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

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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.

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KEY WORDS

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

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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, 3].

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 [4]. 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 [5]. Plants are able to reducing contaminants from the environment in different ways. They can achieve this through uptake, stabilization and translocation of materials [6, 7]. 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 [8, 9]. 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 [10].

Environmental risk and damage occurs when the metals are available to living organisms [11]. 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 [12, 13]. 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 [14, 10]

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The main goal of this study was to determine the ability of Platanus orientalis, Robinia pseudoacacia and Fraxinus rotundifolia 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 (**Fig. 1**).

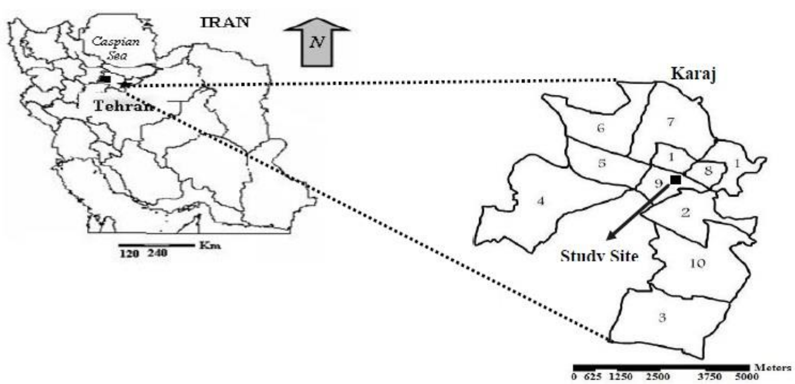

Fig: 1. Location of investigation area (Jahan Park located in district 9 of Karaj city)

Field Sampling

Twenty trees of the nearly even-aged trees of Plain tree (Platanus orientalis), Black locust (Robinia pseudoacacia) and Persian Ash (Fraxinus rotundifolia) 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	Soil texture	pH	EC (mS)
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.

THE IIOAB JOURNAL ISSN: 0976-3104

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) [15].

RESULTS

The concentrations (ppm) of Cd and Pb in the leaves and shoots of the Platanus orientalis, Robinia pseudoacacia and Fraxinus rotundifolia 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 [15, 16].

Concentrations of Cd and Pb in the leaves of Platanus orientalis, Robinia pseudoacacia and Fraxinus rotundifolia were shown in `**Figs. 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 Platanus orientalis 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 *Platanus orientalis, Robinia pseudoacacia* and *Fraxinus rotundifolia*.

Species		The average of concentration (ppm)	
		Cd	Pb
Platanus orientalis	Leaf	2.7±0.2	12.7±1.9
	Shoot	2.4±0.1	11±2.1
Robinia pseudoacacia	Leaf	2.3±0.1	11.3±2.1
	Shoot	2.6±0.1	9.7±1.5
Fraxinus rotundifolia	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	Soil

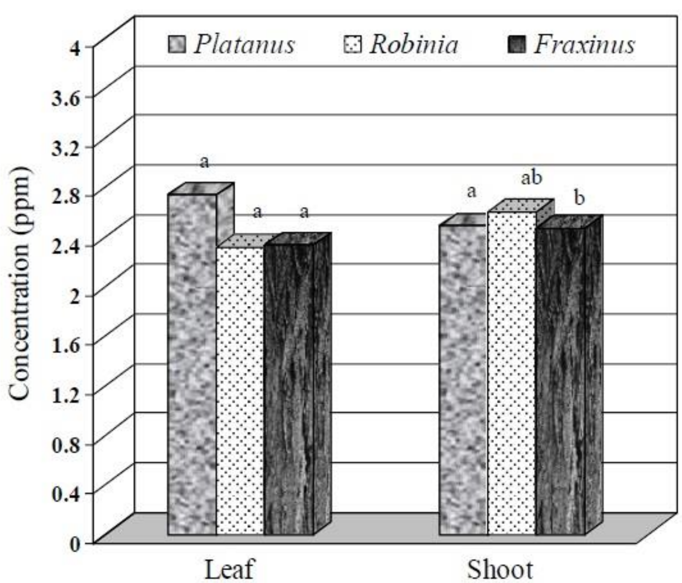

Fig: 2. Comparison of Cd uptake by the leaves and shoots of the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$)).

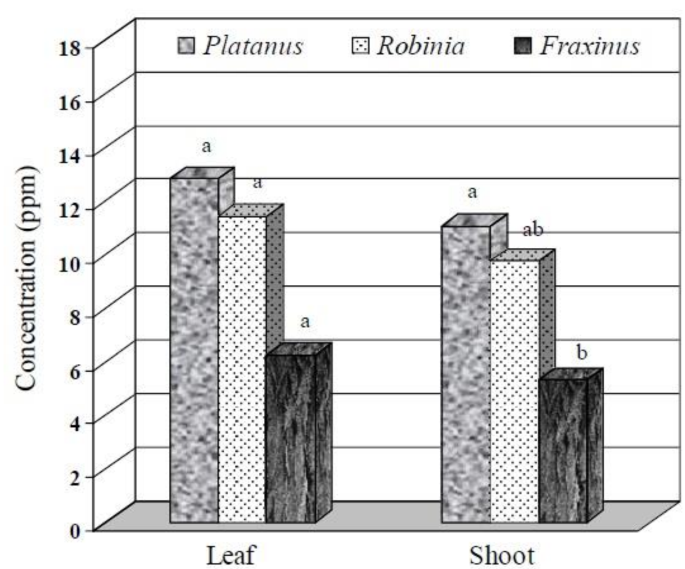

Fig: 3. Comparison of Pb uptake by the leaves and shoots in the studied species (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other ($p \leq 0.05$)).

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 `Figs. 4

THE IIOAB JOURNAL ISSN: 0976-3104

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**) [17].

As shown in `Figs. 6 and 7` there was no significant differences between leaves and shoots in all of the species in absorption of Cd and Pb.

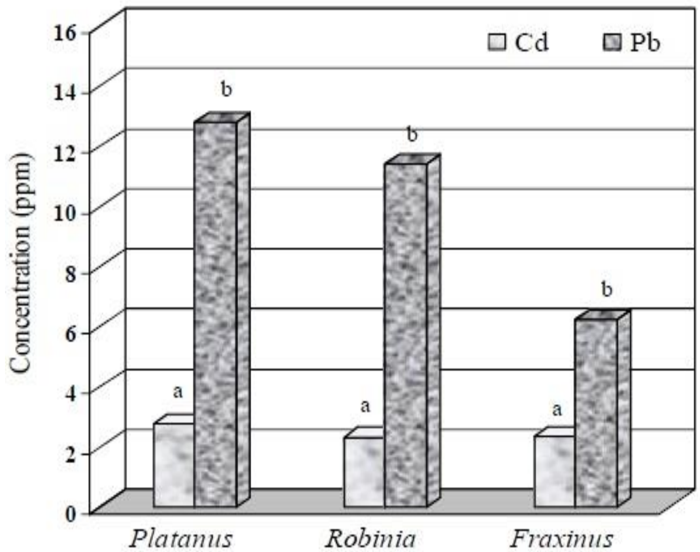

Fig: 4. Comparison of Cd and Pb uptake by the leaves in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other (p ≤ 0.05)).

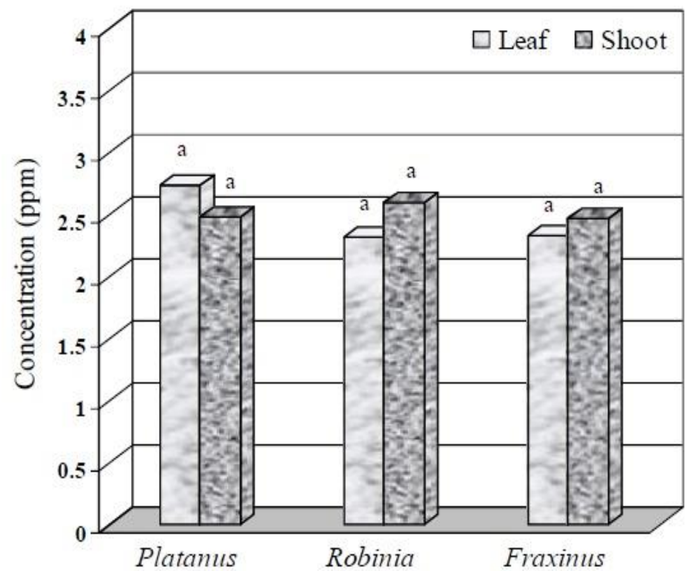

Fig: 6. Comparison of the leaves and the shoots uptake of Cd in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other (p ≤ 0.05)).

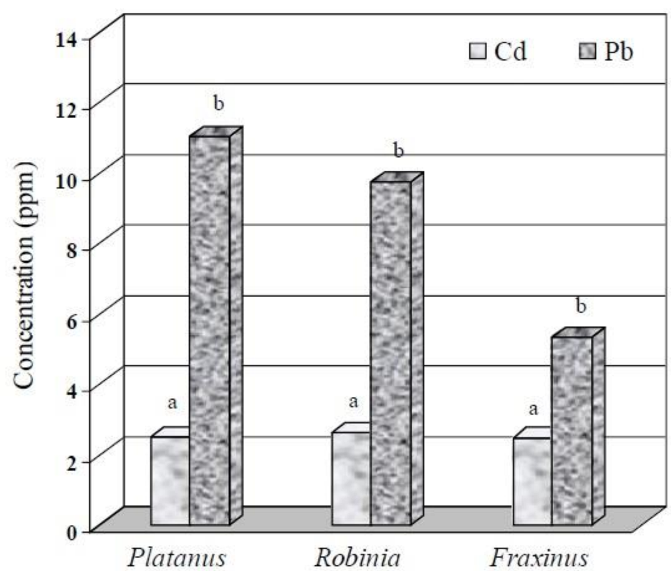

Fig: 5. Comparison of the amounts of Cd and Pb uptake by the shoots in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other (p ≤ 0.05)).

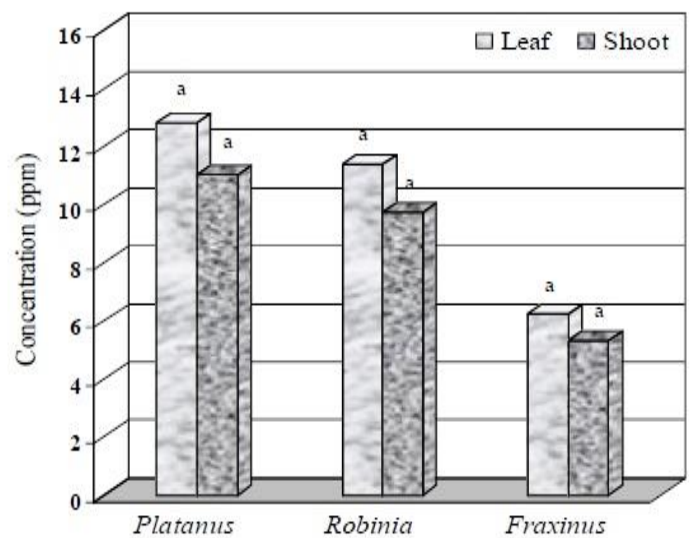

Fig: 7. Comparison of the stems and leaves uptake of Pb in the studied spices (Error bars show the Standard Error of Mean (SE); means with similar letters do not differ from each other (p ≤ 0.05)).

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As explained before, we used metal accumulation index to assess the overall performance of the trees in terms of metal accumulation [15]. By applying this index to individual species, we found that Fraxinus rotundifolia had the highest MAI value for leaves (2.22) and for shoots (2.75) further than the Platanus orientalis and Robinia

THE IIOAB JOURNAL ISSN: 0976-3104

pseudoacacia (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
Platanus orientalis	2	2.68
Robinia pseudoacacia	1.95	2.53
Fraxinus rotundifolia	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 Platanus orientalis leave absorption in Cd and Pb versus Cupressus arizonica. Shoots absorption of Cd and Pb in Platanus orientalis was significantly higher than Fraxinus rotundifolia and Robinia pseudoacacia. While the MAI index for Fraxinus rotundifolia 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 Platanus orientalis is the most suitable species for phytoremediation as Zeynep and Atmaca (2011) announced similar condition for Platanus orientalis.

CONFLICT OF INTEREST
Authors declare no conflict of interest.

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FINANCIAL DISCLOSURE
No financial support was received to carry out this project.

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