



## The Role of Tree Species in Reducing Air Pollution Caused by Copper, Zinc and Cadmium (Case Study: Isfahan Town)

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### ABSTRACT

*Introduction and objective:* Environmental pollution is one of nowadays modern life phenomena resulting from waste generation, wastes, sewages and pollutant gases and human activities. It directly or indirectly impact on living creatures negatively. Present study aimed to investigate the role of tree species in reducing air pollution caused by copper, zinc and cadmium in Isfahan Town.

*Materials and method:* given the weather conditions of studied stations, especially, wind speed and direction, sampling was conducted at the end of June and at the end of December. Sample size was determined according to the number of studied tree species (pine, cypress, sycamore and ash), organs of tree species (leaves and roots), the number of stations (Azadi Square, Ahmad Abad Square, Sabahi Street), sampling interval (June and December) and repetition of testing (3 replications).

*Results:* variance analysis and SAS software were used to analyze the data. Duncan test was used to compare the averages. Significance level was considered 95%. Excel software was used to plot the charts and graphs.

*Conclusion:* in present study, it was observed that the absorption rate of metals (copper, zinc and cadmium) in the leaves of studied trees at polluted stations was more than control station and it increases at Sabahi, Ahmad Abad and Azadi stations, respectively. Also, the results showed that the absorption of these metals in the leaves of studied tree species has fluctuated at different times and its trend was increasing in March, January, July and September, respectively.

**Keywords:** tree species, copper, zinc, cadmium

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### INTRODUCTION

Environmental pollution is one of nowadays modern life phenomena resulting from waste generation, wastes, sewages and pollutant gases and human activities. It directly or indirectly impact on living creatures negatively (Abbaspour, 2004: 1107). With the increase in population and the phenomenon of industrialization of societies, the further use of fossil fuels, especially oil products, in order to produce electricity for transportation systems, industrial use, household consumption and etc., has led to environmental problems and issues due to production of hydrocarbons, polluting gases and heavy metals (Dabiri, 2000, 399). Environmental pollution has different shapes such as pesticides and organic chemicals, cleaners and detergents, dyestuffs, oil, sewage and toxic compounds. Recently, heavy metals have been known as new type of pollutions which may be more dangerous than other environmental pollutants (Abbaspour, 2004, 1107). Heavy metals are the metals that their density is more than 5gr/cm<sup>3</sup> and small amounts of them can be found in the soil. These metals are very important due to their non-biodegradability and their physiological effects on living organisms, even at very low concentrations and they are considered as the factors disturbing ecosystems (Al-Khlaifat, 2007). An important feature of heavy metals compared to other pollutants, is their stability and as the result, their gradual

accumulation in the soil. Soil organic matters increase their bioavailability, toxicity, mobility, and distribution in soil and water systems (Tipping, 2004). One of the main sources of heavy metals in cities are vehicles that pollute the soil around the roads by producing emissions and entering then into the environment and especially the air (Fakayoda & Owolabi, 2003). Among heavy metals, cadmium and lead are very important due to their long half-life in humans and other animals and their high toxicity. Lead is commonly entered into the urban environment as the result of using leaded gasoline fuels. In recent years, due to the removal of lead from gasoline, its entry into the urban environment has declined significantly, but still its former accumulation remains in the environment. Cadmium is also found in the tire and it enters the urban environment through depreciation of cars and traffic. Both metals have toxic impacts on the human body and create various complications such as blood, nervous and skeletal diseases (Sarkar, 2002). In present study, in order to investigate the absorption of heavy metals in some tree species in Isfahan Town, some parts of urban areas (parks, boulevards, streets and highways) and industrial areas where different tree and shrub species are used in, were selected as habitat and research stations. Then, during specific times, the leaves, branches and surface roots of species are sampled and the rate of pollution of each of them are determined and accordingly, the species which have the maximum absorption rate of heavy metals and show greater

resistance to these metals, are identified and used in contaminated areas.

#### Literature

Koneshlou (2006) have studied on the role of forestry in restoring damaged forest ecosystems and concluded that species of Eucalyptus sp have the highest ability to absorb heavy metal (lead, zinc and cadmium) of the soil and the species of Acacia Mill and Dalbergia sissoo Roxbg are placed in next places. Analysis of leaves showed that the species of Populus euphratica Oliv and Dalbergia sissoo Roxbg have highest absorption rate of heavy metals compared to foreign species.

Taebi et al. (2007) stated that the concentration of lead and cadmium decreases logarithmically with increasing distance from the roadside. They stated that with the increase in traffic volume, the concentration of lead linearly increases and the concentration of cadmium increases exponentially.

Maddah et al. (2013) have measured the lead levels in extracts of root, stem and leaf and soil at the end of November by ICP device. The results showed that *P. sylvestris* is a good species for phytoremediation of lead, at the concentration of 800 ppm, lead accumulation is more in roots and stems while at the concentration of 1600 ppm, the highest lead accumulation is observed in roots and leaves. Comparison of different soil horizons showed that lead is accumulated more in the surface horizon.

Shanker et al. (2005), in their study on the effects of chromium on plants, concluded that this metal has negative impact on the growth of plants, including changing the process of germination, growth of root, branches and leaves. Also the results showed that chromium has harmful effects on plant physiological processes such as photosynthesis system and vegetal sap flow.

Glowacki et al. (2006), in their study on the impact of heavy metals pollution on genetic variation of *Pinus sylvestris* L. population, concluded that there is a significant difference between the genetic makeup of *Pinus sylvestris* L. and heavy metal pollution so that these metals impact on genetic structure of *Pinus sylvestris* L.

Grytsyuk et al. (2006) concluded that accumulation intensity of heavy metals such as copper, zinc, lead and cadmium in plants depends on plant species, soil type, physical and chemical properties of metals and their amount in the soil.

Maher et al. (2008) have performed a study to determine the pollution caused by vehicles in the area of urban green space by analyzing the leaves of *Betula pendula* R. and concluded that the highest concentrations of lead and iron is in leaves of trees located at roadside and it decreases by distancing from the street.

The results of a study by Kord et al. (2013) showed that species of eldarica pine, Arizona cypress and acacia had the highest lead concentration in their shoots and the maximum lead-transfer coefficient from root to shoot, respectively.

#### METHOD AND MATERIALS

##### Case study

In present study, case study is Isfahan Town. Meteorology inventory was 10 years and related to the years 2004- 2014.

##### MATERIAL

In present study, in order to identify and implement research station on the city map, GPS was used. The pruning scissors was used to separate branches and surface roots. Hoes was used to digging the soil profile. Paper packets were used to gather and transport soil and plant samples. Distilled water was used to wash plant parts. Air Sampling Pump was used to assess heavy metal levels in the air and atomic absorption spectroscopy

(model: Varian 220) was used to measure the concentration of studied heavy metals in soil and plant samples. Excel software and Spss software were used to analyze the data.

#### METHOD

##### Identification of sampling stations

Given that the levels of pollution caused by studied heavy metals are not the same in all parts of the town, according to the air pollution reports provided by Environmental Protection Agency and Department of Transportation in Isfahan, Azadi Square station, Ahmad Abad station were selected as the stations with maximum and minimum pollution and Sabahi Street station as selected as control station to be used as a basis for comparison with other polluted stations.

Determining the levels of studied heavy metals in the air

Since the levels of heavy metals are not measured at air pollutants measuring stations in Isfahan Town, because of the type of study, it was required to measure the heavy metals levels in the air at the polluted and control research stations before sampling different parts of trees. Accordingly, during two periods in the June and December, the air was sampled for 45 minutes and the volume of 150 liters (with three replications) at each studied stations by air sampling pump. Then, the cellulose filter of air sampling pump was transported to the laboratory. In the laboratory, atomic absorption spectroscopy was used to determine the concentration of studied heavy metals in the air at each studied station. In order to determine the studied tree species, the species were selected from evergreen and deciduous species and broadleaf and conifer species based on the dominant species in Isfahan Town and also, the dominant species in all four studied areas. The tree species jointly found at all studied stations were identified and among them, 2 broadleaf species of sycamore and ash and two conifer species of pine and cypress were selected to do comparisons necessary to determine the amount of studied heavy metals among different parts of mentioned tree species such as leaves and surface roots.

Sampling time

Given the weather conditions of studied stations, especially, wind speed and direction, sampling was conducted at the end of June and at the end of December.

#### Results

##### Data analysis

In present study, the effects of variables including tree species, research stations, sampling interval on the concentration of studied heavy metals in leaves and roots of trees were investigated. Sampling was performed in the form of randomized complete block design in three replications. Variance analysis and SAS software were used to analyze the data. Duncan test was used to compare the averages. Significance level was considered 95%. Excel software was used to plot the charts and graphs.

**Table1. Variance analysis of studied traits (the June)**

Source of changes	D f.	Mean of squares					
		Cadmium Leaves	Cadmium Root	Zinc leaves	Zinc Root	Copper Leaves	Copper Root
Species	3	45.86**	8.56**	1.47**	0.33**	7.79**	2.49**
Habitat	2	137.73**	25.31**	2.94**	0.37**	4.31**	1.79**
Species*habitat	6	1.54**	2.72**	0.05**	0.03**	0.13*	0.07*
Error	60	0.39	0.19	0.01	0.01	0.04	0.02
CV(%)		12.62	18.18	8.13	11.18	11.51	15.66

Table2. Variance analysis of studied traits (the December)

Source of changes	D f.	Mean of squares					
		Cadmium Leaves	Cadmium Root	Zinc leaves	Zinc Root	Copper Leaves	Copper Root
Species	1	9.99*	0.96*	1.63**	0.15**	1.51**	0.12*
Habitat	2	69.85**	6.06*	14.33**	1.38**	2.87**	0.36**
Species*habitat	2	0.63*	0.06*	0.12**	0.02**	0.02**	0.01**
Error	30	0.47	0.16	0.1	0.04	0.05	0.02
CV(%)		12.23	21.68	14.53	27.64	10.41	20.14

The result of comparing the averages showed that the impact of station on the concentration of cadmium in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest cadmium concentration in leaves and roots was 10.23 ppm and related to pine species at Azadi Station and the lowest concentration was 0.57 ppm and related to ash species at Sabahi station.

The result of comparing the averages showed that the impact of station on the concentration of zinc in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest zinc concentration in leaves and roots was 2.14 ppm and related to pine species at Ahmad Abad Station and the lowest concentration was 0.64 ppm and related to ash species at Sabahi station.

The result of comparing the averages showed that the impact of station on the concentration of copper in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest copper concentration in leaves and roots was 3.76 ppm and 2.22 ppm respectively and related to pine species at Ahmad Abad Station and the lowest concentration was 0.71 ppm and 0.43 ppm respectively and related to ash species at Sabahi station.

Also about the results related to the December, the result of comparing the averages showed that the impact of station on the concentration of cadmium in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest cadmium concentration in leaves and roots was 9.43 ppm and 3.34 ppm respectively and related to pine species at Azadi Station and the lowest concentration was 2.07 ppm and 0.58 ppm respectively and related to cypress species at Sabahi station.

Also about the results related to the December, the result of comparing the averages showed that the impact of station on the concentration of zinc in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest zinc concentration in leaves and roots was 4.21 ppm and 1.49 ppm respectively and related to pine species at Ahmad Abad Station and the lowest concentration was 1.06 ppm and 0.33 ppm respectively and related to cypress species at Sabahi station.

Also about the results related to the December, the result of comparing the averages showed that the impact of station on the concentration of copper in leaves and roots of these trees was significant at significance level of 95% (p<0.05). The results of multiple comparisons using Duncan analysis suggests that the highest copper concentration in leaves and roots was 3.42 ppm and 1.27 ppm respectively and related to pine species at Azadi Station and the lowest concentration was 1.47 ppm and 0.4 ppm respectively and related to cypress species at Ahmad Abad station.

### DISCUSSION AND CONCLUSION

In present study, it was observed that the absorption rate of metals (copper, zinc and cadmium) in the leaves of studied trees at polluted stations was more than control station and it increases at Sabahi, Ahmad Abad and Azadi stations, respectively. Since, an environment play an important role in absorption of metals by plant species, it seems that given the higher concentration of metals in the air at Azadi station compared to other stations, absorption of these metals in the leaves of tree species was higher at this station. Heidari et al. (2005) stated that the absorption of lead by plants increases in proportion to its concentration in the environment. Marry et al. (1996), in their study, stated that there is a significant relationship between the absorption of lead by plants and its concentration in the environment.

The results showed that the absorption of these metals in leaves of studied tree species has fluctuated at different times and its trend was increasing in March, January, July and September, respectively. Given that absorption of elements in plants is an active physiological phenomenon, so, in the cold months, absorption decreases with decreased temperature and decreased breathing. Safdari (2004), in a study, noted that air pollutants have more impact on conifers because of their evergreen leaves and their greater leaf cross-section area in the air.

In present study, absorption of studied heavy metals in the roots of studied tree species at polluted stations was higher than control station and it increases at Sabahi, Ahmad Abad and Azadi stations, respectively. Since the environment plays a key role in absorption of lead by the parts of plant species, it seems that given the higher concentration of metals in the air at Azadi station compared to other stations, the absorption of metals in the roots of tree species has increased at this station. The results showed that the concentration of lead in the roots of tree species has fluctuated at different times and it was higher in the June comped to the December. Given that absorption of elements in plants is an active physiological phenomenon, so, in the cold months, absorption decreases with decreased temperature and decreased breathing. Pour Farhadi (1994) and Shah Mansouri (1995), in their studies, have investigated the role of different seasons in the absorption of lead in plants and stated that the highest concentration of lead occurs in the summer. Department of Parks and green spaces in Tehran (1994) reported that the highest lead concentration in organs of plant species occurred in

late September. In studied treatments, the lead concentration in the roots of conifer species was higher than broadleaf species and its trend increased in the elm, acacia, Arizona cypress and pine in Tehran. It seems that this can depend on concentration of lead in the soil and the ability of the roots of coniferous deciduous trees to absorb and accumulate the lead. Zahedipour (1996) stated that the concentration of heavy metals in the roots of plants approximately follows its concentration in the soil. As mentioned, the concentration of cadmium absorbed by studied species was higher at more polluted stations and the leaves of pine at Azadi station showed the highest concentration of the metal. Like cadmium, the results showed that the concentration of copper absorbed by the leaves of studied species has increased in the species of ash, sycamore, cypress and pine and the highest concentration of the metal was observed in the leaves of pine species. In terms of the impact of station on the concentration of copper absorbed by the studied species at Azadi station showed higher absorption of the metal. The concentration of zinc absorbed by the leaves of studied species increases in ash, sycamore, cypress and pine, respectively that the leaves of pine showed the highest concentration. The impact of stations on the absorption of the metal looked like two above metals and the highest concentration of zinc by studied species was observed at Azadi station.

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