African Journal of Biotechnology Vol. 11(77), pp. 14146-14152, 25 September, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.3613
ISSN 1684–5315 © 2012 Academic Journals

Full Length Research Paper

Lead contamination in soil and vegetation of areas surrounding different mining activity zones in Kerman Province of Iran

Salari Hassan[1]*, Oloumi Hakimeh[1], Afzali Daryoush[2] and Ahmadi Mosavi Effatosadat[3]

[1]Department of ecology, International Center for Science, High Technology & Environmental Sciences, Kerman, Iran.
[2]Department of environment, International Center for Science, High Technology & Environmental Sciences, Kerman, Iran.
[3]Laboratory staff, International Center for Science, High Technology & Environmental Sciences, Kerman, Iran.

Accepted 27 January, 2012

Lead (Pb) is a toxic element that was used for many years in products found in our environment. One of The most serious sources that Pb can be emitted into the environment is industrial and mining activities. A study was carried out, samples collections from soil and wastewater in Ghanat Marvan lead mine, Tarz lead mine, Shahid Bahonar Copper Industries Company (CSP), Industrial zone No.1 and Sarcheshmeh Copper Complex in Kerman province. The results show that Sarcheshmeh Copper Complex soil sample had Pb content less than other sites. Lead concentration in industrial wastewater in Sarcheshmeh Copper Complex and CSP did not show significantly different with Environmental Protection Agency (EPA) standard. Positive correlation was shown between the Pb in wastewater and plant concentration. The results show significant negative correlation between waste pH and Pb in industrial waste, plant and soil. Also the results show that *Acantholimon* sp. and *Astragalus glancanthus* were dominant plant in two mines upon floristic quantities assay. Lead concentration was 15.8 mg/kg DW and 1.61 mg/kg DW in Ghanat Marvan and Tarz soil respectively. According to these finding we recognized that these plant were the best hyper accumulator in lead mines.

Key words: *Acantholimon* sp., *Astragalus glancanthus,* hyperaccumulators, Kerman province, lead.

INTRODUCTION

Nowadays the evaluation, mechanism and biotechnological cleaning of heavy metal pollution near the mine were discussed all over the world (Liao et al., 2008; Byong et al., 2010; Nikolaidis et al., 2010). Although advances in technology in last decades have greatly increased the quantity and quality of metal production world-wide, mining remains one of the main sources of heavy metal pollution. Some mine tailings have been left without proper management in closed metal mines and have become the source of heavy metal contamination in adjacent agricultural soils and crops. Lead is one of the best known toxic heavy metals, and become a general environmental contaminant (Prathumratana et al., 2008; Mitchell, 2009). The most serious sources of Pb pollution are industrial and mines activities (Kim et al., 2002; Lee et al., 2001; Mitchell, 2009, Steinbo and Breen, 1999). Pb concentration measurements provide useful information about potential enrichment of this element, and lead isotopes have been introduced as fingerprints of environmental pollution.

In metal-contaminated soils, vegetation growing on such soils can take up metals via the roots, and these metals are firmly bound to the plant tissues (Steinbo and Breen 1999). Higher plants contain heavy metals from the soil via root systems as well as aerial deposition (Antonious and Snyder, 2007; Arthur et al., 2003).

Kerman Province (Iran) has a long history of metalliferous and elemental mine enrichment (National Geosciences Database of Iran, 2011) and the most extensive activities occurred during the twentieth century.

*Corresponding author. Email: h_salari57@yahoo.com.

Table 1. Characteristics of sampling zones.

Mine	Soil pH	waste pH	Pb plant	Pb waste	Pb soil (mg/g)
ICP	5.97	8.47	2.19	0.046	0.045
IN. 1	7.16	7.73	1.76	0.143	0.63
Semirara Mining Corporation (SCC)	4.38	6.14	1.82	0.031	0.039
G.M	7.56	6.37	114.37	32.6	15.8
T	7.48	6.59	98.67	24.268	1.61

G.M., Ganat Marvan; ICP, Idaho Cobalt Project; T, Tarz lead mines; IN. 1, Industrial zone no. 1.

There are several metal mines and mine industrial companies in Kerman province of Iran that tailings have been left in the vicinity of these mining areas. The tailings contain several kinds of toxic contaminations, which include heavy metals like lead, and these may cause deterioration in the ecosystem around the metal mines.

In this study, different mining activity zones including Ganat Marvan lead mine, Tarz lead mine, Copper Industries Company (CSP) and Industrial zone No. 1 (IN. 1) of Kerman were chosen and soil samples collected in 2010 from closest agricultural fields to mine activity zones were analyzed for lead content and pH to understand the lead contamination in terms of Pb concentration and its correlation with soil acidity.

There are many metal hyperaccumulators in the world (Antonious and Snyder, 2007); however, a limited number of these are lead hyperaccumulators. The hyperaccumulation of lead is rare due to the limited free lead (Pb^{2+}) available in soil for absorption.

In this investigation most common plant species growing near the surrounding areas of the study area were also identified. Plant samples were analyzed for Pb accumulation and the correlation between various parameters were investigated to find and introduce more Pb resistant plant species.

The aims of this study were to investigate lead contamination in soil and vegetation of area surrounding different mining activity zones in Kerman Province of Iran.

MATERIALS AND METHODS

Site description

Field situation of investigation

Ganat Marvan (G.M.) lead mine is located in 25 Km northeast of Baft in Kerman Province with the coordination (29° 20' 40″N, 56° 46' 56″ E). Tarz (T) lead mine is located in the Northwest of Ravar in Kerman Province. CSP Shahid Bahonar Copper Industries Co. is located in 12th km of Kerman-Baghin. It covers an area of about 200 ha and contains four factories, The Foundry Shop, Rolling Shop, Extrusion Shop and Coin Shop. Shahid Bahonar Copper Industries Company produces a vast variety of sheets, strips, foils, sections, tubes of different alloys and dimensions. It also produces the coin circles to be minted in the central bank. Industrial Zone No. 1 located in south of Kerman Province at a distance of about 5 km from Kerman. Sarcheshmeh Copper Complex is located in 160 km the southwest of Kerman and 50 km the south of Rafsanjan. The region's altitude averages about 2600 m, the highest spot of which approximates 3000 m. Sarcheshmeh ore bodies; situated in the central part of Zagros ranges, consist of folded and faulted early tertiary.

Soil sampling

Four soil samples

From the closest farmland to mining, activity areas were collected around Ganat Marvan lead mine, Tarz lead mine, Shahid Bahonar Copper Industries Co. and Industrial zone no. 1 of Kerman. Each sample was taken within a depth of 15 cm from the surface. Characteristic of sampling zones is listed in Table 1.

Air-dried soil samples were disaggregated, sieved on a 2 mm sieve, then quartered, pulverized and passed through an 80 mesh (< 180 µm) sieve. All soil was analyzed for lead levels, and the pH of the soil samples was also measured.

In order to determine the concentrations of Pb, 1 ml of HNO_3 and 3 ml of HCl (aqua regia) were added to 0.25 g of the samples. These were heated to 70°C and shaken for 1 h, and 6 ml of deionized water was added to the solution. These solutions were analyzed for Pb by atomic absorption spectrometry (Varian 220 A).

Plant sampling

According to the results of lead concentration on various site of sampling, the highest concentration of lead were in Ghanat Marvan and Tarz lead mines of which sampling of plant carried was out from these sites. Via floristic method by minimal quadrate level (25 × 25 m) the frequency, cover surface of plant were measured. The frequency and cover percent mean of dominant plant on Tarz and Ghanat Marvan lead mines is shown in Tables 2 and 3.

Plant samples were taken from area surrounding the mining zones and vigorously washed in deionized water to remove soil particles or dust adhering to the plant surface. Samples were then air-dried on covered trays in a filtered air-drying cabinet at 40°C for 48 h. The dry crop samples were milled, digested with nitric acid, and the resultant solutions were analyzed for Pb. The plant lead concentration of two mines is listed in Table 3.

Statistical analysis

The data were analysed for correlation between various parameters by SPSS 15 and graphs were design by Excel software 2007 (Figures 1a to i).

Table 2. Frequency and cover percent mean of dominant plant on Ghanat Marvan lead mine.

Dominant plant	Frequency (mean)	Cover present (mean)
Stipa barbata	1.36	3.6
Astragalus glancanthus	2.1	16.4
Stachys inflate	1.4	13.33
Acantholimon sp.	2.76	7.4
Scariola arientalis	0.41	1.6
Thlaspi rotundifolium	0.74	0.36

Table 3. Frequency and cover percent mean of dominant plant on Tarz lead mine.

Dominant plant	Frequency (mean)	Cover present (mean)
Stipa barbata	0.36	1.8
Astragalus glancanthus	1.7	23.1
Stachys inflate	0.78	8.06
Acantholimon sp.	2.3	11.03
Scariola arientalis	0.26	0.28
Thlaspi rotundifolium	0.31	0.46

RESULTS AND DISCUSSION

Results indicate that there is a statistical different between the average concentration in the contaminated soil and the control site. The results show that lead concentrations of five zones are different. These results are listed in Table 1.

In Idaho Cobalt Project (ICP) and Semirara Mining Corporation (SCC) zones, soil pH was acidic and it may be related to the oxidation of sulphidic minerals at natural oxidation. The other zones are neutral, so the oxidation of metals does not influence pH of soils. The Pb absorption by plant in total zone is related by its concentration in the soil. It is clear that increasing soil lead causes the enhancement of lead uptake and accumulated in plants. The highest content of lead was found in the G.M. and T lead mine respectively, 15.8 mg/kg DW and 1.61 mg/kg DW. Obtained results indicate that living organisms are under unsafe conditions of the environment. Lead contaminated soils can influence the metal uptake by plant grown on this soil and in this study soil; plant has been contaminated by past mining activity.

The results show significant negative correlations which were obtained between pH and Pb in waste, plant and soil.

According to these results, the correlation between lead in plant and lead in waste is significantly different at 0.01 and 0.05 level and R^2 = 0.991. Thus, it is necessary to find metal-accumulating plants to extract lead at the nearest location to the waste of mine and industries. There are at least 400 known metal hyper accumulators in the world; however, a limited number of these are Pb^{2+} hyper accumulators. Tables 3 and 4 show the frequency and cover present in abundance plant lead accumulated. Normally plant lead level is in range of 1 to 16 mg/kg wt. The plants listed in Table 5 were the highest lead accumulates finding in the waste lead mine.

Some plants that have been known as hyper accumulators can accumulate extremely high concentrations of lead. Our finding shows that *Astragalus glancanthus* and *Stachys inflate* were the highest cover in Ghanat Marvan lead mine with 16.4 and 13.33 percent, respectively. These about Tarz lead mine were *A. glancanthus* and *Acantholimon* sp. with 23.1 and 11.03 percent, respectively. The best plant accumulator lead listed is in Table 5. It looks like the lead is immobile in soils. Therefore, for greater uptake of lead, it is important to find ways to enhance the bioavailability of Pb^{2+}. Amendments can be added to either help phytoextract lead in soils (Arthur et al., 2003; Zhu et al., 2004). Amendments can also improve the condition of the soil for plant growth. Soil pH is a significant parameter in the uptake of lead contaminant. In a report, the uptake of lead and cadmium were positively influenced by increasing pH (Kiewiet and Ma, 1991). It is essential to

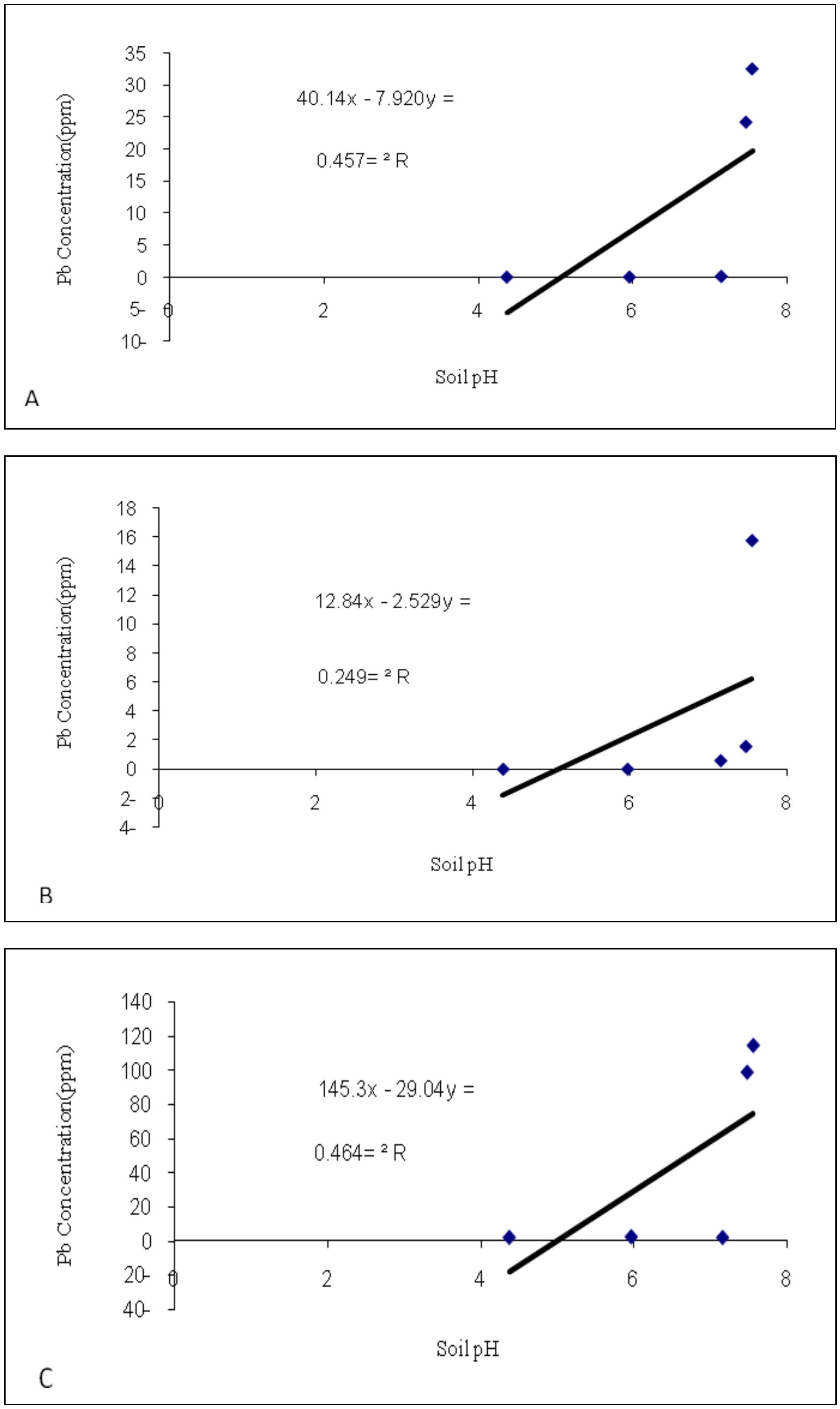
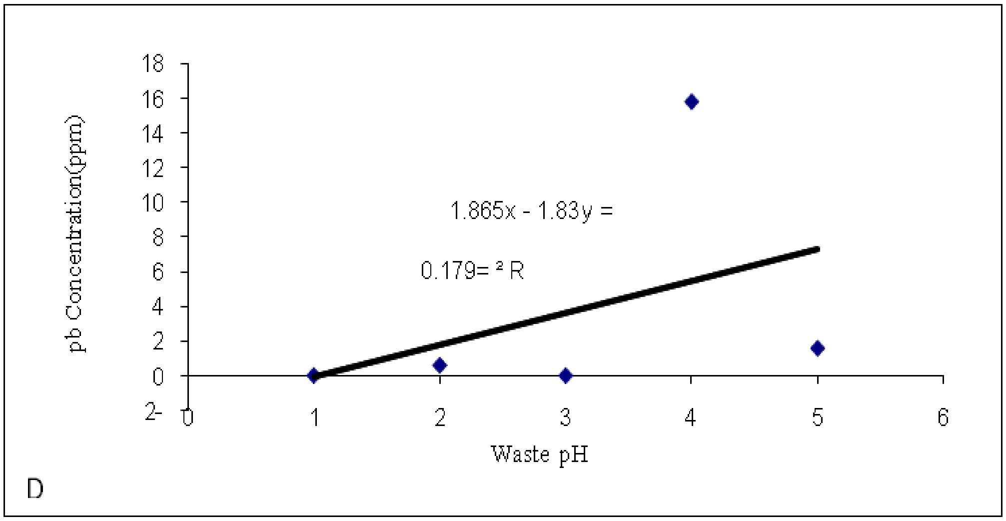
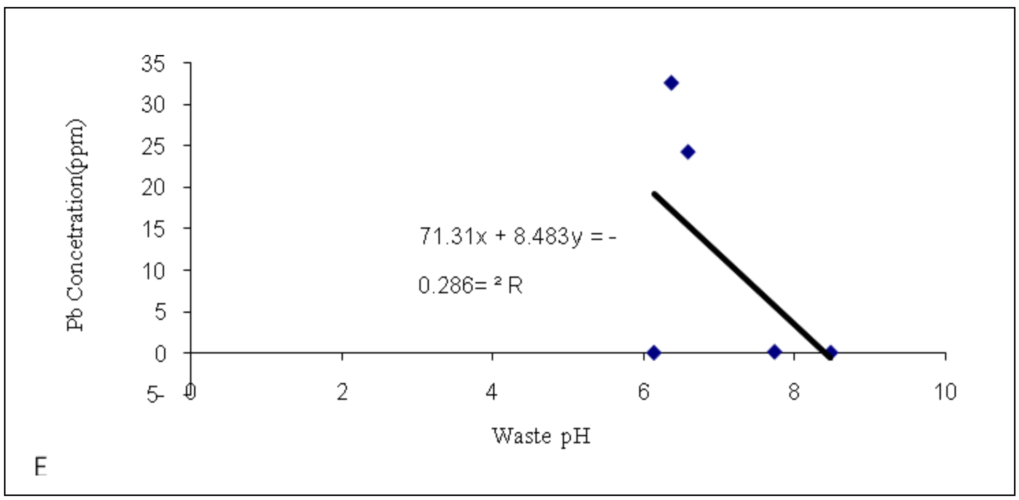


Figure 1. Schematic correlation between various parameters. A, Relationship modeling between soil pH and waste Pb concentration; B, relationship modeling between soil pH and soil Pb concentration; C, relationship modeling between soil pH and plant Pb concentration; D, relationship modeling between waste pH and soil Pb concentration; E, relationship modeling between waste pH and waste Pb concentration; F, relationship modeling between waste pH and waste Pb concentration; G, relationship modeling between waste pH and plant Pb concentration; H, relationship modeling between soil pH and waste pH; I, relationship modeling between soil Pb concentration and plant Pb concentration.





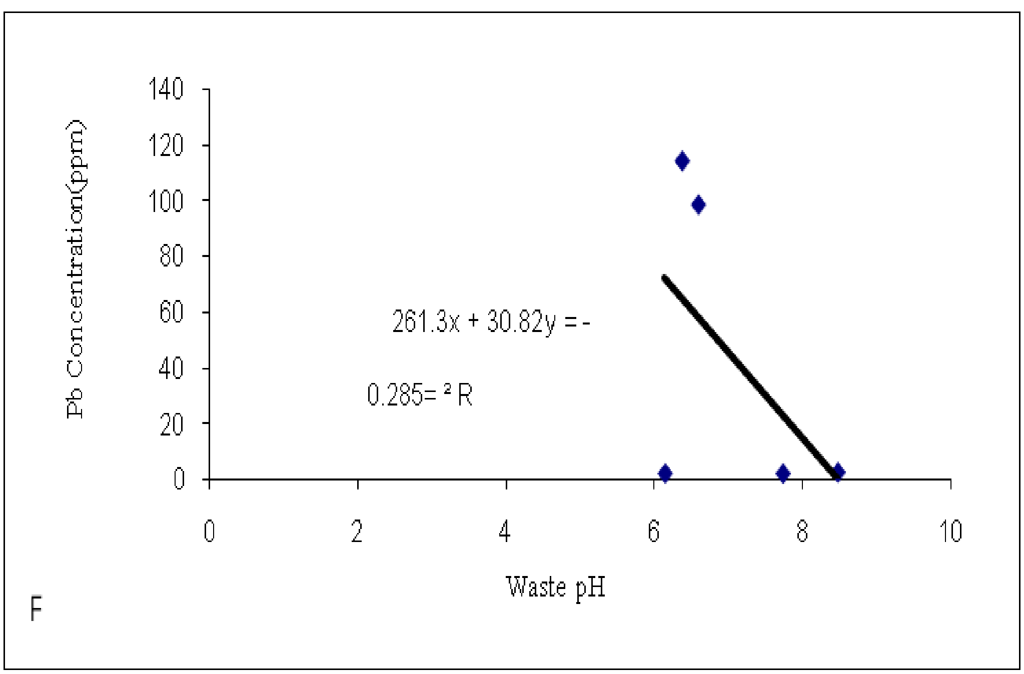


Figure 1. Contd.

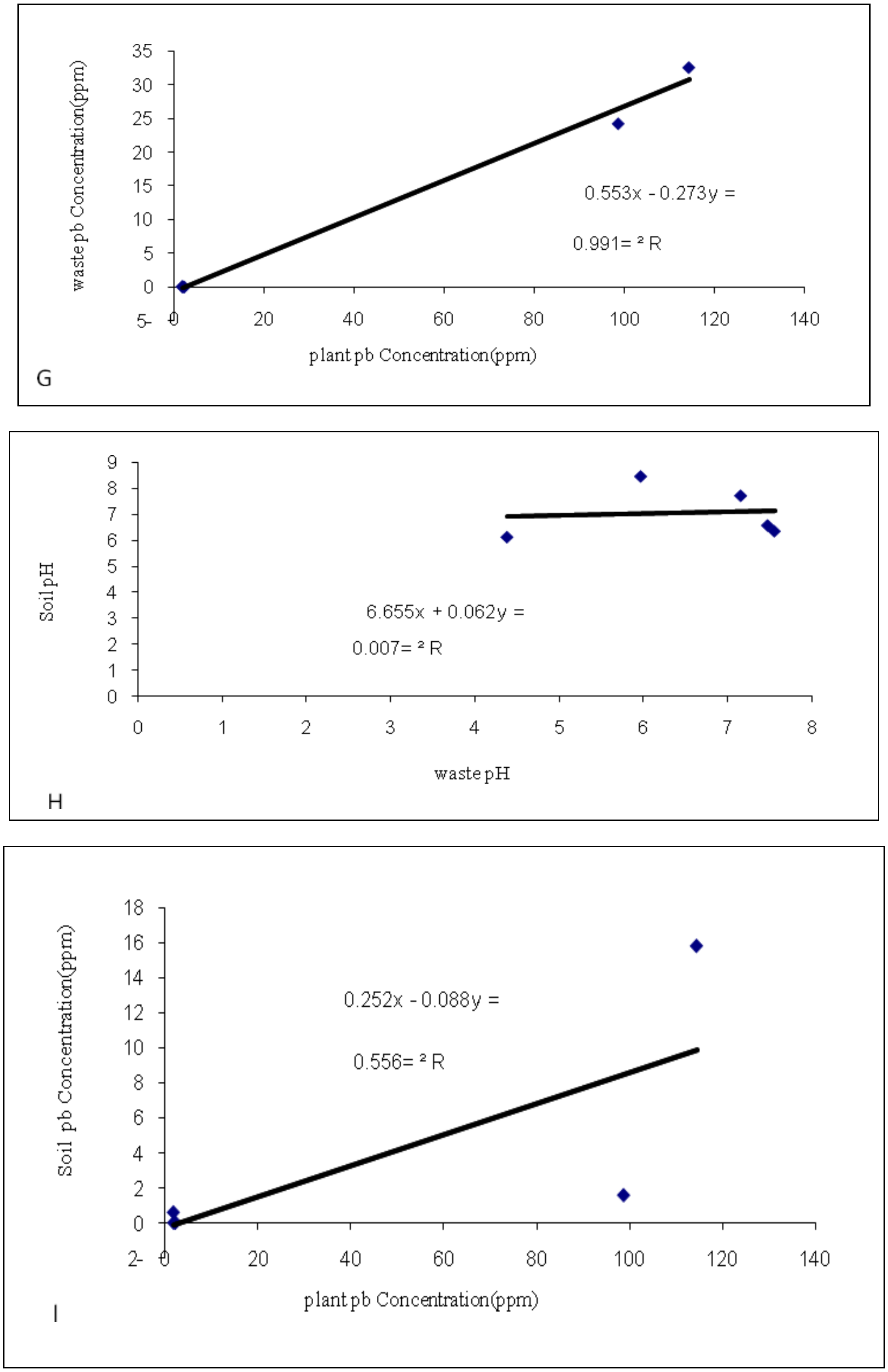


Figure 1. Contd.

find that the pH range for the growth of most plants and grasses is from 5.0 to 8.0. Thus, a pH around 5.0 seems to be an optimum pH level, since lower values may inhibit plant growth.

The Pb absorption of plant is directly related to the rate in the soil. It is reported that when Pb content is over 20 mg/kg in the soil, it can reach 1 mg/kg in most seeds in the perennial polluted and irrigation zones.

Table 4. Pearson correlation of various parameters of samples collected in contaminated zones.

Parameter	Stat. analysis	Soil pH	Waste pH	Plant Pb	Pb Waste	Soil Pb
Soil pH	Pearson Correlation	1	0.084(**)	0.681(**)	0.676(**)	0.500
	Sig. (2-tailed)	.	0.766	0.005	0.006	0.058
Waste pH	Pearson Correlation	0.084(**)	1	-0.534(**)	-0.535(**)	-0.411(**)
	Sig. (2-tailed)	0.766	.	0.040	.040	0.128
Plant Pb	Pearson Correlation	0.681(**)	-0.534(**)	1	0.996(**)	0.746(**)
	Sig. (2-tailed)	0.005	0.040	.	0.000	0.001
Waste Pb	Pearson Correlation	0.676(**)	-0.535(**)	0.996(**)	1	0.803(*)
	Sig. (2-tailed)	0.006	.040	0.000	.	0.000
Soil Pb	Pearson Correlation	0.500	-0.411(**)	0.746(**)	0.803(*)	1
	Sig. (2-tailed)	0.058	0.128	0.001	0.000	.

**Correlation is significant at the 0.01 level (2-tailed); *correlation is significant at the 0.05 level (2-tailed). Stat. analysis, Statistical analysis.

Table 5. Pb concentration (ppm) in dominant plant in lead mines.

Dominant plant	Pb Concentration (ppm)	
	Ghanat Marvan lead mine	Tarz lead mine
Stipa barbata	359	426
Astragalus glancanthus	748	568
Stachys inflate	674	458
Acantholimon sp.	968	759
Scariola arientalis	354	218
Thlaspi rotundifolium	117	647

ACKNOWLEDGEMENT

We would like to acknowledge the international center for science, high technology and environmental sciences in Iran for their financial support during this study under number contract 1.3540.

REFERENCES

Antoniousi GF, Snyder JC (2007). Accumulation of heavy metals in plants and potential phytoremediation of lead by potato, *Solanum tuberosum* L. J. Environ. Sci. Health Part A. 42: 811-816.

Arthur LS, Kelly LH, Jae-Min L, David JB (2003). Phytoremediation of Arsenic and Lead in Contaminated Soil Using Chinese Brake Ferns (*Pteris vittata*) and Indian mustard (*Brassica juncea*). Int J. Phytoremediation, 5(2): 89-103.

Byong GK, Seong Jp, jung GB, Kim MK, Kim GY, Hong SY, Lee DB (2010). Characteristics of soil heavy metal content in the agricultural areas near closed mine in Korea. World congress of soil science, soil solution for a changing world. 1-6 August, Brisbane, Australia. pp. 27-30.

Kiewiet AT, Ma WC (1991). Effect of pH and calcium on lead and cadmium uptake by earthworms in water. Ecotoxicol Environ. 21: 32-37.

Kim YJ, Kim KW, Lee JU, Lee JS, Cook J (2002). Assessment of As and heavy metal contamination the vicinity of Duckum Au-Ag mine, Korea. Environ. Geochem. Health. 24: 215-227.

Lee CG, Chon HT, Jung MC (2001). Heavy metal contamination in the vicinity of the Daduk Au-Ag- Pb-Zn mine in Korea. Applied Geochemistry, 16: 1377-1386.

Liao GL, Liao DX, Li QM (2008). Heavy metals contamination characteristics in soil of different mining activity zones. Trans Nonferrous Met. Soc. China. 18: 207-211.

Mitchell JW (2009). An assessment of lead mine pollution using macro-invertebrates at Greenside Mines. Glenridding Earth *Environment.* 4: 27- 57.

National Geoscience Database of Iran (2011). Available from: http://ngdir.org/minemineral/MineMineralChapterDetail.asp?PID=6596 [Accessed 14 Dec. 2011].

Nikolaidis C, Zafiriadis I, Mathioudakis V, Constantinidis T (2010). Heavy metal pollution associated with an abandoned lead- zinc mine in the Kiriki region NE Greece. Bull Environs Cintam Toxicol. 85(3): 307-312.

Prathumratana L, Kim R, Kim KW (2008). Heavy metal contamination of the mining and smelting district in Mitrovica, Kosovo. Proceeding of the international symposia on Geoscience resources and environments of Asian terranes. 24-26 November Bangkok, Thailand. 479-482.

Steinborn M, Breen J (1999). Heavy metal in soil and vegetation at Shallee mine, Silvermines, CO. Tipperary. Biology and environment, proceeding of the royal, Irish academy. 1: 37-42.

Zhu YG, Chen SB, Yang JC (2004). Effects of soil amendments on lead uptake by two vegetable crops from a lead-contaminated soil from Anhui, China. Environment International. 30: 351-356.