Assessing *Chenopodium album L.* potential for phytoremediation of lead-polluted soils

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***Abstract*—**The objective of this study was to investigate the capability of *Chenopodium album L.* to remediate lead polluted soils. For this purpose, a randomized block experiment design was performed. The soil was contaminated with $PbNO_3$ and the treatments were consisted of 0 (standard), 150, 300, 600, 900 and 1200 mg/kg lead. After development, plants were harvested and divided into shoot and root parts. The lead content of shoot, root and also the soil-lead were measured. The results indicated that by increasing the lead concentration in soil, its accumulation in plant tissues was also increased. By increasing lead concentration in the soil,the metal transport factor was decreased. According to the obtained results, the resistance index of *Chenopodium album L.* was more than 1. Therefore, concerning its resistant and its high biomass, halophyte *Chenopodium album L.* can be used as a hyperaccumulator plant to remediate lead polluted soils.

Keywords—*Chenopodium album L*, lead, phytoremediation, pollution

I.INTRUDOCTION

Phytoremedian is one of the newly proposed methods to remediate soils from heavy metals. In this method plants are used to clean up the contaminated soils [3]. Many investigations by several researchers were conducted on different aspects of phytoremediation [9]-[12]-[4]-[7]-[8]-[10]-[5]-[6]-[1]and all confirm that this technology is sustainable to clean up the contaminated soils, Although this method is inexpensive, efficient and environment-friendly, but it is a time-consuming method. The first recognized plants to accumulate heavy metals belonging to *Brassicaceae* and *Fabaceae* families [2]. The objective of this study was to investigate the capability of *Chenopodium album L.* to extract lead from contaminated soils with high content of Pb.

II. Material and methods

This research was conducted in a randomized block experimental design with six treatments and four replicates. The designed treatments were consisted of 150 (standard), 300, 600, 900 and 1200 mg/kg lead.To get some information about physical and chemical properties of the experimental soils, some soil samples wereair dried, mixed, passed through 2 mm sieve to measure their cadmium contents. Experiments including electricalconductivity of saturation extract was measured with a conductivity meter, soil organic matter concentration with WalkleyandBlackmethod, soil texture with hydrometer method, calcium carbonate content with titration method, bulk density with cylinder method, cation exchange capacity with cations situation with sodium acetate and soil pH was measured with with a pH meter. Table 1 gives some physical and chemical properties of the experimental soils.

Table 1. Some physical and chemical properties of the experimental soil

Soil texture	EC_e (dS/m)	O.M (%)	CaCO3 (%)	CEC (cmolc/kg)	pH	Bulk density (gr/cm^3)
Sandy clay loam	6.71	0.7	7.5	14	7.58	1.33

To contaminate the experimental soils, the soils were first thoroughly sprayed with PbNO3. Five other treatments including 150, 300, 600, 900 and 1200 mg/kg lead denoted as Pb2, Pb3, Pb4, Pb5, Pb6 were established withfour replicates for each treatment. To obtain chemical equilibrium between contaminant and soil and also to create natural contamination conditions,the experimental treatments with their replicates were left for 50 days, receiving enough water every 24 hours. When the chemical equilibrium between lead and soil was obtained, different lead forms in the soil treatments were measured. The soils were weighted about 7 kg for each pot and were carefully packed in the pots to obtain a uniform bulk density of 1.33 g/cm^3. After that the seeds were seeded in the pots. To prevent any water stress during the growth period, soil water content was always held at field capacity.

When plants were fully developed, plants were harvested and divided into shoot and root parts. Different chemical forms of lead concentrations in the soil were then measured with continuous extraction method [11]. The lead concentration in shoots and roots was measured by digestion with complex of nitric acid-perchloric acid and sulfuric acid with 1:4:40volume based and analyzed for Pb by ICP-ES apparatus.The soil lead concentration was measured, using theAtomic Absorption apparatus. Finally, the effect of soil lead concentration on lead absorbed by different parts of plant including shoot and roots was performed with statistical comparison of averages, using the Duncan's multiple range test method with SPSS software.

III.Results

Metal or metalloid transport factor is the amount of accumulated metal in shoot per amount of accumulated metal in root (shoot/root ratio). By increasing the lead concentration in the soil, the metal transport factor was decreased under 600 mg kg^{-1} soil Pb content, but from 600 to 1200 mg kg^{-1} soil Pb content, metal transport factor was increased, which was not considerable. The relationship between soil Pb concentrations and metal transport factoris presented in Fig. 1.

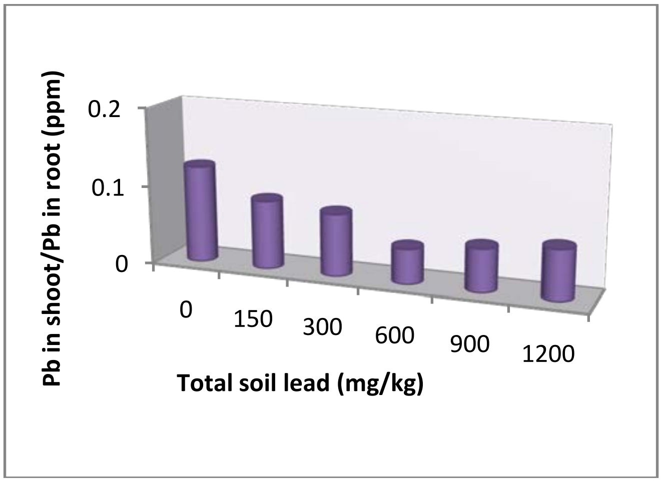

Fig. 1 Relationship between soil Pb concentrations and metal transport factor in plants

Phytoextractionefficiency determine with two key factors of hyperaccumulator plants capacity to heavy metal absorption and high biomass production. Though that this plant can accumulate lead in shoot and root but, its capability to phytoextraction process is depended on amount of produced dry matter.

To calculatethe relative performance, the plant dry weight in standard treatment was assumed to be equal to maximum dry weight of plant. Thus, relative performance was obtained by dividing dry weight of plants in various contaminated treatments to the maximum dry weight.Fig. 2 shows the influence of total soil lead on relative performance of plant.Byincreasing the lead concentration in soil, Plant yield (performance) was also increased and in 600 mg/kg lead treatment, the maximum yield was obtained. Thereafter, yield was decreased and this decreasing trend was continued until treatment of 1200 mg/kg lead. This decreasing trend was not considerable and plant yield in these levels was more than standard treatment.

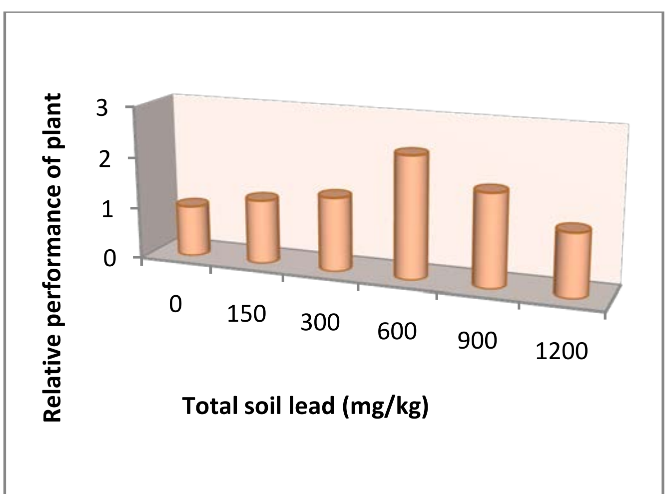

Fig. 2 Relative performance of plant in different soil Pb concentrations

The relationship between soil Pb concentrations and lead removal by shoots in one harvest time are presented in Fig. 3. According to increasing dry matter until treatment of 600 mg/kg lead, lead removal was also increased and by decreasing amount of dry matter in high Pb concentration lead removal was also decreased.

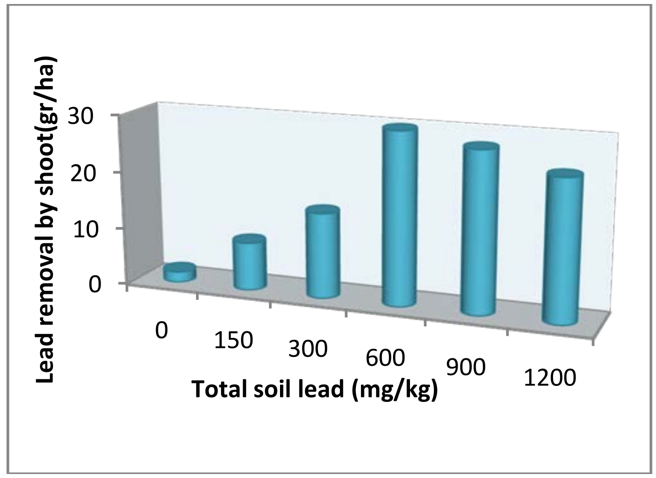

Fig. 3 The relationship between soil Pb concentrations and lead removal by shoots in one harvest

The results obtained from statistical comparison of average accumulative lead in roots and shoots with the Duncan's multiple range test indicate that the highest lead absorption occurred in the treatment with 1200 mg/kg Pb (P = 0.01). But there isn't meaningful difference between amount of lead accumulated in roots of treatments with 600, 900 and 1200 mg/kg Pb.

One of important characteristics of hyperaccumulator plants is high resistance of these plants into high levels of heavy metals. This characteristic with title of resistance index or tolerance index of plant is mean of plant dry matter in highest level of heavy metal per mean of plant dry matter in standard treatment. Plant resistance index for*Chenopodium album* L. was 1.22.

$$\text{Resistance index} = (\text{mean of dry matter in high level of pollution}) \,/\, (\text{mean of dry matter in standard treatment})$$

$$\text{resistance index} = 17691/14485 = 1.22$$

IV.Conclusion

The overall results obtained in this study indicate that by increasing the lead concentration in soil, its accumulation in plant tissues was also increased, furthermore, there was no toxicity for this plant up to 1200 mg/kg soil lead and the highest lead absorption occurred in the treatment with 1200 mg/kg Pb. finally, according to plant resistance index of *Chenopodium album* L. was more than 1. Therefore, concerning its resistant and its high biomass, halophyte *Chenopodium album L*. can be used as a hyperaccumulator plant to remediate lead polluted soils.

References

[1] Asadi Kapourchal, So., Asadi Kapourchal, S., Pazira, E. and Homaee, M. (2009). Assessing radish (*raphanus sativus* L.) potential for phytoremediation of Lead- contaminated soils resulting from air pollution. Soil plant and environment, 55 (5): 202-206.

[2] Chaney R.L., Li Y.M., Brown S.L., Homer F.A., Malik M., Angle J.S., Baker A.J.M., Reeve R.D., Chin M. (2000). Improving metal hyperaccumulator wild plants to develop commercial phytoextraction systems: Approaches and progress. In: Terry N., Banuelos G. (eds): Phytoremediation of Contaminated Soil and Water. Lewis Publishing, Boca Raton, 129–158.

[3] Cunningham, S.D., W.R. Berti and J.W. Huang. (1995). Phytoremediation of contaminated soils. Trends Biotechnol. 13: 393–397.

[4] Finžgar N., Tlustoš P., Leštan D. (2007). Relationship of soil properties to fractionation, bioavailability and mobility of lead and zinc in soil. Plant, Soil and Environment, *53*: 225–238.

[5] Grejtovský A., Markušová K., Nováková L. (2008). Lead uptake by *Matricaria chamomilla* L. Plant, Soil and Environment, *54*: 47–54.

[6] John R., Ahmad P., Gadgil K., Sharma S. (2008). Effect of cadmium and lead on growth, biochemical parameters and uptake in *Lemna polyrrhiza* L. Plant, Soil and Environment, *54*: 262–270.

[7] Kalaji H.M., Loboda T. (2007). Photosystem II of barley seedlings under cadmium and lead stress. Plant, Soil and Environment, *53*: 511–516.

[8] Komárek M., Tlustoš P., Száková J., Chrastný V., Balík J. (2007). The role of Fe- and Mn-oxides during EDTAenhanced phytoextraction of heavy metals. Plant, Soil and Environment, *53*: 216–224.

[9] Kos B., Grčman H., Leštan D. (2003): Phytoextraction of lead, zinc and cadmium from soil by selected plants. Plant, Soil and Environment, *49*: 548–553.

[10] Turan M., Esringü A. (2007). Phytoremediation based on canola (*Brassica napus* L.) and Indian mustard (*Brassica juncea* L.) planted on spiked soil by aliquot amount of Cd, Cu, Pb, and Zn. Plant, Soil and Environment, *53*: 7–15.

[11] United States Environmental Protection Agency (1986). Acid digestion of sediment, sludge and soils. In: Test methods for evaluating solidwastes. EPA SW-846. US Government Printing Office, Washington D.C.

[12] Vysloužilová M., Tlustoš P., Száková J. (2003). Cadmium and zinc phytoextraction potential of seven clones of *Salix* spp. planted on heavy metal contaminated soils. Plant, Soil and Environment, *49*: 542–547.