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Effects of Iron Sprays on Pb lead and Cadmium Cd Absorption by Ashtrees

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ABSTRACT: Considering the importance of phytoremediation as an effective method in reducing environmental pollutants, especially heavy metals, an experiment using the split plot in time arrangement with three replications was conducted in this research to study the extent the two heavy metals lead and cadmium were absorbed by ash trees planted in the green space of our country. The experimental treatments included iron sulfate and iron chelate sprays and the control at three different sampling times (start of the growing season, end of the growing season, and the onset of leaf fall). According to the results, the highest lead concentration was observed in the iron sulfate treatment that, of course, was not significantly different from that of the iron chelate treatment. The maximum cadmium concentration belonged to the iron chelate treatment. The maximum cadmium concentration was observed in the treatment with iron chelate. In this treatment, the highest leaf chlorophyll a content was measured, but it decreased significantly with the passage of time. Chlorophyll b and total chlorophyll reached their minimum levels at leaf fall, but carotenoid content was not influenced by various spray treatments, while the maximum total chlorophyll content was that of the iron chelate treatment. The mutual effects of treatment and time on leaf carotenoid content showed that its minimum content was observed in both the control and the iron chelate treatments at leaf fall, while its maximum content was measured at the beginning of the growing season and in the control. However, there were no significant differences between leaf carotenoid contents in the three spray treatments at the end of the growing season. The mutual effects of treatment and time on changes in lead content indicated that lead content at the studied times was the same in all treatments. Leaf iron content increased in all of the three spray treatments with the passage of time. It reached its maximum at leaf fall in the iron chelate treatment, which was significantly higher compared to those at other times.

Keywords: Heavy metals, phytoremediation, chlorophyll, iron chelate, iron sulfate, lead, cadmium

INTRODUCTION

One of the most important effects of green space in cities is their environmental functions because green space creates a balance in the urban metabolism on the one hand and, on the other hand, improves the quality of urban life through raising the beauty level of cities. Environmental pollution is one of the phenomena of modern life that results from waste materials, effluents, and polluting gases produced in nonstop human activities, and directly or indirectly influences living organisms (Abbaspour, 2004). Heavy metals are indecomposable and have physiological effects on living organisms even at very low concentrations and, hence, are considered one of the factors that disrupt ecosystems (Dabiri, 2000).

Although a number of heavy metals are necessary for plant growth, almost all of them are considered toxic at high concentrations. Their undesirable effects on plants include reduced plant growth, decreased plant cover, and loss of plat species that cannot tolerate heavy metals, while reduced fertility and soil erosion are among their adverse effects on soils (Moosavinasab, 2003; Dabiri, 2000).

In general, growth inhibition, damage to plant structure, and decreased plant physiological and biological activities such as yield are among the undesirable influences of heavy metals on plants. In addition to plant growth, these elements influence photosynthetic pigments (Oancea *et al.,* 2005).

Lead is one of the heavy metals that are not chemically decomposed by microorganisms, and tends to accumulate in soils (Baker and Brooks, 1989). It does not play an important role in the physiological reactions of plants, but may be absorbed by plants due to its chemical similarity with elements that are essential for plant growth. Generally, all plants are able to absorb lead, but trees play a more effective role in absorbing lead present in urban environments, and can protect residential areas and centers where humans gather against its undesirable effects. Cadmium is not an essential element for plants, but has great pollution potential because it is readily absorbed by plants and accumulates in them and, therefore, it is the first heavy metal that has attracted great interest from the environmental point of view (Dabiri, 2000). Cadmium is two to 20 times more toxic than many other heavy metals (Ghosh & Singh, 2005). Therefore, considering the ability of plants in absorbing heavy metals, expansion of green space through identifying and employing plants tolerant to heavy metals can be very effective in cleaning the environment.

Phytoremediation, use of plants that absorb heavy metals present in high concentrations, reduces concentrations of these elements in soils to below their critical levels, and is a simple, low cost, and eco-friendly method for removing heavy metals from soils (McGrath *et al.,* 2001). In this method, some plant species are used as absorbers of heavy metals from soil solution, and with their continuous cultivation in polluted regions, the level of soil pollution gradually declines.

Lead and cadmium reduce germination percentage and speed and speed of plant growth and development, with this reduction being dependent on the content and concentration of these heavy metals in the environment and on the length of time plants are exposed to them in the polluted environment. In a study with cadmium concentration of 10 mol / L, rate of germination decreased by 45% and growth and development of roots also declined (Zhang, 1997). In another research, cadmium and lead caused browning of plant pigments so that cadmium stress finally led to plant death (Mo, Li 1992). Roots are the first organ that are exposed to heavy metals, and absorb and accumulate greater quantities of them. Therefore, when roots are damaged, so are all other plant organs.

With increases in lead nitrate concentration, photosynthetic pigments chlorophyll a and b, and a+b significantly decreased in colza leaves, and leaf and root proline contents significantly increased (with the increase in roots greater than that in the leaves) (Lari Yazdi *et al.,* 2011). In another experiment, it was observed that increases in lead and zinc reduced alfalfa chlorophyll content, and that alfalfa had greater ability in producing chlorophyll and accumulating lead and zinc compared to green pea and common vetch (Kalantari *et al.,* 2011).

Iron absorption is greatly influenced by other cations so that competitive effects of ZN30, Mn20, Cu20, and Mg20 ions have been observed in iron absorption (Lingle *et al.,* 1963). Such effects on iron absorption may somewhat due to the ability of heavy metals in causing iron deficiency in some plant species (Hewitt, 1963).

Ash trees are extensively planted in green spaces in Iran, and incidence of leaf chlorosis resulting from iron deficiency caused by soil alkalinity is rising. These two important factors prompted us to study the behavior of ash trees as suitable plants for phytoremediation through absorbing lead and cadmium, and to investigate the response of these trees to applying fertilizer treatments containing iron.

MATERIALS AND METHODS

Experimental treatments: Iron sulfate spray (5g/l), iron chelate (5g/l), and control (water spray) applied on ash trees immediately after the first and second sampling. Plant samples were taken at three different times: the start of the growing season, the end of the growing season, and the onset of leaf fall.

Sampling method: Leaf samples were randomly taken from each ash tree at three different heights (the upper, middle, and lower parts) and from four directions of the crowns of the trees with emphasis on identical conditions of taking samples from different trees. After mixing the different samples taken from each tree, measurements related to the tree were made.

Assessed features:

Leaf dry weigh to fresh weight ratio: To determine this indicator, two grams of leaf tissue were weighed separately for each experimental unit. The samples taken from the trees were dried in an oven at 60?C for 72 hours for their water to evaporate and for their weight to become constant. The weights of the dried samples were recorded, and dry to fresh weight ratios and the water content of the leaves were calculated (Otsubo and Iwaya-Inole 2000).

Leaf chlorophyll and carotenoid contents: One-half gram of fresh leaves was weighed and completely ground using liquid nitrogen in a mortar. A specific quantity of 80% acetone at 0?C was then added to each sample, the samples were centrifuged for 15 minutes, and the supernatant was used to measure chlorophyll and carotenoid contents. Degrees of absorption were read in a spectrophotometer at 663.2 and 646.8 nm for chlorophyll and at 470 for carotenoid nm, and were used to determine chlorophyll and carotenoid contents.

Chlorophyll content (in mg/g fresh leaf weight) was determined using the related equations (Lichtenthaler, 1987)

Carotenoid content (in μg/ml was calculated using the related formula (Hill *et al.*, 1986)

Leaf lead, cadmium, and iron contents: Twenty-five hundredths (0.25) gram of the powder obtained from dried leaves was poured into a 100-ml beaker, 4 ml of sulfuric acid was added, and the beaker was shaken several times and put inside a Digesdhal digestion apparatus for extraction. After digestion of the plant samples, cadmium, lead, and iron contents in the obtained solution were assessed and read using an inductively coupled plasma spectrometer (Hakimi, 2014).This research was conducted using the split plot in time arrangement with three replications. Ash trees in the University College of Agriculture and Natural Resources School of Tehran University, located in a 40-ha area in the Dolatabad region of Karaj, were the statistical population, and the data was recorded in Excel and statistically analyzed with the help of SPSS and the ANOVA test.

RESULTS

Table 1: The Analysis of the Studying Variance Factors Affecting by Time and Treatment.

		Studying Features							
Change sources	**df**	**Chlorophyll a**	**chlorophyll b**	**Chlorophyll (a+b)**	**carotenoid**	**dry to fresh weight**	**Fe**	**Pb**	**Cd**
Rep	2	6.94*	0.36 ns	5.62*	0.82 ns	0.009 ns	21345.6 ns	4.9 ns	0.108 ns
Tr.	2	12.29**	1.62**	9.91**	0.52 ns	0.012 ns	114462.3 **	74.7 ns	1.195**
Error	4	1.89	0.23	1.66	0.46	0.007 ns	13526.4	41.6	0.082
Time	2	16.33**	22.32**	44.3**	16.55**	0.198**	181076.2**	623.3**	1.229**
Time*Tr.	4	11.26**	4.32**	5.61 ns	13.12**	0.003 ns	127512.3**	22.6 ns	1.039**
Rep.*Time	4	8.23**	4.21ns	31.42*	6.88**	0.004 ns	6544.3 ns	29.8 ns	0.039 ns
Error	8	0.82	0.79	0.84	0.46	0.011	6635.2	11.9	0.012
CV		11.4	17.7	7.1	13.6	18.7	16.9	17.8	14.6

Results of ANOVA showed the effect of replication on chlorophyll a and chlorophyll (a+b) contents was significant at the 5% level, but not on chlorophyll b and carotenoid contents (Table 1). The effects of treatments on all features were significant at the 1% level, except for carotenoid contents at the tested levels. The effect of time on all studied features, the mutual effects of time and treatment on all features except for chlorophyll (a+b), and the mutual effects of time and replication on chlorophyll a and carotenoid were significant at the 1% level (Table 1). However, the mutual effects of time and replication on chlorophyll b content were not significant. As shown in the ANOVA table, the effects of replication and the mutual effects of time and replication were not significant on any of the studied features at the tested levels (1 and 5%). Furthermore, the effects of time on all the studied features were significant at the 1% level, and the effects of treatment and the mutual effects of treatment and time on Fe and Cd contents were significant at the 1%, but not on the leaf dry weight to fresh weight ratio or on Pb content. Table 2 indicates that chlorophyll a content significantly declined with the passage of time. Moreover, the maximum chlorophyll b content was observed at the end of the growing season (which was significantly greater compared to the start of the growing season and at the onset of leaf fall).

Table 2: The Comparison of the Average of Time Effects on Studying Indicators.

	Studying Features							
Time	**chlorophyll a (mg/g)**	**chlorophyll b (mg/g)**	**chlorophyll (a+b) (mg/g)**	**carotenoid(μg/ml)**	**dry to fresh weight**	**Fe (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**
start of the growing season	12.95 a	3.85 b	16.80 a	7.26 a	0.71 a	221.2 c	13.9 c	0.83 a
end of the growing season	5.81 b	9.82 a	15.62 b	7.37 a	0.54 b	352.9 b	16.9 b	0.53 b
onset of leaf fall	4.95 c	1.44 c	6.39 c	2.71 b	0.60 b	870.1 a	27.6 a	0.90 a

The trend of changes in chlorophyll (a+b) content with the passage of time seemed to be similar to that of chlorophyll a. It appears there is an inverse relationship between chlorophyll (a+b) content and time: chlorophyll (a+b) content significantly declined with the passage of time. Carotenoid contents at the start and end of the growing season were not significantly different, but carotenoid content decreased with the passage of time and was significantly lower at leaf fall. Independent of the effects of the other experimental factors, the maximum leaf dry weight to fresh weight ratio was that of the start of the growing season, which was significantly higher compared to those at the end of the growing season and at leaf fall. There was a linear relationship with a positive slope between time and Fe changes: with the passage of time, Fe content increased significantly. The trend in Pb changes was similar to that of Fe: its content increased significantly with the passage of time. At the end of the growing season, the Cd content significantly decreased compared to the start of the growing season, but it increased significantly again at the onset of leaf fall compared to the end of the growing season.

Table 3: The Comparison of the Average of Treatment Effects on Studying Indicators.

	Studying Features							
Treatment	**chlorophyll a (mg/g)**	**chlorophyll b (mg/g)**	**chlorophyll (a+b) (mg/g)**	**Carotenoid (µg/ml)**	**dry to fresh weight**	**Fe(mg/kg)**	**Pb(mg/kg)**	**Cd(mg/kg)**
Iron sulfate	7.69 b	5.14 a	12.7 b	5.90 a	0.64 a	412.2 b	20.9 a	0.60 b
Iron chelate	8.49 a	5.15 a	13.6 a	5.80 a	0.62 a	548.5 a	19.7 ab	0.99 a
Control	7.52 b	4.82 b	12.4 c	5.60 a	0.59 a	484.1 ab	17.8 b	0.66 b

Comparison of the means of the studied factors under the influence of the treatments shows that the treatment of iron chelate had the maximum chlorophyll a content (which was significantly greater compared to the iron sulfate treatment and the control). The minimum chlorophyll b content was that of the control, while there were no significant differences between the iron sulfate and iron chelate treatments with respect to chlorophyll b content. The studied treatments were in separate statistical groups in relation to chlorophyll (a+b). The trend of changes in chlorophyll (a+b) content in the treatments was similar to that of chlorophyll a. The treatments were not significantly different in relation to carotenoid content, nor were there differences between them with respect to leaf dry weight to fresh weight ratio. There were no significant differences between the iron chelate treatment and the control and between the iron sulfate treatment and the control with respect to the Fe content, but the Fe content in the iron chelate treatment increased significantly compared to iron sulfate treatment. No significant differences were observed between the iron sulfate and iron chelate treatments and between the iron chelate treatment and the control in relation to Pb content, but Pb content in the control was significantly lower compared to that of the iron sulfate treatment. The Cd content increased significantly in the iron chelate compared to the control, but no significant differences were observed between the iron sulfate treatment and the control with respect to Cd content. The mutual effects of treatment and time on leaf chlorophyll a content show leaf chlorophyll content was at its maximum at the start of the growing season in all treatments, but it declined at the end of the growing season and at leaf fall.

Table 4: Interaction of Measuring Time and Treatment on Studying Indices.

		Studying Features							
Treatment	**Time**	**chlorophyll a (mg/g)**	**chlorophyll b (mg/g)**	**chlorophyll (a+b) (mg/g)**	**Carotenoid (µg/ml)**	**dry to fresh weight**	**Fe (mg/kg)**	**Pb (mg/kg)**	**Cd (mg/kg)**
Iron sulfate	T1	10.47b	3.13d	13.60c	6.39b	0.74a	227.7e	15.8bc	0.32b
	T2	5.99bc	10.13a	16.12b	7.53a	0.54c	349.5d	19.6b	0.42b
	T3	6.62b	2.15e	8.77d	3.79c	0.63bc	659.3c	27.3a	1.05a
Iron chelate	T1	14.52a	4.33c	18.85a	7.50a	0.74a	221.8e	14.5bc	1.45a
	T2	5.0bc	9.92a	15.72b	7.49a	0.55c	353.8d	15.5bc	0.69b
	T3	5.15b	1.18f	6.33e	2.40d	0.58bc	1069.8a	28.9a	0.84ab
Control	T1	13.73a	4.09c	17.82a	7.89a	0.65b	214.2e	11.3c	0.71b
	T2	5.75bc	9.41b	15.16bc	7.11ab	0.53c	355.5d	15.6bc	048b
	T3	3.09d	0.97f	4.06f	1.94d	0.60bc	882.5b	26.5a	0.80ab

The maximum chlorophyll a content at the start of the growing season was observed in the iron chelate treatment and the minimum in the control treatment and at the onset of leaf fall. At the start of the growing season, chlorophyll b content was low in all of the treatments, but it gradually increased and reached its maximum at the end of the growing season, and then decreased again. The maximum content of chlorophyll b was observed in the iron sulfate and iron chelate treatments at the end of the growing season, and its minimum content in the iron chelate treatment and the control at leaf fall. In the iron sulfate treatment, chlorophyll (a+b) content increased significantly at the end of the growing season compared to the start of the growing season, while its content at the onset of leaf fall decreased significantly compared to the end of the growing season. Moreover, in the iron chelate treatment and the control, chlorophyll (a+b) content decreased significantly with the passage of time. The studied treatments exhibited different reactions in relation to time because of the strong mutual effects of treatment and time so that, in the iron sulfate treatment, the carotenoid content at the end of the growing season increased significantly compared to the start of the growing season. However, it declined significantly at the onset of leaf fall compared to its previous levels. In the iron chelate treatment and the control, the maximum carotenoid content was observed at the start and end of the growing season, which was significantly greater compared to that at the onset of leaf fall.

As shown in the table of comparison of the means, the trend of changes in leaf dry weight to fresh weight ratio at the different studied times was the same in all of the treatments because the mutual effects of treatment and time were not significant. Therefore, the maximum leaf dry weight to fresh weight ratio was observed at the start of the growing season (which was significantly greater compared to that at the end of the growing season), while there were no significant differences between the start and the end of the growing season with respect to this ratio. The mutual effects of treatment and time on Fe content were not significant, therefore, the trend of changes in Fe at different time levels was the same in all of the treatments, and Fe content increased significantly in all three treatments with the passage of time. Since the mutual effects of treatment and time were not significant, changes in Pb were similar in all of the treatments at the studied times. Consequently, no significant differences were observed between the start and end of the growing season with respect to Pb content, but Pb content increased significantly at the onset of leaf fall compared to the other studied times. The mutual effects of treatment and time were significant in relation to Cd content so that there were no significant differences between the start and end of the growing season with respect to Cd content in the iron sulfate treatment. However, the Cd content at the onset of leaf fall was significantly higher compared to its previous levels. In the iron chelate treatment, the Cd content at the start of the growing season was significantly higher compared to the end of the growing season, but in the control there were no significant differences between the studied times with respect to Cd content.

DISCUSSION

Results of this research show that Chlorophyll a and (a+b) contents in the iron chelate treatment were greater compared to the other treatments, but no significant differences were found between the iron sulfate and iron chelate treatments in relation to chlorophyll b content, although both had higher chlorophyll b contents compared to the control. Carotenoid contents were not significantly different in the various treatments either. In this relation, Babaei *et al*. (2014), conducted research to study the content of photosynthetic pigments in strawberries under the influence of various iron fertilizers applied at different times and in various concentrations. They found that the fertilizer treatments had significant effects on chlorophyll a content but not on chlorophyll (a+b) content, so that the maximum leaf chlorophyll a content belonged to the iron sulfate treatment (10 mg of iron/kg of soil) and the Sequestrene Fe treatment (7.5 mg iron/kg soil) applied at planting.

Moreover, in a study Mohammadi *et al.* carried out in 2010 on peppermint, it was noticed various iron levels had significant effects on flavonoid, chlorophyll a and b, total chlorophyll, and on the chlorophyll a/b ratio.

In our experiment, chlorophyll a and (a+b) contents decreased but leaf lead content increased with the passage of time, while the trend of changes in chlorophyll b and carotenoid contents in the trees was contrary to that of cadmium. Therefore, the maximum chlorophyll b and carotenoid contents were observed at the end of the growing season, while cadmium content was at its lowest level at that time.

When lettuce seedlings were exposed to cadmium, chlorophyll content decreased after 6 and 12 days but contrary to photosynthesis, the passage of time had no significant effect chlorophyll content. Chlorophyll content decreased more compared to photosynthesis rate when cadmium concentration increased (Haghighi, 2008).

Early studies on various species indicated considerable reduction in photosynthesis rate under the influence of cadmium (Sawhney *et al.,* 1990; Shearan *et al.,* 1990a). Cadmium affects photosynthesis negatively in various ways. These adverse effects influence the extent of chlorophyll biosynthesis, biochemical activities in photosynthesis, and enzymatic activities in the Calvin cycle (Shearan *et al.,* 1999a).

Experiments on pea seedlings showed that increases in the duration of applying the cadmium treatment decreased photosynthesis rate after 6 and 12 days, and it was suggested the reason for this decline was reduced chlorophyll content (Chugh *et al*., 1999). Presence of cadmium in seedbeds of Brassica napus reduced total chlorophyll and carotenoid contents with the passage of time (Sanita di Toppi and Gabrielli, 1999). Our results showed the maximum iron and cadmium contents were observed by applying the iron chelate treatment and the maximum lead content in the iron sulfate treatment and, hence, there was no logical relationship between iron concentration and the concentrations of these two heavy metals. However, in research conducted by Rabbanifar (1998), it was found that there was a negative relationship between the iron content and the contents of heavy metals such as copper, manganese, magnesium, and zinc in peach tree leaves. Furthermore, considering the effect of iron in increasing chlorophyll a content (and, eventually, increased photosynthesis and plat metabolism rates), we can expect lead and cadmium absorption to increase. Therefore, it seems further research is required to determine the effects of iron on heavy metal absorption.

Ghorbanli *et al.* (2007) studied the effects of lead on chlorophyll and iron and manganese ions in colza (Brassica napus L.) and concluded that increases in lead content in this plant reduced leaf chlorophyll and calcium and iron ions in the roots and in the aerial organs. These results are in exact agreement with those we found in our research. In ash trees, lead content increases and chlorophyll content decreases with the passage of time.

In our research, the highest leaf dry weight to fresh weight ratio was observed at the beginning of the growing season, declined to its minimum at the end of the growing season, but then increased again.

Mahdavi and Kharmandar (2013) also showed in their experiment on Victorian Acacia that features such as stem fresh weight, total fresh weight, stem dry weight, and total dry weight were significantly influenced by lead. Moreover, Aladini (2007) studied physiological effects resulting from lead on growth parameters of alfalfa (*Medicago sativa* L.), and stated that fresh and dry weights of the roots and aerial organs, root and stem lengths, and leaf blade area decreased at the end of a 10-day treatment.

According to research conducted by Iqbal *et al*. (2012) also, the maximum fresh weight of the aerial organs of cabbage cultivars was observed in control plants, and the next greatest fresh weight was that of plants treated with 100 mg/kg of lead. The minimum fresh weight was obtained by using cadmium at 40 mg/kg, the largest dry weight of aerial organs belonged to the control plants and, compared to that, the maximum dry weight was achieved in the treatment of applying cadmium at 50 mg/kg. Moreover, the smallest dry weight of aerial organs was observed when plants were treated with lead at 200 mg/kg.

Results obtained by Haghighi (2008) indicated that increased cadmium absorption greatly reduced plant growth, which showed this element had toxic effects on the plant and created stress in it. Moreover, cadmium stress reduced plant weight considerably. Other researchers found similar results. Reduced plant weight under the influence of cadmium was reported in rice by Shah (2001) and in lettuce by Ostman (1996).

Sharifnia (2012) observed that increases in cadmium and lead concentrations, in general and in most cases, reduced fresh and dry weights of ornamental cabbage. Results of research by Farooqi *et al.* in 2009 on Persian silk trees (pink silk trees) indicated that fresh and dry weights of aerial organs decreased considerably under the influence of using cadmium and lead.

Research on cotton showed that during the first week that the seeds were planted and the cadmium treatment was applied, there were no changes in the natural trend of seedling growth but that, when cadmium concentration was raised in the second week after planting the seeds, plant growth and plant fresh and dry weights decreased (Aycicek *et al.,* 2008).

Comparison of previous studies with results obtained in our research leads us to conclude that increases in concentrations of heavy metals in plants are one of the reasons for the reduction in the dry weight to fresh weight ratio. However, in our study, before the second sampling at the end of the growing season (which coincided with rises in ambient temperature), drought stress reduced plant dry weight to fresh weight ratio, but this ratio increased somewhat after regular irrigation was performed.

Results of our research indicate that lead concentration increased with the passage of time and with approaching leaf fall (in early autumn), while cadmium concentration decreased, and reached its minimum level, at the end of the growing season, but then increased until the onset of leaf fall. In this relation, Pourfarhadi (1994) studied absorption of lead from the air in Tehran by the evergreen trees oleander and privet, and stated that leaves of these two species of trees absorbed lead particles in the air and, therefore, could act as a biological filter to reduce pollution caused these particles. Moreover, he investigated the role played by different seasons of the year in the extent of lead absorption from the air, and found that maximum lead absorption took place in summer, which conforms to the results of our study. Furthermore, the Parks and Green Space Organization of Tehran Municipality (1994) determined the extent of absorption of lead particles in the air by some species of ornamental plants in the Parks in Tehran, and concluded they absorbed lead in summer in the order of pine< ivy<European privet<magnolia<bay leaf<plane trees.

Lead concentration in these plants reached its maximum in August. Pourfarhadi (1994) and Shahmansoori (1995) also studied the role seasons and months of the year played in lead absorption by plants, and stated maximum lead absorption took place in summer (in August).

Results suggest lead content in tree species studied in our research fluctuated at various times and had an increasing trend in February, December, July, and August, respectively. Since absorption of elements by plants is an active physiological phenomenon, the degree of absorption increases in the warm months of the year with increases in temperature and respiration. Our results indicated that, contrary to lead, cadmium concentration decreased at the end of the growing season compared to the start of the growing season. However, results of a study carried out in Quetta in Pakistan showed that the extent of cadmium content in *Robinia pseudoacacia* was 0.71±0.3 and that of Fraxinus excelsior 0.90±0.4 mg/kg. Moreover, leaf cadmium content in the growing season was higher compared to that at leaf fall (Zaidi *et al*., 2005). Furthermore, Khajeh *et al.* (2011) noticed cadmium absorption by ash tree leaves in August was greater compared to those by leaves at leaf fall and to those by roots and stems, and found that greater quantities of cadmium were absorbed by ash tree leaves and acacia stems. Therefore, environmental pollution could be reduced by removing ash tree leaves from the environment. In addition, Aftabtalab (2008) showed that the degree of cadmium absorption by two-year old *Cupressus arizonica* leaves in June was greater compared to October, but the reverse was true in the case of *Platanus orientalis.*

Considering cadmium is mostly absorbed by roots from soils rather than by aerial organs and since, contrary to lead, cadmium is easily translocated from the roots to the aerial organs, water shortage and drought stress in the studied plants reduced the speed of raw sap translocation in plants and, therefore, less cadmium was absorbed and translocated to aerial organs.

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