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Effect of Heavy Metals Pollution (Cr,Cd,Pb) of Soils on Cultivated Plant in Road Side Area

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ABSTRACT

Heavy metal pollution of plants and soil near the roads is of concern in human and animal health since could get into food chain. To study the concentration of pollution in soil and plants, soil and pine needle leaves were collected at the four stations with different traffic intensity. After preparation and acidic digestion, the concentration of Pb, Cr and Cd were measured by atomic absorption. The amount of pollution was assessed by using a "geo-accumulation" metric method. Results showed that the Pb concentration in the soil near high-traffic station was 103.6 mg/kg while the concentration in proximity to low-traffic roads was 31.6 mg.kg. The concentration of cadmium in the soil was 1 mg/kg near high-traffic roads and 0.5 mg/kg near low traffic roads and the concentration of Cr was less than the detection limits. The concentration was higher in un-washed pine needle samples than the washed samples. Using the Muller geoaccumulation Index, the Lead concentration was 'medium' in near refinery station and 'high' in the overcrowded high way and near steel factory station. The control stations showed no lead pollution. None of the samples showed any chromium pollution. We conclude that the concentration of lead in the soil and plants are directly correlated with traffic intensity in each station.

Key-words: *Geo-accumulation Index, Heavy metals, Soil pollution, Plant pollution.*

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INTRODUCTION

The increasing of city development, rapid growth of urbanization and industrial revolution has caused a lot of environmental effects inside and around the cities (Ather et al., 1995). In order to protect ecosystems from toxic metals, the study of soil and plant pollution in road side area is very important (Hegazi and Elkadr , 2010). The heavy metals in fuel, tire and rusty parts of vehicles can probably enter the soil and wastewater and due to the probability of plant irrigation with wastewater. The aim of present study is measuring the level of Pb, Cd and Cr on road side soil and its relationship with plant pollution in this area and control samples.

MATERIAL & METHODS

Isfahan city with an area of about 15774/39 km^2 is located between 30 degree and 43 minutes to 34 degrees and 27 minutes of northern latitudes and 49 degrees and 36 minutes to 55 degree and 31 minutes of eastern longitude in prime meridian (governor general office and management and planning organization of the province), [Figure 1]

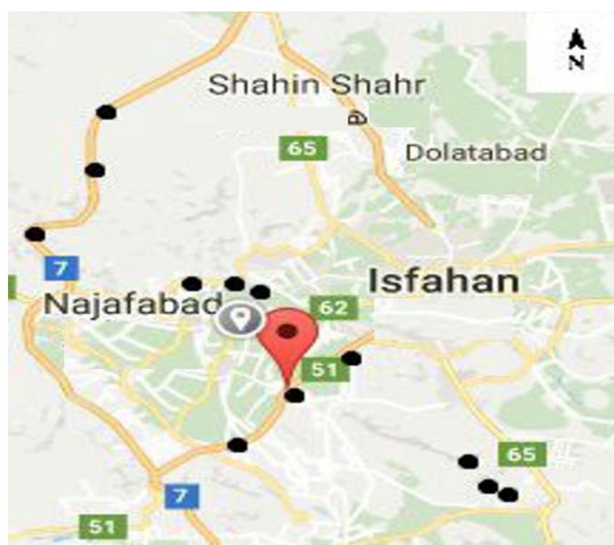


Figure 1: Isfahan map, locating the stations.

Four stations were considered to study the concentration of pollutants [Table 1].

Table 1: The characteristics of the studied stations.

Station	Characteristics	Daily Traffic
First	High traffic, near refinery, petrochemical and hospital	12800 vehicles
Second	Overcrowded highway with high traffic, near steel factory	24800 vehicles
Third	Control (Third)	Less than 200 vehicles
Fourth	Control (Fourth)	More than 20 vehicles

The studied plant is pinus eldarica medv (Tehran pine). The original version of this pine is from Caucasus and Iran's Azarbaijan. The usual pine in Isfahan has 12 to 20 meters and the diameter of its trunk is about 40-50 cm. Its leaves are 2 to 3 in each node and have a length of 10-15 cm.

Plant and soil sampling

In summer, 18 samples of Pinus Eldarica Medv at the height of 1/5-2 meters above the ground at 4 sides of the tree and 4 stations were taken from the boulevard edge with 0/5meter distance and were mixed together. Then, they were placed inside numbered plastic packages and transferred to laboratory. Eighty percent of plant samples were washed and the rest were unwashed and placed for 48 hours in the oven at temperature of 75 degrees of centigrade. Then, they were powdered by porcelain mortar and passed through sieve with mesh 35 and were ready for decomposition. The number of 12 soil samples were taken from the 10 cm depth of surface soil in quadruple regions by sampling shovel and all soil samples were kept at temperature of 110 degrees in an oven for 24 hours in order to destroy soil moisture and then were passed through a 2 mm sieve (mesh 10) according to the standard method and then the mixture samples were transferred into marked cans and made ready for chemical decomposition (ASTM, 2014).the data that were read by atomic absorption system were multiplied by the sample size and divided into the dry weight of plant/soil in order to be turned into MG/KG. Data analysis was performed by Excel and SPSS statistical software. kruskal-wallis test and Pearson test was used. Then, to study the normality of data distribution, the Shapiro test was used. (Mohammadi, 1998) To determine the degree of pollution, the Muller geochemical index was used. The formula is as follows:

Formula 1

$$I_{geo} = Log_2\left[\frac{Cn}{Bnx1.5}\right]$$ (Muller, 1979)

Cn= current concentration of element in soil and sediment
Bn= Element Concentration in Shale
1.5= shale correction factor

In this formula, the shale concentration that is a kind of sedimentary rock must be used since the previous concentration of the element is not obtained through the complete decomposition. Because the average concentration of elements in shale is less than the average concentration of elements in non-polluted sediments, it is multiplied by 1/5 for balancing. (Muller, 1979). Then, the of Muller geoaccumulation index is used to determine the level of pollution and in [Table2], the shale average was shown for the studied elements[Table3] (Woitke et al., 2003).

Table 2: The classes of Muller geoaccumulation index

Pollution status (Muller area)	Degree of pollution	Igeo
Non-polluted	0	≤0
From non-polluted to average pollution	1	0-1
Average pollution	2	1-2
From average pollution to high pollution	3	2-3
High pollution	4	3-4
High pollution to very high pollution	5	4-5
Very high pollution	6	≥5

Table 3: The shale average for the studied elements

Element	Shale average
Cadmium	1.1
Lead	23
Chromium	90

RESULTS

On the basis of results, in high-traffic stations, the Pb and Cr concentration in soil has a significant difference to the control stations and some standards values [Table 4, Figure 2].

Table 4: The Cd and Pb concentration in soil for each station

Metal	Station n.	Sample n.	Min	Max	Mean	Standard deviation	Variance
Pb	1	3	41.0	89.5	58.0	27.3	745.7
	2	3	43.0	203.0	149.3	92.0	8480.3
	3	3	29.5	34.0	31.16	2.4	6.0
	4	3	31.5	33.0	32.1	0.7	.58
Cd	1	3	1.0	1.5	1.16	.28	.08
	2	3	.50	1.5	.83	.58	.33
	3	3	.50	.50	.50	0	0
	4	3	.50	.50	.50	0	0

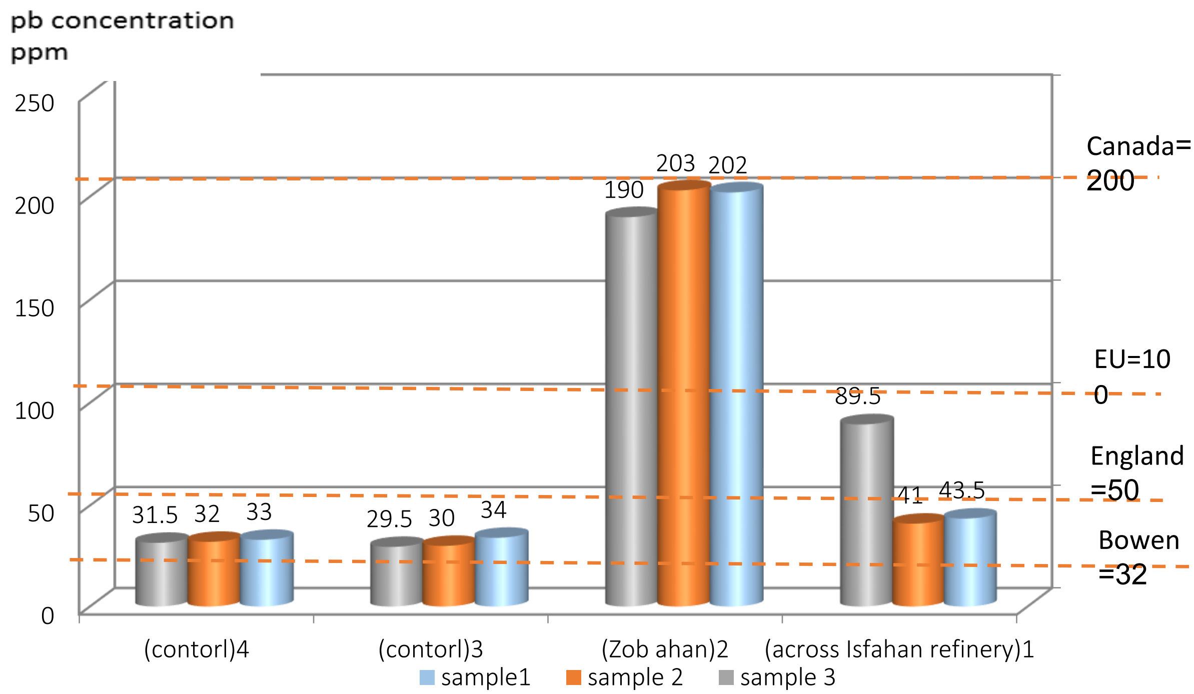


Figure 2: The comparison of soil pb concentration (mg/kg) to standard values

At 0/05 error level, the concentration level of soil cd was significantly less than 8 i.e. the Canada standard and also less than 3 i.e. the England and EU standard but at 0/05 error level, the Cd concentration in soil was significantly bigger than the Bowen global average standard. To compare the control and main stations, the nonparametric kruskal-wallis test was used. The results of kruskal-wallis test show that Pb concentration has a significant difference between the main and control stations but cd concentration is the same among all stations [Table 5].

Table 5: The results of kruskal-wallis test

	Pb	Cd
Chi-square	8.74	7.11
df	3	3
Asymp.sig	.033	.068

In [Table 6] since Pb concentration is not equal in control and main stations, the paired comparisons show which ones have a difference with the control group. According to P values, it can be said that the control stations number 3 and 4 have a significant difference with station 3 and the other stations have the same concentration of Pb.

Table 6: Paired comparison for Pb concentration among the control and main stations

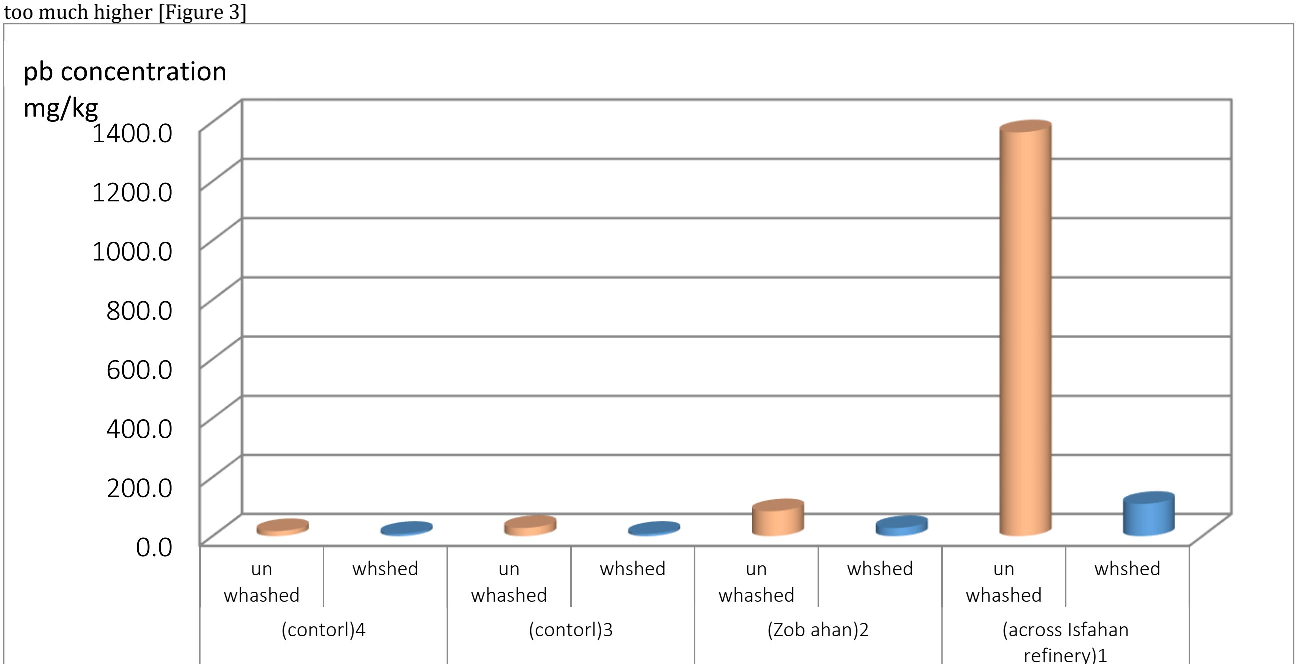
	Station n	Correlation	Std. error	Sig
	2-1	-1.66	2.94	0.571
	4-3	-1	2.94	0.734
	1-4	4.66	2.94	0.113
	1-3	5.66	2.94	0.054
	2-4	6.33	2.94	0.031
	2-3	7.33	2.94	0.013

The maximum average of Pb concentration in plant (109/5 mg/kg) is related to the first station and the minimum average of Pb concentration in plant (7/8 mg/kg) is related to station 4 [Table7]. The concentration of Cd in all stations has the same and constant values equal to 0/50.

Table 7: The Pb and Cd concentration in plants for each station.

Metal	Station n.	Sample n.	Min	Max	Mean	Standard deviation	Variance
Pb	1	3	5.00	294.00	109.5	160.2	2568.2
	2	3	19.00	39.5	27.6	10.6	112.5
	3	3	5.00	11.00	8.00	3.00	9.00
	4	3	5.00	11.5	7.8	3.3	11.00
Cd	1	3	.50	.50	.50	0.00	0.00
	2	3	.50	.50	.50	0.00	0.00
	3	3	.50	.50	.50	0.00	0.00
	4	3	.50	.50	.50	0.00	0.00

The concentration of pb in unwashed plant in all stations is more than the washed samples and this amount in station 1 is too much higher [Figure 3]



	(contorl)4 un whashed	(contorl)4 whshed	(contorl)3 un whashed	(contorl)3 whshed	(Zob ahan)2 un whashed	(Zob ahan)2 whshed	(across Isfahan refinery)1 un whashed	(across Isfahan refinery)1 whshed
mean	17	7.8	28	8	84.5	27.7	1365	109.5

Figure 3: The Pb concentration for washed and unwashed plant leaves

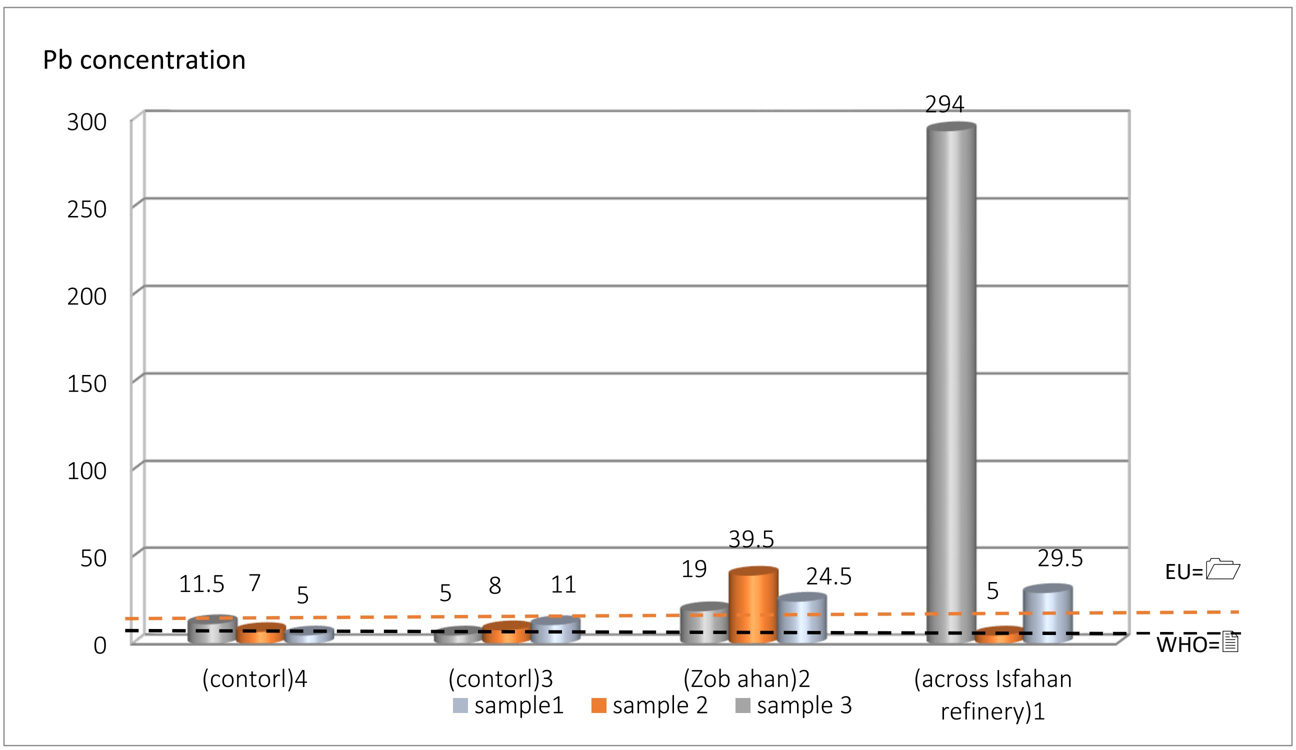
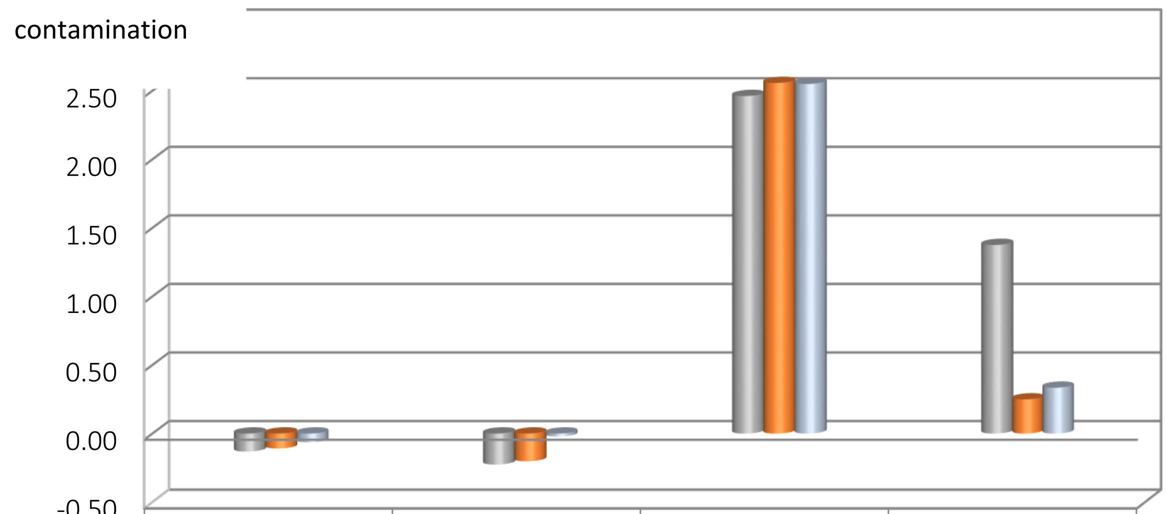


Figure 4: The comparison of Pb concentration in plant to international standard values.

To study the relationship between heavy metals concentration in soil and plant, in the Pearson correlation coefficient was used.

The concentration of plant Pb in this case has a direct but weak relationship with each other that is not significant at 0/05 error level [Figure 4]. It can be said that when all samples are washed in leaf sample, no significant relationship can be considered between soil and plant Pb concentration. Determining the soil pollution degree was done by SPSS (Version 22) software.



	(contorl)4	(contorl)3	(Zob ahan)2	(across Isfahan refinery)1
sample1	-0.06	-0.02	2.55	0.33
sample 2	-0.11	-0.20	2.56	0.25
sample 3	-0.13	-0.23	2.46	1.38

Figure 5: IGEO for Lead at each station.

According to Muller geochemical index, the Igeo for lead concentration had the highest average in station 2 and the least average in the first station [Figure 5]. Also, Igeo for chromium is equal in all stations. The Igeo for cadmium had the highest average in station 1 and the least average in stations 3 and 4. With the help of Muller ruler, it can be said that lead in the first station has an average pollution. Also, it has the high pollution in the second station and the control stations have no lead pollution. Also, soil is located at non-polluted area than chromium. To compare the cadmium concentration in treatment and control stations, it can be said that the station number1has more potential than the second and control stations for being polluted with cadmium.

DISCUSSION

There is direct relationship between lead concentration in soil and plant with the traffic intensity, also significant difference in heavy metal concentration of washed and unwashed plants. Also we confirmed transferring of Pb and cd to soil and plant through road traffics and the increase of heavy metals concentration in soil and plant of the studied region due to heavy metals in tire, battery and erosion of vehicles. (Khodaverdi et al2012)Rolli .et al., (2016); Salimi et al., (2014) also came to these conclusions. The present study showed that the lead concentration in soil and plants has a direct relationship with traffic intensity as Celik(2004) found it. The amount of chromium in soil often recognized by device. The results have shown that leaves have no chromium absorption. Cd and pb are usually released by vehicles and found in road dust (Jaradat, 1999). In general, the Lead average concentration in soil at high traffic area (station 2) was 7 times the Bowen global average (32 mg/kg) for soil. The presence of high concentration of lead in unwashed plants in the present study shows that lead can be absorbed by plants through the air and soil. Abechi in (2010) and Buachoon(2014), came to the same conclusion. In comparison of the washed plant and unwashed plant, the concentration of plant lead in unwashed plant in station 1 was 13 times than the washed plant. Also, in comparison of lead concentration to the who standard, station 1 is 55 times the who standard (2 mg/kg). Also, in comparison to Muller geochemical pollution index, the second station has high pollution and the first station had average pollution.

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