

COMPARISON OF PHYTOREMEDIATION POTENTIAL AND MAI INDEX IN PLATANUS ORIENTALIS, ROBINIA PSEUDOACACIA AND FRAXINUS ROTUNDIFOLIA

Mojtaba Akhavan Armaki*

Elite club, Karaj Branch, Islamic Azad University, Karaj, IRAN

ABSTRACT

Phytoremediation, or the use of green plants to extract, sequester, and detoxify pollutants, has shown considerable promise as a low-cost technique and has received much attention in recent years. Plants are capable of reducing environmental pollutions through uptaking contaminants in their tissues. This study was conducted to determine the uptaking ability of Cd and Pb by the leaves and shoots of *Platanus orientalis*, *Robinia pseudoacacia* and *Fraxinus rotundifolia* in Karaj city, the western Tehran, Iran. In the study site, twenty one-year-old leaves and shoots as well as twenty soil samples were sampled and analyzed by ICP. The results indicated that there was no significant difference in uptaking contents of Cd and Pb in the leaves among the trees. However, the mean concentration of the contaminants in shoots of *Platanus orientalis* was significantly higher than those of *Fraxinus rotundifolia*. No significant difference, however, was observed between the contaminants concentration in shoots of *Robinia pseudoacacia* and those in the others. The amount of Pb in the soil of the study area was significantly higher than Cd. Concentration of Cd and Pb in leaves of the species had the equal amount between all three species vary between 2.3 - 2.7 for Cd and 5.3 - 12.7 ppm for Pb. *Fraxinus rotundifolia* had the highest MAI value for leaves (2.22) and for shoots (2.75) further than the *Platanus orientalis* and *Robinia pseudoacacia*.

Published on: 25th– Sept-2016

KEY WORDS

Fraxinus rotundifolia, *Robinia pseudoacacia*, *Platanus orientalis*, Heavy metals, Phytoremediation

*Corresponding author: Email: mtakhavan@ut.ac.ir; Tel.:+9836525470; Fax:036525218

INTRODUCTION

Phytoremediation, or the use of green plants to extract, sequester, and detoxify pollutants, has shown considerable promise as a low-cost technique and has received much attention in recent years. Additionally, this method can be accomplished in situ, it is environmentally friendly and the soil can be utilized immediately after treatment [1]. The term “heavy metal” refers to any metallic element with an atomic density greater than 6 g/cm³. These metals are ubiquitous, highly persistent and nonbiodegradable. [2].

Increasing industrialization and human activities intensify the emission of various pollutants into the environment and introduce various harmful substances into the atmosphere. Atmospheric pollution has harmful effects on humanity and plant growth [7]. Air pollution in urban areas could be caused by many sources and several methods have been developed to determine the sources and the level of this pollution. One of these techniques is using organisms as bioindicators and biomonitors [18]. Plants are able to reducing contaminants from the environment in different ways. They can achieve this through uptake, stabilization and translocation of materials [4, 6]. Excessive ability of some species in selective uptake of elements and contaminants, therefore, has provided a favorable use of plants in phytoremediation, use of plants to remove pollutants from the environment or to render them harmless [3, 15]. During the last decades, phytoremediation has grabbed researcher’s attentions because of being cheaper than other common methods and also being in harmony with environment [8].

Environmental risk and damage occurs when the metals are available to living organisms [10]. Some heavy metals such as lead (Pb) and cadmium (Cd) which are not essential nutrients in organisms and exposure to low concentrations of them and cause high toxicity to plant and animal, can be removed from environment by plants. As well Pb and Cd can concentrate in aerial organs, annual and perennial shoots of some plants [5, 16].

Thus the researchs which probe the ability of the plants for remedy of the Pb and Cd will help us to introduce more suitable plants for phytoremediation in contaminated regions [2, 8]

The main goal of this study was to determine the ability of *Platanusorientalis*, *Robiniapseudoacacia* and *Fraxinusrotundifolia* in uptaking of Cd and Pb from air and soil in one of the biggest park in Karaj city, Iran. The selected trees were extensively planted in Karaj and exposed to varying extents of Cd and Pb due to industrial and other activities.

MATERIALS AND METHODS

Study Site

The study site is located in Karaj (Jahan park, with an area about 110753 m²), 20 Km west of Tehran-Iran (Latitude 35° 51' N, Longitude 50° 50' E and 1300 m above sea level). The climate of the area is semi-arid with mild- cold winters and 7 months (Mid April-Mid November) dry season. Average annual rainfall and average annual temperature are 232 mm and 13.3° C, respectively. The highest rainfall is in March (41.32 mm) and the lowest in August (0.89 mm). The warmest month occurs in August and the coldest in January [Figure- 1].

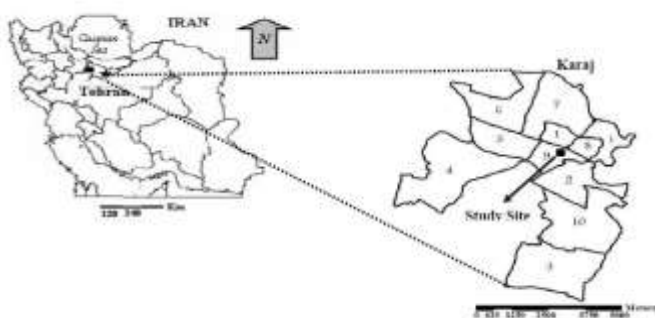


Fig:1. Location of investigation area (Jahan Park located in district 9 of Karaj city)

Field Sampling

Twenty trees of the nearly even-aged trees of Plain tree (*Platanusorientalis*), Black locust (*Robiniapseudoacacia*) and Persian Ash (*Fraxinusrotundifolia*) were selected. 20 even-aged trees of each mentioned species were relatively even-aged, were selected. The annual shoots and leaves from the lower part of crown were collected in four different directions at October, 2015. In total, 20 samples were taken from leaves and shoot of each species (60 leaves and 60 shoot samples). To determine the concentrations of Cd and Pb in the soil of mineral depth, 20 soil samples were taken in the depth of 0-30 cm from surface to rooting layer.

Laboratory Measurements

Soil properties of the study area are shown in Table 1. For determining the concentrations of Cd and Pb in leaves and shoots, leaves samples were washed with a shaving brush and double-distilled water to eliminate surface contaminants. Then samples were dried in oven 78 °C for 48 hours and pulverized with a chipper. Then 4-mL sulphuric acid and 16-mL Hydrogen peroxide were added to 0.5-g sample for digestion process. The extracts were exposed at 440°C in the Digesdahl. After 5 min the digestion process were completed and metal accumulation of extracts were measured by ICP (OES) set. The calibration process was done by the 1,000 mg-Kg-1 solution for Lead and Cadmium (MERCK), respectively.

Table: 1. Soil characteristics in the investigation region (Jahan park)

The investigation area			
Jahan park	Sandy-clay-loam	8.1	0.74

Data Analysis

Finally, means of lead and cadmium in each organ were statistically compared using SPSS software and Games-Howell test. We used an accumulation index to assess the overall performance of the trees. Since this index is for metals, therefore it was termed as metal accumulation index (MAI) [9].

RESULTS

The concentrations (ppm) of Cd and Pb in the leaves and shoots of the *Platanusorientalis*, *Robiniapseudoacacia* and *Fraxinusrotundifolia* as well as in the soil of study area are shown in [Table- 2]. The total amount of Cd and Pb in the soil of this region are low and the pollution rate could not be announced as a problem [9, 13].

Concentrations of Cd and Pb in the leaves of *Platanusorientalis*, *Robiniapseudoacacia* and *Fraxinusrotundifolia* were shown in [Figure- 2 and 3]. The results showed that there were no significant differences among leaves of the species in concentration of Cd and Pb. However accumulation of Cd and Pb in shoots of *Platanusorientalis* was significantly higher than concentrations of Cd and Pb in shoots of the other species. The significance different between species in shoots opposite of leaves introduce a transporting process from leaves to shoot in all of the species at the end of October.

Table 2. The concentrations of Cd and Pb (ppm) in the leaves and shoots of the *Platanusorientalis*, *Robiniapseudoacacia* and *Fraxinusrotundifolia*

Species		The average of concentration (ppm)	
		Cd	Pb
Platanusorientalis	Leaf	2.7±0.2	12.7±1.9
	Shoot	2.4±0.1	11±2.1
Robiniapseudoacacia	Leaf	2.3±0.1	11.3±2.1
	Shoot	2.6±0.1	9.7±1.5
Fraxinusrotundifolia	Leaf	2.3±0.1	6.2±1.3
	Shoot	2.4±0.1	5.3±0.9
Soil		3.4±0.3	11.2±2.4

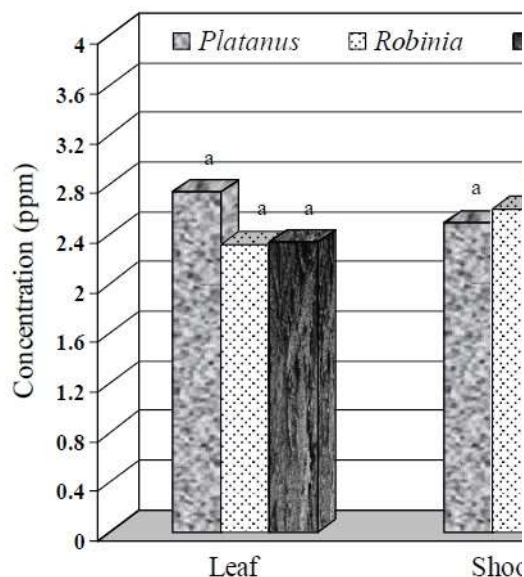


Fig: 2. Comparison of Cd uptake by the leaves and shoots of the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other (p ≤ 0.05))

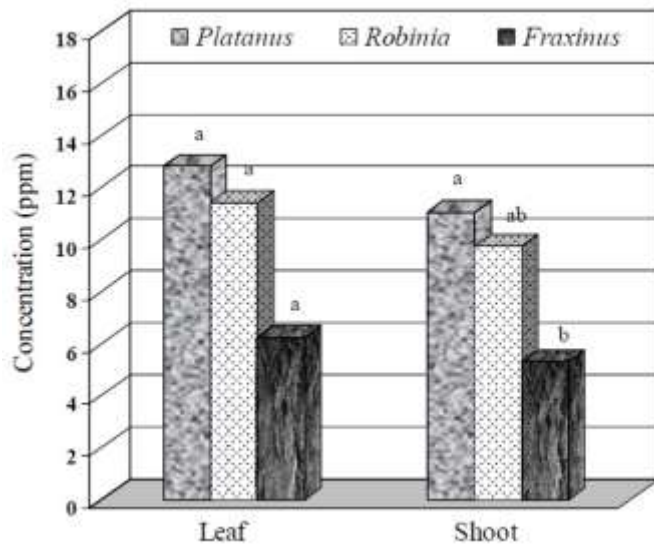


Fig. 3. Comparison of Pb uptake by the leaves and shoots in the studied species (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$))

Also the results indicated that there was a significant difference between absorption of Cd and Pb in leaves and shoots of the tree species. The concentration of pb in leaves and shoots of the species was heifer than Cd [Figure-. 4 and 5]. This could be due to the fact that the concentration of the Pb in the soil (11.2 ppm) was heifer than Cd (3.4 ppm) [Table- 2] [11].

As shown in [Figure- 6 and 7] there was no significant differences between leaves and shoots in all of the species in absorption of Cd and Pb.

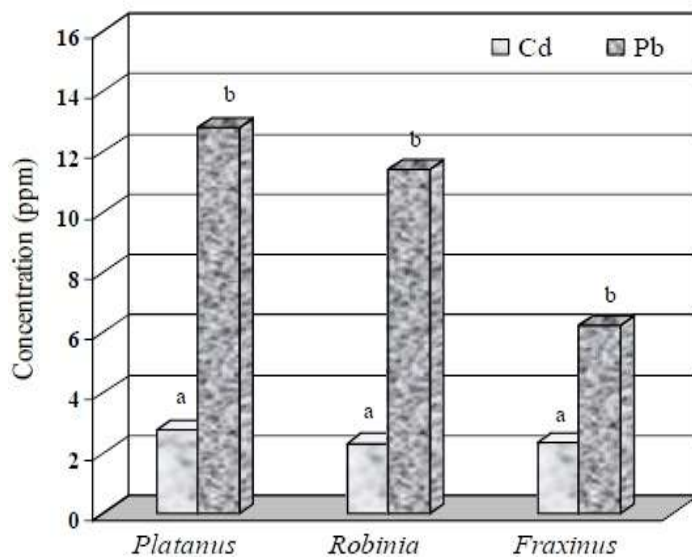


Fig:4. Comparison of Cd and Pb uptake by the leaves in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$)).

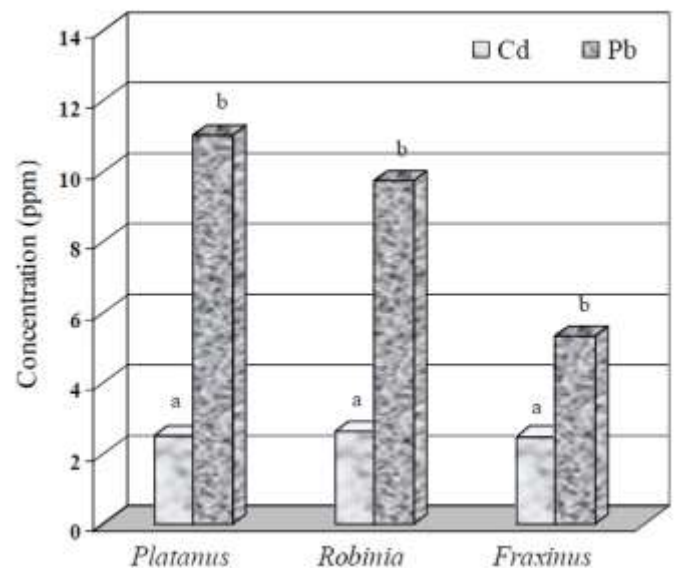


Fig: 5. Comparison of the amounts of Cd and Pb uptake by the shoots in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$))

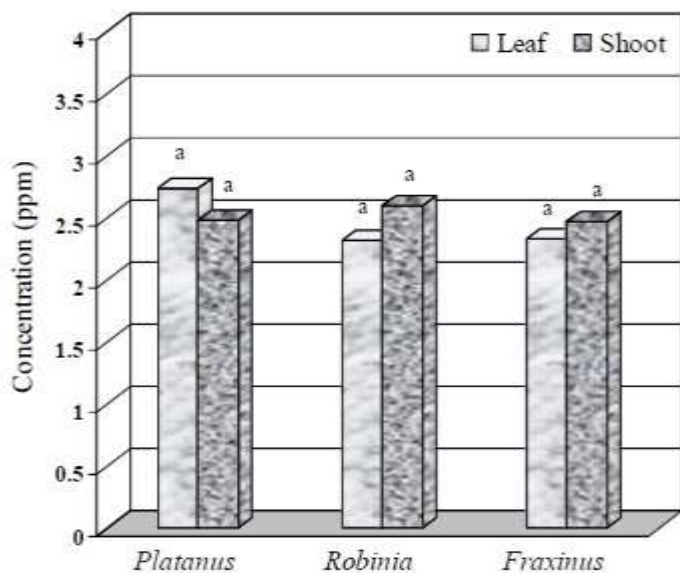


Fig: 6. Comparison of the leaves and the shoots uptake of Cd in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$)).

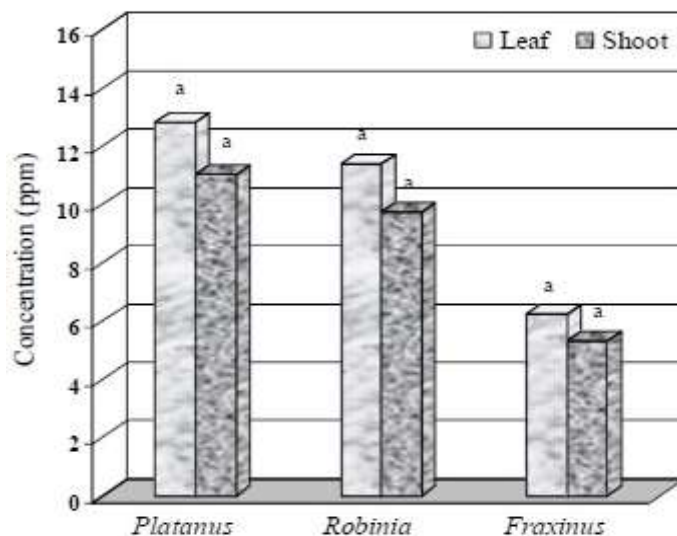


Fig: 7. Comparison of the stems and leaves uptake of Pb in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$)).

As explained before, we used metal accumulation index to assess the overall performance of the trees in terms of metal accumulation [9]. By applying this index to individual species, we found that *Fraxinusrotundifolia* had the highest MAI value for leaves (2.22) and for shoots (2.75) further than the *Platanusorientalis* and *Robiniapseudoacacia* [Table- 3]. It is clear that the total amount of contaminant in this region is apparently very low and the pollution rate could not be announced as a problem.

Table: 3. The values of metal accumulation index (MAI) for studied species

Species	Metal accumulation index	
	Leaf	Shoot
<i>Platanusorientalis</i>	2	2.68
<i>Robiniapseudoacacia</i>	1.95	2.53
<i>Fraxinusrotundifolia</i>	2.22	2.75

Concentration of Cd and Pb in leaves of the species had not any significance different between different species, whereas Aftabtalab (2008) demonstrated the higher amount of *Platanusorientalis* leaf absorption in Cd and Pb versus *Cupressusarizonica*.

Shoots absorption of Cd and Pb in *Platanusorientalis* was significantly higher than *Fraxinusrotundifolia* and *Robiniapseudoacacia*. While the MAI index for *Fraxinusrotundifolia* was a little higher than the other species both for leaves and shoots.

CONCLUSION

In conclusion, it seems that the little amount of pollutants in soil of the study area is the most important reason for lower absorption of Cd and Pb in the leaves and shoots of the trees. In addition the significance difference between species in shoots versus leaves suggested a transporting process from leaves to stem in all of the species at the end of October. We found out that *Platanusorientalis* is the most suitable species for phytoremediation as Zeynep and Atmaca (2011) announced similar condition for *Platanusorientalis*.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

ACKNOWLEDGEMENT

None

FINANCIAL DISCLOSURE

No financial support was received to carry out this project.

REFERENCES

- [1] Aftabtalab N. [2008] Ability of Phytoremediation of Lead and Cadmium by *Platanusorientalis* and *Cupressusarizonica*. M.Sc Thesis, University of Tehran. Karaj, Iran. (in Persian with English extended abstract).
- [2] Amalia M, Favela-Torres E, Rivera-Cabrera F, Volke-Sepulveda T. [2011] Lead bioaccumulation in *Acacia farnesiana* and its effect on lipid peroxidation and glutathione production. *Plant and Soil* 339: 377-389
- [3] Casado M, Anawar HM, Garcia-Sanchez A, Santa Regina I. [2008] Cadmium and zinc in polluted mining soils and uptake by plants (El Losar mine, Spain). *International Journal of Environment and Pollution* 33: 146-159
- [4] De franca E, DN Fernandes E, A Bacchi M, R Rodrigues R, Bode P, Saiki M. 2010. Native plant bioaccumulation strategies: a baseline study for biomonitoring the Atlantic Forest. *International Journal of Environment and Health* 4:181-200
- [5] Dong J, Wu F, Zhang G. [2005] Effect of cadmium on growth and photosynthesis of tomato seedlings. *Journal of Zhejiang University Science* 6:974-980
- [6] Ghosh M, Singh SP. [2005] A review on phytoremediation of heavy metals and utilization of its byproducts. *Applied Ecology and Environmental Research* 3:1-18
- [7] Huseyinova R, Kutbay HG, Bylgyn A, Kilic D, Horuz A, Kirmanodlu C. [2009] Sulphur and Some Heavy Metal Contents in Foliage of *Corylusavellana* and Some Roadside Native Plants in Ordu Province, Turkey. *Ekoloji* 70:10-16
- [8] Khodakarami Y, Shirvany A, Zahedi G, Matinizadeh M, Safari M. [2009] Evaluation of soil bioremediation in *Pistaciaatlantica* and *Quercusbrantii*. *Iranian Journal of Forest* 1:313-320. (in Persian with English abstract)
- [9] Liu YJ, Zhu YG, Ding H. [2007] Lead and cadmium in leaves of deciduous trees in Beijing, China: Development of a metal accumulation index (MAI). *Environmental Pollution* 145:387-390
- [10] Mah F, Sit V, Blok H. 2007. The Effect of Cadmium Ions on the Growth Rate of the Freshwater Macrophyte Duckweed *Lemna minor*. *Ekoloji* 62:9-15
- [11] Prasad MNV. [2004] Heavy metal stress in plants: From Biomolecules to Ecosystems. Narosa Publication, America
- [12] Pulford ID, Watson C, Mcgregor SD. [2001] Uptake of chromium by trees: prospects for phytoremediation. *Environmental Geochemistry and Health* 23:307-311
- [13] Purohit SS, Agrawal A. [2006] Environmental pollution Causes, Effects And Control. Agrobios Publication. India
- [14] Rafati M, Khorasani N, Moattar F, Shirvany A, Moraghebi F, Hosseinzadeh S. [2011] Phytoremediation Potential of *Populus Alba* and *Morus alba* for Cadmium, Chromium and Nickel Absorption from Polluted Soil *Int J Environ Res* 5(4):961-970
- [15] Salt DE, Smith RD, Raskin I. [1998] Phytoremediation. *Plant Physiology and Plant Molecular Biology* 49:643-668
- [16] Tang Y, Qiu R, Zeng X, Fang X, Yu F, Zhou X, Wu Y. [2009] Zn and Cd hyperaccumulating characteristics of *Picrisdivaricata* Vant. *International Journal of Environment and Pollution* 38: 26-38
- [17] Torresday JL, Videa JR, P Rosa GD, Parsons J. [2005] Phytoremediation of heavy metals and study of the metal coordination by X-ray absorption spectroscopy. *Coordination chemistry Reviews* 249:1797-1810
- [18] Yildiz A, Aksoy A, Akbulut G, Demirezen D, Islek C, Altuner EM, Duman F. [2011] Correlation between Chlorophyll Degradation and the Amount of Heavy Metals Found in *Pseudeverniafurfuracea* in Kayseri (Turkey). *Ekoloji* 78:82-88
- [19] Zeynep D, Atmaca M. [2011] Influence of Airborne Pollution on Cd, Zn, Pb, Cu, and Al Accumulation and Physiological Parameters of Plant Leaves in Antakya (Turkey). *Water, Air, and Soil Pollution* 214:509-523

article is published as it is provided by author and approved by reviewer(s). Plagiarisms and references are not checked by IIOABJ.