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Research Article

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Lead, Cadmium and Nickel Contamination of Roadside Soils and Plant Leaves in Baghdad City

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ABSTRACT

Concentrations of lead, cadmium and nickel in soils and leaves of Eucalyptus camaldulensis in different areas (AL-Záfaraniya, AL-Jadryia and Jisr Diyala) at Baghdad were investigated. Soil and plant samples were collected from roadsides at distances of 0, 10 and 50 meter. Analysis was accomplished by atomic absorption spectrometry (AAS) after total digestion. The results revealed a significant difference in the concentrations between soil and plant leaves. Heavy metal contents in the soil and plant leaves were found in the following order: lead > nickel > cadmium. The soil from Al-Záfaranya had the higher concentration of lead and cadmium reached 170.42 and 12.16 ppm, respectively. While, Jisr Diyala soil sample was higher in nickel as 37.54 ppm. According to Eu Standards, concentration of Pb and Cd were found above the acceptable limits in the soil sample at the three areas. While the concentration of Ni was within the recommended limit. The effect of traffic emissions appeared through decreased the concentrations of heavy metals in soil and plant leaves as the distance from the road increase. These findings suggest that a special attention should be paid to this traffic related environmental issue and a serious effort is required to reduce these highest levels by soil remediation.

Keywords: Heavy metal; Roadside; Soil; Plant; Traffic emissions

INTRODUCTION

The contribution of cars and road transports to the global emission of atmospheric pollutants is highly increasing. The vehicle's fuel considered as the main source of heavy metals pollution. These metals are found in vehicle's fuel, catalytic converters, fuel tanks, tires and brake pads, engines and other vehicle components, as well as in road surface materials [1]. Heavy metals are released in the form of air particulates in urban atmosphere as liquid or solid particles. The emitted particulates in urban are rich in potentially toxic heavy metals such as lead, cadmium, nickel, chromium and zinc which can be a genuine health hazard [2]. Pollution with heavy metal have a large impact on the environment as road transports contaminate the atmosphere, water and soil near the highway through atmospheric fallout. Soil considers the primary recipient of these pollutants as they enter the plants and then the food chain. The non-biodegradable heavy metals are the most serious of these contaminants, with long biological half-lives. They are toxic even in very low concentrations and can accumulate over time within the body organs and constitute serious disruption to normal body function [3,4]. Monitoring the endangerment of soil with heavy metals is so interest due to their influence on groundwater and surface water [5] also on plants [6], animals and humans [7]. Determination the concentrations of heavy metals in soil and plants has a significant importance in terms of their content that comes from the exhaust may contaminate plants which exist nearby the roads. Previous studies on roadside heavy metal contamination have been conducted in different important cities in such as Turkey’s Elazig and Jordan’s Amman [8,9]. The concentrations of pollutants can be detected both from soil and atmospheric by trees as an effective bio monitors. Although it is sometimes difficult to distinguish between the amounts of heavy metal taken up from soil and then deposited on trees, leaves. The accumulation of heavy metals in plants affirms its availability in the soil; nevertheless it is often difficult to determine its source [10]. The objectives of the present study were to assess the contamination of heavy metals in the surrounding area of the roadside. Three different sites in Baghdad city were chosen to explore the relationship between heavy metal concentrations in soils and roadside distance. Commonly planted tree leaves and soils were used to compare the heavy metal concentration. The study provides information about the danger and spread of heavy metal pollution on the environment.

MATERIALS AND METHODS

Study Area

Three areas were chosen to take plant leaves and soil samples located in different sites in Baghdad (AL-Záfaraniya, AL-Jadryia and Jisr Diyala) as shown in Figure 1. The samples were collected from roadsides at different distances of 0, 10 and 50 meter. These roads are very crowded with automobiles and many light and heavy vehicles pass through it daily.

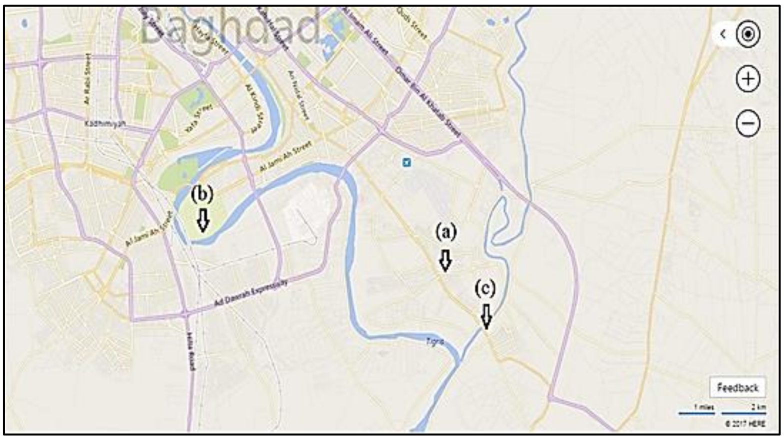

Figure 1: Map of Baghdad city indicating the studied cities: a) AL-Záfaraniya b) AL-Jadryia c) Jisr Diyala

collection of soil sample

Samples were collected from exposed, uncovered soil near the road mentioned above. Each sample was collected from the upper soil layer 5-10 cm of soil at different distances perpendicular to roadside, using plastic measuring cup and stored into plastic bags for the transport. Samples were weighed then dried in an oven with a fan at 60°C until constant weight was reached, crushed then passed through sieve of 2 mm mesh size to remove all the unwanted particles before the chemical analysis [11].

Collection of Plant Materials

Leaves of *Eucalyptus cmaldulensis* (family: Myrtaceae) were collected in June 2016 at the same distances from the roadsides as the soil samples. The plant materials were packaged in plastic bags for preservation until laboratory analysis. The taxonomic identification of plant was confirmed in biology department, College of Science, Baghdad University. The leaves were first rinsed with distilled water and oven dried at 100°C for 48 h. The dried leaves were grounded into fine powder using electrical grinder. The powders were preserved in a glass jar and stored in a refrigerator at 4°C [12].

Chemical Analysis

Soil samples and leaves of *E. cmaldulensis* were collected from distance of 0, 10 and 50 (meter) from the edge of the road. One gram dry soil or plant leaves sample was weighed into volumetric flask (50 ml), then 10 ml mixture of analytical grade acids HNO_3: $HClO_4$ in the ratio 5:1 was added. At a temperature of about 190°C for 1.5 h the digestion was performed. The solution were cooled and completed with distilled water to the final volume.

Atomic absorption spectrometry (AAS) was used to determine the heavy metal concentrations. Analysis of each sample was carried out three times and the concentrations of heavy metals were expressed in ppm. Statistical differences were conducted by Tukey's test using spss version 22.0. For every distance the sample were replicated thrice.

RESULTS AND DISCUSSION

Concentrations of Heavy Metals in Soil on Different Distance

The concentrations of lead, cadmium and nickel in soil from each study area are shown in Table 1. The value of each site revealed differences in the concentration of studied heavy metals. Lead and cadmium maximum concentration was 170.42 and 12.16 ppm, respectively were found in Al-záfaranya. While, Jisr Diyala was the most polluted with nickel ranged from 37.54- 33.66 ppm at 0- 50 m distance from roadside. The sequences of heavy metals contents in soils sample was found in the following order: Pb > Ni > Cd.

Table 1: Mean lead, cadmium and nickle concentration (±, standard deviation) of soil in three different sites from 0, 10 and 50 m away from roadside

Distance from roadside	AL-Záfaraniya			Al-Jadryia			Jisr Diyala		
	Pb	Cd	Ni	Pb	Cd	Ni	Pb	Cd	Ni
0 m	170.42 ± 6.20 c	12.16 ± 4.21 b	30.07 ± 4.96 b	145.54 ± 7.81 c	10.65± 3.01 b	28.33 ± 5.85 b	160.67 ± 5.63 c	9.50 ± 4.94 b	37.54 ± 3.74 b
10 m	150.81 ± 7.67 b	9.50 ± 3.43 a	29.2 ± 4.31 b	125.24 ± 8.22 b	9.20 ± 4.99 a	26.62 ± 5.72 a	130.32 ± 6.74 b	8.55 ± 3.71 b	35.50 ± 4.31 a
50 m	105.03 ± 4.70 a	8.73 ± 3.02 a	25 ± 5.85 a	100.25 ± 7.54 a	8.25 ± 4.14 a	24.11 ± 4.02 a	102.67 ± 7.1 a	7.04 ± 2.76 a	33.66 ± 4.85 a

Note: Mean values within the same column with a common letter do not differ significantly (P <0.05)

The lead, cadmium and nickel concentrations which were found in the soil are summarized in Figures 2-4. Regarding the acceptable limits of heavy metals in soil and according to European Union's Standards [13] and FAO/WHO Guidelines [14] , Pb and Cd contents were above the limits at all the three site; as they ranged from 170.42- 100.52 ppm, and from 12.16- 7.04 ppm, respectively, compared to EU standards which were 100 and 3 mgkg^{-1}, respectively. Although the concentration of Ni was found to be within the recommended limit and ranged from 24.11-37.54 ppm, compared to EU limit (50 mgkg^{-1}) [15]. According to ATSDR [16] approximately 10-20% of the populations are sensitive to nickel.

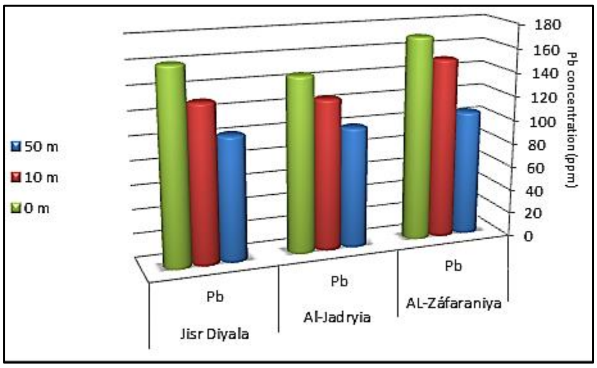

Figure 2: Concentration of lead in different soil sample at 0, 10, and 50 m distance from roadside

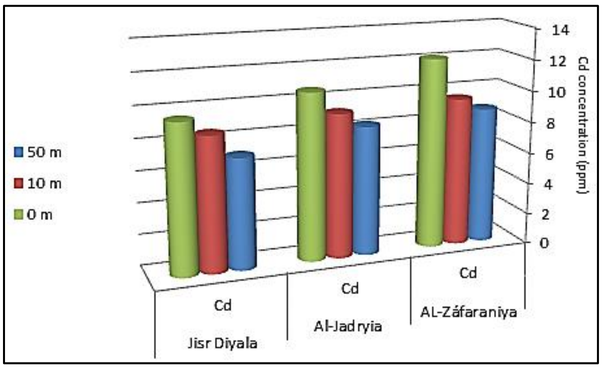

Figure 3: Concentration of cadmium in different soil sample at 0, 10, and 50 m distance from roadside

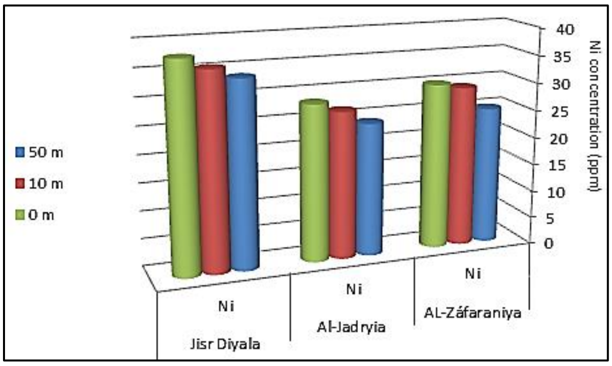

Figure 4: Concentration of nickel in different soil sample at 0, 10, and 50 m distance from roadside

The results of heavy metals are expected because of the increasing in cars number after 2003 in Iraq, which in turn increased the traffic activity and their emissions to the environment [17]. The world health organization estimates that 15-18 million children in developing countries suffer from permanent brain damage due to lead poisoning. In 2011 only six countries still use amounts of lead compared to the 82 countries that were leaded in 2002 when the partnership for clean fuels and vehicles (PCFV) was formed. These are Myanmar, Iraq, Afghanistan, Algeria, Yemen, and North Korea [18]. Lead is still using in fuel since many years till nowadays in Iraq and the lead has long half-life, therefore the concentrations of lead is expected to be high and that may cause to contamination the environment. The soil of roadside is a major reservoir of traffic related heavy metals [19]. A long-term exposure of heavy metals contaminants from transport could be the reason of Pb, Cd and Ni higher concentrations of in the soils near in a roadside. The dispersion of contaminants is influenced by meteorological conditions, such as rainfall, wind, profiles or traffic intensity [20]. The concentrations of metals in the roadside soil are influenced by the same factors [21] and by soil parameters.

Concentrations of Heavy Metals in *E. cmaldulensis* Leaves

Lead, cadmium and nickel concentrations in plant leaves from each sampling area are shown in Table 2. The heavy metal contents in plant followed the same sequence of soil as: Pb> Ni> Cd. Maximum concentration of lead was found in plant leaves from Al-Jadryia site (120.11- 85.71 ppm) at 0 to 50 m distance from road. While, samples from Al-záfaranya site had the higher concentration of cadmium (3.81- 2.74 ppm) at 0 to 50 m distance from road. Meanwhile, Jisr Diyala was the most polluted site with nickel ranged from 9.55- 6.24 ppm at the same distance mentioned before. With increasing the distance from the road, the concentration of heavy metals was found to decrease in both soil and plant leaves (Figures 2-7). This indicated that these contaminates are caused by emission of road traffic. A significant difference was found between the concentrations of lead, cadmium and nickel in the soils and plant leaves with different distances. The study results indicated that the concentration of Pb, Cd and Ni in both soil and plant leaves varied significantly between the sites, furthermore the concentrations of all heavy metals were higher in soil sample than in plant leaves (Tables 1 and 2).

Table 2: Mean lead, cadmium and nickle concentration (±, standard deviation) of leaves in three different sites from 0, 10, and 50 m away from roadside

Distance from roadside	AL-Záfaraniya			Al-Jadryia			Jisr Diyala		
	Pb	Cd	Ni	Pb	Cd	Ni	Pb	Cd	Ni
0 m	105.50 ± 8.21 c	3.81 ± 4.06 b	8.50 ± 4.90 b	120.11 ± 8.64 c	3.27 ± 2.10 b	8.25 ± 4.57 b	102.33 ± 6.44 c	3.54 ± 3.54 b	9.55 ± 3.78 b
10 m	96.38 ± 6.33 b	3.45 ± 2.21 b	7.52 ± 3.64 b	100.05 ± 6.77 b	2.85 ± 3.92 b	7.51 ± 4.63 b	90.52 ± 7.28 b	2.82±3.00 b	8.52 ± 2.02 b
50 m	72.10 ± 5.71 a	2.74 ± 2.21 a	5.55 ± 3.66 a	85.71 ± 5.32 a	1.40 ± 3.62 a	6.34 ± 3.92 a	76.62 ± 6.73 a	2.07 ± 2.54 a	6.24 ± 3.08 a

Note: Mean values within the same column with a common letter do not differ significantly (P <0.05)

A comparison between the concentrations of heavy metals observed in the present study with the safe limit provided by WHO [22]. The extent of Pb (120.11), Cd (3.81) and Ni (9.55) concentrations were exceeded the acceptable tolerance levels. However, the allowable WHO tolerance limit of heavy metals for vegetables are 0.002 g/kg Pb, 0.001 g/kg Cd and 0.001 g/kg Ni [23]. In comparison with values mentioned in Turkey, Libya and Kuwait vegetables, the lead concentration were found higher [8,24].

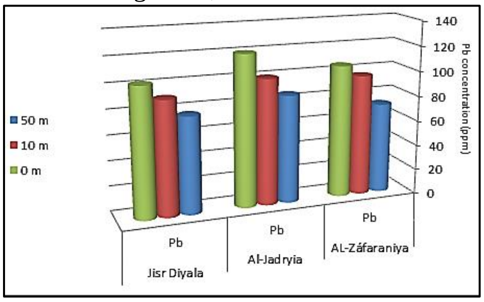

Figure 5: Concentration of lead in different plant sample at 0, 10, and 50 m distance from roadside

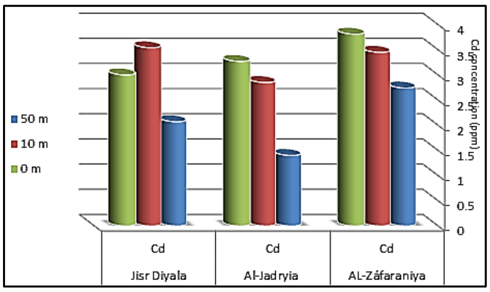

Figure 6: Concentration of cadimum in different plant sample at 0, 10, and 50 m distance from roadside

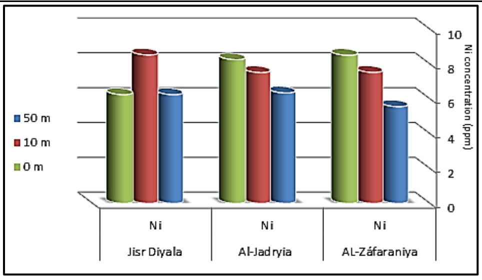

Figure 7: Concentration of nickel in different plant sample at 0, 10, and 50 m distance from roadside

CONCLUSION

Previous studies also have shown that the heavy metals contents in soil and plant samples near the roads decreased as the distance from roadside increased [25,26]. Another study found that most discharge of Pb from motor vehicles is limited within 33 m wide from the road edge [27]. The maximum influential roadside distance for the different types of heavy metals, may vary substantially. Generally, most of the metals' influential roadside distances are less than 50 m, but may be up to 100 m [28,29]. Chambers and Sidle [30] conducted that heavy metal concentrations in plant highly varied when related to soil levels. Also, Word [31] reported that road vehicle traffic in New Zealand is responsible for building up nickel and cadmium in vegetation's and soils along a motor way. Therefore, biomonitoring for heavy metals in soils, plants and vegetables are important as well applying different management methods to decrease the concentration of metals and reduce the contamination in soil, plants and the food chain.

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