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Biomonitoring of Trace Element in Air and Soil Pollution by Using Acacia

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ABSTRACT
Effects of soil and atmosphere pollution on some heavy metals (Fe, Zn, Pb, Cu, Mn and Cd) concentration in Acacia (*Robinia psudo acacia* L.) leaves were studied in the city of Isfahan, Iran. Samples were collected from four sampling sites representing area of high traffic density, light traffic area near the city, industrial area and one village far from pollution source as a control. Samples were collected in two seasons (June and September) in 2010 for chemical analysis. Based on the results, the collection time of leaf sampling did not showed any significant effects on concentration of the measured heavy metals in leaf samples. Chemical analyses of soil samples at depth of 0-10cm showed that concentration of these elements in most cases were lower than the maximum recommended levels. Lower concentrations of all measured heavy metals were found in washed leaves in comparing with unwashed ones. In spite of that, there was no significant correlation between the concentrations of heavy metals in washed leaves and in soil samples. Results of this investigation showed that the industry and traffic were the main source of air pollution in Isfahan, and acacia tree is a dependable biomonitor for air and soil pollution investigations.

Keywords: Biomonitor, Acacia tree, Heavy metals, Air pollution, Soil pollution

INTRODUCTION

Environmental pollution has serious public health implications with changes on physical, chemical and biological characters of main sources such as water, air and soil which has effect in survival of human and other living organs or limit their activities (Markert, 1993). Changes in the environment, like impaired air quality can be mirrored in the physiological status of plants which have interact with environment such as plant elements concentrations. In severe case, pollutants can cause visible ecotoxicological effects and, in some extreme cases, even plant death (Rossini Oliva and Rautio, 2005).

Heavy metals are naturally present in soil; contamination comes from local sources, mostly industry, agriculture, waste incineration, combustion of fossil fuels and road traffic are the major anthropogenic sources of heavy metals. Long-range transport of atmospheric pollutants adds to the metal load is the main source of heavy metals in natural areas (European Environmental Agency, 1995). Due to pollutant dangerous of living organs it is considerable to collect about its quality and quantity. One of the newest ways for determined amount and kind of environmental pollutants is natural biomonitoring. Recently, biomonitors mostly used for estimating air pollution but nowadays they use for estimating and measuring water and soil pollution (Soylak *et al*., 2000; Mulgrew *et al*., 2004). Changes in foliar elements concentrations, however, can take place long before pollution-mediated plant injuries, and hence foliar element composition is commonly used as biomonitor to investigate the spatial distribution of atmospheric pollution.

Bioindication refers to the use of animals and plants as instruments for assessing past, current, or future conditions or processes. The particular advantage of bioindication is that animals and plants must cope with partly changing or fluctuating environmental conditions for a fairly long period and so integrate in the course of this fairly long period. Bioindicators are accordingly species or groups of species that provide information about the long-term quality of environmental changes and fluctuations (McGeoch, 1998). Biomonitoring with plants is cheap and valuable method to study the environmental pollution effects (Celik *et al*., 2004; Monaci and Bargagli, 2000). This feature of foliage's capability to accumulate contaminants has been used for years to study pollution effects in forests (Morrison, 1974; Rautio and Huttunen, 2003) as well as in urban areas (Alban, 1985, Baragagli, 1998, Alfani *et al*., 2000, Rossini Oliva and Fernández Espinosa, 2007). Density of air pollution and collecting data for this aim could be helpful to find applied solution for air pollution controlling (Aksoy and Sahin, 2000, Adel, 2003). earlier investigations have shown a positive relation between deposition of atmospheric pollutants and foliar concentrations of the same pollutants in several forest plants species (e.g. Berthelsen *et al*., 1995, Wyttentenbach *et al.,*1985), common herbs (Cook *et al.,* 1994) and ornamental plants (Rossini Oliva and Rautio, 2005). In addition to anthropogenic factors, variation in the element composition in plants is influenced by, for instance, climatic factor causing temporal fluctuation (Kovacheva *et al*., 2000).

Biomonitors were classified as active biomonitoring and inactive biomonitoring. Some plants grown in research areas used as inactive biomonitoring plants such as aborigine, Horticultural plants and Crops. Some of these plants were used in last researches are poplar, pine, palm, silverberry, fig, ash, apple, birch, ailanthus, elder, oak and acacia. Leaves, bark and sometimes wood of them were used for tracing the pollutions (Madettoin *et al*., 2004) also some kinds of herbs were used as inactive biomonitors (Markert *et al*., 1993). Mosses and lichens were used for studying air pollution. In addition fish and most other animals (especially aquatics) were used for these researches (Madejon *et al*., 2004). In active biomonitoring, plants showed genetically reaction to air pollution were planted in research areas or collected from other unpolluted area and transferred there (Djingova and Kuleff, 1993). Pollutants disturb the ecosystems and heavy metals in low density (because of indissoluble and physiological effects on organism such as plants and animals) need more studies. (Diatta and Grezebisz, 2003).

The present research has been conducted to study the performance of using the acacia leaves as biomonitor to determine air and soil pollution (Cd, Cu, Fe, Mn, Pb and Zn) in different sites (industrial and non-industrial) of Isfahan city. In addition the effect of washing treatments on metal concentration in plant leaves was investigated.

MATERIALS AND METHODS

Site of research

The experiment was performed in four places in Isfahan region to study the type and density of soil and air pollutants. Isfahan is third largest city of Iran and because of intensity of traffic and industrial factories around the city has high level of air pollution.

The sampling sites were campus of University of Khorasgan, which is a low traffic area near of Isfahan city, City center of Isfahan that has an intense traffic, Isfahan steel company area that represents an industrial zone, Bagh-Bahadoran village as a control site, which represents the non-polluted area.

Samples collection

The leaves of acacia and soil samples were collected during July and August 2010. Soil samples (20 samples) were collected from 0 to 10 cm height around the acacia tree in the four sampling sites. Samples were prepared with organic matter destruction-acceleration wet digestion method suggested by Owen Plank (1992).

The pH of soil samples were measured by using pH-meter (Model 262). Determination of six elements (Fe, Zn, Pb, Cu, Mn and Cd) was carried out with using atomic absorption spectrometry (AAS) (Pydtt *et al.,* 1999; Soon and Abboud, 1993).

Plant sampling at each site was carried out by collecting randomly samples from 5 trees at 1 meter height. Afterward, every individual samples were mixed and divided into two equal parts. One sub-sample was washed with distilled water and the other one was unwashed. Vales of Cd, Cu, Fe, Mn, Pb and Zn were determined by Atomic Absorption spectrophotometer (Perkinelmer 400).

To test the washing effect, the t-test was employed to compare the means of amount of heavy metals in washed and unwashed leaves sampled on each site. Also F test (ANOVA) was employed to compare the means of different sampling site and heavy metal in washed leaves and soil. The required statistical calculations were carried out by SAS and MINITAB softwares.

RESULTS

Soil analysis

Means values of elements determinate in soil and the chemical characteristics are shown in Table 1 and Fig.1.The pH values in all soil sampling are similar and all soils can be classified as alkaline. Means of organic matters were from 0.37 to 0.72 %. Soil organic matters increase cation exchange capacity and make complex with heavy metals in soil area. Results showed that with increasing pH and organic materials in soil a decrease on bioavailability of heavy metals in plants occurred. (Handreek *et al*, 1994, Kabata – Pendias and Pendias, 1994). Lime has effects on bioavailability of heavy metals. (Kabata –Pendias and Pendias, 1994). The studied soils had significant content of lime (Table 1)The comparison of means of Cd, Cu, Fe, Mn, Pb and Zn in the different sampling sites showed that the City center of Isfahan had a significant higher level of heavy metals than other sites. Source of major part of them in sample soil probably were corrosion of tire of vehicles, power fuel burning and traffic in this zone (Kabata–Pendias and Pendias, 1994; Aksoy *et al.*,1999).

Table 1. Comparison of soil properties for investigated soils

Site	$CaCO_3$%	O.M%	pH
Khorasgan University	47.5^B	0.37^C	7.71^A
City center	38.6^B	0.7^A	7.69^A
Steel mill	60.4^A	0.27^C	7.83^A
Bagh Bahadoran	21.8^C	0.63^B	7.74^A

Means in column that do not have common alphabets are not significant

Results shown that measured amount of heavy metals in soil samples were more than recommended values except Cd and Fe. Variation of Fe and Cd in different sites hadn't significant differences but Cu, Mn, Zn, Pb and organic material in 1% and pH in 5% had significant differences. This research had shown that source of heavy metals in all sites directly or indirectly related to human activities and classified as "pollution with human source".

Plant analysis

The mean comparison of heavy metals (Fe, Cu, Mn, Zn, Cd and Pb) concentrations measured in washed and unwashed leaves in stage one (June) and stage two (september) in four separate zones are in Figure 2 and 3.

Iron is of the essential microelement for plants and plant couldn't complete its survival cycles without it. But high density of iron in plant had a toxicity effects. Its recommended value in plant issue is about 50-500 $\mu g.g^{-1}$ and critical value in some plants is 50 $\mu g.\ g^{-1}$ (Kabata –Pendias and Pendias, 1994). Iron is released by

Combustion process of fossil fuels and an important part in fly ashes (Hunn *et al.*, 1995). Thus, both Fe and Cu are easily transported via air and deposited on plant surfaces. Other sources of Fe are soil dust and asphalt. Result shown that density of Iron in washed and unwashed leaves were difference and is lower on washed leafs. This result shown that all of deposit Iron on leaves hadn't enough time for absorbed by this organ and partial of it with soluble iron content in soil, absorbed by plants. Also mean of density in both stage were similar. Mean squares of sampled plants had significant difference at 1% levels of probability. Density of iron in all zone were higher than recommended value (150 $\mu g.g^{-1}$) that reported by Markert (1993).

Maximum value of Iron accumulation was in Steel mill (856 $\mu g.g^{-1}$) and minimum value was in BaghBahadoran zone (405 $\mu g.g^{-1}$). Researches shown that density of Iron in soil and plant in industrial and heavy terrifically areas were higher than recommended values.

As an essential element, iron was used by special enzyme and protein in respiration and photosynthesis reactions. Iron was also reported as the accumulation factor in photosynthesis associated with accumulation of iron in chloroplasts (Kim and Jung, 1993). Iron is one of the principal elements in the earth crust. The high values of iron detected in this study may be partly due to the absorption from soil by the roots of plants.

Manganese is one of the microelement essential for plants. Iron and manganese oxides play an important role in the soil in fixing trace elements such as cobalt, copper, zinc and nickel as well as pollutants like lead (Norrish,1975). The association of these elements with manganese and iron in soils has important implications for agriculture and plant growth in general. The toxicity of Mn is commonly associated with acidic soils and warm climates.

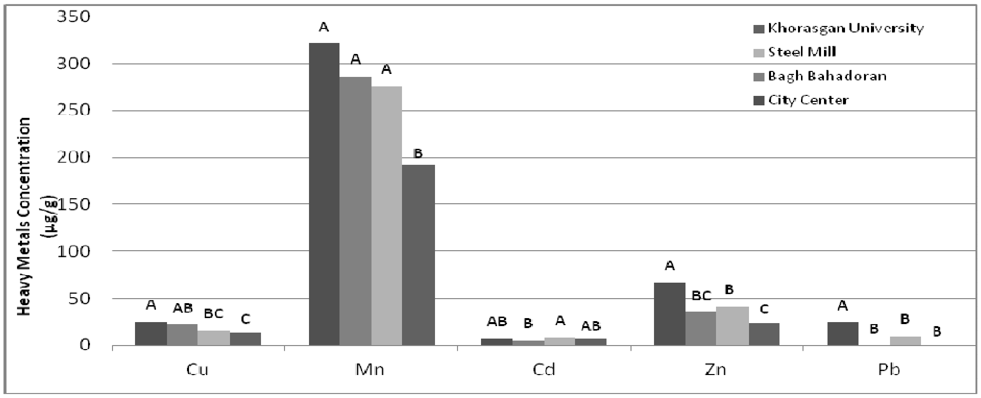

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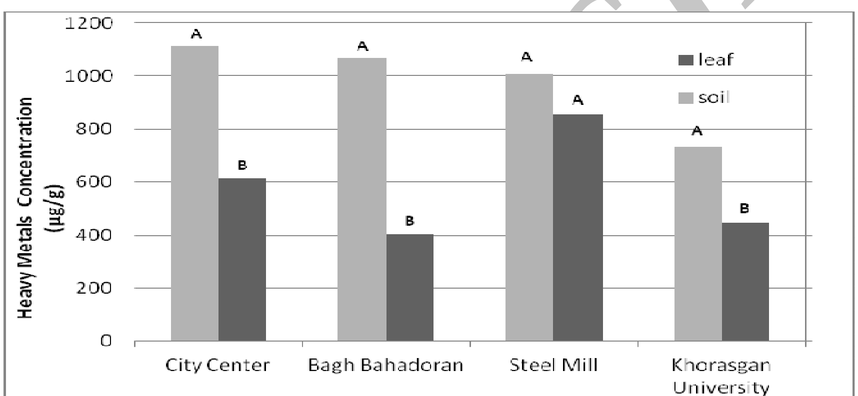
Figure 1. Means of heavy metals concentration (µg.g^{-1}) in sampled soils



Means in column that do not have common alphabets are not significant

Figure 2. Means of Iron (µg.g^{-1}) in soil and leaf samples

Recommended value in plant tissue is about 100-500 µg.g^{-1}.

Critical values of Mn in most of the plants are 200-300 µg.g^{-1} (Kabata–Pendias and Pendias, 1994). Research zones hadn't significant differences also mean values of Mn in leaves in all zone were under recommended value. Main source of Mn existing in air and soil was skid (Monaci *et al*., 2000; Celik and Aslihan, 2004).

Copper is one of the microelement that is essential for plants. About 70% of copper in leaves contained in the chloroplast of land plants (Wikinson, 1994). It has been suggested that photosynthesis function is highly sensitive rch zones hadn't significant difference ato copper toxicity (Ouzouidou, 1994). Disturbances in Cu supply can cause significant modification of biochemical process in plants leading to lower yields and quality of agricultural crops. Amount of copper in the atmosphere is usually related to traffic density, since it is produced by tire and broke shoe abrasion (Cook *et al*., 1994; Angoletta *et al*., 1993). Recommended value of it in plant issue is about 5-30 µg.g $^{-1}$ and more than 20-30 µg.g^{-1} have toxicity effects in plants (Kabata –Pendias and Pendias, 1994). Mean squares of copper in all reseand compactness of copper in two steps of sampling was approximately the same (Figure 2). Means of density in stage one and two were near-by each other's But values were more than 10 µg.g^{-1} that reported by Markret (1993).

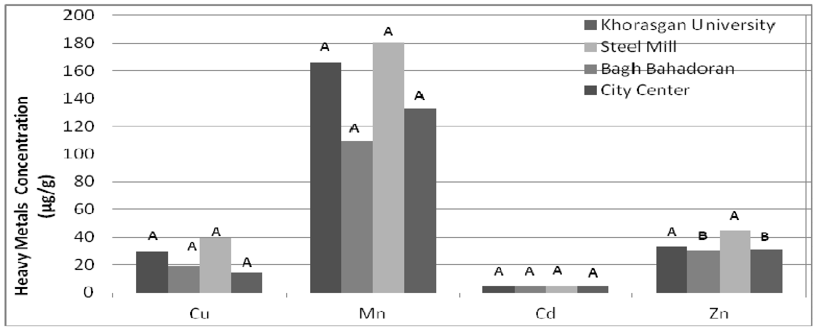
Maximum value of pollution was in Steel mill zone (39.8 µg.g^{-1}) afterward City center of Isfahan had high Cu density (29.6 µg.g^{-1}). This research had similar result comparing other researches that shown source of copper pollution in air were oil oxidation, corrosion of tire of vehicles and industrial wastage (Celik and Aslihan, 2004; Monaci and Bargali, 2000; Harrison and Chirawi, 1989).

Zinc is an essential microelement in all organisms and play an important role in the biosynthesis of auxins, enzymes and some proteins that are essential for plants and plant with symptoms of Zn deficiency experiences a retarded elongation of cells (Raven and Johnson, 1986).

Recommended value in plant issue is about 20-100 µg.g^{-1}. Critical value of Zn in most of the plants is 15 µg.g^{-1} (Kabata – Pendias and Pendias, 1994). Mean squares of Zn in four research zones at 1% levels of probability had significant differences. But in two steps of sampling were approximately same in additional amount of Zn in leaves in research zones, were below of recommended values. Therefore, pollution in research areas hadn't seen.

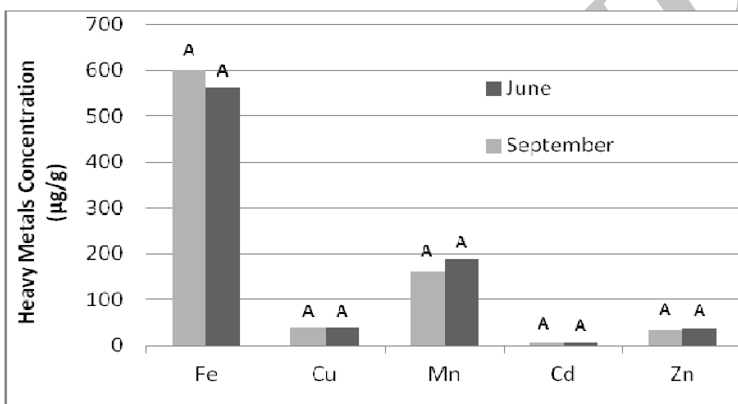
Cadmium is an especially mobile element in the soil and is taken up by plants primarily through the roots. Decisive for transfer into plants are cadmium levels, pH values and humus levels that determine cadmium levels in the soil solution and thereby the plants availability to cadmium (Fahrenhors and kornhardt, 1990). Mean amounts of Cd in all of four research zone were more than recommended values offered by Kabata-pendias (1994) (Figure 2). Researcher reported that amount of Cd in plant is 0.1-1 µg.g^{-1}. Also plant and animals are needless from this element (Celik and Aslihan, 2004). Also it was reported in an industrial research area that amount of Cd was more than recommended values**.** Source of Cd on weather is metal-working industrial, corrosion of tire of vehicles and power fuel burning. (Celin and Aslihan, 2004; Pydtt, 1999)

Lead is available to plants from soil and aerosol sources. The chemical form of lead as it impacts plants is of critical importance, however, as this is a factor in movements in to plants, in translocation and in the toxic effectiveness of lead within the plants. Lead pollution on a local scale is caused by industrial emissions, and on a larger scale is caused by emission from motor vehicles using leaded gasoline (Koeppe, 1981). Amount of Pb in most of leaf samples under study in this research, were below the level of machine detection. Recommended value of it in soil and plant were 30-189 and 30-300 µg.g^{-1} respectively (Rahmani *et al*., 2001; Kabata–Pendias and Pendias, 1994). Several researches reported that density of Pb in soil had significant relation with amount of traffic (Rahmani *et al*., 2001; Pydtt, 1999; Celik and Aslihan, 2004).



Means in column that do not have common alphabets are not significant

Figure 3. Heavy metals concentration (µg.g^{-1}) in Acacia leaves

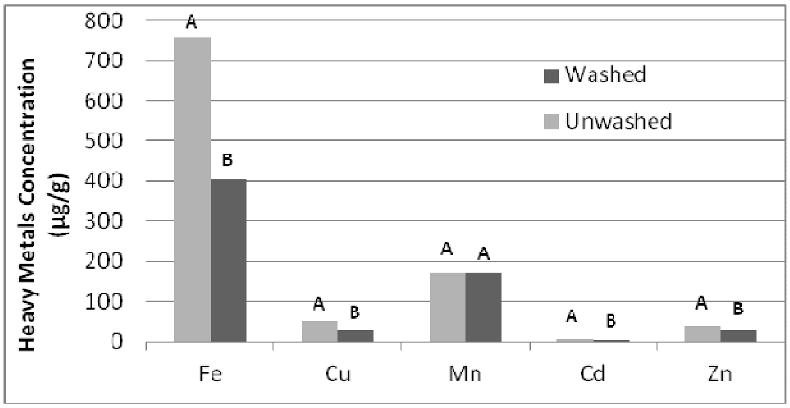


Means in column that do not have common alphabets are not significant

Figure 4. Comparison of heavy metal concentration (µg.g^{-1}) in different time sampling in Acacia leaves

Washing effect

The ability to distinguish airborne and soil borne contamination was assessed by washing the leaves. The results showed that removal of the metals from the leaves by washing was significantly different from unwashed leaves and it depends on the pollutant level in sampling sites. There was substantial aerial deposition on the leaves for all four sites, which were removed by washing procedure (Figure 4).



Means in column that do not have common alphabets are not significant

Figure 5. The effects of washing treatment on heavy metal concentration ($\mu g.g^{-1}$) in Acacia Leaves

Metal concentrations are affected by washing, which can remove different amounts of pollutants, but this varies according to the species and physical and chemical characters of pollutants (Lin and Schuepp 1996; Rea *et al*., 2000). Some studies have demonstrated that washing does not affect some elements such as Zn concentration (Wyttenbach *et al*. 1985, Worley 1993, Alfani *et al*., 2000). However, other investigations showed that Zn can be eliminated by washing (Little, 1973; Moraghan, 1991; McCrimmon 1994) and this suggests that the effect of washing varies from one species to another. In this study, washing the leaves significantly reduced the Zn, Cd, Cu, and Fe concentrations in acacia from all sites (as indicated by t- test results).It was not possible to compare washing effects for Pb because most values for this element were below detection limits. As Mn is not an important component of adhering dust (Wyttenbach *et al*., 1985), washing does not make any significant difference. In some cases, including the control sample (Alcala del Rio), there is an even higher concentration in washed than in unwashed samples but in this study, unwashed leaves have higher amount of Mn than washed leaves.

CONCLUSION

The main reason of high concentrations of heavy metals in plants localized in industrial areas and in urban roadsides are the industrial activity and density of the traffic. Nonetheless, results of this study showed that acacia leaves is not a reliable biomonitor for heavy metals such as Cu, Mn, Cd, and Pb in the urban area, since acacia seems not to retain in amounts, high enough to related to their variation within different impact zones. Therefore, using bark of acacia the same as leaf, for tracing air pollution need more exact investigation. In fact, content of metals in serious part of plant had significant differences**,** hence, using bark and leaf together for tracing heavy metals in air. Because of directly exposed to air, had suggested. Exclusive of acacia that is broad leaved, some of narrowed leaved plants such as pine because of their thick and rough bark are suitable for biomonitoring. This idea need more research in future.

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