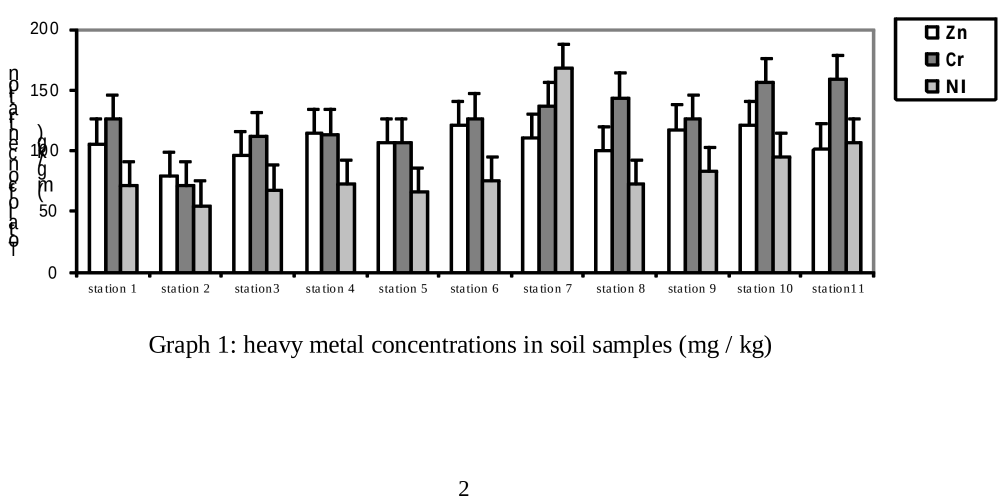


Figure1-different concentrations of the elements Cr, Ni, Zn in soil

RESULTS AND DISCUSSIONS

In this study, in soils around the Iralco factory, chromium has the highest average concentration and nickel has the lowest Studies show that some elements bioavailability thought the plants is affected by soil pH and C.E.C. .Based on this, table (1) shows the results of analysis of soil samples. Amounts of heavy metal concentrations in 11 soil samples can be seen in graph (1).

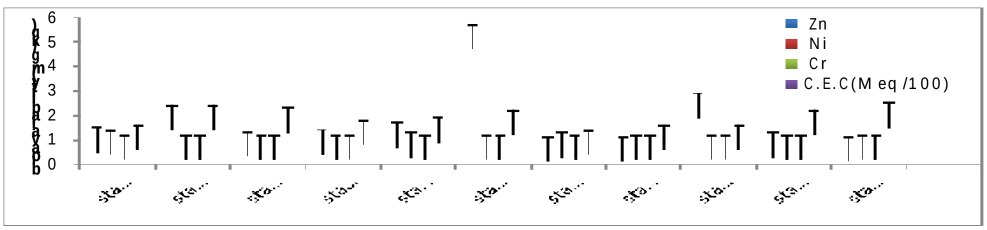


Graph 1: heavy metal concentrations in soil samples (mg / kg)

Table 1: Comparison of bioavailability and CEC in the study area considering the average

Sample	Sampling Site	Bioavailability for Ni	Bioavailability fot Cr	Bioavailability for Zn	C.E.C Meq/100 Soil	pH
Station1	*Iralko vicinity*	*0.4*	*0.2*	*0.5*	*6.0*	7.5
Station2	*Iralko vicinity*	*0.2*	*0.2*	*1.4*	*14.0*	7.5
Station3	*Iralko vicinity*	*0.2*	*0.2*	*0.32*	*13.0*	7.5
Station4	*Iralko vicinity*	*0.2*	*0.2*	*0.42*	*8.0*	7.4
Station5	*Iralko vicinity*	*0.3*	*0.2*	*0.7*	*9.0*	7.7
Station6	*Iralko vicinity*	*0.2*	*0.2*	*4.7*	*12.0*	7.4
Station7	*Iralko vicinity*	*0.3*	*0.2*	*0.1*	*4.0*	7.8
Station8	*Iralko vicinity*	*0.2*	*0.2*	*0.1*	*6.0*	7.8
Station9	*Iralko vicinity*	*0.2*	*0.2*	*1.9*	*6.0*	7.7
Station10	*Iralko vicinity*	*0.2*	*0.2*	*0.3*	*12.0*	7.8
Station11	*Iralko vicinity*	*0.2*	*0.2*	*0.1*	*15.0*	7.8
Avrage	*Iralko vicinity*	*0.2*	*0.2*	0.4	*9.5*	7.6

According to the elements concentration in bioavailability phase and the amount of C.E.C in neutral soil, by increasing C.E.C in soil, the bioavailability of nickel and chromium in soil has decreased. But about Zink with the highest bioavailability, 0.4 mg/kg such relationship was not found, graph 2 shows this fact.



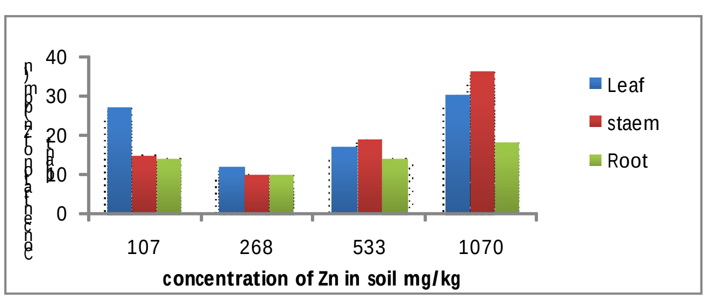
Graph2 -Amounts of heavy metals fractions in bioavailability(mg/kg) compared with C.E.C

According to average concentration in soil samples(Table 2) and compare with average earth crust, As it can be seen concentrations of Cr, Zn are more than average earth crust ,and average concentration of Ni is close to the average earth crust. So these elements were known contaminants and attempted to cleanup the soil of the area using Artemisia sieberi such as invasive weeds in different treatments of Average elements concentration.

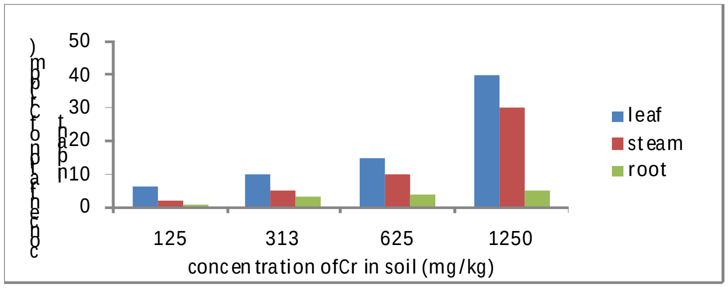
Table 2 – average concentrations of study elements compare with the average earth crust

Elements	*Zn*	*Cr*	Ni
Average element in 11 samples(mg/kg)	85	125	107
Lee&yao 1970(mg/kg)	89	110	94
Taylor 1964(mg/kg)	75	100	70
AlinaKabata 2007(mg/kg)	20	100	70

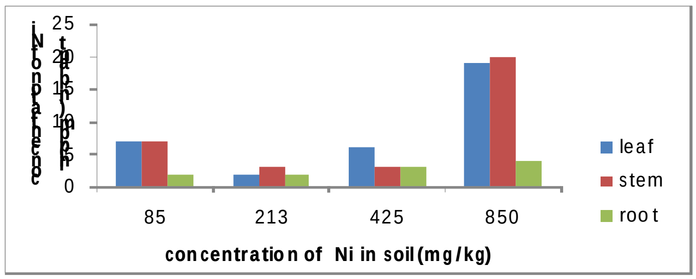
At the end of the work , the different organs of the plant were sampled to measure and examine the elements accumulation in them. Results suggest that most plants absorption is in leaves and then in its steam.



Ghraph3-Estimate of absorbtion Zn in members of Artemisia sieberi



Ghraph3-Estimate of absorbtion Cr in members of Artemisia sieberi



Ghraph3-Estimate of absorbtion Niin members of Artemisia sieberi

Bioavailability of Chromium in the study was, 0.2 mg / kg, Also Artemisia sieberi has the ability to absorb it especially from leaves, so considering the control sample it can be suggested that this plant can do more effective absorption of chromium than Nickel from the soil of the area.

Zinc (Zn) is one of the essential elements of plant and a lack of it usually seen in early season plant growth, also comparing the control sample results with contaminant samples, the average concentration in the soil is 107mg/kg and its bioavailability is 0.4 mg / kg. As it was expected the absorption of Zn is more than Cr, Ni and the highest average concentration could be seen in its leaves.

According to the results, this plant has absorbed zinc more than other two elements. Also results shows that the average concentration of chromium in study area is more than zinc and nickel. Graphs (1). But not necessary all elements in soil have bioavailability, only a few of them can be absorbed by plants. Major absorption is done by tiny stems grows from the root (rhizome). It should be noted that the rhizome produces secretion around the roots, which is so important in C.E.C

Nickel, like zinc, according to its bioavailability and concentration in sample soils and its absorption rate in both control and contaminant samples, has no high absorption rate and its concentration can be seen especially in leaves and steam of the plant.

Considering the inverse relation between and bioavailability of elements studied, Zink did not follow this relationship and has the highest absorption in plant leaves. Absorption is influenced by many variables. Among them, the type of link between elements and soil, presence of organic matter, oxidation and reducing conditions and the presence of carbonate materials could be motioned.

According to Table (1) and the results can be stated that zinc has highest concentration in leaves and then in steam, 37.05% and 37% respectively. In chromium Cr maximum absorption is in leaves, 58% and about nickel is 45% in steam. This plant, considering its morphology and also its resistance to both water shortages and contamination, can act effective in absorption of Zink and somewhat in absorption of chromium from the soil around the Iralko complex. On the condition that they not used as livestock forage in inappropriate circumstances of pastures.

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