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Original article

Determination of Heavy Metal Contamination with Soil and Plant Samples (*Pinus sylvestris*) on roadside and intersections in Erzurum/Turkey

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Abstract

In this research, heavy metal contamination of both soil and plant samples collected from 11 different locations where Scotch pine (*Pinus sylvestris*) was grown on was determined. The soil and plant samples were obtained both during January and August 2008 year and then heavy metal contents were analyzed in the labarotory. Heavy metal contens of plant and soil samples were compared by using standard values. The results showed that there were statistical differences among all elements considering both locations and sampling points. The soils sampled from 11 different locations analysed and the results indicated that some heavy metals were over critical levels. Fe and Cu in 100.yıl park, Cu in all 11 locations and Zn in 100. yıl park, Yenişehir and Havuzbaşı ıntersection were over critical level. On the other hand, Pb, Cd and Ni were within the normal limits in all sampling areas. In plant samples, Fe and Cu in all the sampling areas during both January and August, Cu during January and August only in the Migros ıntersection and Station ıntersection , Mn in January in all the locations, Zn in January in between Havuz Basi and Universite Roundabout were found over the limit value. Pb was found higher over the limit values in Havuzbaşı ıntersection, Tebrizkapı ıntersection, Migros ıntersection and Kayak road in January. Ni found over the limit value in Gez ıntersection, Yenisehir ıntersection and Kayak road ıntersection during January.

Keywords: Heavy metal, Traffic junction soil, Scotch pine, *Pinus Sylvestris*.

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INTRODUCTION

In the recent years, there have been a vast number of reports on the presence of heavy metals, such as cadmium, chromium, lead and mercury in higher the plants. Most of these reports were concerned mainly with environmental pollution. The presence of heavy metals in the food chain may result in genotypical differences in the critical toxicity levels of heavy metals in those plants. The accumulation of heavy metals in the environmental samples (plants, sediments, soils, sewage sludges, solid residues, *etc.)* causes a potential risk to human health due to transfer of those elements in aquatic media, their uptake by plants and their subsequent introduction into the food chain. The contamination of plants by toxic heavy metals has a major impact on both the environmental cycling of nutrients and the quality of foodstuffs. Plants can accumulate trace elements, especially heavy metals, from soil, water or air. There was a wide variability in the bioaccumulation of trace elements among different plant species. For example, some elements such as B, Cd, Rb and Cs are readily taken up, whereas Fe and Se are slightly available to plants (Yildiz and Aksu, 2008).

Many studies has been conducted to investigate the heavy metal contamination of soil. Generally, it was observed that there was a significant increase in total content of the heavy metals in soil closer to the source, which clearly decreases with the increase distance. Many trace metals are present in leaded and unleaded petrol, diesel oil, anti-wear substances added to lubricants, brake pads, and tires, and emitted by vehicle exhaust pipes. Lead is added to gasoline to prevent engine knock, so that the cars become a major source of lead to the environment. Metals such as Fe, Cu, and Zn are essential components of many alloys, pipes, wires and tires in motor vehicles and are released into the roadside environment as a result of mechanical abrasion. Many studies investigated the heavy metal concentration profiles in the soil. The results showed that very high concentrations in the top few centimeters of the soil and then the heavy metal concentration decrease with depth and reach the background levels between 30 and 100 cm (Qasem et al., 2005).

The concentration of heavy metals and toxic elements in roadside soil can provide valuable information about pollution levels in urban and industrial areas, since, in most cases, such concentrations reflect the role of the emissions of these elements from anthropogenic sources (Fergusson, 1990; Harrison et al., 1981). Most of such works focused on measuring heavy metal contents in soil surrounding roadways since they are greatly increased by automobile fuel, exhaust, tires, mechanical friction, wire and tire, etc (Gulser and Eraydin, 2004). Natural resources or through contamination arising from high concentrations of some heavy metals, edible and nonedible plant and animal feed can negatively be affected. Chromium, nickel and lead in the soil between 10-100 ppm, and less than 1.0 ppm cadmium in the normal levels if these amounts are considered to be (Mattigod and Page, 1983). The aim of this study was to assess the heavy metal contamination in Erzurum City Center. Therefore; 11 different locations considering intensivity of traffic (Rectorate ıntersection, Üniversity ıntersection,

Havuzbaşı ıntersection, Ilica Road, Station ıntersection Migros ıntersection, Tebrizkapı ıntersection , Gez intersection, 100.yıl Park, Kayak road, between Havuzbaşı –Üniversity and Yenişehir (Günsazak) ıntersection were selected and the soil samples was taken in August and plant samples was taken in both January and August (*Scotch pine, Pinus sylvesteris*). In order to determine heavy metal contamination in both soil and plant, Fe, Cu, Zn, Mn, Cd, Pb and Ni pollution was investigated.

MATERIALS and METHODS

Scotch pine (Pinus sylvesteris) is resistant to strong wind and cold of Erzurum and it can survive as low as temperature of -45ºC (Yilmaz, 2000). Plant samples Scotch pine (*Pinus sylvestris*) were collected from eleven locations. The collected plant samples were put in pre-washed plastic bags then stored in refrigerator for subsequent analysis. The field soil and plant sampling points in the studied area were shown in Figure 1. Soil samples were collected during August, 2008 to avoid leaching of the heavy metals out of the sampled materials by rain. Air dried soil samples were sieved using a sieve of 2.0mm size. The soil properties that were determined are as follows; texture (Bouyocous, 1951; Gee and Bauder, 1986), pH (McLean, 1982). $CaCO_3$ % (Nelson, 1982). Soil organic matter content (Nelson and Sommers, 1983), cation exchange capacity (Rhoades, 1983), exchangable cations (Rhoades, 1982), available phosphorus (Olsen and Sommers, 1982). Available heavy metal content (Lindsay and Norvell, 1969). Nitrogen content of soil (Kacar and İnal, 2008). The data were subjected to ANOVA test and compeared using Duncan's multiple comparison test method using (SAS Windows Pakage Vol. 9.0).

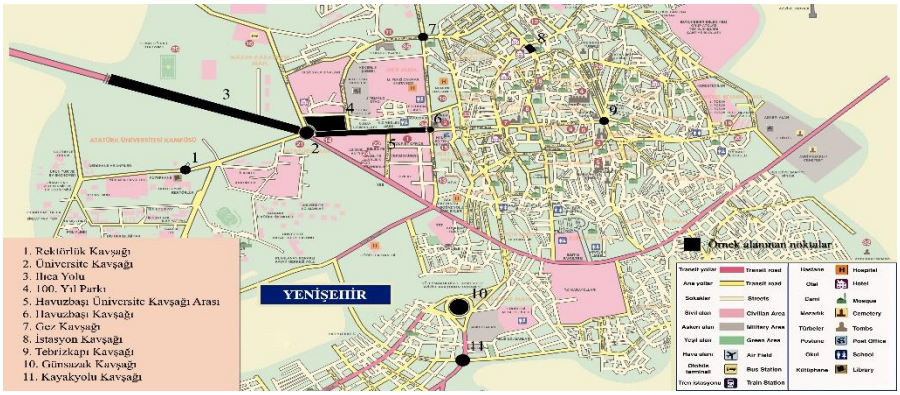

Figure 1. Plant and Soil Samples location.

Table 1. Some Chemical and Physical Properties of Soil Samples

Sampling Points (Intersection Roadside)	Clay (%)	Silt (%)	Sand (%)	Texture Class	pH (1:25)	CaCO3 (%)	Nitrogen (%)	O. M (%)	P (ppm)	CEC cmol/kg	Exchangeable K cmol/kg
Rectorate I.	12	31.13	56.63	Sandy-loam	7.36	1.625	0.147	1.188	13.11	10.69	3.07
Üniversity I.	10	25.27	64.06	Sandy-loam	7.08	0.715	0.315	2.72	12.75	11.48	2.51
Havuzbaşı I.	13	35.02	51.47	Loam	7.57	8.62	0.434	2.86	8.39	12.28	2.76
Ilica Road	14	44.05	40.98	Loam	7.77	1.46	0.231	5.87	15.24	10.7	3.18
Station I.	14	27.28	58.48	Sandy-Loam	7.15	8.62	0.364	1.69	29.76	11.05	3.13
Tebrizkapı I.	12	25.42	62.08	Sandy-Loam	7.45	3.09	0.252	2.33	62.00	12.00	2.35
Gez I.	10	26.8	63.1	Sandy-Loam	7.41	3.42	0.266	1.14	34.13	11.66	2.93
100.Yıl Park	10	22.65	67.27	Sandy-Loam	6.77	6.99	0.504	3.55	105.34	17.39	4.35
KayakRoad	8	23.36	69.58	Sandy-Loam	7.28	4.72	0.1855	1.75	22.44	10.09	2.82
Between HÜ.R	10	19.02	70.93	Sandy-Loam	7.02	1.398	0.168	0.86	23.38	18.27	4.1
Yenişehir I.	5	27.33	66.72	Sandy-Loam	7.46	0.748	0.252	1.73	31.17	11.66	2.72

RESULTS and DISCUSSION

Results

The highest amount of Fe in the soil samples was 10.8 ppm at 100.Yıl Park, which was very high. While the lowest value was 0.68 ppm from Migros ıntersection, which was in the acceptable range. The amount of Cu in the soil samples was 13.19 ppm in the 100.yıl Park, and 1.07 ppm at the Rectorate ıntersection. Thus, the amount of Mn in the soil samples was 17.14 ppm at Yenişehir Intersection, this amount of Mn was very low compared with the value of 3.02 ppm, which was obtained. Jones et al. (1991) determined similar results.

Human activities have dramatically changed the balance, biochemical, and geological cycles of many heavy metals. The content of heavy metals in soil and their impact on ecosystems can be influenced by many natural factors, such as parent material, climate, soil processes and anthropogenic activities such as industry, agriculture and transportation (Pivic et al., 2014).

The highest value of Pb in the soil samples was 2.26 ppm at Kayakyolu, which was less than the one at Havuzbaşı Intersection, Migros Intersection, and Tebrizkapı Intersection. Kabata-Pendias and Pendias (1992) in their study also determined a very low concentration of Pb. In terms of Nitrogen, the values were significant at the level of 0.05 at 100.yıl park and highly significant at the level of 0.01 at Yenişehir Intersection, which was on the same track with Jones et al. (1991). On the other hand, the value of Cd in the soil samples was 0.39 ppm at 100.yıl Park, while it was 0.102 ppm between the HÜ Also, the Havuzbaşı and Yenişehir intersections from other sampling sites showed sufficient Cd and Ni content. These results are close to the results of Kabata-Pendias and Pendias (1992).

In terms of available P to the plant from the soil samples; the value of P was 62 ppm at Tebrizkapı Intersection, while it was 8.9 ppm at Havuzbaşı Intersection which was at a sufficient level according to Jones et al. (1991). While the vales of Zn was 11.27 ppm at 100th year park and it was very high at hot spring road with a value of 0.57 ppm, which was similar to Jones et al. (1991) results.

The results of the scotch pine showed that the highest Fe value 872.2 ppm was determined at the junction of the highest ski road in August whereas in January it was 1126.2 ppm at 100.yıl park. Periodically, the Fe value in January was higher than in August. Since the limit value given for Fe was 98 ppm, the values determined at all points were found to be much higher than the limit value according to Jones et al. (1991).

The highest value of Cu in Scots pine was determined at the Migros ıntersection in August and January, with values of 17.2 ppm and 16.4 ppm respectively. When we look at it periodically, these values were higher than the value of 14.41 ppm. Since the limit value given for Cu was 9 ppm, the limit value was exceeded at Gez Intersection and Yenişehir Intersection, except for the samples taken in August. On the other hand, a value of 6.05 ppm was found below the limit value in the sample taken in August from Ilıca road this result was agreed with Jones et al. (1991).

The highest Mn amount in Scotch pine (*Pinus sylvestris)* was determined at the Tebrizkapı ıntersection was 79 ppm in August and while at Migros ıntersection was 44.2 ppm in January. When we evaluate it periodically, August has a higher mean value of 59.59 ppm than January. Since the limit value given for Mn is 407 ppm (Jones et al. 1991), all locations were very low. In terms of Zn, the highest value 51.4 ppm was determined at the Üniversity ıntersection in August and 105.9 ppm at the poolside-university junction in January. When we evaluate it periodically, August has a higher mean value than January with a value of 40.75 ppm. Since the limit value given for Zn was 59 ppm, all points were sufficient in terms of Zn content. However, the sample taken from poolside-university junction in January exceeds the limit value twice with the value of 105.9 ppm Jones et al. (1991).

The highest value of Pb 8.9 ppm in Scotch pine was determined at the Rectorate ıntersection in August, and 26.5 ppm at Migros ıntersection in January. When we evaluate it periodically, January has a higher mean value than August with a value of 13.12 ppm. Since the limit value given for Pb was 0.2-20 ppm, the limit value is exceeded at Migros ıntersection, Kayak roadside, Tebrizkapı ıntersection and Havuzbaşı ıntersection. Whereas the other points were within the limit value as supported by Kabata-Pendias and Pendias (1992).

The highest value of Cd 1.3 ppm in Scotch pine (*Pinus sylvesteris)* was determined at Migros ıntersection in August and 1.6 ppm at poolside-university ıntersection in January. When it was evaluated periodically, January resulted a value of 0.99 ppm, which was higher than the mean value of August. The limit value of Cd is 0.01-2.4 ppm, and the values of this study were within the limit range, which

agreed with Kabata-Pendias and Pendias (1992). Thus, the highest value of Ni 3.9 ppm in Sarıçam was determined at 100.yıl park ıntersection in August and at Yenişehir ıntersection with a value of 29.85 ppm in January. When this value was evaluated periodically, January has a value of 6.41 ppm, which was higher than the mean value in August. The limit value for Cd was between 0.1-5 ppm, and Yenişehir ıntersection exceeded the limit value 5 times. Gez ıntersection and Kayak road exceeded the limit values with 6.12 ppm and 9.26 ppm values respectively. The rest of the values were within the limit rage Kabata-Pendias and Pendias (1992).

In terms of phosphorus value, the highest value in scotch pine (*Pinus sylvestris)* was 0.4902 ppm in August and 0.1113 ppm in 100.Yıl Park ıntersection in January. When these values were evaluated periodically, August has a mean value of 0.1568, which was higher than the mean value in January. According to Jones et al. (1991), the limit value for P was 0.18. On the hand, the highest value of N 0.98 in Scotch pine was determined at Tebrizkapı ıntersection in August, while in 100.yıl Park it was 2.4 in January. When these values were evaluated periodically, January has a value of 1.99, which was higher than the mean value of August. Jones et al. (1991) stated that the limit value for N was 1.79.

Discussion

The statistical analysis of the 11 sampling areas during the two (January and Augoust) seasons showed a highly significant differences on all plant heavy elements under the study (Table 2). In January the results showed that Iron (Fe) content ranged between 336.20-872.20 ppm and Cu was between 6.05-17.20 ppm Mn was between 41.30-79.00 ppm, Zn was between 29.70-51.40 ppm, Pb was between 0.01-8.90 ppm, Cd was between 0.50-1.30 ppm, Ni was 1.26-3.90 ppm whereas in they were 446.30-1126.20 ppm, 10.10-16.40 ppm, 5.10-44.20 ppm, 24.30-105.90 ppm, 4.50-26.50 ppm, 0.39-1.70 ppm and 1.93-29.85 ppm (Table 2). The highest content for Fe 1126.20 ppm was determined from between Havuzbaşı-Üniverisite roadside in August, Cu 17.40 ppm from Migros in January, Mn 79.00 ppm from Tebrizkapi in January, Zn 105.90 ppm from Havuzbaşı-Üniveriste Arası, Pb 26.50 ppm from Migros in August, Cd 1.70 ppm from Rectorate ıntersection and Ni 29.85 ppm from Yenişehir ıntersection in Augoust (Table 2).

In plant samples, Fe and Cu in all sampling areas in both January and August, Cu in January and August only in Migros ıntersection, Mn during January in all locations, Zn during January between Havuzbaşı and Üniversity roadside were found over the limit value (Jones et al., 1991). Pb was found higher over the limit values in Migros and Rectorate ıntersection in August and January respectively this result was supported by (Jones et al., 1991). Ni found over the limit value in 100.Yıl and Yenişehir ıntersection in January and August respectively (Table 2), the result seconded by (Kabata-Pendias and Pendias, 1992).

The statistical analysis of the 11 sampling areas showed a highly significan differences on all the soil heavy elements under the study (Table 3). The results showed that soil heavy metals content was between Iron (Fe) 0.68-10.80 ppm, Cu 1.07-13.19 ppm, Mn 3.02-17.14 ppm, Zn 0.57-11.27 ppm, Pb 0.10-2.26 ppm, Cd 0.10-0.39 ppm and Ni 0.01-1.80 ppm (Table 3). The highest results was obtained Fe 10.80 ppm and Cu 13.19 ppm from 100.Yıl sampling area, Mn 17.14 ppm from Yenişehir ıntersection sampling area, Zn 11.27 ppm 100.Yıl sampling area, Pb 2.26 ppm from Kayakroad sampling area, Cd 0.39 ppm 100.Yıl sampling area and Ni 1.80 ppm ıntersection sampling area (Table 3).

Table 2. Heavy Metal Contents of Plant Samples (Scotch pine,) [1]

	Sampling points	**Fe**	**Cu**	**Mn**	**Zn**	**Pb**	**Cd**	**Ni**
	Rectorate I.	642.80^{d}	10.50^{e}	60.80^{c}	38.40^{f}	8.90^{a}	0.30^{i}	2.72^{d}
	Üniversity I.	363.01^{g}	10.20^{e}	59.40^{c}	51.40^{a}	5.80^{c}	0.75^{f}	1.26^{j}
	100.Yılpark I.	584.40^{e}	13.50^{c}	57.10^{cd}	43.90^{d}	4.80^{d}	0.70^{e}	3.90^{a}
	Between HÜ I	763.60^{c}	16.19^{b}	59.20^{c}	41.20^{e}	0.01^{g}	1.20^{b}	1.92^{i}
	Havuzbaşı I	585.90^{e}	11.28^{de}	53.80^{d}	48.10^{b}	3.20^{e}	0.50^{h}	2.40^{f}
August	Tebrizkapı I.	347.80^{gh}	10.85^{de}	79.00^{a}	35.40^{g}	5.70^{c}	0.75^{ef}	2.38^{g}
	Migros I.	798.90^{b}	17.20^{a}	70.10^{b}	46.60^{bc}	7.05^{b}	1.30^{a}	3.66^{b}
	Gez I.	474.90^{f}	9.10^{f}	41.30^{e}	38.80^{f}	3.50^{e}	0.50^{h}	1.27^{j}
	Yenişehir I.	486.70^{f}	8.75^{f}	43.40^{e}	29.90^{h}	2.10^{f}	0.59^{g}	2.90^{c}
	Kayak Road	872.20^{a}	11.80^{d}	59.20^{c}	44.90^{cd}	0.01^{g}	0.80^{d}	2.04^{h}
	Ilıca road	336.20^{h}	6.05^{g}	72.20^{b}	29.70^{h}	0.01^{g}	0.90^{c}	2.52^{e}
Average		**568.70^{b}**	**14.41^{a}**	**59.59^{a}**	**40.75^{a}**	**3.73^{b}**	**0.75^{b}**	**2.45^{b}**
	Rectorate I.	626.30^{d}	11.90^{bcde}	26.30^{d}	24.30^{e}	4.50^{d}	1.70^{a}	3.72^{f}
	Üniversity I	496.10^{e}	10.10^{e}	21.90^{e}	35.90^{cd}	13.03^{c}	0.98^{b}	1.93^{j}
	100.Yılpark	1126.20^{a}	13.70^{b}	21.80^{e}	33.90^{cd}	13.00^{c}	0.88^{bc}	3.96^{e}
	Between HÜ.R	1084.50^{ab}	12.70^{bc}	19.40^{e}	105.90^{a}	6.00^{d}	1.60^{a}	2.70^{i}
	Havuzbaşı I.	1046.50^{b}	13.70^{b}	30.20^{c}	38.90^{c}	22.06^{b}	0.65^{d}	3.61^{g}
January	Tebrizkapı I.	824.70^{c}	12.90^{bc}	29.60^{cd}	49.10^{b}	21.90^{b}	0.76^{bcd}	2.90^{h}
	Migros I.	775.50^{c}	16.40^{a}	44.20^{a}	31.01^{de}	26.50^{a}	0.85^{bcd}	3.90^{d}
	Gez I.	446.30^{e}	10.50^{de}	5.10^{g}	24.60^{e}	6.20^{d}	0.39^{e}	6.12^{c}
	Yenişehir I.	673.40^{d}	10.20^{e}	14.50^{f}	32.40^{cd}	5.30^{d}	0.74^{cd}	29.85^{a}
	Kayak Road	765.07^{c}	10.90^{cde}	37.20^{b}	29.90^{de}	22.05^{b}	0.80^{bcd}	9.26^{b}
	Ilıca Road	776.70^{c}	10.60^{de}	13.70^{f}	33.20^{cd}	3.80^{d}	1.60^{a}	2.68^{i}
Average		**785.60^{a}**	**12.14^{b}**	**24.00^{b}**	**39.91^{b}**	**13.12^{a}**	**0.99^{a}**	**6.41^{a}**

[1] The means marked with the same letter are not different from each other (ns).

The soils sampled from the 11 different locations analysed and the results showed that some heavy metals have been found over critical levels (Table 3). For example, Fe and Cu in 100.yıl Park, Cu in all 11 locations and Zn in 100. yıl Park, Yenisehir and Havuzbaşı ıntersection were over critical level, this

results are agreed with (Jones et al., 1991). On the other hand, Pb, Cd and Ni were found within normal limits in all sampling areas, which was in agreement with (Kabata-Pendias and Pendias, 1992).

Table 3. Heavy Metal Contents of Soil Samples [1]

Sampling Points (Intersection Roadside/)	Fe	Cu	Mn	Zn	Pb	Cd	Ni
Rectorate I	0.92^{f}	1.07^{h}	0.51^{de}	0.57^{j}	0.10^{e}	0.10^{c}	1.80^{a}
Üniversity I	2.76^{b}	1.12^{h}	3.03^{f}	1.97^{i}	0.10^{e}	0.13^{bc}	0.31^{h}
100.Yıl park I	10.80^{a}	13.19^{a}	11.04^{b}	11.27^{a}	0.10^{e}	0.39^{a}	0.01^{i}
Between HÜ.R	1.30^{e}	1.85^{ef}	0.26^{def}	2.33^{g}	0.10^{e}	0.10^{c}	1.40^{b}
Havuzbaşı I.	2.77^{b}	3.06^{c}	0.36^{def}	9.03^{b}	0.60^{b}	0.13^{bc}	0.40^{g}
Tebrizkapı I.	0.42^{de}	2.05^{e}	5.20^{c}	2.09^{h}	0.14^{d}	0.11^{bc}	1.20^{c}
Migros I	0.68^{g}	5.50^{b}	3.21^{ef}	4.48^{e}	0.47^{c}	0.12^{bc}	1.46^{b}
Gez I.	0.56^{cd}	1.41^{g}	5.27^{c}	2.74^{f}	0.10^{e}	0.10^{c}	0.83^{e}
Yenişehir I.	1.69^{c}	1.70^{f}	17.14^{a}	8.38^{c}	0.10^{e}	0.13^{bc}	0.60^{f}
Kayakyolu I	1.37^{e}	2.77^{d}	3.61^{d}	4.65^{d}	2.26^{a}	0.17^{b}	0.81^{e}
Ilıca Road	0.54^{cd}	1.50^{g}	3.02^{f}	0.57^{j}	0.10^{e}	0.12b^{c}	1.13^{d}
Average	**2.43**	**3.20**	**5.60**	**4.37**	**0.37**	**0.14**	**0.90**

[1] The means marked with the same letter are not different from each other (ns).

Urban roadside soils are the ‘‘recipients’’ of large amounts of heavy metals from a variety of sources including vehicle emissions, coal burning waste and other activities Automobile traffic pollutes roadside environments with a range of contaminants. Heavy metals are found in fuels, in the walls of fuel tanks, engines and other vehicle components, in catalytic converters, tires and brake pads, as well as in road surface materials (Pivic et al., 2014).

Contamination of the soil over the natural level by Pb, Zn, Cr and Co could be one of the indicators of anthropogenic environmental pollution. Fast development of industry, continuously increasing population, and intensification of road traffic are regarded as the foremost causes of ecosystem pollution in urban areas. Averages of Cu and Pb are compared with other cities around the world are significantly lower meaning the anthropic activities have a low impact on the soil heavy metal concentrations in the study area. (Pivic et al., 2014).

These results showed that the road junctions, which had toxic level of heavy metals, are also found higher emission capacity of those heavy metals. In particular, Pb emissions has been due to the use of vehicles using unleaded gasoline and the other heavy metals has been the result of construction, industral activities, urban wastes etc. When those heavy metals found over the critical levels, habitat can be destroyed and had negative effect on human health.

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