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CASE STUDY

Reducing industrial dust pollution by Ash tree *Fraxinus excelsior* in urban green belt

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ABSTRACT

Heavy metal pollution is one of the largest problems in the Environment and human being. In industrial and urban areas trees can give better quantifications for pollutant concentrations and atmospheric deposition than non-biological samples. In order to know ability of *Fraxinus excelsior* (Ash tree) to reduce the concentrations of heavy metals and compared with the concentration of these pollutants in falling dust urban green belt. The results showed that the concentration of Iron, Manganese, Zinc, Lead, and Cadmium in falling dust respectively were the highest to the lowest. The distance from the highway in the concentration of pollutants in leaves and bark of the Ash tree showed significant results. Also, the effect of pollutant in the leaf of this plant was higher than that of bark, except for Cobalt. Concentrations of Zinc, Cobalt, and Nickel, increased with increasing distance from the road due to multi-directional winds and the presence of other contaminants. The Pearson correlation analysis between heavy metals found in the falling dust and Ash tree showed that the input and controlling factors of these elements in the Ash tree are probably the same as the dust. The results showed that the *Fraxinus excelsior* leaf with the amount of accumulation index of 1607 mg/kg has more ability to simultaneously absorb different metals. As a result, since this green belt surrounds Yazd urban area, it is hoped that a significant amount of heavy metals will be absorbed by these trees.

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INTRODUCTION

A green belt is a land use planning to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighboring urban areas. Trees leaves are used as indicators of heavy metal pollution.in industrial and in urban areas (Dadea *et al.,* 2017). Urban forests are an important part of the urban ecosystem, providing a myriad of ecological services that contribute and enhance human welfare, but at the same time, are profoundly influenced by urbanization (Ordóñez Barona 2015; fathizad *et al*., 2018). Due to rapid urbanization and industrialization during the past few decades, heavy metals concentrations in urban areas have reached a toxic level due to anthropogenic activities such as vehicle exhaust emissions, pesticide and fertilizer application, sewage sludge amendment, which release traces of heavy metals into the air, water and soil (Liu *et al*., 2016; Peng *et al.,* 2016). These heavy metals enter the environment through various human activities and affect the air quality and, by hanging and mating with dust particles, rainfall are deposited at the surface of the earth and vegetation,

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due to the wind speed or the precipitation of the heavens and they will remain in human being life cycle (Zhao *et et al*., 2018). Abbaspour *et al.*, (2017) investigated the effect of urban gardens on the PM_{10} emission of particulate matter using the Geographic information system (GIS) software, and concluded that by increasing the distance from the source (the center of the Laleh Park) to the particle propagation and diffusion the suspension has been added up to a distance of 3000 meters from the source in the Fatemi Square, which has been fixed and continued in the form of a smooth line. Hassanvand *et al*., (2018) by examining the amount of heavy metals (Pb, Cu and Zn) adsorption in soil and leaves (*Quercus brantii)* of oak tree in Alashtaer-Khorramabad highway, concluded that the concentration of heavy metals in soil increased with distance from the road and the concentrations of heavy metals in leaves of oak trees are less than the standard values of the world, so this tree has accumulated heavy metals. Saikachout *et al*., (2015) studied lead poisoning in *Atriplex* and concluded that stem growth and dry weight of root of *Atriplex* plant were exposed to high concentrations of Pb contaminated soil. After being exposed to lead stress, a significant increase in chlorophyll content was observed in the leaves of type plants (Iqbal *et al.,* 2015). Hassan Farid *et al*., (2017) have determined concentration of Pb from street falling dust on the leaves in 29 sites in Karachi urban, they concluded that the amount of Pb found on the leaves are more in the areas which have more printing, welding, soldering, and battery recycling shops. In Iran and in some region such as Yazd province, dust storms have induced harmful influences on human societies and caused economic, social, environmental, and political and security problems the dust storms caused destruction of farms, reducing people's income and forcing them to migrate. Dust particle contains large quantities of toxic substances that pose a risk to the health of living organisms and ecosystems. Dust sources are also associated with an increase in the amount of radioactive contamination due to the high emission of dust particles in the environment, heavy metals may be released on a large scale by binding to those particles. Heavy metals are also important due to physiological effects on humans and other living organisms, even at low concentrations (Wan *et al*., 2016). Cao *et al*., (2015) evaluated social, economic and environmental impacts of dust storms in Iran. Lyu *et al*., (2017) studied falling dust of three dust storms in 2010. They showed that these dust storms moved from northwestern to eastern regions of China. The ranges of dust deposition flux and soil D_{50} were 1.5-25.1 g/m^2 and 9-26.1 µm respectively. One of the most important air pollutants in Yazd city is suspended particles, from the industries close to the urban along with some heavy elements, it can cause pollution of environment. Hence the lack of urban garden and per capita green space and establish pollutant industries, in the Yazd-Ardakan plain, have created many problems for Yazd urban. Therefore, to develop the green space and create forest parks, the green belt design in the western part of Yazd has been studied and implemented, one of the dominant species planted in the green belt of Yazd highway is Ash tree. The purpose of this research is to investigate the effectiveness of Ash tree *(Fraxinus excelsior)* in reducing the pollutants of heavy metals in the environment by determining the concentration of some heavy metals in the leaves and bark of the ash tree and comparing with the concentrate of heavy metals in the falling dust. This study has been carried out in Yazd Province in 2017.

MATERIALS AND METHODS

Study area

Yazd is in the plain of Yazd-Ardakan with a dry weather in the coordinates of 54° 17′ E and 31° 54′ N. The wind direction is dominant in the northwest for 6 months from the 12 months (spring and summer seasons) and inside the 4 months (from November to February) in the southeast and in March; in a 24-year period, the wide variety of dusty days is 59 days and the most commonplace is 60 the summer day take place inflicting tangible and intangible damage to the human beings of Yazd (Hakimzdeh and vahdati, 2018). Yazd is one of the important cities in Iran in terms of industry, trade, tourism, the rapid growth of industries such as steel industry, the growth of vehicles, the lack of promotion of urban traffic and the desert climate of this region, exacerbates the inflow of contaminated micro flora due to lack of proper planting and vegetation cover, or vegetation loss in the western part of Yazd urban. Considering that the western part of Yazd is one of the important transit ports and industrial towns and factories, construe of the green belt in the western part of Yazd city has been studied and implemented (Fig. 1).

Fraxinus excelsior from Oleaceae family, the natural range of ash (*Fraxinus excelsior* L.) includes almost entire Europe except central and southern parts of the Iberian Peninsula, southeast Turkey, northern Scandinavia, and is present in parts of Western Asia and North Africa (Kerr and Cahalan, 2004), it is a valuable broadleaved tree due to its ecological characteristics, outstanding wood properties and high economic value. It is a fast growing species, associated with several forest types and with a scattered distribution in many different forest communities (Dobrowolska *et al*., 2011) (Fig. 2). The green belt region is irrigated with the resource of drip technique from well water in Shahid Bahonar Station. In order to investigate the quantity of heavy metals within the falling dust of the study area used Marble Dust Collector (MDCO) In an evaluation between horizontal and vertical samplers, it changed into concluded that the MDCO has the best efficiency for amassing dust (Gossen *et al*. 2008). (Fig. 3).

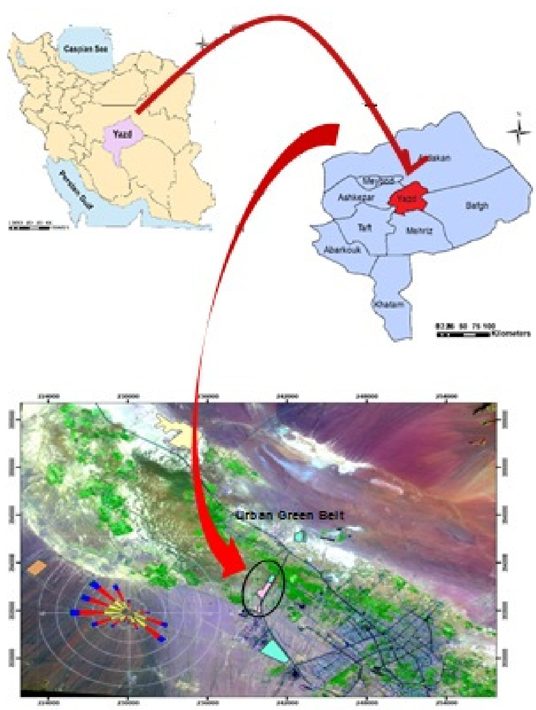

Fig. 1. Location of the study area along with wind direction

The sediment collector designed for this study comprises a 22 cm diameter circular plastic container, poured into a three-row or glass marble with an average diameter of 1.6 cm, and then on a polyethylene base at the height of one centimeter closed and placed inside the soil. After three months of autumn, collected falling dust transferred to the lab. After drying the specimens at 50 to 55 degrees in an oven, one gram of dust was weighed with a precision of 0.0001. In each sample, 7 ml of concentrated chloride-containing acid was added and after evacuation of the vapors, 2.5 ml of concentrated nitric acid and then 5 ml of dilute nitric acid (0.5 mol) was added. At last, after cooling the samples, 33.3 ml of diluted nitric acid was added and then the solution was made of filter paper the extract was transferred to the volume (Klute, 1986).The concentration of heavy metals (Zn, Pb, Cd, Co, and Ni) in a solution digested by a flame atomic absorption device Analytical Jena 330 model was determined. From healthy trees were harvested from leaf and bark tree from height 1 to 1.5 meters in all directions of the cover. Vegetative samples were dried and then milled in a temperature of $70^{\circ C}$ for 72 hours in an oven. Then concentrations of heavy metals (Zn, Pb, Cd, Co and Nickel) in leaves

Fig. 2. Ash (*Fraxinus excelsior*)

Fig. 3. Specimen of the dust collector

and bark Ash tree samples were Measured by the Analytik Jena 330 model atomic absorption (Klute, 1986).

Metal Accumulation Index (MAI)

Plant organs can be combined of numerous varieties of metal (Sharma, 1999) therefore, the metal accumulation index using Eq. 1 is used (Liu *et al*., 2007) to determine simultaneous accumulation of various metals by using *Fraxinus excelsior* L.

$$MAI = \left(\frac{1}{N}\right)\sum_{i=0}^{n} Ij \quad (1)$$

Wherein: N is the total number of elements measured, and Ij= X/ δX is the sub index for variable j, an outcome by dividing the mean value (X) of each metal by its standard deviation (δX). MAI value of leaves and bark was gained from an Eq. 2

$$MAI=1/5\times[(XCd/\delta Cd)+(XZn/\delta Zn)+(XNi/\delta Ni)+(XPb/\delta Pb)+(XCo/\delta Co)] \quad (2)$$

The Shapiro Wilk test was used to measure the normality of the data and to make trendy comparisons of variance analysis evaluation and to a test of data, the Duncan method was used at 95% significant level, the tests had been finished within the SPSS software.

RESULTS AND DISCUSSION

Descriptive statistics of the concentration of heavy metals in the falling dust of the study area is provided in Table 1. The concentration of Zn, Pb, and Cd in falling dust were the highest to the lowest. The elemental averages found in this study were comparable with the global elemental means in Table 2. The Cd contents observed in this study were multifold lower than those reported from urban settings globally (Isfahan (Iran), Soltani *et al.*, (2015); Nanjing (China), Hu *et al*., (2012); Lahore (Pakistan), Mohmand *et al.*, (2015); Birmingham (England), Charlesworth *et al.*, (2003); Zurich (Switzerland), Amato *et al.*, (2011); Islamabad (Pakistan), Faiz *et al.*, (2009); Rawalpindi (Pakistan), Abbasi *et al.*, (2013); Hangzhou (China), Zhang and Wang (2009); Huludao (China), Zheng *et al.*, (2010), Selangor (Malaysia), Latif *et al.*, (2009); Barcelona (Spain), Amato *et al.*, (2011). and higher than elsewhere WMZ (Pakistan), Eqani *et al.*, (2016); Newcastle (UK), Okorie *et al.*, (2012), Urumqi (China), Wei *et al.*, (2009); Ottawa (Canada), Rasmussen *et al.*, (2001) (Table 2). The Pb, Ni, and Zn averages of this study were multifold lower than elsewhere (Table 2).

The results of the analysis of variance (mean square) the impact on distance from the highway on the concentration of some heavy metals in the leaves and bark of *Fraxinus excelsior L* showed that the effect of distance from the highway in leaf and bark tree on the concentration of some heavy metals shows that there is a significant effect on Pb, Co, Ni, Zn and Cd in 1% level ($P \leq 0.01$). The concentrations of Zn, Cd and Ni in the leaves and bark of *Fraxinus excelsior* was different at 1% level ($p \leq 0.01$). while with Co metal in the bark and leaves Ash there was no significant difference and concentrations of Pb in the leaves and bark of *Fraxinus excelsior* was different at 5% level ($p \leq 0.05$) (Table 3). According to the results presented in Table 4, the interactive effects of the elements showed that in the three studied intervals, the amount of Ni at all three distance in the bark was greater than the leaves and its maximum value was 350 meters (24.75 mg/kg) is. The lowest amount of Ni in the leaves was got at a distance of 170 meters from the highway (18.23 mg/kg). The highest amount of Zn in the bark was at 350 meters distance from the highway (43.40 mg/kg) and the lowest in the bark at 35 meters (11.77 mg/kg). The highest amount of Co was found in the bark at a distance of 350 meters (6.08 mg/kg) and the lowest in leaves at 170 meters (4.93 mg/kg), and a significant difference between leaves and bark in there was no significant of 35 meters. The highest amount of Cd was in the distance of 35 meters and in the leaves (100.38 mg/kg) and the lowest in the bark at a distance of 170 meters (0.57 mg/kg), with a significant difference with the bark at 350 meters from the highway. The maximum

Table 1. Descriptive statistics of the concentration of heavy metals in falling dust

Metals		Min (mg/kg)	Max (mg/kg)	Mean ± S.D
Falling dust	Cd	0.35	3.28	1.56 ± 0.91
	Co	1.17	4.19	2.60 ± 0.29
	Ni	2.13	6.01	4.04 ± 0.86
	Pb	8.09	40.63	19.12 ± 3.92
	Zn	4.42	66.33	22.87 ± 3.98

Table 2. Mean concentrations of heavy metals in dusts of the world in comparison to Yazd

City/region	Mean elemental concentrations (mg/kg)					References
	Cd	Co	Ni	Pb	Zn	
WMZ (Pakistan)	0.42	4.89	14.4	63.9	116.4	Eqani *et al*. (2016)
Isfahan (Iran)	2.14	13.93	70.04	393.33	707.19	Soltani *et al.* (2015)
Newcastle (UK)	1	-	26	992	421	Okorie *et al*. (2012)
Urumqi (China)	1.17	10.97	43.28	53.53	294.47	Wei *et al*. (2009)
Nanjing (China)	13.2	13.6	24.7	655	1889	Hu *et al*. (2012)
Lahore (Pakistan)	2.3	3	93 8	170.2	196	Mohmand *et al.* (2015)
Ottawa (Canada)	0.37	-	15.2	39.05	112.5	Rasmussen *et al*. (2001)
Birmingham (England)	1.62	-	-	48	534	Charlesworth *et al.* (2003)
Zurich (Switzerland)	10	-	504	247	2183	Amato *et al*. (2011)
Islamabad (Pakistan)	5	-	23	104	116	Faiz *et al*. (2009)
Rawalpindi (Pakistan)	8.4	-	47.8	145.8	890	Abbasi *et al*. (2013)
Hangzhou (China)	1.59	20	26	202	321	Zhang and Wang (2009)
Zhejiang (China)	-	-	125	589	686	Zhu *et al*. (2008)
Huludao (China)	72.84	-	-	533	5271	Zheng *et al*. (2010)
Selangor (Malaysia)	250	-	510	430	210	Latif *et al*. (2009)
Barcelona (Spain)	3	-	58	248	1572	Amato *et al*. (2011)

Table 3. Analysis of variance (mean square) of *Fraxinus excelsior L.*

		Mean square				
Sources of changes	df	Pb	Cd	Co	Ni	Zn
Distance	2	531.5**	3185.17**	2.08**	34.12**	848.18 **
Organs	1	46.7*	23409.38**	0.45ns	45.51**	1544.33 **
Organ * Distance	2	13.44*	2135**	0.17 ns	0.59*	175.92 **
Error	18	3.84	1.07	0.12	0.16	0.11
CV %		11.99	17.81	14.31	14	15.56

*Significance at 0.05 level, ** Significance at 0.01 level. ns: No significant difference

Table 4. The effect of distance from the highway within the bark and leaves of Fraxinus excelsior L

Distance from the highway (m)	Organs	Measured elements (mg/kg)				
		Pb	Cd	Co	Ni	Zn
35 meters	Leaf	23.51±0.51[a]	100.38±2.34[a]	5.89±0.41[ab]	20.34± 0.05[d]	27.67±0.31[b]
35 meters	Bark	17.81±4.7[b]	8.1±0.52[d]	5.97±0.14[ab]	23.71±0.39[b]	11.77±0.36[e]
170 meters	Leaf	5.58±0.38[c]	28.10±0.24[c]	4.93±0.35[c]	18.23±0.89[e]	13.44±0.24[d]
170 meters	Bark	4.85±0.57[c]	0.57±0.08[e]	5.05±0.38[c]	20.56±0.33[dc]	6.75±0. 4[f]
350 meters	Leaf	18.44±0.34[b]	68.32±0.75[b]	5.47±0.38[bc]	22.18±0.53[c]	43.40±0.36[a]
350 meters	Bark	16.5±0.31[b]	0.74±0.07[e]	6.08±0.38[a]	24.75±0.34[a]	17.95±0.25[c]

*Average with at least common the letter have not any significant difference in the 5% Duncan test.
The values represent the mean with S.D.

Pb concentration at 35 meters and in the leaves (23.51 mg/kg) and the lowest dose was observed at a distance of 170 meters and in the bark (4.85 mg/kg), which had no significant difference with the leaves at 170 meters (5.58 mg/kg). In many studies, correlation coefficients have been used to express the possible origin of heavy metals. The correlation coefficients between metals can provide useful information about the origin and ways of entering them (Facchinelli *et al*., 2001; Lu *et al*., 2010; Maisto *et al.,* 2004).

According to the results of Table 5 in falling dust there's a significant correlation between Zn with Cd and Pb on the 1 % (p≤0.01). Cd metal has a positive and significant correlation with Ni metal with a correlation coefficient (0.71). Co metal has a positive and significant correlation with Pb metal with a

Table 5. Correlation coefficients among heavy metals concentrations in falling dust and Fraxinus *excelsior* L.

Heavy Metals		Ni	Co	Cd	Pb	Zn
Fraxinus excelsior	Ni	1				
	Co	0.66 **	1			
	Cd	- 0.33	0.09	1		
	Pb	0.48 *	0.65 **	0.61 **	1	
	Zn	0.27	0.17	0.57 **	0.61 **	1
Falling dust	Ni	1				
	Co	0.33	1			
	Cd	0.71 **	0.31	1		
	Pb	0.13	0.75 **	-0.13	1	
	Zn	0.27	-0.35	0.64 **	- 0.75**	1

*Significance at 0.05 level, ** Significance at 0.01 level. ns:No significant difference

correlation coefficient (0.75). Other research has also confirmed the direct courting between falling dust roadside contamination of heavy metals and traffic (Addo *et al*., 2012; Werkenthin, *et al.,* 2014). Biased on the outcomes of the correlation between heavy metals within the *Fraxinus excelsior* Ash trees in Table 5 , there's an advantageous and widespread correlation among Ni with Co with a correlation coefficient (0.66) on the 1 % (p≤0.01). Zn metal has a positive and significant correlation with Cd and Pb metals with a correlation coefficient (0.57 and 0.61) on the on the 1 % (p≤0.01). Pb metal has a positive and significant correlation with Ni metal with a correlation coefficient (0.48) on the on the 5 %(p≤0.05) also Pb metal has a positive and significant correlation with Co and Cd metals with a correlation coefficient (.065 and 0.61) on the on the 1 % (p≤0.01). Other researches have also confirmed the direct relationship between roadside contamination of heavy metals and traffic volumes in the plants (Azeem Jadoon *et al*., 2018; Skrbi´ca *et al*., 2012).

CONCLUSION

Urban green belts are considered the lungs of the cities as they act as an absorbent for some of the harmful gases released by vehicles and industries operating in the urban areas. Whether sprawling over a large area or a small belt, these green belts are found in all cities and play a vital role in reducing the industrial oriented pollution in the urban areas. The intention of this research was to investigate the capability of Ash tree *(Fraxinus excelsior)* in urban green belt vicinity of Yazd highway regarding the absorption of some heavy metals (Ni, Zn, Co, Cd and Pb) in the leaves and bark of the tree at different distances from the highway and its correlation with the falling dust. The results show that the average concentration of heavy metals elements (Cd, Co, Ni, Pb, and Zn) in falling dust were increased. Evaluation of plant samples from different distances from the highway showed that the concentration of Zn, Co and Ni are increased as the distance from the highway increased and this can be due to other pollutants and also the reduction of road traffic and winds blowing in the study area. Investigating plant samples at different intervals of highway showed that the concentrations of zinc, cobalt and nickel metals increased with distance from the highway, but in the case of other metals, this result was not applicable and this could be due to the existence of other Pollutants, apart from traffic jams and winds in the province, are somewhat different, although the distance from the highway and the trees in the green belt is somewhat safe from the traffic jams, but from The other side is against the winds of the western sector that carries out pollutants from the activity of industrial settlements and steel factories, ceramic tiles Therefore, the proximity to other pollutants can be due to this event. The highest correlation on falling dust was found between the Pb with the Zn and Co (0.75) and in *Fraxinus excelsior* L. Ash tree had the highest correlation among Co with Ni (0.66). The metal accumulation index (MAI) within the bark and leaves of *Fraxinus excelsior* was 1109.38 and 497.64 (1607) respectively. According to the accumulation index of metals in the ash tree, it can be concluded that this type of tree is resistant to the accumulation of heavy metals in its barks and leaves because of its adaptation to hard environmental conditions such as hot water, heat and drought and is one of the most resistant tree species. Therefore, in arid and rain-fed areas such as Yazd province, wind turbines and green spaces are suitable when the construction of streets, parks and urban boulevards are in mind.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues; including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy have been completely observed by the authors.

ABBREVIATIONS

Cd	Cadmium
Co	Cobalt
gm^{-2}	Gram per Square meters
Max	Maximum
Min	Minimum
mg kg^{-1}	Milligram per Kilogram
µm	Micrometer
Ni	Nickel
Pb	Lead
SD	Standard Deviation
Zn	Zinc

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