Study the Accumulation of Strontium in Plant Growing around Sarcheshmeh Copper Mine, Iran

S. Azad Shahraki a), A. Ahmadimoghadam b), F. Naseri c), E. Esmailzade d)

[a) b)] *Dept. of Biology, Shahid Bahonar University of Kerman, Iran*
e-mail: saleh.azad@yahoo.com
e-mail: ahmadimoghadam@yahoo.com
[c)] *Dept. of International Center for Science, Hight technology & Environmental Science, Kerman, Iran*
e-mail:naseri@icst.ac.ir
[d)] *Environment researcher in R&D Sarcheshme copper complex, Iran*
e-mail:esmaeilzadeh@nicico.com

Abstract
Sarcheshmeh copper mine is located in the south-East of Iran. It is revealed that heavy metals concentrations are high in the region due to the naturally mineralization process. In addition, mining activities have brought more heavy metals from belowground into the surface and caused more pollution in the area. Plants in these sites showed grow apply specific strategy to cope with these elements. In the study samples of shoots, roots and soil of around the roots of plants in Sarcheshmeh region were collected and their strontium contents were measured by using ICP in Admel laboratory in Australia. The highest amount of strontium in soil samples was 1140 ppm and highest amounts in shoot of Urtica urens was 350 ppm, 383 ppm in the roots of Rumex ribes. Cultivating of these plant is suggested for phytoremediation of the polluted sites.

Key word: strontium, phytoremediation, Sarcheshmeh copper mine*, Rumex spp, Urtica spp*

Introduction

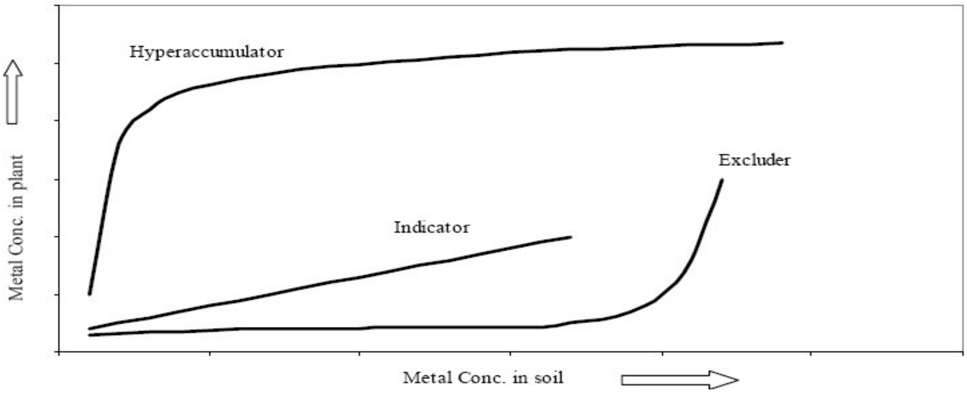
The concentration of Heavy metal and radioactive elements in some natural environments is high. These elements can cause poisonous disorders in some plants. Some plants can absorb these elements naturally but high amount of heavy metal enter the food webs and produce pollution in the environments [1]. Heavy metals increase in soil due to the human activities like mining, using fossil fuels and metal industries [2]. Only %1 or less of total plant body is consisted of heavy metals. Some of these elements are present in the protein structure in high amounts and essential role in protein structures especially in enzymes [3]. However Presence of heavy metals in the environment of plants is a kind of stress that will lead to physiological changes them and also decrease the physiological abilities of plants and in most cases will destroy them. Sensitive plants in such conditions will be harmed and or destroyed while resistant plants will raise and reproduce [4] Plants have three basic strategies for growth on metal contaminated soil [5]: (fig1)

-Metal excluders: They prevent metal from entering their aerial parts or maintain low and constant metal concentration over a broad range of metal concentration in soil, they mainly restrict metal in their roots. The plant may alter its membrane permeability, change metal binding capacity of cell walls or exude more chelating substances [6].

-Metal indicators: Species which actively accumulate metal in their aerial tissues and generally reflect metal level in the soil. They tolerate the existing concentration level of metals by producing intracellular metal binding compounds (chelators), or alter metal compartmentalization pattern by storing metals in non-sensitive parts.

-Metal accumulator plant species: They can concentrate metal in their aerial parts, to levels far exceeding than soil. Hyperaccumulators are plants that can absorb high levels of contaminants concentrated either in their roots, shoots and/or leaves [5,9,10]. Baker and Brooks 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. For cadmium and other rare metals, it is > 0.01% by dry weight [44]. Researchers have identified hyperaccumulator species by collecting plants from the areas where soil contains greater than usual amount of metals as in case of polluted areas or geographically rich in a particular element [8]. Approximately 400 hyperaccumulator species from 22 families have been identified. The Brassicaceae family contains a large number of hyperaccumulating species with widest range of metals, these include 87 species from 11 genera [7].

Figure 1 *Conceptual response strategies of metal concentrations in plant tops in relation to increasing total metal concentrations in the* soil



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].
In this study plants growing around Sarcheshmeh copper complex were collected and analyzed for their Sr amounts to evaluate their ability to accumulate the element materials

Methods
The study site, Sarcheshmeh copper mine, 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 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 [14] and Flora of Iran [15]. 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, Sr. 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 Sr. Following the obtaining the results of the As content of the roots and shoots each data of the shoot was divided on the Sr content of the root to get translocation factors (TF). Concentration factor (CF) were also calculated by dividing the Sr content of the shoots the Sr content of the soil samples (table1). Data were demonstrated in table-1.

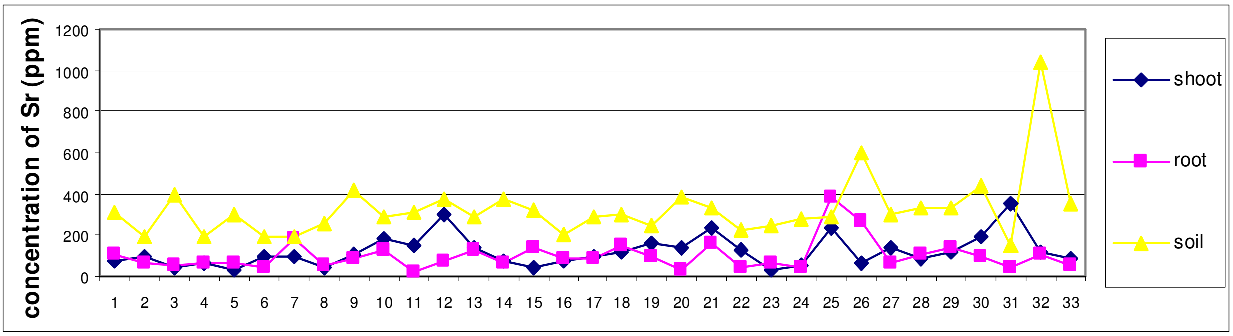
Results and Discussion
According to the results (table 1) total concentration of Sr in soil was 190 to 1140 ppm. Strontium amounts in the aerial parts of the plants changed from 29.2 ppm in *Gundelia tournefortii* to 350 ppm in *Urtica urens.* The range of Sr in roots was 23.1 ppm in *Isatis cappadociaca* and 383 ppm in *Rheum ribes* (table 1,Fig2).

Table 1 *Plants and Sr amount (ppm) in soil, shoot, root and concentration factor (CF) and translocation factor (TF)*

Plant species	Sample number	Family	Concentration of Sr			TF	CF
		Apiaceae	**Soil**	**Root**	**Shoot**		
Ferula oopoda	1		307	104	71.9	0.69	0.23
Prangos asperula	2		190	60	91.7	1.52	0.48

Artemisia aucherii	3		400	52.7	41.6	0.78	0.10
Taraxacum syriacum	4		196	66.8	59.3	0.88	0.30
Gundelia tournefortii	5		300	59.9	29.2	0.48	0.09
Hertia intermedia	6		196	48.1	100	2.07	0.51
Eryngium bungei	7	**Asteraceae**	193	183	100	0.54	0.57
Launaea acanthodes	8		261	49.7	41.6	0.83	0.15
Brassica deflexa	9	**Brassicaceae**	417	88.1	112	1.27	0.26
Cardariad draba	10		289	130	177	1.36	0.69
Isatis cappadociaca	11		313	23.1	146	6.32	0.46
Salsola kali	12	**Chenopodiaceae**	380	70	300	4.28	0.78
Chenopodium album	13		289	131	142	1.08	0.49
Chenopodium folisum	14		379	61.6	76.8	1.23	0.2
Silene spergulifolia	15	**Caryophyllaceae**	321	143	44.1	0.30	0.13
Astragalus myriacanthus	16	**Fabaceae**	200	80.7	70.7	0.87	0.35
Astragalus rhodosemius	17		288	84.7	93.8	1.1	0.32
Cicer spiroceras	18		295	149	115	0.77	0.38
Glycyrrhizia glabra	19		250	92.7	159	1.71	0.63
Marrubium crassidens	20	**Laminaceae**	382	34.2	135	3.94	0.35
Cynedon ductylon	21	**Poaceae**	327	162	233	1.43	0.71
Phragmites australis	22		222	47.4	132	2.78	0.59
Polypogon fugax	23		251	66.8	35.2	0.52	0.14
Melica persica	24		282	40	57.7	1.44	0.20
Rheum ribes	25	**Polygonaceae**	289	383	237	0.61	0.82
Rumex crispus	26		604	270	63.9	0.23	0.1
		Scrophulariacea'					
Verbascum songaricum	27		296	67.6	135	1.99	0.45
Scrophularia spp	28		331	109	80.9	0.74	0.24
Solanum nigrum,	29	**Solanaceae**	336	134	115	0.85	0.34
Tamarix ramossima	30	**Tamaricaceae**	444	98.8	188	1.90	0.42
Urtica urens	31	**Urticaceae**	150	48.2	350	7.26	2.3
Peganum harmala	32	**Zygophyllaceae**	1040	108	115	1.06	0.1
Equisetum arvens	33	**Equisetaceae**	356	56	81.7	1.45	0.2

Figure 2 *Concentration(ppm) Sr in soil, shoot, root of plans samples (number of samples, n = 33) sampled in sumer.*



Conclusions

In phytoremediation process, plants with high growth rate, strong root system and high CF and TF can accumulate high levels of heavy metals in their organs.

According to the results *Urtica urens* had the higest levels of CF and TF among the examined plants. In addition, plants grow well in this environment and posses a strong root system and showed a high potential of Sr accumulation. *Isatis cappadociaca , Salsola kali, Marrubium rassidens* showed lower values of accumulation and can be ranked after *Urtica urens* respectively.

More extensive studies in the effects of pH and adding chelators and employing of bio technical method and selecting more proper species and varieties may lead to enhancement of the ability of these plants to accumulate Sr.In generally it can be postulated that due to different features of the plants studied in this research, they can be considered on phytoremediators.

Reference

[1]Hung, W .J, and Blaylock, M., J. 1998. phytoremediation of uranium – contaminated soil :role of organic acids in triggering uranium hyperaccumulation in plants. Enviornment science and technology . 32:2004-2008

[2]Baker, A. J. M., Reeves, R. D. and Hajar, A. S. M. 1994. Heavy metal accumulation and tolerance in British populations of the metallophyte *Thlaspi caerulescens* J. & C. Prese (Brassicaceae). *New Phytologist.* 127: 61-68.

[3]Shallari, S., Schwartz, C., Hasko, A., Morel, J. L. 1997. Heavy metals in soils and plants of serpentine and industrial site of Albania. Science of Total Environment.209:133-142

[4]Baker, A. J. M. and Brooks, R. R. 1989. Terrestrial higher plants which hyperaccumulate metallic elements a review of their distribution, ecology and photochemistry. *Biorecovery.* 1: 81-126

[5] Raskin, I, Kumar, P.B.A.N., Dushenkov, S. and Salt, D. (1994): Bioconcentration of heavy metals by plants. – Current Opinion Biotechnology 5; 285-290.

[6] Cunningham, S. April 19-22, (1995): In Proceedings/Abstracts of the Fourteenth Annual Symposium, Current Topics in Plant Biochemistry, – Physiology, and Molecular Biology Columbia; pp. 47-48.

[7] Baker A. J. M. and Brooks R. R., (1989): Terrestrial higher plants which hyperaccumulate metalic elements. A review of their distribution, ecology and phytochemistry. – Biorecovery 1; 81-126.

[8] Gleba D., Borisjuk, N. V., Borisjuk, L. G., Kneer, R., Poulev, A., Skarzhinskaya, M., Dushenkov, S. Logendra, S. Gleba, Y. Y., Raskin, I. (1999): Use of Plant root for phytoremediation and molecular farming. – Proc. Natl.Acad.Sci, USA. 96; 5973-5977

[9] Cunningham, S.D., and Ow, D.W. (1996): Promises and prospects of phytoremediation. – Plant Physiol. 110; 715-719.

[10] Baker, A.J.M., McGrath, S.P., Sidoli, C.M.D. and Reeves, R.D. (1994): Thepossibility of in situ heavy metal decontamination of polluted soils using crops of metal-accumulating plants. – Resour. Conserv. Recycl. 11; 41-49.

[11] Yanqun, Z., Yuan, L., Jianjun, C., Haiyan, C., Li, Q. and Schvartz, C. 2005. hyperaccumulation of Pb, Zn and Cd in herbaceous grown on lead–zinc mining area in Yunnan, China. Environment International. 31:755-762.

[12] Yanqun, Z., Yuan, L., Schvartz, C., Langlade, L. and Fan, L. 2004. Accumulation of Pb, Cd, Cu and Zn inplants and hyperaccumulator choice in Lanping lead–zinc mine area, China. Environment International. 30:567–576

[13] Fytianos, K., Katsianis, G. and Zachariadis, G. 2001. Accumulation of heavy metals in vegetables grown in an industrial area in relation to soil. Environmental Contamination and Toxicology. 67:423-430.

[14] Rechinger, K. H. 1963-1999. Flora Inranica. Vol. 1-176. Akademische Druck- U Verlagsantalt. Geraz. Austria.

[15] Mozafarian, V., Asadi, M.,Masomi,A.,Khatamsaz, A. 1988-2003. Flora of Iran. Vol 1-44. Research Institute of Foressts and Rangelands.