

## Assessment Some of Heavy Metals in Black Locust (*Robinia pseudoacacia*) in the Yazd Highway Green Belt

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The aim of this study was to assess the performance of *Robinia pseudoacacia* (black locust tree) to accumulation some of heavy metals and compared with the concentration of these metals in falling dust Yazd highway green belt. In order to an experiment was conducted as factorial based on completely randomized design with four replications. The results showed that the concentration of, iron, manganese, zinc, lead and cadmium metals in falling dust were the highest to the lowest, respectively. The distance from the highway in the concentration of heavy metals in leaves and bark of the black locust tree showed significant results ( $P < 0.01$ ). Also, the effect of heavy metals in the leaves of this tree was higher than that of bark. Concentrations of manganese, cobalt, nickel and cadmium metals increased with increasing distance from the highway due to multi-directional winds and the presence of other contaminants. The Pearson correlation analysis between heavy metals found in the falling dust and *Robinia pseudoacacia* showed that the input and controlling factors of these metals in the black locust tree are probably the same as the dust. The results showed that the leaves of *Robinia pseudoacacia* with the amount of metal accumulation index of 4438 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.

Abstract

**Keywords:** Falling dust, Heavy metals, *Robinia pseudoacacia*, Yazd green belt.

## INTRODUCTION

Due to rapid urbanization and industrialization during the past few decades, heavy metals concentrations on urban areas have reached a toxic level due to anthropogenic activities such as vehicle exhausts 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, due to the wind speed or the precipitation of the heavens and they will remain in human being life cycle (Zhuang *et al.*, 2018).

Trees as living elements in the environment are capable of via respiratory and absorption through the roots in addition to photosynthesis and different important functions, convert some of the pollutants into non-dangerous materials, and save part of them within their tissues and reduce their density of the environment (Chen and Haixiao, 2018). Dust storms are one of the natural events taking place in warm and humid regions such as Yazd province (Esfandiari, 2018), typically, desert dust contains wide quantities of toxic substances that pose a hazard to the health of living organisms and ecosystems, because of the high emissions of dust debris inside the environment doses, heavy metals may be released on a large scale by binding to those particles; heavy metals due to physiological effects on humans and other residing organisms at concentrations low significant are important (Wan *et al.*, 2016).

Jahanbazy Goujani *et al.* (2018) by measuring heavy metals (Pb, Cd, Ni, Ar and Hg) in the leaves of *Quercus brantii* healthy and dry trees, of Helen area of Chaharmahal and Bakhtiari province. Hassanvand *et al.* (2018) by examining the amount of heavy metals (Pb, Cu and Zn) adsorption in soil and leaves (*Q. brantii*) of oak tree in Alashtae-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 Pb 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. 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 of 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; Hakimzadeh, 2014).

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<sub>50</sub> were 1.5- 25.1 g m<sup>-2</sup> 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 capital green space and establish pollutant industries, in the Yazd-Ardakan plain, have created many problems of 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 black locust tree. The purpose of this research is to investigate the effectiveness of black locust tree (*Robinia pseudoacacia*) 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 City is located in the Yazd-Ardakan plain with a dry weather in the coordinates of 54° 17' E and 31° 54' N. Yazd has a warm, dry, and desert climate, and the temperature fluctuations in the summer and winter, even at night and in the day, are high and variable, and this is one of the climatic characteristics of this region has the maximum and minimum altitude is respectively 2684 and 997 m. The rainfall in this region is low and irregular (the mean rainfall is 118 mm per year) and its evaporation rate is between 2200 and 3200 mm per year. Yazd has mainly two seasons: the long hot season (from March to October) and the short cold season (from November to late February). (fathizad et al., 2018). 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 (Hakimzadeh Ardakani and Vahdati, 2018). Yazd is one of the important cities in Iran in terms of industry and 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 are 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).

Black locust (*Robinia pseudoacacia*) from Fabaceae family, native to the south and east of the united states, has alternate leaves, gray to caffeine the bark, and elongated branches of a rope-shaped bark (Fig. 2).

The green belt area 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 (Gossens and Rajort, 2008) (Fig. 3).

### Research methodology

Marble Dust Collector (MDCO) was used to measure the quantity of HMs within the falling dust in the study area. The sediment collector designed for this study comprises a circular plastic container 22 cm in diameter, placed into a three-fold glass marble with an average diameter of 1.6 cm, and then on a polyethylene bases on the height of 1 cm closed and placed inside the soil. After three months of autumn, dust samples were taken from the marble dust collector and then transferred to the laboratory. After drying the specimens at 50 to 55 °C in an oven, 1 g of dust was weighed with of 0.0001 g precision balance. Furthermore, 7 mL of concentrated chloride-containing acid was added in each sample, followed by adding 2.5 mL concentrated nitric acid after evacuation of the vapors, and finally, adding 5 ml diluted nitric acid (0.5 mol). After cooling the samples, 33.3 mL diluted nitric acid was added. Then the was passed through filter paper and the

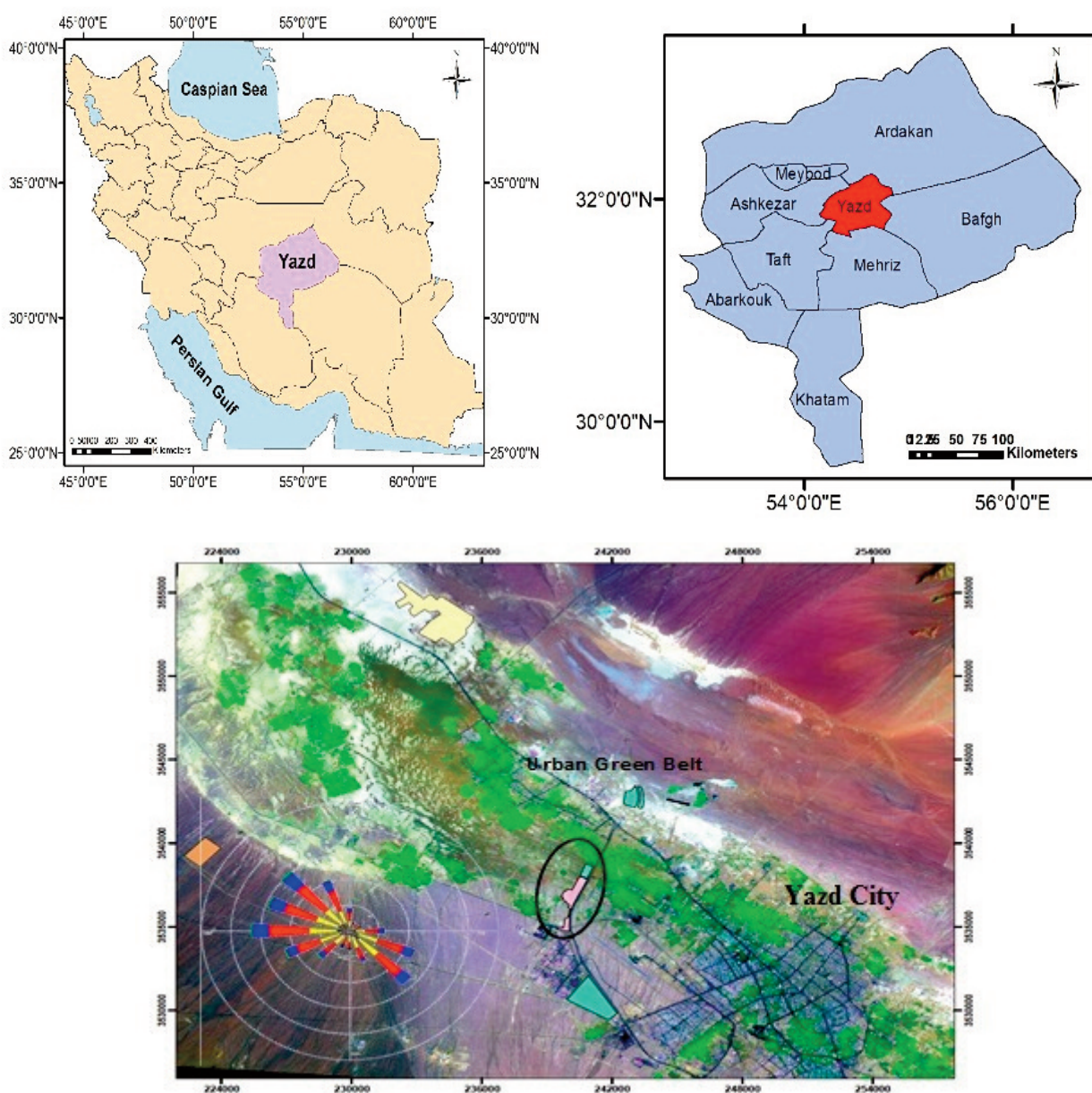


Fig. 1. Location of the study area.

extract was reached to the certain volume. The concentration of heavy metals (Zn, Pb, Cd, Co, Fe, Mn, Cu and Ni) in a solution digested by a flame atomic absorption device Analytical Jena 330 model was determined.

In order to evaluate the function of black locust from trees in the green belt at 3 distances from the highway (35, 170 and 350 meters from the highway) 24 plant samples were in 4 replicates from the healthy trees were collected. After washing, samples were dried and then milled in a temperature of 70 °C for 72 hours then concentrations of heavy metals (Zn, Pb, Cd, Co, Fe, Mn, Cu and Ni) in leaves and bark were measured by the Analytic Jena 330 model atomic absorption (Klute, 1986).



Fig. 2. *Robinia pseudoacacia*.



Fig. 3. Specimen of the Marble Dust Collector.

### Metal accumulation index (MAI)

Leaves and barks can be combined of numerous varieties of metals (Sharma, 1999) therefore, the metal accumulation index using Eq. 1 (Liu *et al.*, 2007) was used to determine the simultaneous accumulation of various metals using Robinin Pseudoscacia.

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

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

$$MAI = MAI = 1/8 \times [ (XCd/\delta Cd) + (XZn/\delta Zn) + (XNi/\delta Ni) + (XPb/\delta Pb) + (XCo/\delta Co) + (XMn/\delta Mn) + (XFe/\delta Fe) + (XCu/\delta Cu) ] \quad (2)$$

An experiment was conducted as factorial based on completely randomized design with four replications then 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, data were analyzed with SPSS software.

### RESULTS AND DISCUSSION

Descriptive statistics of the concentration of heavy metals in the falling dust of the study area is show in table 1. The concentrations of Fe, Mn, 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. The Cd contents observed in this study were multifold lower than those reported from urban settings globally, 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). The Pb, Ni, and Zn averages of this study were multifold lower than elsewhere.

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

	Matals	Minimum (mg kg <sup>-1</sup> )	Maximum (mg kg <sup>-1</sup> )	Mean ± Standard deviation
Falling dust	Cd	0.35	3.28	1.56 ± 0.91
	Co	1.17	4.19	2.60 ± 0.29
	Cu	2.4	15.43	8.63 ± 3.65
	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
	Fe	63.23	723000	160100 ± 2.62
	Mn	26.41	4220.83	2256 ± 12.76

The results of the ANOVA the impact on distance from the highway on the concentration of some heavy metals in the leaves and bark of *Robinia pseudoacacia* showed that the effect of distance from the highway in leaf and bark tree on the concentration of some heavy metals is a significant effect on (P< 0.01) (Table 2). The concentrations of Fe, Zn, Cd, Co, Pb, Mn, Cu and Ni in the leaves and bark of *Robinia pseudoacacia* was different at (P<0.01).

According to the outcomes presented in (Table 3), the interaction of factors confirmed that, inside the 3 studied intervals, the best amount of Ni were becoming found at a distance of 350 meters from the highway, in the leaf of the *Robinia pseudoacacia* and the bottom quantity of Ni in the tree bark were determined on 170 meters. The very best amount of Zn metal changed into acquired in leaf black locust tree, 35 meters from the highway and the bottom concentration of Zn within the acreage leaf tree of *Robinia pseudoacacia* 170 meters highway, the results of Moameri *et al.* (2017) showed Pb and Zn concentrations in the plants were higher than standard range in rangelands around Zanjan.

The very best amount of Fe was located in barks at 35 meters from the highway and the lowest amount changed into determined in bark black locust tree, 170 meters from the highway. The highest quantity of Co becomes found in leaf form 35 meters, and its lowest value of the bark changed into 350 meters. The highest amount of Cu metal was found within the leaf of the tree 35 meters from the highway and its lowest value became found within the barks of the black locust tree at a distance of 350 meters from the highway. The very best quantity of Mn metal became obtained 35 meters from the highway in leaves and the lowest amount become in the bark of the *Robinia pseudoacacia* at 350 meters from the highway. The highest amount of Cd metal changed into observed at 350 meters in leaves *Robinia pseudoacacia* and the lowest amount was found in the barks at 170 meters from the highway. The highest concentration of lead metal turned into found at 35 meters from the highway in leaves *Robinia pseudoacacia* and the lowest quantity of lead became observed in the bark in 170 meters from the highway.

The correlation coefficients between metals can provide useful information about the origin and ways of entering them (Facchinelli *et al.*, 2001; Maisto *et al.*, 2004).

According to the table 4 in falling dust there's a positive and significant correlation between Pb with Co and Zn on the percent (P<0.01).

Werkenthin *et al.* (2014) also reported that Pb is a metal that it has a high quality correlation with traffic intensity. Cd metal has a positive and significant correlation with Cu, Zn, Mn and Ni metals with a correlation coefficient (0.79, 0.64, 0.76 and 0.71).

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Table 2. Analysis of variance the impact on distance from the highway on the concentration of some heavy metals in the leaves and bark of black locust (*Robinia pseudoacacia*).

SoV	df	MS							
		Ni	Zn	Fe	Cu	Co	Mn	dC	bP
Distance	2	634.08**	603.40**	2041000**	111.40**	12.53**	2624.96**	61.07**	789.78**
Organ	1	583.51**	8113.03**	1067660**	166.37**	328.96**	4418**	24.75**	505.31**
Organ × Distance	2	318.79**	59.59**	120621**	23.82**	25.47**	3872.19**	10.51**	89.66**
ErrorCV (%)	18	0.2245.76	0.1146.47	132.381.46	0.30514.51	0.2538.86	16.653.82	0.19511.32	1.627.74

\*\* Significance at 0.01 level.

Table 3. The effect of distance from the highway within the bark and leaves of black locust (*Robinia pseudoacacia*) at the concentration of heavy metals.

Distance from the highway (m)	Organ	Measured metals (mg kg <sup>-1</sup> )							
		Ni	Zn	Fe	Cu	Co	Mn	Cd	Pb
35	Leaf	26.41±0.39 <sup>b</sup>	57.72±0.39 <sup>a</sup>	4457.8±1.88 <sup>a</sup>	14.30±0.97 <sup>a</sup>	9.56±0.66 <sup>b</sup>	144.9±4.8 <sup>b</sup>	7.5±0.60 <sup>c</sup>	39.82±2.87 <sup>a</sup>
35	Bark	24.4±0.23 <sup>c</sup>	22.76±0.24 <sup>d</sup>	4221.8±2.86 <sup>b</sup>	5.29±0.32 <sup>c</sup>	7.39±0.36 <sup>c</sup>	73.8±3.44 <sup>d</sup>	8.81±0.33 <sup>a</sup>	20.84±0.49 <sup>b</sup>
170	Leaf	17.97±0.86 <sup>e</sup>	38.67±0.55 <sup>e</sup>	1542.5±1.19 <sup>d</sup>	9.57±0.63 <sup>b</sup>	7.60±0.61 <sup>c</sup>	124.8±4.81 <sup>c</sup>	3.57±0.51 <sup>d</sup>	14.53±0.65 <sup>c</sup>
170	Bark	14.81±0.15 <sup>f</sup>	6.57±0.28 <sup>f</sup>	1213.2±0.85 <sup>f</sup>	5±0.24 <sup>e</sup>	6.41±0.17 <sup>d</sup>	21.84±0.45 <sup>e</sup>	2.84±0.09 <sup>e</sup>	8.7±0.42 <sup>d</sup>
350	Leaf	47.1±0.53 <sup>a</sup>	52.92±0.25 <sup>b</sup>	2172.8±1.49 <sup>c</sup>	3.56±0.51 <sup>d</sup>	13.40±0.66 <sup>a</sup>	173.8±6.43 <sup>a</sup>	9.44±0.50 <sup>a</sup>	20.3±0.72 <sup>b</sup>
350	Bark	22.86±0.25 <sup>d</sup>	10.12±0.12 <sup>e</sup>	1472.5±13.5 <sup>e</sup>	1.34±0.26 <sup>e</sup>	5.69±0.29 <sup>e</sup>	15.79±0.33 <sup>e</sup>	6.27±0.45 <sup>e</sup>	10.07±0.4 <sup>d</sup>

In each column, means with the similar letters are not significantly difference ( $P < 0.05$ ) using the Duncan test.

Co at ( $P < 0.05$ ) confirmed a positive and significant correlation with Cu and Fe metals with a correlation coefficient (0.53, 0.55). Ni contained in the falling dust at ( $P < 0.01$ ) had a positive and significant correlation with Mn metal with a correlation coefficient (0.71), Mn also had a positive and significant correlation with the Zn metal (0.51) and content with the Cu and Fe metals (0.59, 0.58). There has been a positive and significant correlation (0.56) with Cu and Zn metals ( $P < 0.05$ ). Addo *et al.* (2012), additionally stated that increasing the quantity of heavy metals inside the soil margin of roads with the aid of increasing site visitors quantity and evidently their launch into road dust is assets aside from the ignition of Pb gas and the damage to automobiles tires, and trees are a good biochemical indicator for the study of atmospheric pollution such as heavy metals pollution of dust and rain on the leaves are caused.

Based on the outcomes of the correlation between heavy metals within the black locust tree in table 4, there's an advantageous and widespread correlation between Mn and Cu (0.57) at ( $P < 0.05$ ). It expresses the relation between those objects of each other and the elements within the falling dust, other researches have also confirmed the direct relationship between roadside contamination of heavy metals and traffic volumes of the plants (Azeem Jadoon *et al.*, 2018; Skrbic *et al.*, 2012).

There may be an advantageous correlation among some of heavy metals at ( $P < 0.01$ ) according to table 4, the highest correlation is 0.89 between Ni and Co in *Robinia pseudoacacia*. Cd metal has a correlation with Fe, Ni and Co with correlation coefficient (0.63, 0.79, 0.63), and Co metal has an advantageous correlation with Zn, Mn and Ni with correlation coefficient (0.81, 0.83 and 0.89) and Ni metal has a correlation with Mn and Zn with correlation coefficient (0.68

and 0.62), and Cu metal has a correlation with Fe and Zn with correlation coefficient (0.54 and 0.63), according to the Table 4.

Table 4. Correlation coefficients among heavy metals concentrations in falling dust and *Robinia pseudoacacia*.

	Metal	Fe	Cu	Zn	Mn	Ni	Co	Cd	Pb
Falling dust	Fe	1							
	Cu	-0.042	1						
	Zn	0.006	0.56*	1					
	Mn	-0.58*	0.59*	0.51**	1				
	Ni	-0.64**	0.48	0.27	0.71**	1			
	Co	-0.55*	0.53*	-0.35	0.33	0.33	1		
	Cd	-0.49	0.79**	0.64**	0.76**	0.71**	0.31	1	
	Pb	-0.64	0.003	-0.75**	-0.10	0.13	0.75**	-0.13	1
<i>Robinia pseudoacacia</i>	Fe	1							
	Cu	0.54**	1						
	Zn	0.48*	0.63**	1					
	Mn	0.38	0.51*	0.96**	1				
	Ni	0.20	-0.18	0.62**	0.68**	1			
	Co	0.24	0.16	0.81**	0.83**	0.89**	1		
	Cd	0.63**	-0.08	0.48*	0.48*	0.79**	0.63**	1	
	Pb	0.85**	0.77**	0.78**	0.64**	0.32	0.48*	.53**	1

\* and \*\*: Significant at P > 0.05 and P > 0.01, respectively.

## CONCLUSION

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 in urban green belt vicinity of Yazd highway regarding the absorption of some heavy metals (Ni, Zn, Co, Cd, Mn, Fe, Cu 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 Cd < Co < Ni < Cu < Pb < Zn < Mn < Fe in falling dust were increased. Evaluation of plant samples from different distances from the highway showed that the concentration of Zn, Co, Fe 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 province. Investigating plant samples at different intervals of highway showed that the concentrations of Zn, Co, Fe and Ni 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, steel factories and ceramic tiles.

Therefore, the proximity to other pollutants can be due to this event. The highest correlation in falling dust was found between the Cd with the Mn (0.76) and in black locust tree (*Robinia pseudoacacia*) had the highest correlation among Ni with Co (0.89). The metal accumulation index (MAI) within the bark and leaves of *Robinia pseudoacacia* was 3910.21 and 4438.57, respectively.



According to the accumulation index of metals in the black locust 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 semi-arid 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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