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Using Pollution Indexes to Assessment of Heavy Metals Pollution in Highway – Side Soils around Baghdad City

Dunya A. AL- jibury[1]*, Salman. K.Essa[2]

1- University of Baghdad / College of Agriculture /Department of Soil and Water Sciences
2- University of Baghdad /College of Agriculture /Department of Desertification Combating

Abstract

Assessment of heavy metal pollutants: Cd, Pb, Zn and Ni was conducted for Soils in surrounding highway of Baghdad city, evaluate the relation between heavy metals concentration in soil, and study effect of distance from pollution source. Study area was including high express way surrounded Baghdad city, in 43 km distance approximately. Four pollution indexes had been used enrichment factor ratios (EF), contamination factor (CF), pollution load index (PLI) and geoaccumulation index (Igeo) methods, to assessment of heavy metals pollution for these Soils.

Results showed that heavy metals concentrations in soil samples took the order of Ni > Zn > Pb > Cd and all was higher than their concentration in comparison soils. The EF and PLI values decreased with increasing distance away of the highway edges for both sides with random distribution in some locations. This indicated to the affected soils of near sites of 1.5 and 10 m from road sides by emitted gases from vehicles exhausts that used the road. The CF values of Cd, Pb, Zn and Ni for all studied soils ranged of lower – moderately polluted (1 > CF – 3 > CF ≥ 1). All values of I_{geo} were within the range $1 > I_{geo} \geq 0$ considered as values ranged between non-pollution – moderately pollution, thus the contribution of geo source supplying with heavy metals was in the lower level. Results indicated that heavy metals concentrations appeared through pollution indexes calculations (EF, CF, PLI and I_{geo}) were from human activities (anthropogenic source), which support assumption of those soils affected by gases emitted from vehicle exhausts or other human activities.

Key words: Heavy metal contamination, roadside soils, enrichment factors, contamination factor, pollution load index, geoaccumulation index, Baghdad, Iraq, AAS.

1. Introduction

Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded. Heavy metals frequently reported in literature with regards to potential hazards and occurrences in contaminated soils are Cd, Cr, Pb, Zn, Fe and Cu (Akoto et al., 2008). Vehicle exhausts, as well as several industrial activities emit these heavy metals so that soils, plants and even residents along roads with heavy traffic loads are subjected to increasing levels of contamination with heavy metals (Ghrefat and Yusuf, 2006). The enrichment of heavy metals in soils nearby roadsides has been reported in several studies (Charlesworth et al., 2003; Turer and Maynard, 2003; Viard et al., 2004). In such studies the heavy metal concentrations were compared according to traffic volumes and distance from (Sezgin et al., 2003; Kalavrouziotis et al., 2006).

Heavy metals are known as non-biodegradable, and persist for long durations in aquatic as well as terrestrial environments. They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops. 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 (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. The city of Baghdad located on Tigris River between latitudes 33.25 – 33.14°N and longitudes 44.31 – 44.17 °E

Besides, the used cars which are second hard remained in service. This exerts a heavy pressure on it's urban environment. This work was carried out on roadsides Soils along the both Sides of highway around to Baghdad city (Figure 1). The objective of this study is to elucidate the distribution of heavy metals (Cd, Pb, Zn, and Ni) in roadsides of highway using an index of Enrichment Factor (EF), Contamination Factor (CF), Pollution Load Index (PLI), and Geo – accumulation (I_{geo}).

2. Materials and Methods

2.1. Study area

Baghdad City, the capital city of Iraq, is situated in the central part of Iraq. The study area includes highways of Mohammed AL-Qasim, Al-Dura, and AL-Tagiyat, the highways are connected with each other to making a circle around to Baghdad City. 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. Traffic density was determined by counting the number of automobiles passing the sampling sites over a period of twelve hours starting 6.00 a.m. to 6.00 p.m. each day for three days (Grace, 2004).

2.2. Sampling description and collection:

Six sites along the highway (The main entrance of Baghdad City at AL-Yusifia, Al-Dura, Mohammed AL-Qasim, AL- Tagiyat, Hay AL-Hussien, and background sample) were chosen for this study (Figure 1). Soil samples were collected from both sides of road (East and West) at four distant (1.5, 10, 25, and 60 m) from road sides. The Soil was generally taken from (0 – 25) cm of the topsoil. Background Sample was collected from site with no industrial activities and characterized by no traffic density.

Figure 1. Map sites study sample on highway traffic.

2.2. Chemical Laboratory tests of soil samples:

The concentrations of total heavy metals (Cd, Pb, Zn, and Ni) were extracted from soil by using a digestion method of (Jones, 2001). Then the concentrations of total heavy metals were measured by using Atomic Absorption spectrophotometer (AAS).

3. Pollution indices:

To interpret and assess the contamination status for heavy metals in the soil samples, four soil pollution indices were used {enrichment factor (EF), contamination factor (CF), pollution load index (PLI), geoaccumulation index (I_{geo})}.

3.1. Enrichment Factor (EF)

Enrichment Factor (EF) of an element in the samples is based on the standardization of a measured element against a reference element Sam et al., (2015).

In this study enrichment factor was used to assess the level of contamination and the possible anthropogenic impact in soils from the vicinity of the highway.

To identify anomalous metal concentration, geochemical normalization of the heavy metals data to a conservative element, such as Al, Fe, and Si were employed. Several authors have successfully used iron to normalize heavy metals contaminants (Baptista Neto et al., 2000; Mucha et al., 2003).

In this study iron was also used as a conservative tracer to differentiate natural from anthropogenic components. According to Ergin et al., (1991) and Rubio et al., (2000) the metal enrichment factor (EF) is defined as follows:

$$EF = \frac{(C_m/C_{Fe})\ \text{Sample}}{(C_m/C_{Fe})\ \text{Background}} \qquad \text{Equation (1)}$$

Where EF is the enrichment factor, $(M/Fe)_{sample}$ is the ratio of metal and Fe concentration of the sample and $(M/Fe)_{background}$ is the ratio of metals and Fe concentration of a background. The background concentrations of metals were taken from soils from an undisturbed area. Table (6, 7, 8, and 9) shows EF values of Cd, Pb, Zn and Ni in soils along with the background concentrations of these metals.

Enrichment factor categories for Equation (1) are outlined as follows:
EF ≤ 1: No enrichment
1 < EF ≤ 3: Minor enrichment
3 < EF ≤ 5: Moderate enrichment
5 < EF ≤ 10: Moderately severe enrichment
10 < EF ≤ 25: Severe enrichment
25 < EF ≤ 50: Very severe enrichment
EF > 50: Extremely severe enrichment

3.2. Contamination Factor (CF)

The level of contamination of soil by metal is expressed in terms of a contamination factor (CF) calculated as:

$$CF = \frac{C_m \text{ Sample}}{C_m \text{ Background}} \qquad \text{Equation (2)}$$

Where, C_m Sample is the concentration of a given metal along the roadside. C_m Background is concentration of an element in the background soil sample (Mmolawa et al., 2011).

Where the contamination factor CF < 1 refers to low contamination; 1 ≤ CF < 3 means moderate contamination; 3 ≤ CF ≤ 6 indicates considerable contamination and CF > 6 indicates very high contamination.

3.3. The Pollution Load Index (PLI)

Each site was evaluated for the extent of metal pollution by employing the method based on the pollution load index (PLI) developed by Tomlinson et al. (1980), as follows:

$$PLI = (CF_1 \times CF_2 \times CF_3 \times ..... \times CF_n)^{\frac{1}{n}} \qquad \text{Equation (3)}$$

Where n is the number of metals studied (four in this study) and CF is the contamination factor calculated as described in Equation (2). 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 pollutants are present and PLI >1 would indicate deterioration of site quality (Tomlinson et al., 1980).

This type of measure has however been defined by some authors in several ways, for example, as the numerical sum of eight specific contamination factors (Hakanson, 1980), whereas, Abrahim (2005) assessed the site quality as the arithmetic mean of the analyzed pollutants. In this study, the authors found it appropriate to express the PLI as the geometric mean of the studied pollutants since this method tends to reduce the outliers, which might bias the reported results.

3.4. Geoaccumulation index (I_{geo})

The geoaccumulation index is generally used to determine the anthropogenic contamination in sediments as introduced by Muller (1969), Muller (1979) and corroborated by prominent works like Loska et al., (1997); Lokeshewari and Chandrappa (2006) and Chen et al., (2001). This index allows us to evaluate the contamination levels by comparing present concentrations with background levels (Table 1).

Geoaccumulation index (I_{geo}) introduced by Muller (1969) was also used to assess metal pollution in soils. It is express as:

$$Igeo = \log_2 \frac{C_m \text{ Sample}}{1.5\, C_m \text{ Background}} \qquad \text{Equation (4)}$$

The factor 1.5 is introduced in this equation to minimise the effect of possible variations in the background values, C_m Background, which may be attributed to lithogenic variations in soils. The seven proposed descriptive classes for I_{geo} values are given in Table 9 (Muller, 1969).

Table 1. The I_{geo} classes with respect to soil quality.

I_{geo} value	I_{geo} class	Designation of soil quality
Igeo ≥ 5	6	Very strongly polluted
4 ≤ Igeo < 5	5	Strongly to very strongly polluted
3 ≤ Igeo < 4	4	Strongly polluted
2 ≤ Igeo < 3	3	Moderately to strongly polluted
1 ≤ Igeo < 2	2	Moderately polluted
0 ≤ Igeo < 1	1	UNP to moderately polluted
Igeo ≤ 0	0	Unpolluted (UNP)

4. Results and Discussion

The results of Cd, Pb, Zn, and Ni in the studied area are listed in table (2, 3, 4, and 5).

4.1. Cadmium

The concentration of cadmium along roadside soils ranged from (0.21-3.93 mg kg^{-1}) and the highest value of Cd was recorded in the distant of 1.5 m at east side of AL- Tagiyat soil (Table 2). The average of Cd in selected areas of Baghdad was found by Habib et al., 2012 to be 19 mg kg^{-1}; it was high due to anthropogenic and industrial activities.

Table 2. Total cadmium concentration along roadside soils (mg kg^{-1})

	Location	Distance from Road m								
		West road ←				East road →				Control
		60	25	10	1.5	1.5	10	25	60	
Cd	Awiridj	0.30	0.45	1.83	2.32	2.81	2.12	1.21	0.21	1.08
	Al-Dura	2.08	2.44	2.78	2.93	2.42	2.81	1.59	1.20	1.08
	Mohammed Al-Qassim	2.26	2.19	2.51	2.36	2.18	1.35	1.31	1.60	1.77
	Al-Tagiyat	2.12	2.71	2.52	2.16	3.93	2.15	2.34	2.51	2.46
	Hay al-Hussein	2.62	2.29	2.82	3.93	2.85	2.59	3.46	2.65	2.46

4.2. Lead

Total Pb concentration along roadside soils ranged from 36.0-129.0 mg kg^{-1}, results in Table 3 showed the highest value of Pb was 129.0 mg kg^{-1} appeared in 1.5 m distant of west side for Hay AL-Hussien soil samples.

Table 3. Total lead concentration along roadside soils (mg kg^{-1})

	Location	Distance from Road m								
		West road ←				East road →				Control
		60	25	10	1.5	1.5	10	25	60	
Pb	Awiridj	36.0	62.0	78.0	96.0	85.0	71.0	53.0	40.0	92.0
	Al-Dura	91.0	97.0	108.0	109.0	106.0	103.0	98.0	87.0	92.0
	Mohammed Al-Qassim	85.0	93.0	90.0	102.0	93.0	102.0	95.0	104.0	89.0
	Al-Tagiyat	86.0	90.0	105.0	96.0	109.0	86.0	97.0	89.0	89.0
	Hay al-Hussein	102.0	109.0	112.0	129.0	109.0	106.0	117.0	119.0	89.0

4.3. Zinc

Total concentration of Zn in highway roadside soils sites ranged from 38.0-240.0 mg kg^{-1} at east side of roadside soil. As well as results in Table 4 showed the highest value of Zn was 240.0 mg kg^{-1} at east side of AL-Tagiyat soil in of 1.5 m distant from roadside.

Table 4. Total Zinc concentration along roadside soils (mg kg^{-1})

	Location	Distance from Road m								
		West road ←				East road →				Control
		60	25	10	1.5	1.5	10	25	60	
Zn	Awiridj	110.0	180.0	195.0	96.0	38.0	176.0	203.0	128.0	123.0
	Al-Dura	151.0	137.0	129.0	176.0	134.0	191.0	168.0	118.0	123.0
	Mohammed Al-Qassim	56.0	63.0	148.0	171.0	124.0	146.0	45.0	103.0	97.0
	Al-Tagiyat	112.0	120.0	176.0	137.0	240.0	173.0	215.0	142.0	132.0
	Hay al-Hussein	135.0	173.0	152.0	160.0	181.0	163.0	149.0	127.0	132.0

4.4. Nickel

The Ni concentration in roadside soils ranged from (95.0-248.0 mg kg^{-1}). As the results of table 5 showed that the highest value, 248.0 mg kg^{-1}, appeared in the western side of Mohammed Al-Qasim Highway road site at 60 m of the road edge. Ni concentrations are high in soil of Mohammed AL- Kasim site and variety from other heavy metals which were all low. It is probably due to the industrial activities in that area leads to this result. These results are similar to those found by Ekmekyapar et al., (2012).

Table 5. Total Nickel concentration along roadside soils (mg kg^{-1})

	Location	Distance from Road m								
		West road				East road				Control
		60	25	10	1.5	1.5	10	25	60	
Ni	Awiridj	144.0	173.0	156.0	162.0	178.0	141.0	170.0	125.0	158.0
	Al-Dura	169.0	202.0	170.0	163.0	150.0	176.0	188.0	181.0	158.0
	Mohammed Al-Qassim	248.0	213.0	159.0	184.0	132.0	151.0	143.0	122.0	164.0
	Al-Tagiyat	182.0	120.0	166.0	152.0	146.0	206.0	137.0	110.0	114.0
	Hay al-Hussein	128.0	178.0	136.0	109.0	173.0	121.0	160.0	95.0	114.0

5. Pollution Index

To determine the real sources of pollution in the soils under the study, a discrimination; between those pollutants resulting from anthropogenic and those derived from geological sources, have been done.

5.1. Enrichment Factor (EF)

Akoto (2008) explained that the enrichment factor ranging between 0.5 – 1.5 indicated that the presence of the element was a result of natural geological processes, while > 1.5 indicate that the sources of the heavy elements derived from anthropogenic.

The results of the tables: 6, 7, 8 and 9 and the figure: 2 showed EF values on both sides of the highway around the city of Baghdad. The EF values of Cd were 0.271 – 3.032 at the eastern and 0.335 – 2.033 at the western side of the road; for Pb were 0.503 – 3.052 at the eastern and 0.471 – 1.549 at the western side of the road; for Zn were 0.360 – 2.774 at the eastern and 0.677 – 2.187 at the western of the road; and for Ni were 0.633 – 2.053 at the eastern and 0.749 – 1.850 at the western of the road. Lowest EF value was for Cd of 0.271 in the soil of eastern side of Awiridj site and the highest value was for Pb of 3.052 in the soil of eastern side of Muhammed Al-Qasim highway. Also, the tables: 6, 7, 8 and 9 showed that, in general, EF values decreased with increasing the distance away of the highway edges for both sides with appearance of random distribution in some locations, and these results explained the impact of vehicle exhaust gases that using the road, the random distribution may be essentially due to the effect of prevalent wind velocity variation at study area and this agreed with many studies (Mmolawa et al., 2011; Mafuyai et al., 2015; Sam et al., 2015).

The results showed that EF Values which exceeded 1.5, suggested by Akoto (2008), appeared all at the sites near the highway edges then decreased with increasing the distance away those edges, thus EF increment, at the site near the edges, was due to vehicle exhaust gases. In addition, this distribution was very clear and had highest values at the eastern side of the road for all metals which indicated the effect of the direction (northern-western) of the prevalent wind velocity in the study area.

Table 6. Relation between distance on both highway sides with (EF) for Cadmium metal

	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
EF - Cd	Awiridj	0.335	0.487	1.774	1.999	3.032	1.657	1.008	0.271
	Al-Dura	1.756	1.778	2.005	1.970	2.015	1.953	1.375	1.161
	Mohammed Al-Qassim	1.498	1.763	2.033	1.630	1.982	1.338	1.743	2.361
	Al-Tagiyat	0.963	1.596	0.827	0.692	0.895	0.455	1.074	1.045
	Hay al-Hussein	0.737	0.849	1.174	1.708	0.663	0.628	0.681	1.556

Table 7. Relation between distance on both highway sides with (EF) for Lead metal

EF - Pb	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	0.471	0.787	0.888	0.971	1.077	0.651	0.518	0.605
	Al-Dura	0.902	0.830	0.915	0.860	1.036	0.840	0.995	0.988
	Mohammed Al-Qassim	1.120	1.489	1.449	1.401	1.682	2.010	2.513	3.052
	Al-Tagiyat	1.080	1.465	0.952	0.850	0.686	0.503	1.230	1.024
	Hay al-Hussein	0.793	1.117	1.289	1.549	0.701	0.710	0.637	1.931

Table 8. Relation between distance on both highway sides with (EF) for Zing metal

EF - Zn	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	1.077	1.709	1.660	0.726	0.360	1.208	1.484	1.449
	Al-Dura	1.119	0.877	0.817	1.039	0.980	1.166	1.275	1.002
	Mohammed Al-Qassim	0.677	0.925	2.187	2.155	2.057	2.640	1.092	2.774
	Al-Tagiyat	0.948	1.317	1.076	0.818	1.019	0.682	1.838	1.102
	Hay al-Hussein	0.708	1.195	1.179	1.296	0.785	0.736	0.547	1.389

Table 9. Relation between distance on both highway sides with (EF) for Nickel metal

EF - Ni	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	1.098	1.279	1.034	0.954	1.313	0.753	0.968	1.101
	Al-Dura	0.975	1.006	0.838	0.749	0.854	0.836	1.111	1.197
	Mohammed Al-Qassim	1.774	1.850	1.390	1.372	1.295	1.615	2.053	1.943
	Al-Tagiyat	1.785	1.525	1.176	1.051	0.718	0.941	1.356	0.988
	Hay al-Hussein	0.777	1.424	1.222	1.022	0.869	0.633	0.680	1.203

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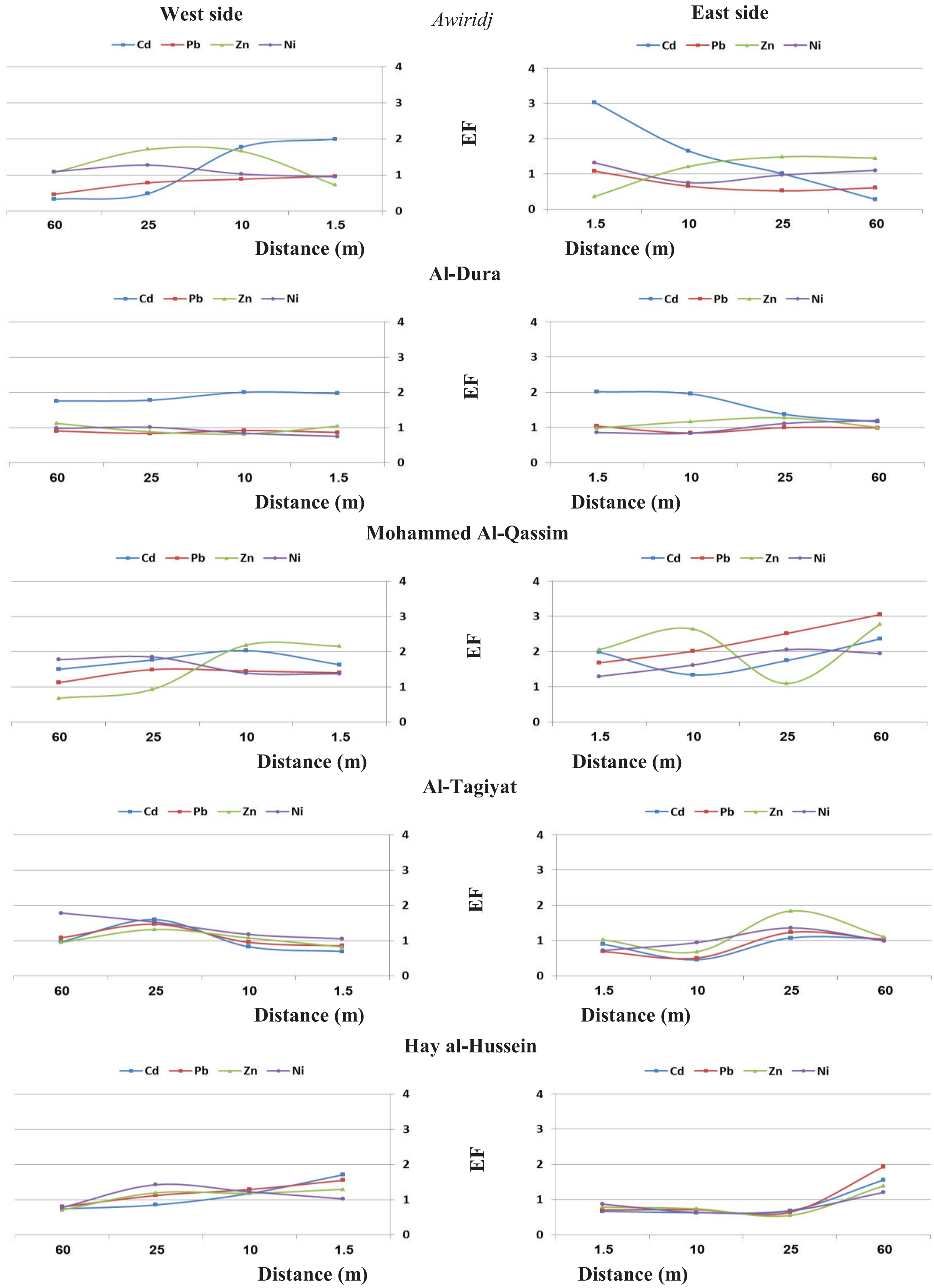

Figure 2. Horizontal distribution for (EF) with metals.

5.2. Contamination Factor (CF)

CF indicates to contamination by anthropogenic for a particular soil (Adamu et al., 2014). The results of the tables: 10, 11, 12 and 13 and the figure: 3 showed the CF values of the highway around Baghdad. The CF values of Cd were 0.194 – 2.602 at the eastern and 0.278 – 2.713 at the western side of the road, for Pb were 0.435 – 1.337 at the eastern and 0.391 – 1.449 at the western side of the road, for Zn were 0.309 – 1.818 at the eastern and 0.577 – 1.763 at the western side of the road, and for Ni were 0.744 – 1.807 at the eastern and 0.911 – 1.596 at the western side of the road; The lower CF value was for Cd of 0.194 at the eastern side of Awiridj site and the higher was of 2.713 at the western side of Al-Dura site.

Results of the tables: 10, 11, 12 and 13 and the figure: 3 showed, in general, that CF values decreased with increasing the distance away from the both sides of the highway with appearance of random distribution in some sites that indicating the effect of emitted gases from exhausts of vehicles used the road on the contamination level in these soils. Also, the random distribution of CF values in some sites may return to the variation in wind velocity and direction in the study area, and these results agreed with many studies (Mmolawa et al., 2011; Rahman et al., 2012; Awadh, 2013). The results showed that the CF values for all heavy metals appropriated with traffic density of the vehicles used the road. The CF increment, in Al-Dura site soils for both sides of the road, was attributed to site nearness to Al-Dura refinery which led to increasing elements concentrations in these soils. Generally, the CF values of Cd, Pb, Zn and Ni for all studied soils ranged of lower – moderately polluted ($1 > CF - 3 > CF \geq 1$) (Adamu et al., 2014).

Table 10. Relation between distance on both highway sides with (CF) for Cadmium metal

CF - Cd	Location	Distance from Road m							
		West road ←				East road →			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	0.278	0.417	1.694	2.148	2.602	1.963	1.120	0.194
	Al-Dura	1.926	2.259	2.574	2.713	2.241	2.602	1.472	1.111
	Mohammed Al-Qassim	1.277	1.237	1.418	1.333	1.232	0.763	0.740	0.904
	Al-Tagiyat	0.862	1.102	1.024	0.878	1.598	0.874	0.951	1.020
	Hay al-Hussein	1.065	0.931	1.146	1.598	1.159	1.053	1.407	1.077

Table 11. Relation between distance on both highway sides with (CF) for Lead metal

CF - Pb	Location	Distance from Road m							
		West road ←				East road →			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	0.391	0.674	0.848	1.043	0.924	0.772	0.576	0.435
	Al-Dura	0.989	1.054	1.174	1.185	1.152	1.120	1.065	0.946
	Mohammed Al-Qassim	0.955	1.045	1.011	1.146	1.045	1.146	1.067	1.169
	Al-Tagiyat	0.966	1.011	1.180	1.079	1.225	0.966	1.090	1.000
	Hay al-Hussein	1.146	1.225	1.258	1.449	1.225	1.191	1.315	1.337

Table 12. Relation between distance on both highway sides with (CF) for Zinc metal

CF - Zn	Location	Distance from Road m							
		West road ←				East road →			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	0.894	1.463	1.585	0.780	0.309	1.431	1.650	1.041
	Al-Dura	1.228	1.114	1.049	1.431	1.089	1.553	1.366	0.959
	Mohammed Al-Qassim	0.577	0.649	1.526	1.763	1.278	1.505	0.464	1.062
	Al-Tagiyat	0.848	0.909	1.333	1.038	1.818	1.311	1.629	1.076
	Hay al-Hussein	1.023	1.311	1.152	1.212	1.371	1.235	1.129	0.962

Table 13. Relation between distance on both highway sides with (CF) for Nickel metal

CF - Ni	Location	Distance from Road m							
		West road ←				East road →			
		60	25	10	1.5	1.5	10	25	60
	Awiridj	0.911	1.095	0.987	1.025	1.127	0.892	1.076	0.791
	Al-Dura	1.070	1.278	1.076	1.032	0.949	1.114	1.190	1.146
	Mohammed Al-Qassim	1.512	1.299	0.970	1.122	0.805	0.921	0.872	0.744
	Al-Tagiyat	1.596	1.053	1.456	1.333	1.281	1.807	1.202	0.965
	Hay al-Hussein	1.123	1.561	1.193	0.956	1.518	1.061	1.404	0.833

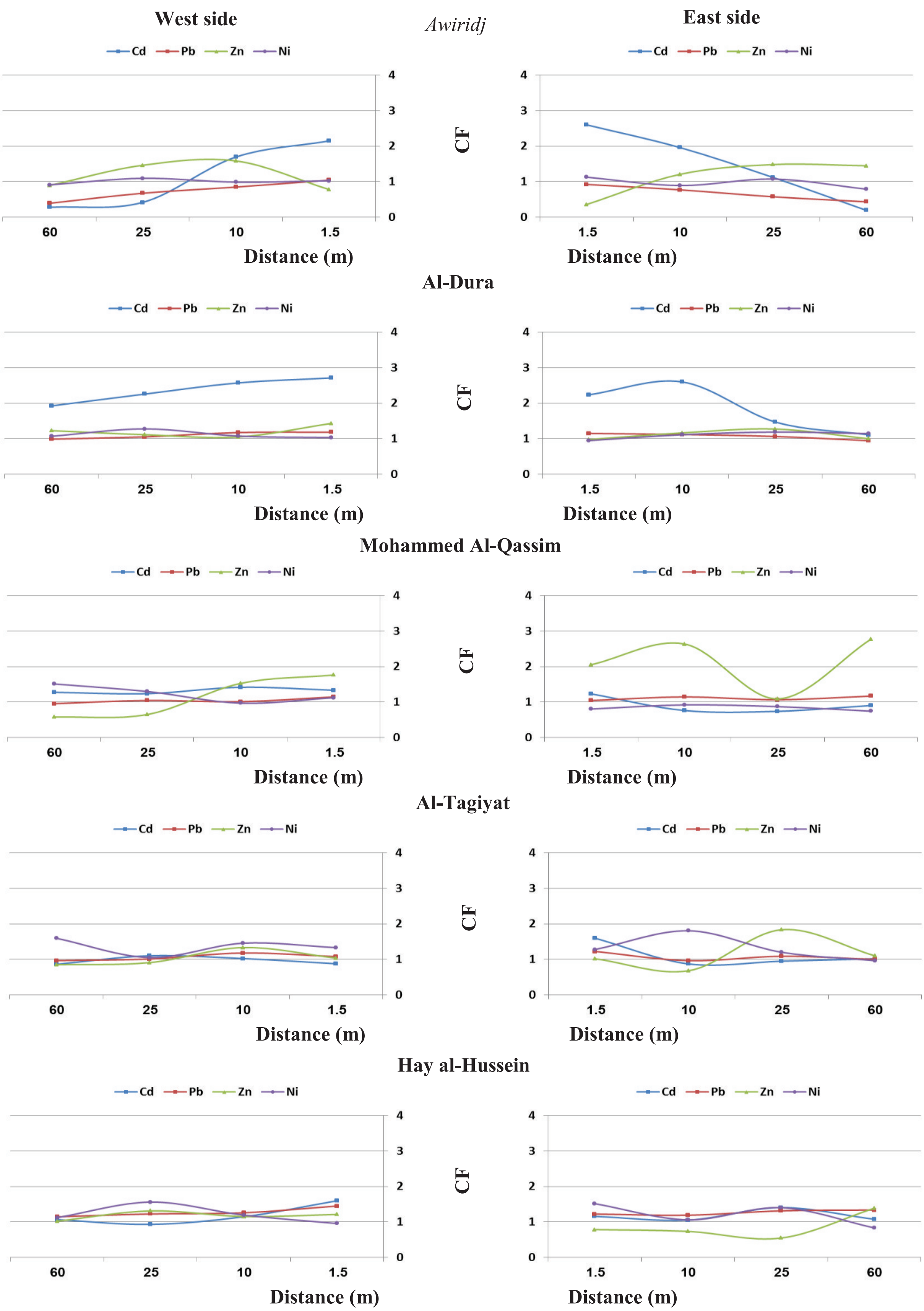

Figure 3. Horizontal distribution for (CF).with metals.

5.3. Pollution Load Index (PLI)

The results of table 14 and figure 4 showed PLI values of the highway soils which showed that the values decreased with increasing the distance away from road edges for both sides which indicated to the affected soils of near sites of 1.5 and 10 m from road sides by emitted gases from vehicles exhausts that used the road, these results agreed with those of Mmolawa et al., (2011) which showed that PLI increased in the soils of near sites from the road sides in Zambia.

The lower PLI value was 0.514 at the eastern side of Awiridj site and the higher value was 1.498 at the eastern side of Al-Dura site.

The increased PLI values of the both sides soils of Al-Dura site, 1.5 and 10 m exceeding 1, indicated the level of contamination with heavy metals at the two mentioned sites (Table 14) due to the site nearness of Al-Dura oil refinery which greatly affected the proportions of heavy metals. Also, it was noted increasing PLI value in the soil of the site 1.5 m at the eastern side of the highway traffic and site Al- Aeltagyat. The traffic density (1500 Car hr^{-1}) at the mentioned site and these results agreed with many studies (Mmolawa et al., 2011; Sam et al., 2015; Jafaru et al., 2015).

Table 14. Relation between distance on both highway sides with (PLI) for heavy metals (Cd, Pb, Zn, and Ni)

	Location	Distance from Road ← m →							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
PLI – (Cd, Pb, Zn, Ni)	Awiridj	0.546	0.819	1.225	1.157	0.956	1.179	1.035	0.514
	Al-Dura	1.258	1.357	1.359	1.476	1.278	1.498	1.264	1.037
	Mohammed Al-Qassim	1.016	1.022	1.207	1.319	1.073	1.049	0.752	0.956
	Al-Tagiyat	1.031	1.016	1.238	1.070	1.461	1.189	1.194	1.014
	Hay al-Hussein	1.088	1.236	1.186	1.280	1.311	1.132	1.308	1.037

5.4. Geoaccumulation Index (I_{geo})

Muller (1969) was the first who suggested this index as an expression of expected source of pollutant and the extent of lithogenic source contribution supplying soil with the heavy metals.

Results of the tables: 15, 16, 17 and 18 and the figure: 5 showed that the I_{geo} values of Cd were -2.948 – 0.795 at the eastern and were -2.433 – 0.855 at the western side of the road, for Pb were -1.787 – -0.166 at the eastern and were -1.939 – -0.094 at the western side of the road, for Zn were -2.280 – 0.278 at the eastern and were -1.378 – 0.233 at the western side of the road, and for Ni were -1.012 – 0.269 at the eastern and were -0.719 – 0.090 at the western side of the road. The lower I_{geo} value was for Cd of -2.948 at the eastern side of Awiridj site soil and the higher I_{geo} value was also for Cd of 0.855 at the western side of Al-Dura site soil.

Results of the tables: 15, 16, 17 and 18 and the figure: 5 showed that I_{geo} values were less than 0, i.e. had negative values for all studied soils and for the evaluated heavy metals: Cd, Pb, Zn and Ni except some of very little sites. These results indicated that concentrations of these metals, which their values appeared within the calculation of other pollution indexes: EF, CF and PLI, had an anthropogenic source which supported the assumption that soils affected by gases emitted from vehicle exhausts or other human activities. The appearance of some I_{geo} values, in some of study sites soils with positive values, but always were less than 1, confirmed that not affected by geo source. I_{geo} values, suggested by Muller (1969), indicated that there were six I_{geo} levels (Table 1) and all values within the range $1 > I_{geo} \geq 0$ considered as values ranged between non-pollution – moderately pollution, thus the contribution of geo source supplying with heavy metals was in the lower level.

These results agreed with Mmolawa et al., (2011), during their calculation for I_{geo} values of the soils of highway both road sides in Zambia, who found that 95% of these values had negative values and attributed the appearance of 5% of these values, that had positive values and within the range $1 > I_{geo} \geq 0$, to no contribution of geo source supplying with heavy metals as they fall within less than 1.

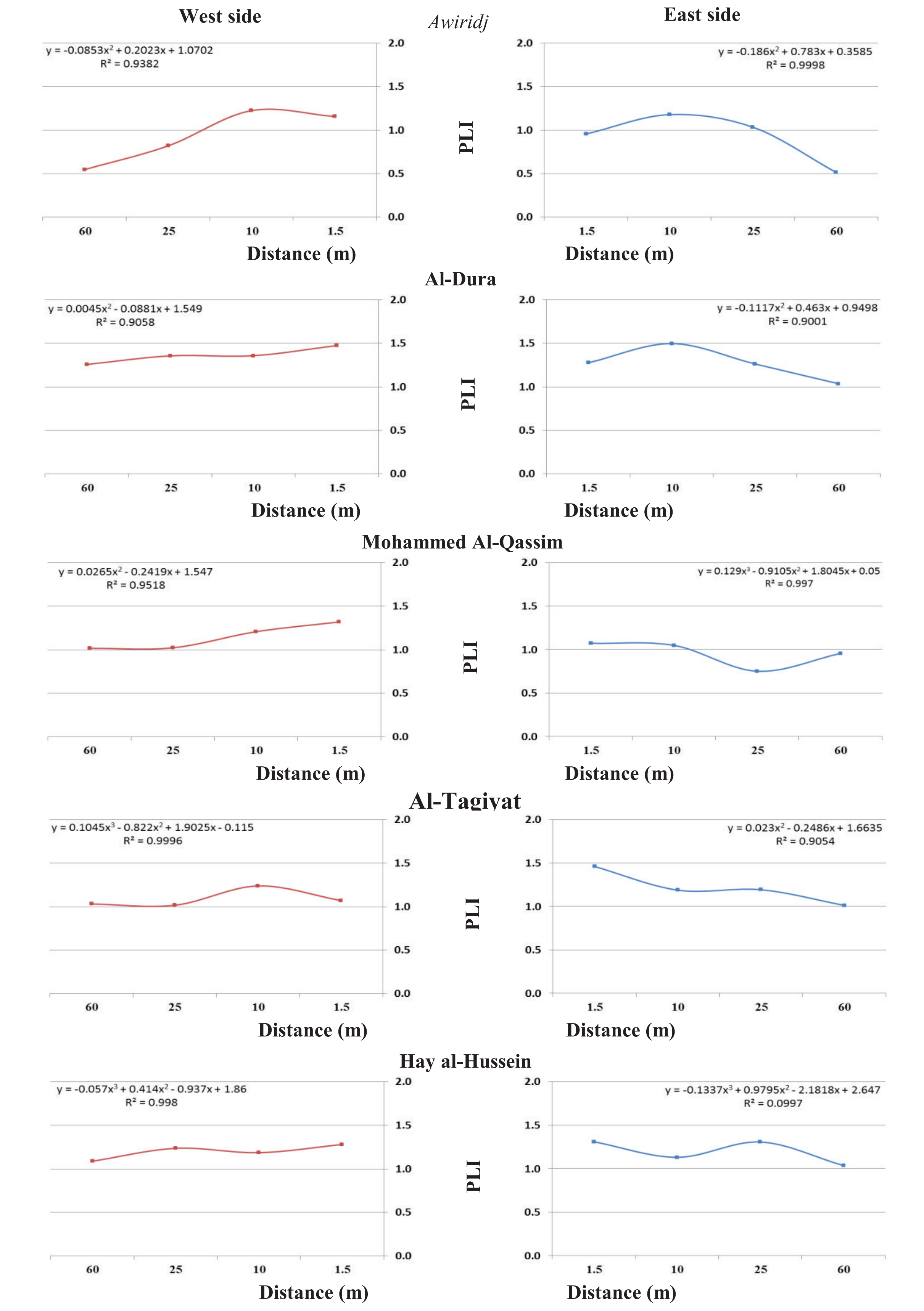

Figure 4. Horizontal distribution for (PLI) for heavy metals (Cd, Pb, Zn, and Ni).

Table 15. Relation between distance on both highway sides with (I_{geo}) for Cadmium metal

	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
Igeo - Cd	Awiridj	-2.433	-1.848	0.176	0.518	0.795	0.388	-0.421	-2.948
	Al-Dura	0.361	0.591	0.779	0.855	0.579	0.795	-0.027	-0.433
	Mohammed Al-Qassim	-0.232	-0.278	-0.081	-0.170	-0.284	-0.976	-1.019	-0.731
	Al-Tagiyat	-0.800	-0.445	-0.550	-0.773	0.091	-0.779	-0.657	-0.556
	Hay al-Hussein	-0.494	-0.688	-0.388	0.091	-0.373	-0.511	-0.093	-0.478

Table 16. Relation between distance on both highway sides with (I_{geo}) for Lead metal

	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
Igeo - Pb	Awiridj	-1.939	-1.154	-0.823	-0.524	-0.699	-0.959	-1.381	-1.787
	Al-Dura	-0.601	-0.509	-0.354	-0.340	-0.381	-0.422	-0.494	-0.666
	Mohammed Al-Qassim	-0.651	-0.522	-0.569	-0.388	-0.522	-0.388	-0.491	-0.360
	Al-Tagiyat	-0.634	-0.569	-0.346	-0.476	-0.293	-0.634	-0.461	-0.585
	Hay al-Hussein	-0.388	-0.293	-0.253	-0.049	-0.293	-0.333	-0.190	-0.166

Table 17. Relation between distance on both highway sides with (I_{geo}) for Zinc metal

	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
Igeo - Zn	Awiridj	-0.746	-0.036	0.080	-0.943	-2.280	-0.068	0.138	-0.527
	Al-Dura	-0.289	-0.429	-0.516	-0.068	-0.461	0.050	-0.135	-0.645
	Mohammed Al-Qassim	-1.378	-1.208	0.025	0.233	-0.231	0.005	-1.693	-0.498
	Al-Tagiyat	-0.822	-0.722	-0.170	-0.531	0.278	-0.195	0.119	-0.480
	Hay al-Hussein	-0.553	-0.195	-0.381	-0.307	-0.130	-0.281	-0.410	-0.641

Table 18. Relation between distance on both highway sides with (I_{geo}) for Nickel metal

	Location	Distance from Road m							
		West road				East road			
		60	25	10	1.5	1.5	10	25	60
Igeo - Ni	Awiridj	-0.719	-0.454	-0.603	-0.549	-0.413	-0.749	-0.479	-0.923
	Al-Dura	-0.488	-0.231	-0.479	-0.540	-0.660	-0.429	-0.334	-0.389
	Mohammed Al-Qassim	0.012	-0.208	-0.630	-0.419	-0.898	-0.704	-0.783	-1.012
	Al-Tagiyat	0.090	-0.511	-0.043	-0.170	-0.228	0.269	-0.320	-0.636
	Hay al-Hussein	-0.418	0.058	-0.330	-0.650	0.017	-0.499	-0.096	-0.848

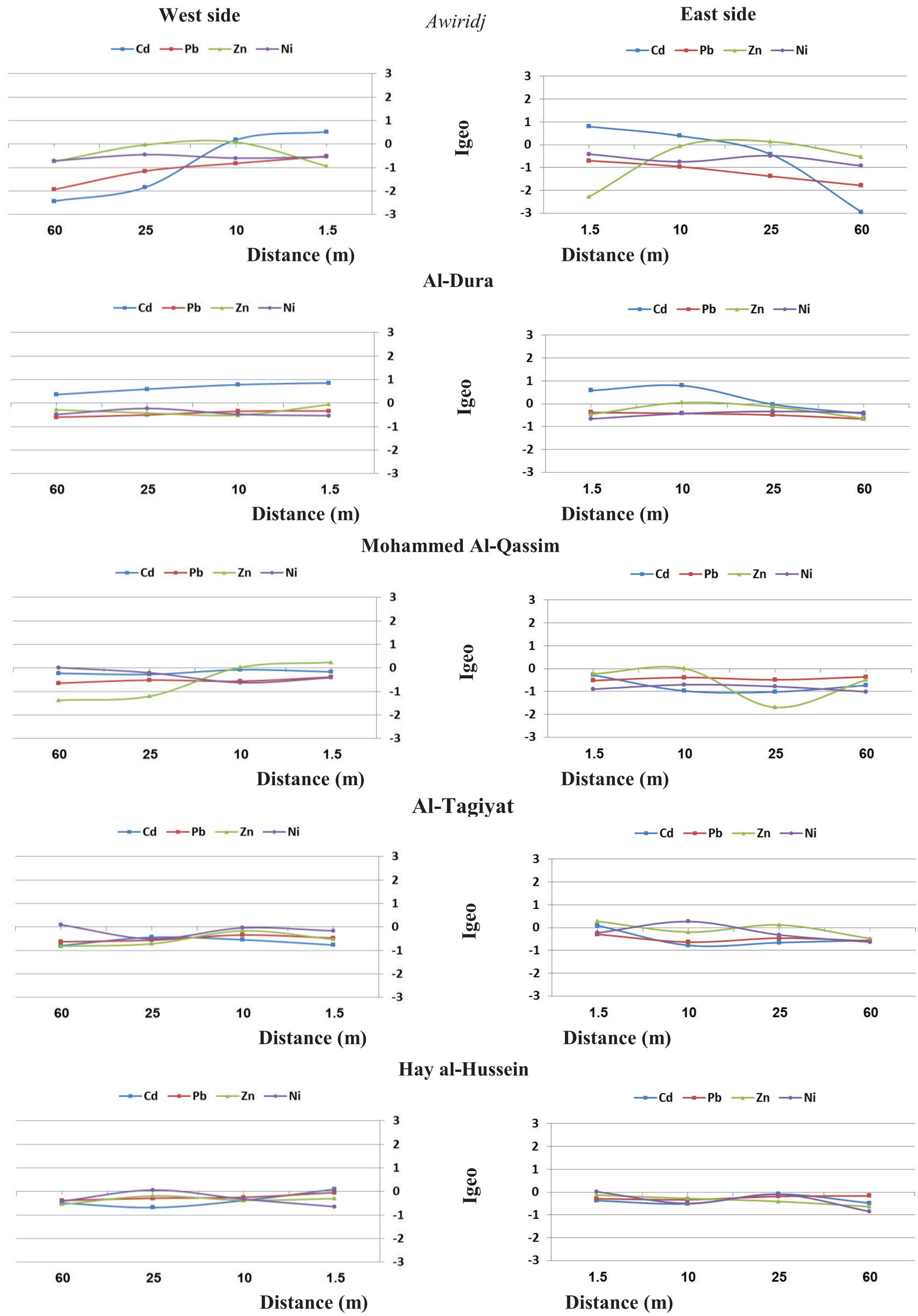

Figure 5. Horizontal distribution for I_{geo} index with metals.

6. Conclusions

From previous results it can be concluded that:

1- It has been shown that metal concentration in soil was related to traffic density and the proximity of the road.

2- The direction of the prevailing wind played a major role in the transport of heavy metals concentrations towards the east of the highway.

3- Main reason for soil contamination was anthropogenic and industrial activities.

4- The results showed that EF values which exceeded 1.5, suggested by Akoto (2008), appeared all at the sites near the highway edges then decreased with increasing the distance away those edges, thus EF increment, at the site near the edges, was due to vehicle exhaust gases. The highest EF values appeared at the eastern side of the road for all metals which indicated the effect of the direction of wind (northern-western) of the prevalent wind velocity in the study area.

5- The results showed that the CF values for all heavy metals appropriated with traffic density of the vehicles used the road. The CF increment, in Al-Dura site soils for both sides of the road, was attributed to site nearness to Al-Dura refinery which led to increasing elements concentrations in these soils.

6- The increased PLI values of the both sides soils of Al-Dura site, 1.5 and 10 m exceeding 1, indicated the level of contamination with heavy metals at the two mentioned sites due to the site nearness of Al-Dura oil refinery which greatly affected the proportions of heavy metals.

7- It was noted increasing PLI value in the soil of the site 1.5 m at the eastern side of the highway traffic and site Al-Aeltagyat. The traffic density (1500 Car hr^{-1}) at the mentioned site.

8- Results showed that Igeo values were less than 0, i.e. had negative values for all studied soils and for all the evaluated heavy metals: Cd, Pb, Zn and Ni, These results indicated that concentrations of these metals, which their values appeared within the calculation of other pollution indexes: EF, CF and PLI, had an anthropogenic source which supported the assumption that soils affected by gases emitted from vehicle exhausts or other human activities.

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