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Heavy Metals Pollution in the Highway – Side Soil around Baghdad City

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Abstract
The study aimed to assessment of pollution status by heavy metals Cadmium, Lead, Zinc, and Nickel 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 include high express way surrounded Baghdad city, starting from main gate in Yusufiyah and ended in Al-Fedaa Company in 43 km distance approximately. Soil samples were collected from 5 locations with 9 km interval between location and other. Soil Samples were taken from surface layer (0 – 25) cm depth, at both road sides (back and forth) within 4 distances (1.5, 10, 25, and 60 m) from each roads sides, and another samples were taken from 2 km distance from road sides, to comparison 3 samples for same depth.
Results that have been achieved by this study can summarize as following:
1. Results showed that heavy metals concentrations in soil samples along highway which surrounded Baghdad city took the following order
$$Ni > Zn > Pb > Cd$$
And all was higher than their concentration in comparison soils.
2. The concentrations of Cadmium were ranged between 0.21– 3.93 mg kg^{-1} in soil samples at high way, In general, the concentrations of Cadmium were decreased with distance from road sides, while the higher values were recorded within first and second distances 1.5 and 10 m.
3. The concentrations of Lead were ranged between 36.0 – 129.0 mg kg^{-1} in soil samples at high way, while the changes in Lead concentrations in some soil locations was refered to effect of environmental changes, like direction and speed of wind.
4. Zinc concentrations were ranged between 240.0 – 380.0 mg kg^{-1} in soil samples at high way, while the increasing of Zinc concentrations in Al-Daura soil samples spite of low traffic jams was due to close located to Al-Daura refinery.
5. Nickel concentrations were ranged between 95.0 – 248.0 mg k^{-1} in soil samples at high way, also the concentrations of Nickel were increased in Mohammed Al-Qassim highway soil samples while others heavy metals (Zn, Pb, and Cd) were decreased and this can be attributed to another Nickel source in that location.

Keywords: Pollution, Heavy metals, Soil, Air, Vehicular Traffic, Traffic density, Baghdad. Iraq, AAS

1. Introduction

Heavy metals are currently of much environmental concern. They are harmful to humans, animals and are susceptible to bioaccumulation in the food chain. Heavy metals may come from many different sources in urban areas. Atmospheric pollution is a major contributor to heavy metal contamination in topsoils (Kelly et al., 1996).

One of the most important sources of air pollution is vehicle emission. Metals such as Fe, Cu and Zn are essential components of many alloy, pipes, wires and tires in motor vehicles and are released into the roadside environment as a result of mechanical abrasion (Jaradat et al., 2005). The metallic pollutants in the air eventually precipitated on the ground surface depending on wind flow patterns and increased their concentration in adjacent areas (Harrison et al., 1981). Therefore, the enrichment of heavy metals in soils nearby roadsides has been reported in several studies (Norrstrom and Jacks, 1998; 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 (Piron-Frenet et al., 1994; 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. 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 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.

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 highwaies of Mohammed AL-Qasim, Al-Dura, and AL-Tagiyat, the highwaies are conacted with each other to making a cercal around to Baghdad City. It is situated on the quaternary unconsolidated sediment of the Mesopotamian plain formed mainly from Tigris 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. The average daily traffic density in the sampling sites as shown in (table .1), the 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).

Table 1. The averages traffic density for Highway road

Highway samples sites	The averages daily traffic density for 3 days (car hour^{-1})
Awiridj southren gate Baghdad (Southern Street)	1300
Al-Dura highway road	850
Mohammed Al-Qassim highway	1200
Al-Tagiyat highway (northern street)	1500
Hay al-Hussein road	1300

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. 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 (Scheme 1). 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. Soil samples were preserved in cleaned polyethylene bag and finally transported directly to the laboratory (Figure 1).

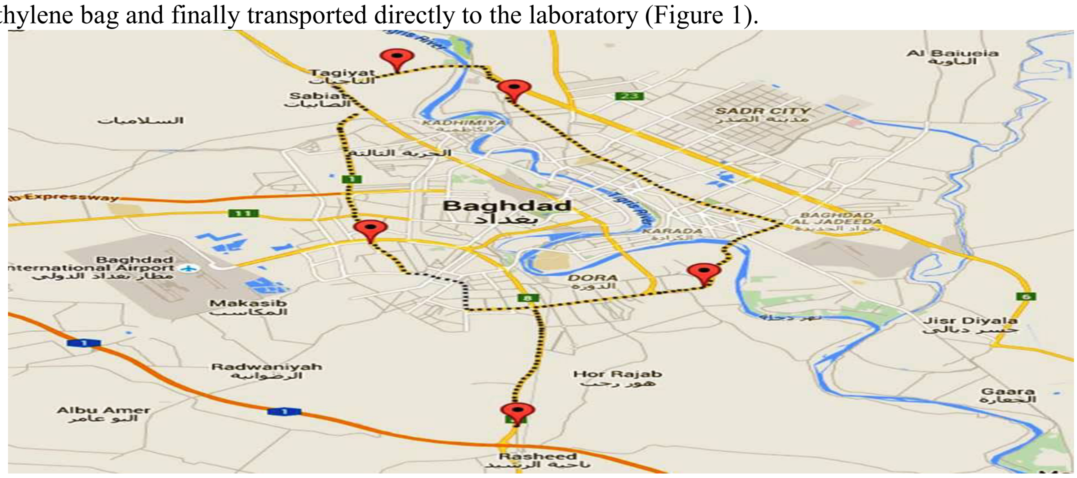
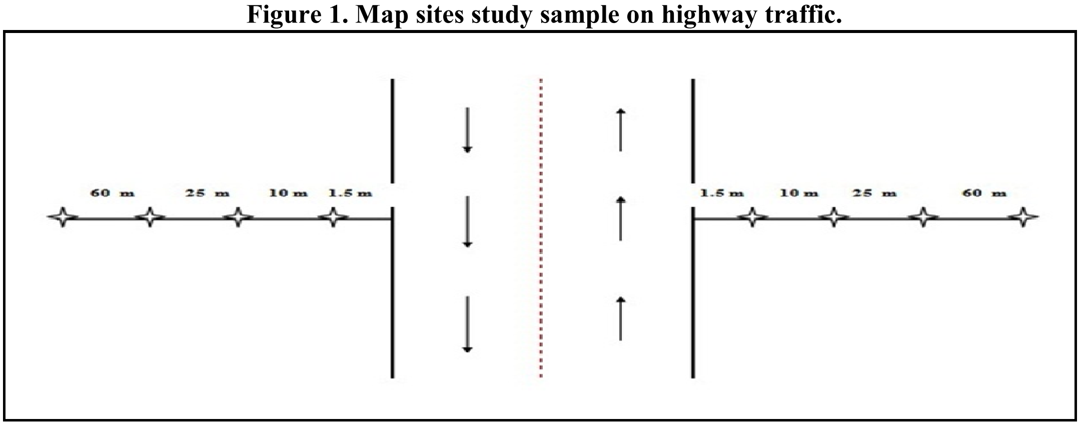


Figure 1. Map sites study sample on highway traffic.



Scheme 1. Soil samples taken positions on both sides of the highway.

2-3- Chemical Laboratory tests of soil samples:

The laboratory tests include determination of pH and Ec according to method of (Page et at., 1982) CaCO3% was measured by using calcimeter (Hesse, 1971) the organic matter was determined by (Walkley and Black, 1934) (Table .2). And cation exchange capacity using (Papanicolaou, 1976) method for calcareous soils. Soil texture was performed following hydrometer method (Day, 1965) (Table .3), the 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).

Table 2. Some soil chemical properties for highway roadsides soils

Distance (m)	EC dS m^{-1}	pH	$CaCO_3$	O.M	CEC C $mole_+$ kg^{-1} Soil
			gm kg^{-1}		
Awiridj southren gate Baghdad (Southern Street)					
East 1.5	15.60	7.10	279	8.0	26.81
East 10	37.50	6.97	302	3.4	26.93
East 25	69.50	6.90	279	5.7	27.15
East 60	8.90	7.13	255	8.0	25.91
West 1.5	25.00	6.91	244	3.4	27.21
West 10	40.30	6.96	232	5.7	27.25
West 25	9.20	7.15	279	6.8	24.20
West 60	15.90	7.08	209	3.4	24.30
Control	148.40	6.85	186	3.4	26.81
Al-Dura highway road					
East 1.5	16.80	7.11	186	5.7	26.71
East 10	7.83	7.19	162	8.0	27.00
East 25	21.20	7.04	209	5.7	27.21
East 60	5.10	7.12	182	3.4	26.91
West 1.5	36.80	6.96	209	5.7	27.23
West 10	40.20	6.98	189	11.4	26.88
West 25	37.10	6.97	209	12.6	27.18
West 60	6.00	7.21	255	3.4	26.89
Control	148.40	6.85	186	3.4	26.81
Mohammed Al-Qassim highway					
East 1.5	6.70	7.20	244	8.0	26.93
East 10	18.40	7.10	232	5.7	27.10
East 25	9.40	7.23	255	10.3	27.23
East 60	17.10	7.09	279	5.7	27.21
West 1.5	17.60	7.08	279	3.4	22.25
West 10	4.80	7.25	255	8.0	28.31
West 25	15.70	7.18	209	10.3	29.91
West 60	2.90	7.31	232	3.4	28.13
Control	2.30	7.35	255	6.8	26.73
Al- Tagiyat highway (northern street)					
East 1.5	72.40	6.89	209	0.34	27.14
East 10	3.20	7.14	186	0.34	27.14
East 25	22.60	7.00	240	0.80	27.18
East 60	10.40	7.21	255	0.80	21.33
West 1.5	20.90	7.10	186	0.34	28.75
West 10	26.10	6.97	255	0.57	29.88
West 25	3.10	7.31	302	0.57	21.80
West 60	4.40	7.22	209	0.57	27.41
Control	5.10	7.20	166	0.81	29.50
Hay al-Hussein road					
East 1.5	20.20	7.01	302	8.0	26.90
East 10	24.50	6.99	209	5.7	27.91
East 25	138.80	6.89	279	4.5	21.95
East 60	155.40	6.80	139	3.4	25.90
West 1.5	121.30	6.95	255	8.0	22.00
West 10	53.00	7.03	267	10.3	26.80
West 25	26.20	6.98	299	8.0	27.13
West 60	8.50	7.17	255	6.8	22.41
Control	5.10	7.20	166	8.1	29.50

Table 3. Soil particles percent for highway locations

Location	Soil particles %	Distance from Road ← m →								
		East road				West road				control
		60	25	10	1.5	1.5	10	25	60	
Awiridj southren gate baghdad (Southern street)	Sand	57.6	51.6	55.6	65.6	43.6	47.6	57.6	57.6	33.6
	Silt	32.0	34.0	34.0	24.0	40.0	38.0	30.0	32.0	48.0
	Clay	10.4	14.4	10.4	10.4	16.4	14.4	12.4	10.4	18.4
	Tex.Clas.	Sandy loam	Loam	Sandy loam	Sandy loam	Loam	Loam	Sandy loam	Sandy loam	Loam
Al-Dura highway	Sand	39.2	29.2	39.2	39.2	29.2	48.4	29.4	35.2	33.6
	Silt	46.0	44.0	48.0	48.0	42.0	36.0	46.0	50.0	48.0
	Clay	14.8	26.8	12.8	12.8	28.8	15.6	24.6	14.8	18.4
	Tex.Clas.	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam
Mohammed Al Qasim	Sand	57.6	31.6	31.6	31.6	30.4	30.4	18.4	32.4	66.4
	Silt	34.0	40.0	40.0	40.0	44.0	42.0	46.0	40.0	20.0
	Clay	8.4	28.4	28.4	28.4	25.6	27.6	35.6	27.6	13.6
	Tex.Clas.	Sandy loam	Loam	Loam	Loam	Loam	Loam	Clay loam	Loam	Sandy loam
At Tagiyat (northern street)	Sand	49.2	28.4	35.4	35.4	67.6	45.6	27.6	73.2	27.6
	Silt	38.0	58.0	45.0	45.0	20.0	32.0	46.0	14.0	42.0
	Clay	12.4	13.6	19.6	19.6	12.4	22.4	26.4	12.4	30.4
	Tex.Clas.	Loam	Sandy loam	Loam	Loam	Sandy loam	Loam	Loam	Sandy loam	Clay loam
Hay al-Hussein	Sand	49.2	28.4	35.4	35.4	67.6	45.6	27.6	73.2	30.4
	Silt	38.0	58.0	45.0	45.0	20.0	32.0	46.0	14.0	42.0
	Clay	12.4	13.6	19.6	19.6	12.4	22.4	26.4	12.4	27.6
	Tex.Clas.	Loam	Sandy loam	Loam	Loam	Sandy loam	Loam	Loam	Sandy loam	Clay loam

3-Results and Discussion

The results of Cd, Pb, Zn, and Ni in the studied areas are listed in table (4, 5, 6 and 7) and distribution patterns of these metals on both sides are illustrates in figures (2, 3, 4, 5).

3-1- 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 .4). 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. Results in (figure 2) showed that the concentration of Cadmium was decreased with distance to the highway. The decrease of heavy metal concentrations with distance to the road is well documented by many authors (Li, 2005; Hjortenkrans et al., 2008; Radziemska and Fronczyk, 2015).

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

Table 4. 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

3-2- Lead

Total Pb concentration along roadside soils ranged from 36.0-129.0 mg kg^{-1}, results in (Table .5) and (figure 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.

When we compare Pb concentrations which obtained in this study with Pb concentrations in highway roadsides soils in many countries, generally we found Pb concentrations within same range in these countries, whereas Nigeria ranged between 89.6-247 mg kg^{-1}, in India 78.4-832 mg kg^{-1}, in Tanzania 9.27-45.92 mg kg^{-1} (Akbar et al., 2006; Luilo and Othman, 2006; Atayese et al., 2008; Sharma and Prasade, 2010).

Results in Table 5 showed that concentration of Pb in soil samples along all highway were too converging within same distance except some locations were difference in Pb concentration. Converge Pb concentration in these soil samples may due to high stabilization of Lead metal in soil. McBride (1994) and Endale et al. (2012) reported that lead is not a biodegradable in soil which adhesion on external surfaces soil particles and remain stable within upper few centimeters of soil as well as overlap with colloidal soil particles. Changes in high lead concentrations in one site were indicate for pollution status for that site and it may refer to environmental effect which occurred in site, most important effect for direction and speed of wind.

Table 5. 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
	Aeltagyat	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

3-3- Zinc

Total concentration of Zn in highway roadside soils sites ranged 38.0-240.0 mg kg^{-1} at east side of roadside soil. As well as results in (Table .6) and (figure 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.

Results showed decreasing of metal concentrations with distance increment from highway (figure 4). Results were similar with Abechi *et al.* (2010); Mmolawa *et al.* (2011); Yan *et al.* (2012); Joudah (2013); Staszewski *et al.* (2015); Mafuyai *et al.* (2015); Çelenk and Fatma (2015); Radziemska and fronczyk (2015) results of soil pollution status with heavy metals for soil along sides of highways which showed decreasing of metal concentrations with distance increment from roadsides edges.

Results in (table .6) showed that concentrations of zinc were increased in soils in the AL- Dura highway location in both east and west sides in spite of reduced traffic density (850 Car hour^{-1}), in addition Zn concentrations were exceed in some soil samples in same location from some soils in other locations which had a higher traffic density as At AL- Tagiyat (1500 Car hour^{-1}), The reason was the location near AL- Dura oil refinery and effects of fumes emitted from refineries from oil refining operations process for addition and accumulation of heavy metals in soils AL- Dura highway.

Table 6. 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
	Aeltagyat	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

3-4- Nickel

Ni concentrations are high in soil of Mohammed AL- Kasim site and variay from another 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).

The Ni concentration along roadside soils ranged from (95.0-206.0 mg kg^{-1}). As the results of (table .7) and (figure 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. Generally, the low concentrations of heavy metals (Cd, Pb and Zn) in the soil of Mohammed Al-Qasim Highway road site referred to sampling location, the site is located within area of dense palm groves, which led to reduced heavy metals concentrations emitted from vehicles exhausts in soil samples. These results agreed with Yan *et al*., 2012, who indicated that soil sites located on the sides of highways surrounded with trees were less pollution and decrease the soil heavy metals concentrations, Nickel oxide and Nickel metal; Habib et al., (2012) attributed increasing Ni concentrations in some locations of the city of Baghdad to the nature of the site sampling and industrial activity in the region.

High Ni concentrations in the soil of Mohammed Al-Qasim Highway road site may return to there are other sources of nickel, other than those resulting from the exhaust emission. Two studies of Habib et al., (2012) and Awadh (2013), to study the pollution with the heavy metals of Baghdad and the road linking between Baghdad and Kirkuk, showed that 35% of Ni sources that caused soil pollution were a result of Nickel alloys manufacturing, Stainless steel, mining, smelting and grinding, and the most important Nickel compounds of those industrial processes was Nickel sulfate.

Table 7. 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
	Aeltagyat	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

Generally results showed total concentration of heavy metals analysis for Cd, Pb, Zn and Ni in Soil sample along the highway road and all were exceed the critical limits values in (table .8), which mean soils are suffering of contamination (pollution) state by heavy metals due to increscent in human activities, including high traffic rates, which led to increased car exhaust emissions containing heavy metals, and tire friction and dusting, Engine oil consumption and car parts damage and painting, as well as increased dust storms and direction of prevailing winds and moving of pollutants in contentious movement; all these factors led to higher rates of contamination in these soils, this agreed with what founded by Swaileh et al., (2004); Awadh (2013); Joudah (2013); Howard and Orlicki (2015); Cheng et al., (2015); Nazzal et al., (2015); Sam et al., (2015); Mafuyai et al., (2015) and Sripathy et al., (2015).

Table 8. Critical values for total heavy metals concentration Cd, Pb, Zn and Ni in soil (mg kg^{-1})

Heavy metals	Cd	Pb	Zn	Ni
ALLOWAY, 1990 From Nazzal *et al.*, 2015	0.35	25	90	40
Swaileh *et al.*, 2004	0.27	87.4	82.2	18.9

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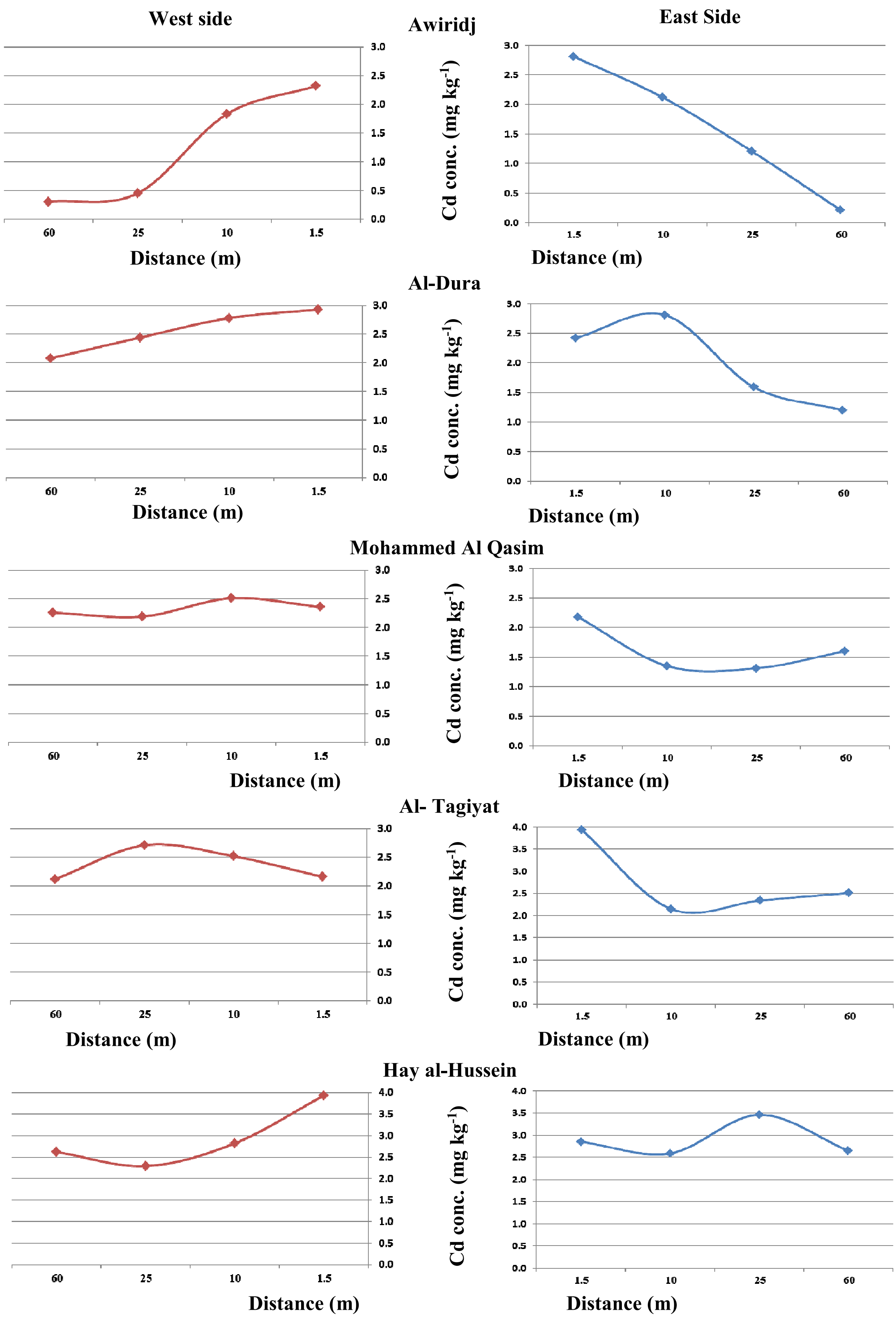

Figure 2. Horizontal distribution for total Cd concentration.

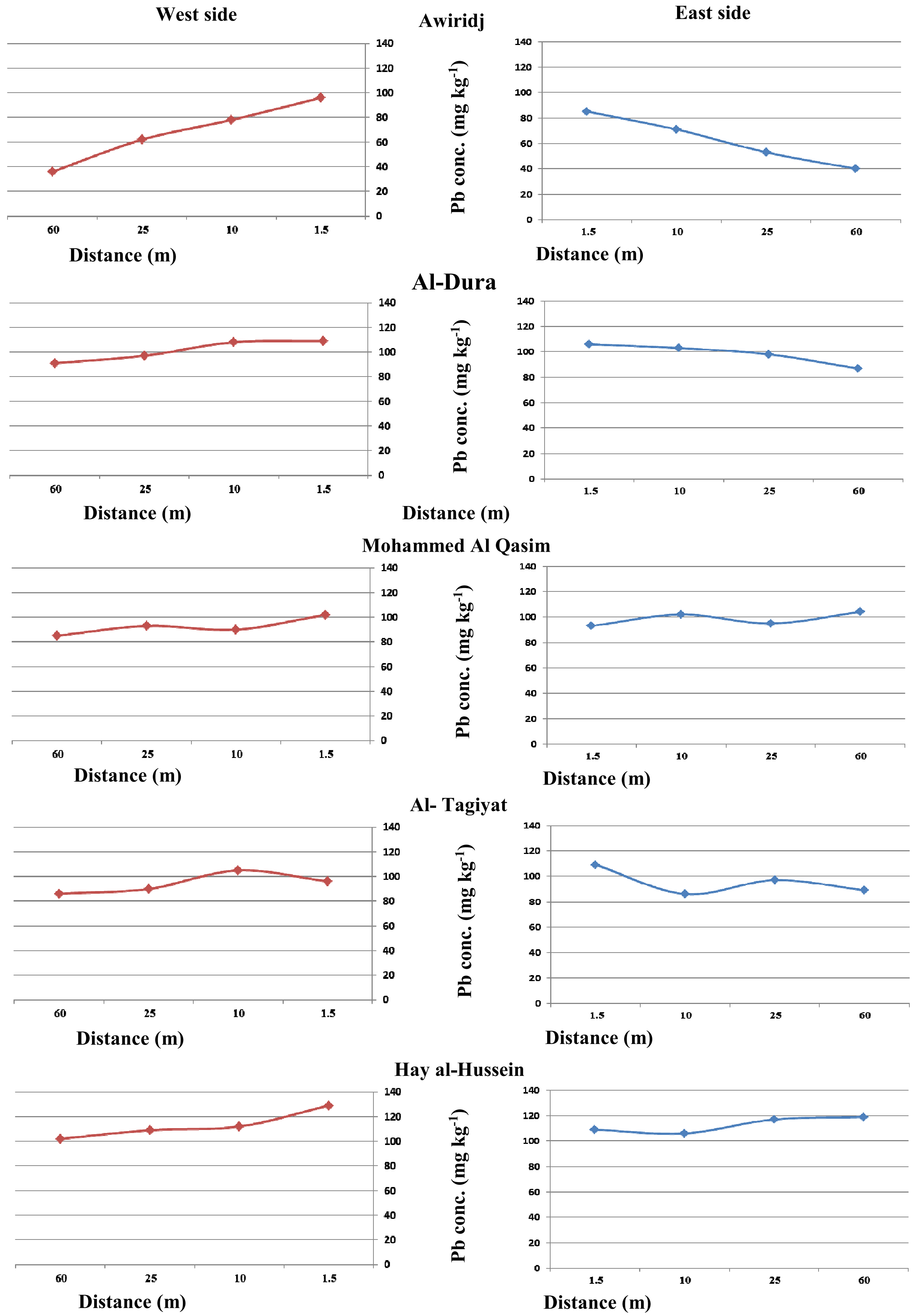

Figure 3. Horizontal distribution for total Pb concentration.

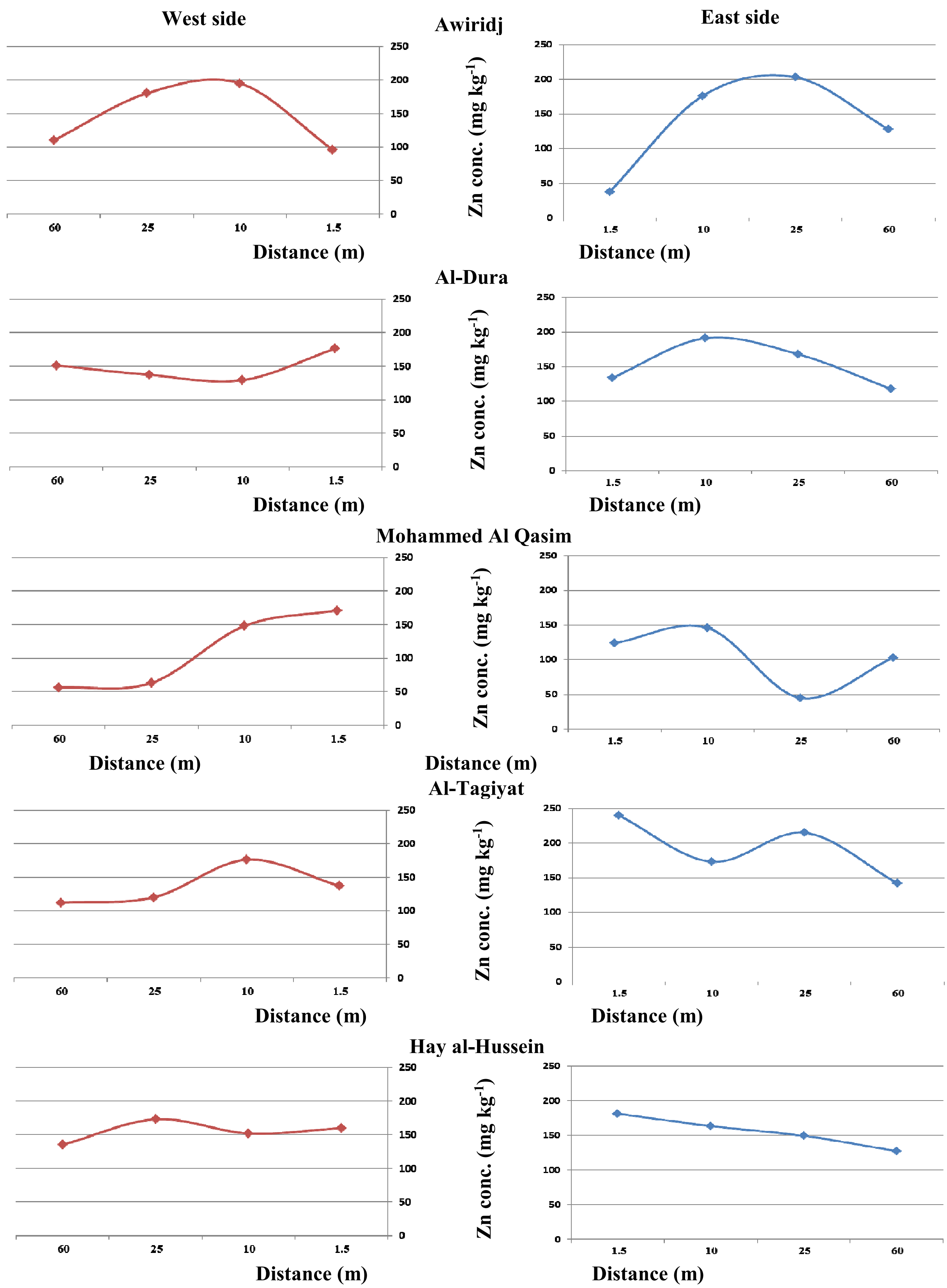

Figure 4. Horizontal distribution for total Zn concentration.

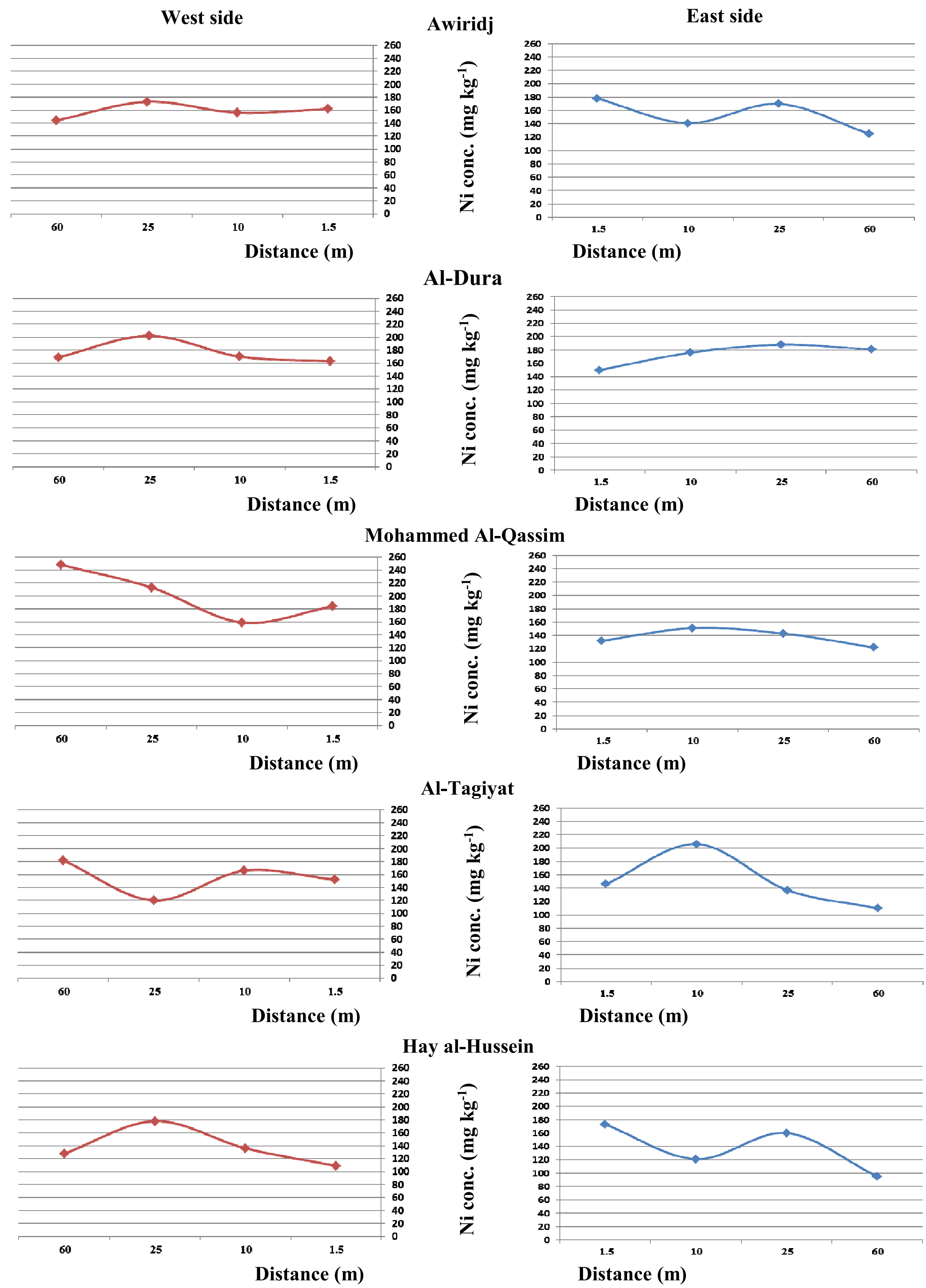

Figure 5. Horizontal distribution for total Ni concentration.

4- Conclusions

From previous results it can be concluded that:

1- The concentration of Cd along roadside soils ranged from 0.21 – 3.93 mg kg^{-1}.
2- The total concentration of Pb along roadside soils ranged from 36.0 – 129.0 mg kg^{-1}.
3- The total concentration of Zn in highway roadside soils sites ranged from 38.0 – 240.0 mg kg^{-1}.
4- The concentration of Ni along roadside soils ranged from 95.0 – 206.0 mg kg^{-1}.
5- It has been shown that metal concentration in soil was related to traffic density and the proximity of the road.
6- The direction of the prevailing wind played a major role in the transport of heavy metals concentrations towards the east of the highway.
7- Main reason for soil contamination was anthropogenic and industrial activities.

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