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Full Length Research Paper

Assessment of the potential pollution of cadmium, nickel and lead in the road-side dust in the Karkh district of Baghdad City and along the highway between Ramadi and Rutba, West of Iraq

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Abstract

Road-side dust samples were collected from selected areas near the fuel stations in the Karkh district of Baghdad city the capital of Iraq as well as both sides of the highway between Ramadi and Rutba. In order to assess the probable pollution level of heavy metals (Cd, Ni and Pb) in the study areas, heavy metal contents were determined in the roadside dust using Atomic Absorption Spectrophotometer. The extent of traffic contribution to road-side dust was assessed by comparing the metal concentrations in road-side dust to those of Upper Continental Crust background considering a Cd background of 0.098 mg/km, Ni background of 44 mg/km and Pb background of 16 mg/km using Geo-accumulation index (Igeo), contamination factor (CF) and Pollution Load Index (PLI). The roadside dust contained relatively elevated levels of heavy metals. Metals that were added to the soil were calculated; the average of Cd, Ni and Pb in Baghdad is 0.17, 25.5 and 14.8 mg/kg, in the north of the highway is 0.14, 23.4 and 14.7 mg/kg, and in the south of the highway is 0.2, 27.4 and 15.6 mg/km. The higher averages these metals were recorded in south of the highway. The assessing methods revealed that the studied areas impacted with considerable quantity of metals. The distribution pattern of the concentrations of metals was affected essentially by exhausted gases emitted from transportation automobile. The direction of the prevailing wind played a major role in the transport of the pollutants causing an increase in metal concentrations towards the south side of the highway.

Keywords: Road-dust, Geo-accumulation index. Contamination factor. Pollution Load Index, Pollution. Heavy metals. Baghdad. Iraq

INTRODUCTION

There is a high probability of contamination by heavy metals, due to the availability of sources of pollution. Soil receives pollutants from a variety of sources, including automobile exhaust gases, and emissions of factory chimneys, household electric power generators and dust storm. Also, tire friction adds some metals, particularly cadmium, the motor oils consumed contain heavy metals, oil burning, waste incineration. Cadmium (Cd). It is known to come from tire abrasion, lubricants, industrial and incinerator emissions (Thorpe and Harrison, 2008; Wilcke *et al.*, 1998). Iraqi fuel also contains significant quantities of Cd (Al-Qaraghuli, 1973). The composition and quantity

Figure 1. The study area and sample locations (Right: Iraq map; left Baghdad land site image).

of chemical matrix of road dust are indicators of environmental pollution (Banerjee, 2003). In recent years, many studies have focused on the concentration, distribution and source identification of heavy metals in roadside dust. Many researchers who studied soil, water and plants in Baghdad have detected high heavy metals concentration in different sampling media. AL-Sayegh and Al-Yazichi, 2001 attributed the high concentration of Pb, Cd, Cu and Zn to the car exhausts in Mosul city. Khuwaidem, 2007 found high concentrations of heavy metals in Basra soil which were mainly attributed to the drilling and oil production. Awadh, 2009 through his study of atmospheric pollution of Baghdad city found the anthropogenic activities are the main responsible sources of pollution. Haqus and Hammed (1986) found high Pb concentration in plants collected from Baghdad and other selected areas the highways and cement plants. Street dust is typically derived from anthropogenic sources via the interaction of natural solid, liquid or gaseous materials with pollutant sources such as water transported material from surrounding soils and slopes, dry and wet atmospheric deposition, biological inputs, road surface wear, road paint degradation, vehicle wear (tires, body, brake lining, etc.) and vehicular fluid and particulate emissions and discharge from metal processing industries (Al-Khashman, 2004).

The importance of this research lies in the risk pollutants and their impact on the public health. Exposure to heavy metals in road dust can occur by means of ingestion, inhalation and dermal contact. The adverse effects of heavy metals in road dust include respiratory system disorders, nervous system interruptions, endocrine system malfunction, immune system suppression and the risk of cancer in later life (Ferreira-Baptista and Miguel, 2005).

Baghdad, the capital city of Iraq, has experienced rapid growth in population and urbanization over the last few decades. It is estimated that between 2003 and 2012 a huge number of vehicles were registered in Baghdad. Besides, the used cars which are second hand remained in service. This exerts a heavy pressure on its urban environment.

This work was carried out on roadside dust in the Karkh district of Baghdad city and along the both sides of the international highway linking Iraq by Syria and Jordan with length 300 km between Ramadi and Rutba (Figure 1). The objective of this study is to elucidate the distribution of heavy metals (Cd, Ni and Pb) and to assess the roadside dust contamination using an index of Geo-accumulation (I-geo), Contamination Factor (CF) and Pollution Load Index (PLI).

MATERIALS AND METHODS

Study area

Baghdad city, the capital of Iraq, is situated in the central part of Iraq. The study area includes Karkh district (the west part of Baghdad) on the west side of the Tigris River (Figure 1). It is situated on the quaternary unconsolidated sediment of the Mesopotamian plain formed mainly from river sediments (sand, silt and clay). The study area is semi arid to arid climate. Naturally, it receipts a significant particulate matter from the atmosphere**,** and it typically influences by gas emitted from the automobile exhausts.

Sampling process

On the basis of traffic load, major roadways near the fuel stations in Baghdad city (Karkh district) and the highway

Table 1. Sample location of 30 samples, B means Baghdad, whilst N means north of highway, S means south of highway. The total samples starting 11N-S to 20N-S are 20 samples, 10 were collected from north of the highway and the remnant 10 were collected from south of the highway, and then each two samples shared with one coordination taken on the highway in the mid distance between sample site.

Sample No.	Area	Longitude	Latitude	Elevation (m)
1B	Dora	33 15 20.18	44 22 05.25	37
2B	Saydiya	33 15 35.34	44 20 34.59	36
3B	Al-Amel	33 16 53.74	44 18 52.53	36
4B	Al-Amria	33 18 25.86	44 11 20.22	43
5B	Yarmuk	33 18 19.53	44 19 44.77	38
6B	Um-Al-Tubul	33 17 14.4	44 20 31.28	37
7B	Alawi	33 19 59.75	44 23 09.72	46
8B	AL-Mansour	33 18 59.95	44 22 02.05	40
9B	Utayfiya	33 21 07 47	44 21 36.1	40
10B	Mula Hwaish	33 18 52.91	44 19 35.46	38
11N-S	Heet crossing	33 25 33.54	42 58 32.94	102
12N-S	Oil station	33 17 58.99	42 20 57.6	277
13N-S	----	33 16 02.21	42 13 08.54	317
14N-S	----	33 13 30.24	42 00 12.04	349
15N-S	----	33 12 40.86	41 47 59.45	368
16N-S	Kilo 160	33 09 28.75	41 38 51.11	408
17N-S	Kilo 90	33 05 23.91	42 21 01.85	468
18N-S	Kilo 70	33 01 20.15	40 56 54.81	536
19N-S	Thabba	33 03 51.62	40 26 16.6	604
20N-S	Rutba	33 03 09.91	40 11 40.60	674

between Ramadi and Rutba were selected for sampling (Figure 1). A total of thirty samples was collected during the period 16-20 Oct. 2011. Ten samples (1B to 10B) were collected from areas near the concrete walls and pavement edges in Karkh district in Baghdad city and close to the fuel stations, whilst 20 samples were collected along two traverses on the north and south sides of the highway between Ramadi and Rutba with 300 km length (10 samples from each side) (Figure 1). Dishes of 30 cm diameter were installed 25 cm above the surface to avoid contamination with the topsoil. The collected samples were carefully transferred to the plastic bags using small brushes and then were brought to the laboratory under the same conditions. The coordinates of the sample locations were recorded with a GPS (Table1).

Sample preparation, digestion and analyses

All samples were transferred to the laboratory of geochemistry in the Geology Department, University of Baghdad and subjected to the drying process by oven at temperature of 60˚C. Method of Singh et al. 2002 was used with little modification. A powdered sample of 0.25 gm of the sample was then transferred into the glass beaker. Then, 2 ml of conc. HNO_3 and 6 ml of HCl acid was carefully added to the reaction beaker. Samples were heated quietly to pre-drought. Digestion process was repeated twice until it was sure the dissolution of the entire sample, then a process of filtration with washing beaker with distilled water many times to ensure the descent of the entire sample. The filtrate was transferred to a volumetric flask of 250 ml to be ready for analysis by Atomic Absorption Spectrophotometry (A.A.S). Chemical analyses were carried out in the Chemistry Department at the University of Baghdad.

Quality assurance

Precision and accuracy of the results were confirmed through an average value of three replicates for each reading and cross checking of the blank or standard at ten sample intervals. The calibration curves of standard solutions of metals were used to justify the quantification. The minimum detection limit for Cd, Ni and Pb is 0.02, 0.10 and 0.06 μg L^{-1} respectively. The relative standard deviation ranging from 5–10% is considered the permissible limit for results to be acceptable. The precision of the analysis of standard solution was better

Table 2. Results of Cd, Ni, Pb and their Geo-accumulation Index (I_{geo}), Contamination Factor (CF) and Pollution Load Index (PLI) compared with the Upper Continental Crust (UCC) according to Taylor and Mclennan, 1985; BDL= below detection limit.

Sample No.	Study area	Conc. (mg/kg)			I_{geo}			CF			PLI
		Cd	Ni	Pb	Cd	Ni	Pb	Cd	Ni	Pb	
1B	Baghdad (Karkh district)	0.11	40	30	-0.42	-0.72	0.24	1.12	0.91	1.76	1.21
2B		0.09	35	14	-0.71	-0.92	-0.87	0.92	0.80	0.82	0.84
3B		0.08	11	9	-0.88	-2.59	-1.51	0.82	0.25	0.53	0.48
4B		0.23	17	14	0.65	-1.96	-0.87	2.35	0.39	0.82	0.91
5B		0.12	25	17	-0.29	-1.40	-0.59	1.22	0.57	1.00	0.88
6B		0.21	33	18	0.52	-1.00	-0.50	2.14	0.75	1.06	1.19
7B		0.16	29	10	0.12	-1.19	-1.36	1.63	0.66	0.59	0.86
8B		0.08	27	11	-0.88	-1.29	-1.22	0.82	0.61	0.65	0.69
9B		0.25	30	25	0.77	-1.14	-0.03	2.55	0.68	1.47	1.36
10B		0.41	25	20	1.48	-1.40	-0.11	4.18	0.57	1.18	1.41
Min		0.08	11	9	-0.88	-2.59	-1.51	0.82	0.25	0.53	0.48
Av.		0.17	25.5	14.8	0.21	-1.37	-0.79	1.73	0.58	0.87	0.96
Max		0.41	40	30	1.48	-0.72	0.42	4.18	0.91	1.76	1.41
Sd*		0.10	8.47	5.12	-0.56	-2.97	-2.32	1.02	0.19	0.30	0.3
11N	North of highway	0.03	17	14	-2.30	-1.96	-0.87	0.31	0.39	0.82	0.46
12N		0.09	19	10	-0.71	-1.80	-1.36	0.92	0.43	0.59	0.61
13N		0.02	20	13	-2.89	-1.73	-0.98	0.20	0.45	0.76	0.21
14N		BDL	33	27	---	-1.00	0.08	---	0.75	1.59	1.10
15N		0.15	12	19	0.03	-2.46	-0.43	1.53	0.27	1.12	0.77
16N		0.19	25	15	0.37	-1.40	-0.77	1.94	0.57	0.88	0.91
17N		0.08	11	21	-0.88	-2.59	-0.28	0.82	0.25	1.24	0.63
18N		0.21	35	20	0.52	-0.92	-0.11	2.14	0.80	1.18	1.26
19N		0.07	23	9	-1.07	-1.53	-1.51	0.71	0.52	0.53	0.58
20N		0.13	30	7	-0.18	-1.14	-1.87	1.33	0.68	0.41	0.72
Min		BDL	11	7	---	-2.59	-1.87	---	0.25	0.41	0.21
Av.		0.14	23.4	14.7	-0.07	-1.50	-0.80	1.43	0.53	0.86	0.87
Max		0.21	35	27	0.52	-0.92	0.08	2.14	0.80	1.59	1.26
Sd*		0.09	8.82	5.73	-0.71	-2.91	-2.16	0.92	0.20	0.34	0.3
21S	South of Highway	0.17	20	23	0.21	-1.73	-0.15	1.73	0.45	1.35	1.02
22S		0.14	17	14	-0.07	-1.96	-0.87	1.43	0.39	0.82	0.77
23S		0.19	22	25	0.37	-1.59	-0.03	1.94	0.5	1.47	1.12
24S		0.35	60	32	1.26	-0.14	0.33	3.57	1.36	1.88	2.09
25S		0.41	55	19	1.48	-0.26	-0.43	4.18	1.25	1.12	1.80
26S		0.36	21	20	1.30	-1.65	-0.11	3.67	0.48	1.18	1.28
27S		0.25	30	21	0.77	-1.14	-0.28	2.55	0.68	1.24	1.30
28S		0.44	66	11	1.59	0.00	-1.22	4.49	1.5	0.65	1.63
29S		0.39	33	10	1.41	-1.00	-1.36	3.98	0.75	0.59	1.21
30S		0.61	59	12	2.06	-0.16	-1.09	6.22	1.34	0.71	1.81
Min		0.14	17	10	-0.07	-1.96	-1.36	1.43	0.39	0.59	0.77
Av.		0.20	27.4	15.6	0.45	-1.27	-0.71	2.04	0.62	0.92	1.05
Max		0.61	66	32	2.06	0.00	0.33	6.22	1.36	1.88	2.09
Sd*		0.14	14.3	6.35	-0.07	-2.21	-2.01	1.43	0.33	0.37	0.41
UCC		0.098	44	17	-0.6	-0.6	-0.6	1.0	1.0	1.0	1.0

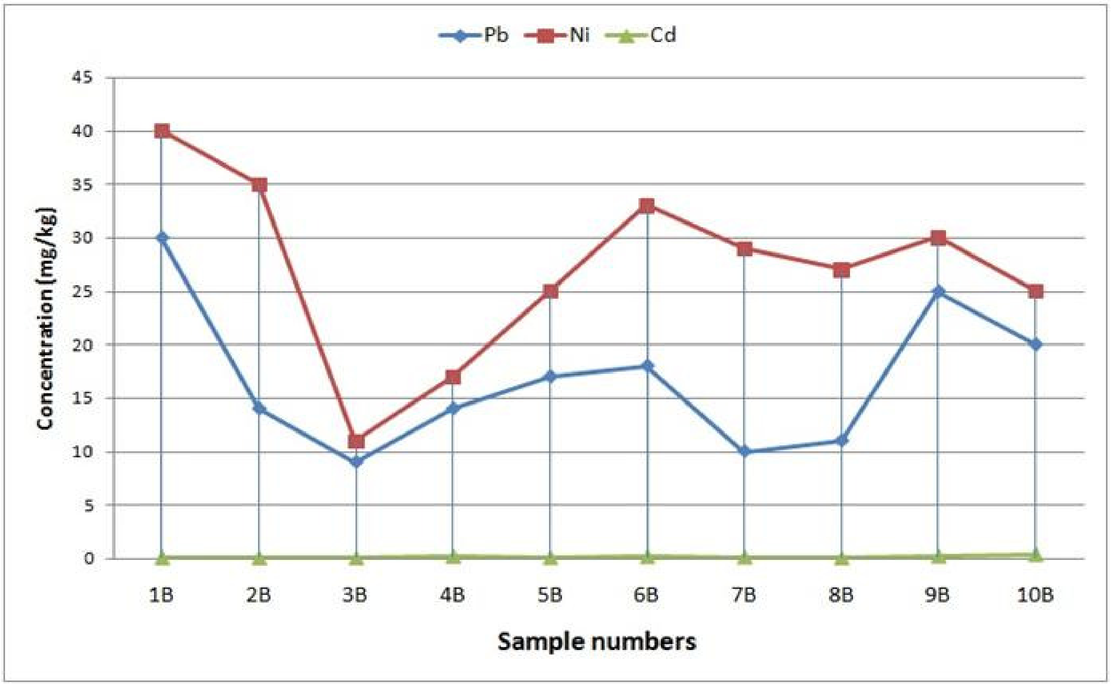

Figure 2. Distribution pattern of Cd, Ni and Pb in Baghdad (Karkh district).

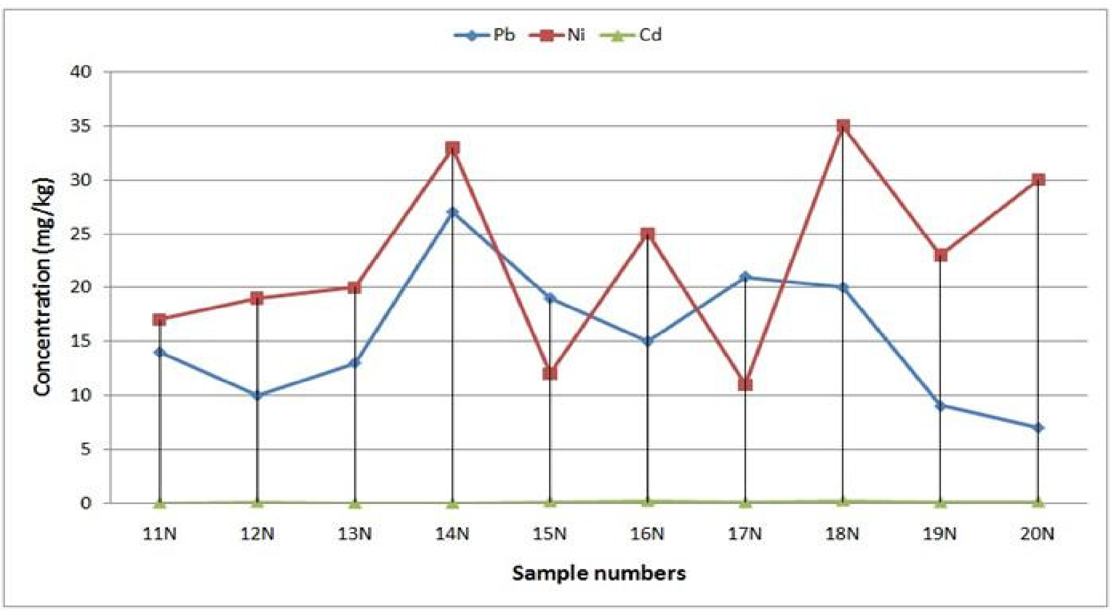

Figure 3. Distribution pattern of Cd, Ni and Pb in north of the highway.

than 5% in all the readings. (Table 1)

RESULTS AND DISCUSSION

The results of Cd, Ni and Pb in the studied areas are listed in Table 2 and the distribution patterns of these metals are illustrated in Figures 2, 3 and 4.

Cadmium

Cadmium is a relatively rare metal with average is 0.25 mg/kg in the earth's crust (Wedepohl, 1969-1978). It

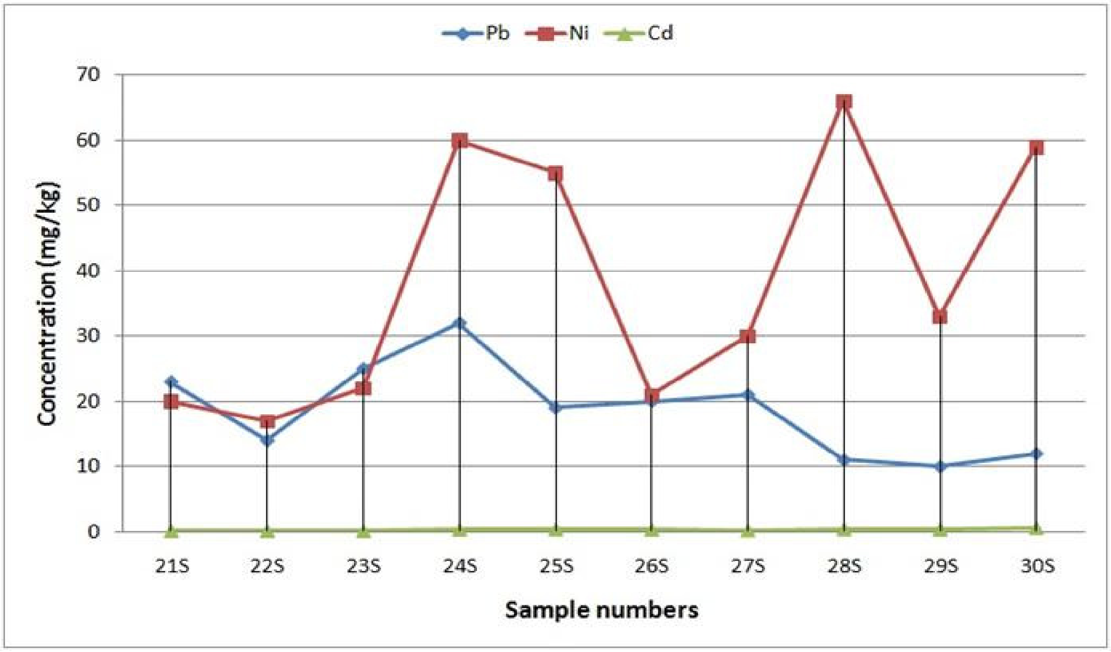

Figure 4. Distribution pattern of Cd, Ni and Pb in south of the highway.

exists mainly with the sulfide ores especially of zinc, lead and copper. Zinc industry also produces Cd as by-product. Cadmium in the atmosphere comes from different sources of natural and anthropogenic. The major natural sources of Cd in the atmosphere are airborne soil particles, volcanogenic aerosols and forest fires, respectively, degassing of crustal rocks (Bennett and Franklin, 1963). The anthropogenic source of Cd compounds are production processes of zinc, copper and lead, combustion processes of coal and oil, refuse incineration (Laskus et al., 1989), stabilizers and pigments in plastics, from iron and steel production and consumed batteries. Road dust receives varying inputs of heavy metals from diversity of mobile or stationary sources such as vehicular emission, industrial plants, power generation plants, oil burning, waste incineration, construction and demolition activities as well as re-suspension of surrounding contaminated soils (Ahmed and Ishiga, 2006; Al-Khashman, 2007).

Cadmium in the south of highway was the highest; it ranges between 0.14-0.61 with an average of 0.2 mg/kg (Table 2). The lowest value of Cd was recorded in the north of highway; it was detected to vary between below detection limit to 0.21 with an average of 0.14 mg/kg. Cadmium in Baghdad (Karkh district) ranges between 0.08-0.41 with an average of 0.17 mg/kg. The average of Cd in selected areas of Baghdad was found by Habib et al, 2012 to be 19 mg/kg; it was high due to anthropogenic and industrial activities.

Nickel

Natural sources of nickel, which are responsible for about 35 % of total global emissions, include windblown soil, volcanoes, vegetation, forest fires, sea salt and meteoric dust (Pfeffer et al., 1999). Nickel compounds are mainly emitted by combustion (heavy residual oil and coal burning units). Other sources are metallurgical operations (stainless steel and nickel alloys manufacturing) and nickel primary production operations such as mining, grinding, smelting and refining. Nickel compounds such as nickel sulfate, oxidic nickel, and nickel metal are the predominant species in stack fly ash from oil-fired combustion.

Nickel in the south of highway was the highest; it ranges between 17 and 66 with an average of 27.4 mg/kg (Table 2 and Figure 4). The lowest value of Ni was recorded in the north of highway; it was detected to vary from 11 to 35 with an average of 23.5 mg/kg (Figure 3). Nickel in Baghdad (Karkh district) ranges between 11 and 40 with an average of 25.5 mg/kg (Figure 2). The average of Ni in the selected areas of Baghdad was found by Habib et al, 2012 to be172 mg/kg; it was high due to sampling nature and industrial activities.

Lead

The major natural source of Pb in the environment is sulfides minerals such as galena (PbS). The anthropogenic source of Pb is leaded gasoline in most as

Table 3. Categories of the Geo-accumulation (I_{geo}), Contamination Factor (CF), and Pollution Load Index (PLI) and their pollution level.

I_{geo}	Class	CF	PLI
<0 practically unpolluted	0		<1 Perfection
0-1 Unpolluted to moderately polluted	1	<1 Low contamination	=1 Baseline level
1-2 Moderately polluted	2	1 ≤ Cf < 3 Moderate contamination	>1 Deterioration
2-3 Moderately to strongly polluted	3	3 ≤ CF< 6 Considerable contamination	
3-4 Strongly polluted	4	>6 Very high contamination	
4-5 Strongly to extremely polluted	5		
>5 Extremely polluted	6		

well as the other varied sources emitting from coal and fuel combustion, and shops of radiator repairer. The average abundance of Pb in the earth's crust is 20 mg/kg.

The range between 10-32 and average of 15.6 mg/kg (Table 2) was the highest value of Pb recorded in the south of the highway. The lowest value of Pb was recorded in the north of highway; it was detected between 7 and 27 with an average of 14.7 mg/kg. Lead in Baghdad (Karkh district) ranges between 9 and 30 with an average of 14.8 mg/kg. The distribution pattern of Pb displayed with Ni and Cd in Baghdad (Karkh district), north and south of the highway can be seen in Figures 2, 3 and 4 respectively. The average of Pb in selected areas from Baghdad was found by Habib et al, 2012 to be 43 mg/kg; it was high due to sampling nature and industrial activities.

Assessment of contamination

There are many indices that can be used to assess the level of contamination by heavy metals. For this purpose and to meet the objectives of this study, three indices were selected to evaluate the contamination level of Cd, Ni and Pb in the roadside dust. These are Geo-accumulation index (I_{geo}), contamination factor (CF) and Pollution Load Index (PLI).

Index of Geo-accumulation

The index of Geoaccumulation (I_{geo}) means the assessment of contamination by comparing the levels of heavy metal obtained to a background levels originally used with bottom sediments (Muller, 1969). It was widely used by many authors. Gowd *et al*. (2010) has applied the index of Geo-accumulation to assess of road dust contamination. The evaluation of contamination with heavy metals was made using the index of Geo-accumulation (I_{geo}) using the following equation

$$Igeo = \log 2\left(\frac{Cn}{1.5Bn}\right) \qquad (1)$$

Where Cn is the measured concentration of the heavy metal in road dust and Bn is the geochemical background concentration of the heavy metal (crustal average) (Taylor and Mclennan, 1985). Lu *et al*., 2009 defined the constant 1.5 in equation 1 as a constant introduced to minimize the effect of possible variations in the background values which may be attributed to lithologic variations in the sediments. Muller, 1969 designed a classification for the Geo-accumulation index. This application was considered by many researchers like Huu *et al*., 2010. The values of this index vary from subzero to more than 5 having 7 grades (Table 3). The highest grade (6) reflects a 100-fold enrichment and (0) reflects the background concentration. Förstner et al. (1990) have suggested I_{geo} as a basis for classification of sediment pollution.

The overall total geo-accumulation index (I_{geo}) shows that the Ni in the Baghdad (Karkh district) and north and south of the highway was found negative (Table 2) and of 0 class. This indicates that the concentrations of Ni in the road-side dust are unpolluted and lower than the background. Lead shows a negative index for all samples indicating no pollution, but it have positive value 0.42, 0.08 and 0.33 for samples 1B, 14N and 24S respectively and belongs to the class 1 indicating un-pollution to moderately pollution. Cadmium exhibited a positive Geo-accumulation index in many samples; 4 samples collected from Baghdad and 3 samples collected from thenorth of highway are classified as class 1 (unpolluted

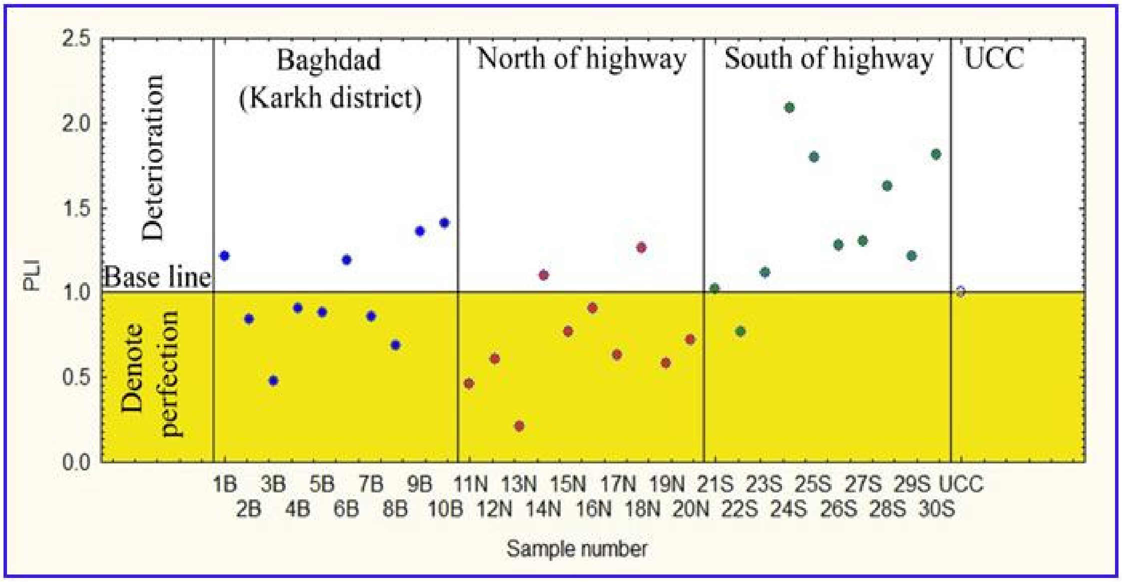

Figure 5. Pollution Load Index (PLI) for heavy metals along roadside for each sampled area.

to moderately polluted). All samples (except sample no. 22S) collected from south of the highway moderately to strongly polluted (Table 2).

Contamination factor (CF)

The level of contamination by metals was established by applying the contamination factor (CF) that can be calculated as:

$$CF = \frac{\text{Cm Sample}}{(\text{Cm Background})} \quad (2)$$

Where the contamination factor $CF < 1$ indicates low contamination; $1 \leq CF < 3$ refers to moderate contamination; $3 \leq CF \leq 6$ means considerable contamination and $CF > 6$ indicates very high contamination as shown in Table 3. The contamination factor (CF) for Cd, Ni and Pb was calculated in the study areas and the results are presented in Table 2. Cadmium (Cd) in Baghdad (Karkh district) classified as class 1 and 2 representing a low contamination to moderate contamination in all samples except sample no.10B represents a considerable contamination (Class 3) (Table 3). Sample collected from north of the highway exhibited contamination factor value not exceed 3belong to the class 1 and 2 exhibit a contamination factor not exceed 3 indicating a contamination level of low to moderate contamination. The contamination factor (CF) for Cd is recorded the highest value (6.22) in south of the highway (Table 2) indicating contamination level vary from low contamination to very high contamination. The source of pollutant materials could be attributed to the automobile emission, where the wind direction played a key role in transfer the pollutants. France reports a percentage of 1.7 % cadmium to be attributed to passenger cars' emissions (1996), Flanders referred a share of 2.2 % (1997) attributed to the sector traffic, Italy (1994) and Luxemburg (1997) a value of about 1 % each to road transport. The cadmium emission from road transport in Austria was estimated to be 4.5 % (1995) (ECDGE, 2001). The heavy metals have been added into urban soils through urban waste, chemical insoilries (Chaoyang *et al*., 2009) and most importantly through the vehicle emission (Xia *et al*., 2011). Contamination factor (CF) for Pb in the studied area is classified as class 1 and 2 (Low to Moderate contamination). Lead, for example is known to come from the use of leaded gasoline whereas Cd from tire abrasion, lubricants, industrial and incinerator emissions (Thorpe and Harrison, 2008). The source of Ni in street dust is believed to be due to corrosion of vehicular parts (Lu *et al*., 2009).

Pollution Load Index (PLI)

Pollution Load Index (PLI) has been proposed by Thomilson et al., (1980) for evaluating a particular site. This index expressed as:

$$\text{PLI} = (\text{CF1} \times \text{CF2} \times \text{CF3} \times \text{CF4} \times \text{CFn} \ldots \ldots)^{1/n} \quad (3)$$

Where n is the number of metals. The PLI provides simple but comparative means for assessing a site quality, where a value of PLI < 1 denote perfection; PLI = 1 present that only baseline levels of pollutant are present and PLI > 1 would indicate deterioration of site quality (Thomilson et al., 1980). PLI results are listed in Table 2.

PLI in the Baghdad (Karkh district) ranges from 0.48 to 1.41 with an average 0.96. Six samples In Baghdad appear no polluted, while four samples have PLI more than 1 indicating local pollution (Figure 5). The average of PLI (0.96) indicates denote perfection and the site is not deteriorating. Only two samples in the north of highway are more than the baseline level (1.0), whilst eight samples are less than the baseline level. The average of PLI is 0.87 indicating a denote perfection. In the south of the highway, all samples except one have more than 1.0 value of PLI. The average of PLI (1.05) indicates a deterioration of site quality. The sample represented of the Upper Continental Crust (UCC) is fitted with the baseline (Figure 5).

CONCLUSIONS

The concentration of heavy metals (Cd, Ni and Pb) in the study areas can mainly be attributed to traffic flow and emission of smoke onto the road side. It has been observed in Baghdad (Karkh district), north and south of highway, In Baghdad (Karkh district), north of the highway and south of highway, the average concentration of Cd was 0.17, 0.14 and 0.2 mg/kg respectively. Ni was 25.5, 23.4 and 27.4 mg/kg, while Pb was 14.8, 14.7 and 15.6 mg/kg respectively. It is clear that the pollutant affected the south side of the highway more than the north side of the highway because of the prevailing wind direction (NW) was a control factor in transferring the pollutants. Pollutants (Cd, Ni and Pb) are added to the road-side dust in quantities equivalent to the amount of gas emitted from automobiles, corrosion and wear of vehicle parts as well as atmospheric additives. The distribution pattern of the pollutants depends on the energy and direction of the wind. The leaded gasoline, diesel fuel and tire abrasion have resulted in widespread contamination of soil near highways with Pb, Cd and Ni.

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