Cypress Tree (*Cupressus arizonica* Greene.) as a Biomonitor of Heavy Metal Pollution in the Atmosphere of Isfahan

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Abstract

Cypress tree with blue green foliage and scaly reddish brown bark is planted throughout world as an ornamental plant. One of the newest ways for determining amount and kind of environmental pollutants is natural biomonitoring. The samples were obtained from three sites (heavy traffic, moderate traffic and control) in Isfahan during August-September and November-December 2013 and February-March 2014. The concentrations of Zn, Ni and Cu in leaf and root were measured by using a flame atomic absorption spectrophotometer. Variations in the studied traits between sites and seasons were observed due to different anthropogenic activities. The higher concentration of the studied heavy metals in leaves rather than in roots in all locations illustrated a contribution of significant atmospheric deposition. The results of correlation coefficients between traits indicated that the sites were influenced by a different source of pollution. There was a positive correlation between zinc and copper, indicating that they could be originated from fuels as well as powder of shoe brake of vehicles. The mean metal concentration values were arranged in the following order: Zn > Cu > Ni. The level of zinc in leaf and root was moderate at the control site indicating that vehicle traffic is a minor emission source for zinc and there may be another zinc source around there, such as industrial activities. The results demonstrated the suitability of the cypress (*Cupressus arizonica* Greene.) tree as a biomonitor of atmospheric pollution in Isfahan.

Keywords: Correlation coefficient, Environmental pollutants, Ornamental plant, Traffic.

INTRODUCTION

Cupressus arizonica is an evergreen tree with small scalelike leaves. This handsome tree with blue green foliage and scaly reddish brown bark is planted throughout world as an ornamental and in shelterbelts (Little and Skolmen, 1989). It is one of the most resistant cedars against hard situations all over the world (Panzani, 2015). It was introduced to Iran in 1954 and has been commonly cultivated in many parts of the country (Sabeti, 1966).

Environmental pollution is the presence of a pollutant in the environment, air, water and soil, which may be poisonous or toxic and will cause harm to living organisms in the polluted environment (Duruibe *et al.,* 2007). The woody plants are an excellent tool for biomonitoring of the metals due to their rapid growth, high biomass, profuse root apparatus and low impact on the food chain and human health (Tomasevic *et al*., 2008; Estrabou *et al.*, 2011).

In developing countries an estimated 0.5-1.0 million peoples die prematurely each year as a result of exposure to urban air pollution (Kojima, 2001). The emission of toxic substances into the environment has spread mainly from industrialized countries. However, many industrial plants and especially road traffic may emit heavy metals into the atmosphere (Mansour, 2014). Some trace metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate them at high concentrations (Hovmand *et al*., 1983; Huckabee *et al.*, 1983).

The use of higher plants, especially different parts of trees, for air monitoring purpose is becoming more and more widespread (Mansour, 2014). Panzani (2015) revealed that higher levels of zinc accumulated in the shoot rather than in the root of *Cupressus arizonica*. Kord *et al*. (2015) reported that the lead, nickel and copper contents were found at high concentrations in the highway sites, whereas industrial areas contained high concentrations of zinc and chromium. This study demonstrated the suitability of the cypress tree bark as a suitable bio-indicator of environmental pollution in areas.

El-Hasana *et al*. (2002) indicated that cypress bark was a good bioindicator for air pollution in arid regions. Variation in Pb, Zn, Mn, Cr, Ni, Cd, and Cu contents between sites was observed due to different types of activities. Traffic emissions were found to be the main source of heavy metal pollution in the atmosphere of Amman. There was high significant correlation coefficient between Zn and Ni. Einollahipeer *et al*. (2013) reported that mangrove (*Avicenia marina*) tissues can be a good bio-indicator for Cu in the Qeshm Island. The root was a good bio-indicator for Pb and Ni. For Zn, however, leaf and stem tissues were the best bioindicators. The direct relationship between Cu and Zn concentration in roots and following it, in leaves and stems was observed.

The aim of this study was to investigate the heavy metal pollution in the atmosphere of Isfahan city using cypress tree (*Cupressus arizonica* Greene.).

MATERIALS AND METHODS

The research was carried out in Isfahan during August-September and November-December 2013 and February-March 2014. Isfahan is the third largest city of Iran with a high level of air pollution because of the heavy traffic and industrial factories around the city. Isfahan has an aititude of around 1570 m above sea level. Three different kinds of sites were chosen for the study located along areas with heavy traffic (Azadi St.), moderate traffic (Ahmadabad St.) and control site (Sabahi St.) with 540, 338 and 128 vehicle movements per hour, respectively. Relative humidity during daytime is relatively high ranging from 30% in July to 91% in December.

The leaf and root samples were collected in polluted and controlled sites in summer, autumn and winter. All the samples were prepared by washing with distilled water and drying them at 70°C for 48 h; the dried samples were then grounded and homogenized by sieving them through 2-mm plastic sieve to remove large particles. Heavy metals were analyzed by digesting 1 g from each pre-washed and dried samples with 10 ml of 50% HNO_3 solution, and leaving overnight. Copper, nickel and zinc heavy metals were determined using Berkin Elmer AAS Analyst 300, with graphite furnace HGA 800, and auto-sampler AS 72 (El-Hasana *et al.,* 2002).

This research was carried out as a factorial experiment based on completely randomized design with six replications. Data were analyzed with SAS software package and the related graphs were drown by MS-Excel 2007 software package. The comparison of means was performed by SAS software package using Duncan's Multiple Range Test at P<0.05. For simple correlation analysis, a matrix of simple correlation coefficients among the traits was computed (Snedecor and Cochran, 1981).

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) was used to compare the significant difference in the mean concentration of heavy metals between seasons and the sampling sites (Table 1). This can be attributed to different anthropogenic activities between the seasons and sites.

The mean levels of Zn, Ni and Cu in leaf and root of *C. arizonica* in different sites and seasons were presented in Table 2. The highest amounts of Zn, Ni and Cu concentrations in leaf and root were related to summer and the lowest amounts to winter (Table 2). It can be related to the wind velocity and its direction, intensity of industrial and mining activities and also the amount of air humidity during the year. Namazi *et al*. (2015) also reported that Ni concentration in summer was the highest among all seasons. The nickel and copper contents in leaf (1.96 and 2.58 ppm, respectively) and root (0.65 and 0.86 ppm, respectively) were found at high concentrations in heavy traffic site (Azadi St.), whereas moderate traffic (Ahmadabad St.) contained high concentrations of zinc in leaf and root (3.16 and 1.06 ppm, respectively) (Table 2).

On the other hand, control site (Sabahi St.) had the lowest nickel and copper contents in leaf (1.15 and 1.82 ppm, respectively) and root (0.39 and 0.61 ppm, respectively) and heavy traffic site had the lowest zinc in leaf and root (1.11 and 0.37 ppm, respectively) (Table 2). The mean metal concentrations were found to be in the order of Zn > Cu > Ni. The higher concentration of the studied heavy metals in leaves rather than in roots in all locations illustrated a contribution of significant atmospheric deposition (Kleckerová and Dočekalová, 2014). Samaral and Tsitsoni

Table 1. Analysis of variance (ANOVA) of the studied traits in various seasons

S.O.V	df	df					
		Zn (leaf)	Zn (root)	Ni (leaf)	Ni (root)	Cu (leaf)	Cu (root)
Season	2	2.13 **	0.24 **	1.04 **	0.12 **	1.97 **	0.22 **
Site	2	18.94 **	2.10 **	3.20 **	0.35 **	3.81 **	0.43 **
Season×Site	4	0.16 ns	0.02 ns	0.03 ns	0.003 ns	0.03 ns	0.004 ns
Error	45	0.13	0.04	0.05	0.02	0.05	0.02
CV(%)		17.03	27.52	14.67	25.05	10.50	21.82

ns and **: Not significant and significant at the 1% level of probability, respectively

Table 2. Heavy metal concentrations of cypress tree collected from different sites in Isfahan city during various seasons

S.O.V		Zn (leaf) (mg l^{-1})	Zn (root) (mg l^{-1})	Ni (leaf) (mg l^{-1})	Ni (root) (mg l^{-1})	Cu (leaf) (mg l^{-1})	Cu (root) (mg l^{-1})
Season	Summer	2.5 a	0.84 a	1.75 a	0.59 a	2.41 a	0.80 a
	Autumn	2.05 b	0.69 b	1.44 b	0.48 b	1.98 b	0.66 b
	Winter	1.82 b	0.61 b	1.28 c	0.43 b	1.76 c	0.59 b
Site	Azadi (Heavy traffic)	1.11 c	0.37 c	1.96 a	0.65 a	2.58 a	0.86 a
	Ahmadabad (Moderate traffic)	3.16 a	1.06 a	1.36 b	0.46 b	1.74 b	0.58 b
	Sabahi (Control)	2.10 b	0.70 b	1.15 c	0.39 b	1.82 b	0.61 b

*Means in each column, followed by similar letter(s) are not significantly different at the 5% probability level using Duncan's Multiple Range Test

Table 3. Correlation coefficients of metal concentration in leaf and root during various seasons

Trait	Zn (leaf)	Zn (root)	Ni (leaf)	Ni (root)	Cu (leaf)	Cu (root)
Zn (leaf)	-					
Zn (root)	0.98 **	-				
Ni (leaf)	-0.22 ns	-0.12 ns	-			
Ni (root)	-0.11 ns	0.02 ns	0.96 **	-		
Cu (leaf)	-0.33 *	-0.23 ns	0.95 **	0.91 **	-	
Cu (root)	-0.18 ns	-0.04 ns	0.92 **	0.97 **	0.95 **	-

ns, * and **: Not significant, significant at the 5% and 1% levels of probability, respectively

(2014) also reported that the leaves of *C. arizonica* had the higher quantities of copper and nickel.

There are many high significant correlation coefficients between heavy metals in some traits such as Zn in leaf vs. Zn in root (r=0.98), Ni in leaf vs. Ni in root, Cu in leaf and Cu in root (r=0.96, 0.95 and 0.92, respectively), Ni in root vs. Cu in leaf and Cu in root (r=0.91 and 0.97, respectively), and also Cu in leaf vs. Cu in root (r =0.95) (Table 3). This indicates that these sites were influenced by a different source of pollution, most probably vehicular emission and motor vehicle tires wheel for Zn, whereas Ni and Cu are major components of the industry dumping areas and automobile parts corrosion. No significant correlation was found between Ni in root vs. Zn in leaf and Zn in root because of low Ni concentration in root. Kord *et al*. (2015) also reported high significant correlation between Ni and Cu in all studied sampling sites.

Plants not only have an ornamental function in urban areas, but also may improve the quality of urban life (Akbari, 2002; Brack, 2002). Moreover, plants can absorb and accumulate pollutants through their roots and leaves (Sawidis *et al.*, 1995). In urban areas woody species are mostly suitable for monitoring metal pollution since lichens and mosses are often missing (Al-Alawi and Mandiwana, 2007).

Zinc is an essential element in all organisms and considered as an important factor in the biosynthesis of enzymes, auxins and some proteins. Plants with symptoms of Zn deficiency experience a retarded elongation of cells. A critical toxic level of Zn in the leaves is about 50 ppm in dry plant matter (Allen, 1989; Yilmaz and Zengin, 2004). According to these values, Zn concentrations found in our study were smaller than the normal limits. Therefore, it can be supposed that all three studied sites were unpolluted with Zn. The level of zinc in leaf and root was moderate at the control site indicating that vehicle traffic is a minor emission source of zinc and there may be another zinc source around there, such as industrial activities.

Ni is an essential element for plants in low concentrations and is absorbed easily and rapidly by them (Gunes and Alpaslan, 2004). Al-Shayeb and Seaward (2001) reported that the highest concentrations of nickel were attributable to emissions from motor-vehicle that used nickel gasoline and by abrasion and corrosion of nickel from vehicle parts. Normal Ni concentration in plants was 0.5-5 ppm. The results showed that Ni concentration in C. arizonica was less than the upper limit.

Copper is an important component of many enzymes, which catalyze oxidation and reduction reactions. The main sources of Cu are home tools production, metal manipulating, road traffic and ashes (Aksoy *et al.*, 2005). The main sources of pollutant copper in the atmosphere were Cu production and handling, fossil fuel combustion and iron steel production. Copper concentrations above 20 ppm are considered toxic to plants (Jones and Belling, 1967). The results of this study for all the sites did not reveal high levels of pollution by Cu since concentrations in *C. arizonica* plant did not exceed the upper limit.

CONCLUSION

The study demonstrated the suitability of the cypress (*Cupressus arizonica* Greene.) tree as a suitable indicator of Zn, Cu and Ni in the atmosphere of Isfahan. The mean concentrations of

the studied metals were ordered as Zn > Cu > Ni. Summer and winter had the highest and lowest amounts of Zn, Ni and Cu concentrations in leaf and root, respectively. This can be related to the wind velocity and its direction, intensity of industrial and mining activities, and also air humidity during the year. The strong correlation between zinc and copper indicates that the source of these metals can be fuels as well as powder of shoe brake of vehicles in the atmosphere of Isfahan. The control site had moderate concentration of zinc in leaf and root indicating that vehicle traffic was a minor emission source of zinc and there might be another zinc source around there, such as industrial activities. Cypress tree had higher metal concentration in their leaves as compared to roots in all locations illustrating a contribution of significant atmospheric deposition. The present results showed that *Cupressus arizonica* Greene. can be used as a simple way to monitor polluted sites.

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