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Pine (*Pinus Eldarica* Medw.) needles as indicator for heavy metals pollution

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ABSTRACT: In this study, the pine tree (*Pinus Eldarica* Medw.) needles were evaluated as the biomonitors of heavy metal contamination in Tehran, Iran. The pine needle samples supplied from the old trees according to the main wind direction (highest wind speed) were obtained from each parts of tree and then were homogeneously mixed. The samples were taken from different locations with different degrees of metal pollution (urban, industrial, highway and control sites). Then, the concentrations of lead, zinc, copper, nickel and chromium were measured using a flame atomic absorption spectrophotometer. The result of this study showed that the highest and the lowest metal concentrations were found in the heavy traffic sites and the control site, respectively. However, samples taken from highway sites contained the high concentrations of nickel, copper and lead. Moreover, industrial areas were found to have high contents of zinc and chromium. The variation in heavy metal concentrations between the studied locations is due to changes in traffic density and anthropogenic activities. This research proved significant correlations between the heavy metal concentrations in pine needle samples. Finally, it is concluded that *Pinus Eldarica* Medw. needles can be applied to monitor polluted sites.

Keywords: *Air pollution; Atomic absorption spectrophotometer; Biomonitor; Heavy metals; Pine tree*

INTRODUCTION

Increasing of anthropogenic activities leads to the emission of various pollutants into the environment and different types of hazardous substances are consequently appeared into the atmosphere (Onder and Dursun, 2006; Kho *et al.*, 2007). Air pollution due to increased human activity is aesthetically offensive and can be a genuine health hazard to human, as well as vegetation, plants and micro-organisms (Boddy *et al.*, 1994; Dursun *et al.*, 2002; Gbaruko and Friday, 2007). The use of plant tissues in sampling has long been shown to be an effective indicator of atmospheric pollution (Goodman and Roberts, 1971). Vegetation is a proper indicator to assess the impact of a pollution source on the vicinity which is due to high metal accumulation of plants (Onder and Dursun, 2006). Furthermore, the observed effect is a time-averaged result, which will be more reliable than direct determination of the pollutant concentrations in air, for a short period. The emission of toxic substances in the environment has been spread from industrialized countries. Many industrial plants and also heavy traffic may produce heavy metal into the atmosphere. Traffic pollutants include potentially toxic metals for health such as lead, zinc and cadmium (Viard *et al.*, 2004; Duran and Gonzalez, 2009). Heavy metals are among the pollutants that need to be removed from contaminated sites. They are considered hazardous contaminants that can accumulate in the human body, with a relatively long half-life. For instance, it has been stated that, Cd has a half-life of 10 years in the human body (Salt *et al.*, 1995). Heavy metals cause serious environmental risks and therefore, its effect has been examined extensively (Abdel-Ghani *et al.*, 2007). Uptake of elements into plants can happen via different ways. The elements can be taken up via roots from soil and transported to the leaves; also they may be taken

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up from the air, or by precipitation directly via the leaves. Trace elements may be also taken up via the mentioned ways. Biological monitors and vegetations are used to measure the levels of atmospheric trace metal concentration (Onianwa *et al.*, 1986; Onasanya *et al.*, 1993; Wolterbeek *et al.*, 1996; Celik *et al.*, 2005; Nabulo *et al.*, 2008). Biological monitors are applied as the cheapest and simplest indicator for monitoring the trace metal concentrations in the atmosphere. Numerous different bio-indicators are used in monitoring air pollution, such as mosses, lichens, vascular plants, woody plants, etc. Both the broad-leaves and coniferous trees are used in air pollution studies (Löstschert and Köhm, 1978; Grodzinka, 1982; Huhn *et al.*, 1995; Lippo *et al.*, 1995; Adeniyi, 1996). The aim of this work is to determine the pollution levels (concentrations) of Pb, Cu, Zn, Ni and Cr in the atmosphere of Tehran city using pine tree (*Pinus Eldarica* Medw.) needles as a bio-indicator. The result could be used as preliminary baseline data for trace elements concentrations in the ecosystems for future assessment and monitoring.

MATERIALS AND METHODS

Study area

Tehran is the capital city of Iran, which has an elevation of around 1400 m above sea level, at latitude (35 °50′N) and longitude (51 °37′E). The average annual precipitation in the investigated area is 246 mm/y. Minimum temperature is 4.5 ºC in January and maximum temperature 31.5 ºC in August. Relative humidity during daytime is relatively low ranging from 28 % in June to 64 % in December. The city suffered from high traffic density caused by vehicles. The average number of vehicle movements per hour in urban, industrial, highway and control sites of the study area are 360, 315, 1400 and < 50, respectively. Nowadays, Pine *(Pinus eldarica* Medw.) covers the majority of urban trees in Tehran due to it's ever greenness (Fig. 1).

Sampling and analysis

The pine needles were collected from old trees about 20-25 years old during July and August 2007. Pine trees are widespread in Tehran with evergreen needle normally 3-5 inches irregularly twisted (Fig. 2).

All of trees were identified according to the documents obtained from the Tehran Municipality and Green Space Organization (Tehran Municipality, 2007).

The needle samples supplied from the trees according to the main wind direction (i.e. the highest wind speed) were obtained from each parts of tree and then were homogeneously mixed. The total number of collected samples was 53, distributed as follows: 15 samples from the urban, industrial and highway sites and 8 samples were from control site. The samples were separately collected into clean cellulose bags and brought to the laboratory on the same day. In laboratory, the samples were carefully washed three times with distilled water to remove adhering particle (Babaoglu, *et al.*, 2004). All needle samples were weighed and then dried in an oven at 70 ºC for 48h. The samples (1 g) of finely ground needles were digested with concentrated HNO_3 in a microwave system. Heavy metal concentrations were measured by the flame atomic absorption spectrophotometer, Perkin-Elmer AAS analysis 300 model, with three replicates. Used metal standards were provided from Merck, Germany. The analysis of variance (ANOVA) was used to compare the significant difference in the mean concentration of heavy metals between the sampling sites. *F* is a parameter in the level of 5 %. Pearson's correlation coefficient was used to measure the degree of correlation between logarithms of the metal concentrations. ANOVA test and Pearson's

Fig 1: Pine trees community cover arrround the traffic zone of urban area in Tehran

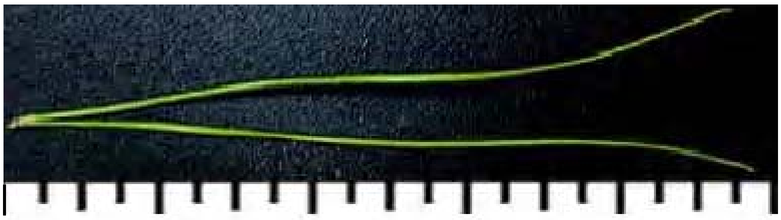

Fig. 2: Evergreen needle; 3 – 5 inches with thin and irregularly twisted

correlation coefficient were performed using the SPSS statistical program.

RESULTS AND DISCUSSION

Heavy metal concentrations in sampled pine needles are shown in Table 1. The results indicate that the highest and the lowest metal concentrations were found in the heavy traffic sites and the control site, respectively. The mean metal concentration values are arranged in the following order: Pb > Zn > Ni > Cu > Cr. The Lead, nickel and copper content were found at high concentrations in the highway sites, whereas industrial areas contained high concentrations of zinc and chromium. The correlations of metal content in samples collected of Tehran are shown in Table 2. There are many high significant correlation coefficients between heavy metals in all sampling sites, such as Pb vs. Cu, Ni and Zn (r = 0.83, 0.79 and 0.77, respectively), Zn vs. Ni, and Cu (r = 0.78, and 0.76, respectively), and also Cu vs. Ni (r = 0.75). This indicated that the origin of metal in the investigated area is related to heavy traffic, industrial activities, structure of the soil and street dust emission. Any meaningful correlation was not found between Cr vs. Pb, Cu, Zn and Ni because of low Cr concentration. The analysis of variance of heavy metal concentrations between the sampling sites are shown in Table 3. The results indicated that there are significant difference in Pb, Cu and Ni concentrations in pine trees samples collected from different sites. However, no significant differences were found for the rest of elements. This can be attributed to different anthropogenic activities between the sites. The Pb levels were the lowest at the control site (14.1 ppm) and the highest at highway sites (62.3 ppm), which have higher traffic density. The chemical form of lead is of critical importance, since this is a factor in movements into plant, translocation and the toxic effectiveness of lead within the plant. Lead pollution on a local scale is caused by emissions from motor vehicle using leaded gasoline (Koeppe, 1981; Yilmaz and Zengin, 2003; Viard *et al.*, 2004). Normal content of Pb in plants is less than 10 ppm (Kabata-Pendias and Piotrowska, 1984). Allen (1989) considered a much lower value of 3 ppm as a normal natural level for plants. The close relationship between lead concentrations and traffic intensity has been demonstrated in detail by many authors (Gromov and Emelina, 1994; Li *et al.*, 2001; Viard *et al.*, 2004). In this research, there was a linear correlation between high Pb level and heavy traffic at Tehran city. The degree of metals content in the pine needles was found to be proportional to industrial, human activities and urbanization. High metal concentrations in plants are contianed in industrial sites and urban and highway roadsides due to the anthropogenic activities in addition to the traffic density (Celik *et al.*, 2005). Zinc is an essential element in all organisms and considered 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 100 ppm in dry plant matter (Allen *et al.*, 1974; Yilmaz and Zengin, 2003). The high contents of zinc in leaves and plant roots may cause the loss of food production and the low levels in plants may cause deformation of leaves (Bucher and Schenk, 2000; Celik *et al.*, 2005; Kashem *et al.*, 2007). The level of zinc in plant samples decreases with decreased traffic density (Table 1). Copper is minor trace metal, with 70 % copper in leaves contained in the chloroplast of land plants (Wilkinson, 1994). It is an important

Table 1: Heavy metal content (ppm) of pine tree needles collected from different sites in Tehran city

Parameters	Urban	Highway	Industrial	control
Pb	39.8	62.3	42.6	14.1
Zn	14.46	18.49	24.16	1.53
Cu	7.93	15.43	10.6	2.5
Ni	10.16	16.7	13.2	1.86
Cr	2.04	3.15	3.97	0.39

Table 2: Correlation of metal concentration in pine trees (n=53)

Parameters	Pb	Zn	Cu	Ni
Pb				
Zn	0.77			
Cu	0.83	0.76		
Ni	0.79	0.78	0.75	
Cr	0.28	0.11	0.19	0.09

Table 3: The result of statistical analysis (ANOVA)

Parameters	Sum of squares between groups	*df*	Mean square between groups	Sum of squares within groups	*df*	Mean square within groups	*F*	Observed α
Pb	12973.66	3	4324.55	20175.23	49	411.74	10.50	0.013*
Zn	895.5	3	298.5	1865.47	49	38.07	7.84	0.54
Cu	349.31	3	116.43	624.12	49	12.74	9.13	0.021*
Ni	248.14	3	82.71	347.45	49	7.09	11.66	0.044*
Cr	114.8	3	38.26	258.63	49	5.28	7.24	0.46

α, significant level
*Significant difference between the samples (P-value<0.05)

constituent of many enzymes of oxidation-reduction reactions (Raven and Johnson, 1986; Celik *et al.*, 2005). Kabata-Pendias and Piotrowska (1984) reported the normal content of Cu in plants ranges to be 2-20 ppm, but in most plants, the normal Cu contents are in a lower range of 4-12 ppm. Results indicated that the lowest mean value of copper (2.5 ppm) was found in samples collected from the control site, but the highest mean copper value (15.43 ppm) was found in sample collected from a highway that has heavy traffic. The highest mean value of nickel, was found in samples collected from the highway sites (16.7 ppm), whereas the lowest mean value was determined in a control site (1.86 ppm). This high concentration is attributed to emissions from motor-vehicle that use nickel gasoline and by abrasion and corrosion of nickel from vehicle parts (Al-Shayeb and Seaward, 2001).

The level of chromium in the study area was generally low (Table 1). Cr is a toxic, non-essential element for plants (Shanker *et al.*, 2005). Effects of Cr on plants are symptoms of chlorosis on leaves and decrease of root growth (Yagdi *et al.*, 2000). In the study area, chromium pollution caused by engine and body erosion of automobiles and extensive road marking by yellow lead chromate paint and some industrial activities (Al-Shayeb *et al.*, 1995).

CONCLUSION

Results of this study show that the highest and the lowest metal concentrations were found in the heavy traffic sites and control site, respectively. The mean values of metal concentrations are lower at the control site compared to all other sites. The variation in heavy metal concentrations between the increasing industrial and traffic activities in the city indicates the need for pollution control in the city environment. The result showed that *Pinus Eldarica* Medw. needles can be used as a simple way to monitor polluted sites.

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