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Full Length Research Paper

Evaluation of some tree species for heavy metal biomonitoring and pollution tolerance index in Isfahan urban zone

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It is well established that trees help to reduce air pollution, and there is a growing impetus for green belt expansion in urban areas. For greenbelt development, it is necessary to select plants that tolerant air pollution. In this study, the air pollution tolerance index (APTI) of plant species was evaluated by analyzing some biochemical parameters. Concentrations of Cu, Fe, Mn, Zn and biochemical parameters were determined in the leaves. The results show that *Morus alba*, *Fraxinus excesior*, *Cupressus sempervirens* and *Ligustrum ovalifolium* could be used as biomonitor species for these heavy metals, especially for Fe, Zn and Cu. Comparison of the four plant species indicated that *M. alba* was the most tolerant plant to air pollution.

Key words: Air pollution tolerance index (APTI), biomonitoring, heavy metals, biochemical parameters.

INTRODUCTION

Currently, air pollution is increasing globally. *Manifold* numbers of cars in urban areas, industrialization along with the expansion of cities, increasing demand of energy and rapid economic development have most effects in increasing air pollution (Oliva ea al., 2007). Lack of enough knowledge about resistant and sensitive species to air pollution has caused the field studies to identify sensitive and resistant species to air pollution (Prajapati and Tripathi, 2008). Biomonitoring with plants is low-cost and valuable method to evaluate the effect of different air and environment pollutants (Oliva et al., 2007). Biological methods can replace physical methods in places where there is limited use of detection of air pollution (Aksoy and and Ozturk, 1997). Isfahan city in terms of establishment of air contaminant industrial units, special heavy traffic conditions and geographical location is at air pollution risk. Thus, we aimed at (i) estimating concentration of heavy metals (Cu, Fe, Mn and Zn) in leaves of different plant species, (ii) identifying best species for absorbing heavy metals from the atmosphere and (iii) determining sensitive and tolerance of species to air pollution.

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MATERIALS AND METHODS

In this study, four plant species were selected in Isfahan city. Leaves samples were collected in July 2009. Leaf samples were dried at 70°C to constant weight. Heavy metals were determined by dry ashing procedure (Peter et al., 2006). The APTI of different plant species were calculated by incorporating ascorbic acid content, leaf extract pH, total chlorophyll content and relative water content into the following mathematical expression (Joshi and Swami, 2007):

$$APTI = \frac{A(T+P)+R}{10}$$

Where, A is the ascorbic acid content of leaf (mgg^{-1} of fresh weight); T is the total chlorophyll of leaf (mgg^{-1} of fresh weight); P is the pH of leaf extract and R is the relative water content, in percentage.

Using amounts of APTI, plants were classified into three groups (Singh and Rao, 1983): APTI < 10 → sensitive; 10 < APTI < 16 → mediocre; APTI > 17 → resistant. All the data obtained were further analyzed by using one-way ANOVA.

RESULTS AND DISCUSSION

Physiological characteristics of plants

Different plant species showed considerable variation in

Table 1. Comparison of the means of physiological parameters in plant species and four different sites.

Treatment zone	Mean				
	pH	Relative water content	Total chlorophyll	Ascorbic acid	Air pollution tolerance index
Azadi Square	586[A]	74.43[A]	0.891[A]	1.932[A]	10.29[A]
Bozorgmehr Square	5.79[A]	80.20[A]	0.855[A]	0.787[A]	9.13[A]
Laleh Square	5.96[A]	78.30[A]	0.823[A]	0.741[A]	8.88[A]
Mellat Ave.	5.81[A]	73.97[A]	0.797[A]	0.854[A]	8.56[A]
Morus alba	6.83[A]	83.85[A]	0.923[A]	0.952[A]	9.91[A]
Fraxinus excelsior	5.628[B]	72.98[B]	0.780[A]	0.757[A]	8.30[A]
Cupressus sempervirens	5.430[B]	67.74[B]	0.794[A]	1.59[A]	8.89[A]
Ligustrum ovalifolium	5.536[B]	82.32[A]	0.869[A]	1.015[A]	9.66[A]

Means in each column having common alphabets are not significant at 1% level.

Table 2. Analysis of variance of physiological characteristics in plants species.

S.O.V	df	Mean				
		Ascorbic acid	Total chlorophyll	pH	Relative water content	Air pollution tolerance index
Site	3	1.305	.0681	0.023	36.567	0.654
Species	3	0.513	0.899	1.712**	235.4**	1.805
Error	9	0.926	0.804	0.114	11.466	0.755
Total	15					

*, **, n.s: Significant at 5, 1% levels of probability and not significant, respectively.

their response to air pollutants. The level of studied parameter in plants reduced to various extents depending on the pollution load and its impact on the sites (Tables 1 and 2). However, plants maintained a certain level of a parameter due to a balance between the injury caused by the pollutants and the homeostatic processes governing repair. The results of the physiological characteristics of the plant species are represented in Tables 1 and 2. There was no significant difference between four sites and four plant species in contents of the acid ascorbic, total chlorophyll, pH, relative water content and air pollution tolerance index. The acidity and relative water content in plant species had different significance at $p<0.01$. Based on the results, pH of leaf samples was between 5.4 and 6.8. The lowest and highest content was measured for cypress and mulberry, respectively. Higher pH is known to improve tolerance to air pollution, while lower pH showed good correlation with sensitivity to air pollution (Yan and Hui, 2007). Relative water content was between 67.7 and 83.8%. The highest relative water content in the mulberry and the lowest was measured in Cypress. The range of total chlorophyll content was between 7.8 and 9.23 mg g^{-1}.

The highest and lowest content of chlorophyll was measured in the leaves of mulberry and ash, respectively. Reduction of chlorophyll in plants could unfavorably affect the photosynthesis, growth and productivity of plants (Yan and Hui, 2007). The range of acid ascorbic content was between 0.75 and 1.59 mgg^{-1} and the highest was in Cypress and the lowest was in ash. Ascorbic acid, a natural antioxidant in plants has been shown to play an important role in pollution tolerance (Joshi and Swami, 2007). The range of the air pollution tolerance was between 8.3 and 9.91, whereas the highest and lowest was in mulberry and ash, respectively. Plants which have higher index value are tolerant to air pollution and can be used as sink to mitigate pollution, while plants having low index value show less tolerance and can be used to indicate levels of air pollution (Singh and Rao, 1983).

Plant analysis

The average concentrations of heavy metals are represented in Tables 3 and 4. There were significant differences between four sites and four plant species in concentrations of Fe, Cu, Mn and Zn at $p < 0.05$. The maximum and minimum heavy metal concentrations were observed in the leaves of Cypress (340.8 $mgkg^{-1}$) and Prim (216.6 $mgkg^{-1}$), respectively. The Fe concentration in the leaves of the studied species was higher than the standard level (150 mg $kg^{-}1$) that has been reported by Markert (1993). Czarnowska and Milewska (2000) measured leaf Fe amounts which is between 121 and 1056 $\mu gg^{-1}{}_{Dw}$ using *Taraxacum officinale* in Warsaw Polonia related with the distance to the motorways. The

Table 3. Comparison of the means **o**f metal concentrations in plant species and four different sites (mg kg^{-1}).

Treatment zone	Mean			
	Fe	Zn	Cu	Mn
Azadi Square	270.5^{AB}	50.74^{A}	11.86^{AB}	63.68^{A}
Bozorgmehr Square	325.3^{A}	54.03^{A}	12.86^{A}	72.96^{A}
Laleh Square	301.4^{A}	46.40A^{B}	13.78^{A}	85.57^{A}
Mellat Ave.	223.5^{B}	24.68^{B}	7.65^{B}	51.6^{A}
Morus alba	280.8^{A}	45.60^{AB}	7.80^{B}	52.19^{A}
Fraxinus excelsior	282.5^{A}	26.13^{B}	12.86^{A}	58.24^{A}
Cupressus sempervirens	340.8^{A}	59.29^{A}	10.94^{AB}	95.31^{A}
Ligustrum ovalifolium	216.6^{B}	44.81^{AB}	14.55^{A}	95.31^{A}

Means in each column having common alphabets are not significant at 1% level.

Table 4. Analysis of variation of metal concentrations in plant species.

S.O.V	df	Mean			
		Fe	Zn	Cu	Mn
Site	3	7731.10*	699.546*	29.293*	2788.442
Species	3	10288.579*	741.585*	33.44*	2155.772
Error	9	1523.441	.192.508	7.326	1316.432
Total	15				

*, **, n.s: Significant at 5, 1% levels of probability and not significant, respectively.

concentration of Mn was very low in comparison with the standard level. Copper is a minor trace metal for the plants. As a result of the measurements, a change of Cu was between 7.8 and 14.5 mg kg^{-1} and the highest concentration was in Prim and the lowest was measured in mulberry leaves. It is accepted that the normal limits of Cu concentrations in plants are in the range of 4 to 15 $\mu gg^{-1}{}_{Dw}$ (Allaway, 1968) and between 20 and 100 $\mu gg^{-1}{}_{Dw}$ are accepted as toxic values (Kabata-Pendias and Pendias, 2001). With regards to these values, the Cu concentrations in this study were within normal limits. Aksoy and Ozturk (1997) used Nerium oleander as a biomonitor in Antalya and found minimum and maximum limits to be 3.2 to 6.18 $\mu gg^{-1}{}_{Dw}$ in unwashed and 3 to 4.45 $\mu gg^{-1}{}_{Dw}$ in washed leaves. Zinc is also one of the essential elements for plants. Plant limitation of this element in the tissue is 20 to 100 mg kg^{-1} (Kabata-Pendias and Pendias, 2001). In this study, the range of Zn in leaves of plant species was between 26.1 and 59.2. Maximum and minimum concentration was measured in cypress and ash, respectively. The normal limit of Zn concentrations in plants is 15 mg kg^{-1} (Markert, 1993). High levels of Zn in plants may cause loss of production, and the low levels may cause deformation of leaves. Zinc is not in harmful levels in our study; it is a major threat to the environment. This study supports the view that ash, mulberry, Cyprus and Prim could be used as biomonitor for Fe, Zn and Cu metals, especially their branches and leaves.

Conclusions

The plant species collected at the study area exhibited different concentrations of metals and the Fe and Cu concentrations in studied plants exceeds the permissible limit, whereas, Zn and Mn concentrations were below the permissible limit. The plants with higher APTI value were found to be tolerant and also act as a biomonitor for air pollutants.

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