

Study of Heavy Metals Released from AL-Battar Asphalt in Soil Pollution

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Abstract

To study the pollutions with some heavy metals (Pb, Ni, Cr), a field study was applied to determine the effect of the asphalt plant in Wasit Province on soil pollutions by heavy metals in some area surroundings the industrials. Sample collected for three locations including 350, 700 and 1400 m away from pollutions sources, and the fourth site (control) was from the northwestern. Soil samples were collected at two depths (0-35) and (35-70) cm from southeastern, and northwestern areas. The result found an increase in total concentrations rate of heavy metal for lead,nickeland chromium in studied sites in the southeastern of the industrial at a depth of (35-0) cm, which is 350 m away from the asphalt industrial.These metals have exceeded the globally permissible limits, especially in the southern direction compared to the soil of the distant sites in the northwestern direction, especially at Depth (35-70) cm.Human activitieswere the main sources of the increase in pollutions standards values (CF and PLI). The CF values indicated the occurrence of large to very large pollution, especially in southeastern compared to northwesternareas, which recorded lower values. For PLI values, it indicated the occurrence of deterioration of the studied soils, especially in the southeasternarea of the soils close to the laboratories. Therefore, the study recommends not to cultivate in the soils close to the asphalt industrial and to use modern methods to reduce the gas emissions.

Keywords: China insurance industry, Foreign fund, Challenge

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1.Introduction

Environmental pollution is any quantitative or qualitative change in the chemical, physical and biological properties of one or more metals of the environment such as air, water and soil, which leads to significant harm that affects human health and all living organisms. The harm of pollution results from different human activities, most notably industrial activities (Ilechukwu etal 2021) Everything that pollutes the air and water in turn affects the soil and contributes to its pollution, as water and air fill the largest part of the interstitial spaces in the soil (Radomirović et al 2-20).

The problem of pollutions is considered one of important problem that began to takes on the serious environmental dimension, especially the industrials revolutions that occurred in Europe and the industrial expansion that occurred, which was accompanied by the emergence of serious pollution in the ecosystems. The problem of pollutions was not a new problem for the ecosystems, but the increase in the severity of pollution is new in our time, and the risk of environmental pollution is no less dangerous than the occurrence of wars and conflicts (Moghtaderi etal 2018).The problem of pollution, especially industrial pollution, is characterized by many characteristics that cause deterioration in the quality of the environment surrounding industrial complexes, oil refineries, power plants and asphalt industrial.

These characteristics are the non-compliance of their location and the ages of these facilities, and their lack of mean to treat pollutions, in addition to their lack of environmentally appropriate technology. All of this leads to a significant increase in the concentrations of pollutants resulting from them (Spreadbury etal 2021).Therefore, this study aimed to estimate the effect of emissions from asphalt industrial on the accumulations of the heavy metal in soil near the industrial, in addition to evaluating the levels of soil pollutions with heavy metal (Pb, Co and Cd) resulting from the combustion of fuel used in asphalt industrial in two different directions and depths and different locations and comparing them with global determinants.

2. Martials and methods

The samples were collected is located in Al-Kut District, Wasit Province, which includes many asphalt industrial and the area is surrounded by agricultural lands. The area divided to two areas, the southeast and the northwestern. Soil samples collected on 9/27/2023 from southeastern, and northwesternareas at three distances from the pollution source. The dimensions were 350 - 700 - 1400 m, respectively, for the southeastern part and the northwestern part. The comparison sample was taken at a distance of 3000 m and at two depths for each site, the first (0-35) cm and the second (35-70) cm, with three sample for each sites.

2.1 ***Estimations of Heavy Metal in the Soil***

Heavy metal(chromium - cadmium - lead - nickel and cobalt) were estimated using a mixture of perchloric and sulfuric acids using an absorption device Atomic Absorption Spectrophotometer (AAS) as described in the method (Page et al 1982)].

2.2. ***Calculating Environmental Pollution Indicators for Soil***

Contamination factor (CF): (Mirage et al 2015)]

Cf=c_m sample/c_m background

Cf=cm samples. cm backgrounds

Cf=Contaminations factors

Cm=Total concentrations of heavy metals in soil samples (mg/kg^{-1} soil)

Cm backgrounds =Total concentrations of heavy metals in control soil samples (mg/kg^{-1}).

2.3 Pollution Load Index (PLI

PLI=$(CF1\times CF2\times CF3\ldots..CF_n)^{1\backslash n}$

Cf=Contamination factors for the first, second, third metals…etc.,

n=Number of heavy metal study.

3.Results and Discussion

3.1 Total Concentrations of Heavy Metal in the Study Soils

3.1.1 Total Lead Pb+2

Table (1) indicates Total lead concentrations in soil for the three studied sites (350, 700 and 1400) m and for both directions (southeast and northwest) and for the two dimensions (0-35) cm and (35-70) cm. The values for the southeast part reached (307.33 and 261.55) mg Pb/kg^{-1} for the dimensions 350 and 700 m respectively compared to third dimensions (1400) m and the comparison samples (3000) m, that reached values of 114.85 and 42.79 mg Pb/kg^{-1} respectively.

The result in Table (1) showed that values achieved for the totals leads concentrations in soil at the first depths (0-35) cm were higher compared to the second depth (35-70) cm for the same direction and dimensions, as the values reached (195.64 and 167.62) mg Pb/kg^{-1} for the first, and second depths, respectively. As for the overlap between the dimension and depth, the high value achieved at the dimension (350) m for the depth (0-35) cm in the south-eastern direction, which was (321.81) mg Pb/kg^{-1}, while low value was achieved at the dimension (1400) m for the depth (35-70) cm, which was (97.96) mg Pb/kg^{-1}. The result of statistical indicated the existence of significant differences for each of the dimension, depth and overlap between them. The result recorded that the value of lead concentrations in the soil in the northwest direction and for all dimension, and depth studied were lower compared to southeast direction.

The average values reached (109.48, 93.91 and 70.05) mg Pb/kg^{-1} for dimension (350, 700 and 1400) m, respectively, compared to the control reached (42.79) mg Pb/kg^{-1} soil while the first depth (0-35) cm achieved higher values compared to second depth (35-70) cm. The result of statistical indicated the presence of significant differences for each of dimension, depth, and the interactions between them. An increase in concentrations of lead in soil at site was close to asphalt industrials, and in both the southeast and northwest directions, according to the permissible global determinant (WHO, 2007) (100 mg Pb/kg^{-1} soil).

This may be because to several reasons, including that sites close to asphalt industrial are affected by the heavy metals and gases released by these industrial into the atmosphere, and these gases are deposited in sites close to the industrial, which effectively contributes to the pollution of the surrounding soil by increasing the concentrations of heavy metal in it. In addition, the level of lead in surface layer of the soil is affected by the rate of accumulation and deposits from the atmosphere emitted from the industrial, and this accumulation gradually decreases the further we move away from the industrial site, in addition to the role of the prevailing winds in the region (north-west), which contribute to the transfer of pollutants from the source to nearby sites and their depositions on the soil surfaces. The result was agreed with (Mirage et al,2018 ; Wu et al,2022 ; Krishna et al ,2014 ; Saeedi & Salmanzadeh, 2012), as their studies indicated that the concentrations of lead in soil increases in site close to pollutions sources.

Table 1. Concentration of lead Pb (mg Pb/kg^{-1} soil) in the studied sites.

Site	**Distance (m)**	**Depth (cm)**		**Average**
		0-35	**35-70**	
southeast	350	321.81	292.86	307.33
	700	284.81	238.29	261.55
	1400	131.75	97.96	114.85
Control	3000	44.21	41.37	42.79
Average		195.64	167.62	---
LSD (0.05)		Distance	Depth	Distance* Depth
		2.27*	2.08*	3.93*
Northwest	350	119.14	99.83	109.48
	700	101.16	86.67	93.91
	1400	76.12	63.99	70.05
Control	3000	44.21	41.37	42.79
Average		85.16	72.96	---
LSD (0.05)		Distance	Depth	Distance* Depth
		1.79*	1.46*	2.30*
Indicators	WHO , 2007		100 mg /Pb kg^{-1}	
	Kabata-Pendias , 2011		300 mg /Pb kg^{-1}	

3.1.2 Total Nickel Concentration Ni in the Study Soils

The results and statistical analysis indicates that there was variations in the total nickel concentrations in soil from one site to another as a result of proximity and distance from the pollution source and the overlap between them. The result showed that distances from pollutions sources affected the soil content of the total nickel metals. There were significant differences in south eastern part of laboratories, as first site has recorded the highest value of the metals concentration of (100.63) mg Ni/kg^{-1} soil compared to control treatment, which achieved the lowest value (9.56) mg Ni/ kg^{-1} soil (Table 2).

This is agreed with (Kong et al.2011) that the concentration of the total nickel metals increases in sites close to brick industrial. He attributed the reason for this to the fact that the gases emitted from brick industrial settle in sites close to the industrial, which increases the concentrations of the total metals in the soil. Also, Tran et al (,2022) found that soils near thermal stations and adjacent to refineries in Baiji. The result showed that concentrations of total nickel in the soil is affected by distance as well as wind direction, and the concentration of the metals decreases the further away we are from the sources of pollutions.

The results in Table (2) showed significant difference in depth in concentrations of total nickel in studied soil sample. The first depth (0-35) cm recorded the highest value of nickel, amounting to (83.35) mg Ni/ kg^{-1}, with increase rate of 40% compared to second depth (35-70) cm, which recorded the lowest value, amounting to (59.62) mg Ni/kg^{-1}.These results are consistent with (Kabir et al ,2022), concluded that the concentration of the metals is higher in the first depth compared to concentrations of metals in the second depth. The result of two-way interactions between dimensions, and depths had significant effects on the concentrations of total nickel in the soil, as the first depth (0-35) cm with the first dimension (350) m recorded the highest value of the metals concentration, reaching (117.14) mg Ni/kg^{-1}, compared to the control samples (3000) m, and the second depth (35-70) cm, where it reached (8.46) mg Ni/kg^{-1}.

Table 2. Nickel concentrations Ni (mg Ni/kg^{-1}) in the soil.

Site	Distance (m)	Depth (cm)		Average
		0-35	35-70	
southeast	350	117.14	84.12	100.63
	700	109.8	80.94	95.37
	1400	95.78	64.95	80.36
Control	3000	10.67	8.46	9.56
Average		83.35	59.62	---
LSD (0.05)		Distance	Depth	Distance* Depth
		1.78*	1.29*	2.08*
Northwest	350	80.66	54.96	67.81
	700	74.82	49.28	62.05
	1400	56.64	37.6	47.12
Control	3000	10.67	8.46	9.56
Average		55.69	37.57	---
LSD (0.05)		Distance	Depth	Distance* Depth
		1.47*	1.06*	1.89*
Indicators	WHO , 2007		50 mg Ni/ kg^{-1}	
	Kabata-Pendias , 2011		60 mg Ni/ kg^{-1}	

For the results of the north western part of the asphalt industrial, the result of Table (2) showed differences in effect of distance, and proximity as well as the overlap between depth and distance in the concentrations of the nickel metals in the soil. It notes that the nickel metals recorded the highest value in the first sites close to the pollution source and the first depth (0-35) cm, as the value reached (80.66) mg Ni/kg^{-1} soil, compared to second depth (35-70) cm and the control samples, where the value reached (8.46) mg Ni/kg^{-1} soil. When comparing these results with the permissible global determinants (WHO, 2007), our result find that concentrations of nickel metals in the south eastern and north western parts exceeded the permissible limits.

3.1.3 Total Chromium Concentrations(Cr) in the Study Soil

The result showed the effect of distances, and proximity to asphalt plant. The total chromium concentration recorded its highest value within the first dimension, reaching (88.99) mg Cr/kg^{-1}, compared to control treatment, that recorded low value (4.48) mg Cr/kg^{-1}(Table 3).The reason for this may be attributed to the gases, and vapours rising from the asphalt industrial and heavy metals they carry, which contribute to increasing the concentration of heavy metals in areas close to pollutions sources.

The result agreed with (Zheng et al ,2020 ;Alsaad & Karem,2018) that the concentration of chromium has increased in the Dora area and attributed reason to activity of the Dora refinery and power station, which contributes to increasing the amount of pollution. The results in Table (3) showed significant effects in depth in total concentrations of total chromium of soil sample within the south eastern part of the asphalt plant. The first depth (0-35) cm gave the highest value of chromium, reaching 54.12 mg Cr/kg^{-1} soil, compared to second depth (35-70) cm, which recorded a value of 40.84 mg Cr/kg^{-1}. The reason for the decrease may be attributed to the accumulation of heavy metal in surface layer of the soil, in addition, to the lack of rainfall, which works to wash away heavy metals and transfer them to the lower soil horizons.

Table 3. Chromium (Cr) concentration (mg Cr/kg^{-1} soil).

Site	Distance (m)	Depth (cm)		Average
		25-0	50-25	
	350	101.16	76.83	88.99
southeast	700	79.21	61.91	70.56
	1400	31.18	20.62	25.90
Control	3000	4.93	4.03	4.48
Average		54.12	40.84	---
LSD (0.05)		Distance	Depth	Distance* Depth
		2.50*	1.63*	3.42*
	350	34.54	26.59	30.56
Northwest	700	22.78	11.91	17.34
	1400	12.74	6.94	9.84
Control	3000	4.93	4.03	4.48
Average		18.75	12.36	---
LSD (0.05)		Distance	Depth	Distance* Depth
		1.37*	1.01*	1.83*
Indicator	Kabata-Pendias , 2011		200 mg Cr/ kg^{-1}	

For the interactions for distance, and depth, it gave significant effects on the concentration of the total chromium metals in soil, as the first depth (0-35) cm with the first dimension gave highest values for chromium metals (101.16) mg Cr/kg^{-1} soil compared to second depths (35-70) cm with the control, which gave 4.03 mg Cr/kg^{-1}, with a clear significant decrease from the rest of the values. The result in Table (3) showed significant differences in the northwestern part of the dimension and depth and their bilateral interactions in the concentrations of total chromium metals in the soil. The chromium metals in the first site recorded a value of (30.56) mg Cr/kg^{-1}, compared to control, that was (4.48) mg Cr/ kg^{-1} soil. The result agreed with Tran et al. (2022).It was found that the effect of depths in taking samples had significant effects on the concentrations of the chromium metals. The first depth (0-35) cm gave the highest values was (18.75) mg Cr/kg^{-1}, with an increase rate of 51% compared to the second depth (35-70) cm, that recorded (12.36) mg Cr/kg^{-1} soil.

The interactions between distance, and depth had significant effects on the concentrations of total chromium, as the first depth (0-35) cm with the first dimension (350) m has recorded high values of (34.54) mg Cr/kg^{-1} soil compared to second depth (35-70) cm and the control recorded the lowest value of (4.03) mg Cr/kg^{-1}.Through the results of our study, the results find that the concentrations of total chromium in soil increased in southesternarea compared to northwastern parts. This is due to nature of the prevailing wind in the region (north-west), and when comparing these result with the permissible limit according to (Bedeeh & Fakher,2022; Davies,1992), it find that the concentrations of total chromium's was below permissible limit in all studied sites and for both the southeastern and northwestern parts.

Pollution Indicator for Heavy Metal in the Study Soil

Pollutions Factor

Table 4. Pollutions factor value.

Depth (cm)	Site	Distance (m)	Pb	Ni	Cr
0-35	southeast	350	7.28	10.98	2052
		700	6.44	10.29	16.07
		1400	2.98	8.98	6.32
	Northwest	350	2.69	7.56	7.01
		700	2.29	7.01	4.63
		1400	1.72	5.31	2.58
35-70	southeast	350	7.08	9.94	19.06
		700	5.76	9.57	15.36
		1400	2.37	7.68	5.12
	Northwest	350	2.41	6.49	6.59
		700	2.09	5.82	2.95
		1400	1.55	4.44	1.72

3.2 Pollution Factor (CF) for Lead Metal Pb

The results showed the value of the pollutions factors for lead metal of sites included in the southeastern, and northwestern parts of the asphalt industrial. In the southeastern part, the first site (350) m and for the first depth (0-35) cm recorded the high value of the pollutions factors, which amounted (7.28), compared to third sites (1400) m and for the same first depth, which recorded the lowest value, which amounted to (2.98) (Table 4).The pollutions factors in first sites indicates the occurrence of very severe pollutions of lead metal, while the value of pollutions factors in third sites indicates the occurrence of medium pollutions according to classifications(Gharaybeh,2010). However, when comparing the depths, we find that the pollution factor has decreased significantly at the second depth (35-70) cm compared to the first depth (0-35) cm.

For the northwestern part of the asphalt industrial, the result showed a decreases in values of the pollutions index compared to southeastern in Table (4).It is found that value of the pollutions factor index for the first, the second, and the third dimensionwere (2.69, 2.29 and 1.72) respectively, and this indicate the occurrence of moderate pollution with lead according to the classification (Hakanson ,1980).

The results of the study agreed with [20]that an increases in value of the pollutions factors for lead in sites close to the Dora refinery. Tran et al., (2022) indicates that reason to impact of the brick plant on soil pollutions. The result showed an increase in the value of the pollutions factors in the south eastern compared to the northwestern of asphalt industrials, and this is attributed to the natures of prevailing wind (northwest) in regions, which work to carry pollutant resulting from industrials activities to southeastern arae of the asphalt industrial.

3.3 Pollution Factor (CF) for Nickel(Ni)

The result of Table(4) showed that there is a variation in level of the pollutions factor for the nickel according to the proximity, and distances from the pollution source, as well as according to the location, and depth of taking soil sample in the southeastern and northwestern parts of the asphalt industrial. In the southeastern of the asphalt industrials, the high values of the pollutions factors was recorded in the first site (500) m and the first depth (0-35) cm, where it reached (10.98), compared to the third site (1400) m and the second depth (35-70) cm, which recorded the lowest value of (7.68). It notes that the values of the pollutions factors in the two sites indicate the occurrence of very severe pollutions, according to the classifications (Miskowiec et al,2015).

In the northwestern part, the pollutions factors value decreased compared to the southeasterns part, as the first site (350) m and first depth (0-35) cm recorded (7.56), while the pollutions factors value decreased in third site (1400) m and the second depth (35-70) cm, which gave the lowest value of (4.44). The results indicate that there were very severe pollutions in the first site and severe pollutions in third site with nickel in the northwestern part of the asphalt industrials, according to the classifications[9].Through the results find that the pollutions factor values have increased in sites close to the pollutions sources, and this is attributed to the activity of asphalt industrialsin the region and the accompanying accumulations of heavy metal in sites close to the pollutions source as a result of gases and vapors emitted from asphalt industrial.

These results are consistent with (Tomlinson et al ,2022), which found that values of the pollutions factors for the nickel metal increases in places close to the pollution source and with different types of pollution sources. In general, we find that the value of the pollutions factors have increased at the first depth (0-35) cm compared to second depth (35-70) cm for all dimensions, and both directions.

3.4 Pollution Factor (CF) for Chromium Metal (Cr)

The result showed that there is a variation in the value of the pollutions factors for chromium metalsin soil of studied sites. In the southeastern of the asphalt industrial and in first site (350) m, the high values of the pollutions factorswere recorded (20.52), and the lowest value was recorded in the third site (1400) m, where it reached (6.32) and for the first depth (0-35) cm Table (4).

Through the values of the pollutions factors, soil of sites is classified, according to standards(WHO,2007)], as very highly polluted .The reason for this is attributed to the high concentrations of total chromium in sites near asphalt industrials as a result of gaseous emissions containing heavy metal that are transported by air, and fall on the soil near the source of pollutions. This is consistent with what was indicated by (Kong et al,2010) about high value of the pollutions factors for heavy metal in the soil of sites near industrial facilities.

In the northwestern of the asphalt, the pollutions factors found low value compared to southeastern part, the first site was (7.01) and the third site recorded (2.58) and for the first depth (0-35) cm, according to the classifications (Tomlinson et al., 1980), the soil was classified from moderately polluted to very severely polluted soil. We note that the result of found that the values of the pollutions factors recorded a decrease at the second depth (35-70) cm compared to the first depth (0-35) cm for both directions. It notes an increase in the values of the pollutions factors in the southeastern compared to northwestern. The reason for this is attributed to the nature of the prevailing north-westerly wind in the regions, which work to carry pollutant from pollutions sources to the southeastern, which lead to an increase in pollutants in it compared to located opposite to the directions of the prevailing winds.

3.5 Pollution Load Index (PLI)

The result in Table (5) indicated variations in the value of the pollutions Load Index (PLI) for studied heavy metal of lead, nickel, cadmium, cobalt, and chromium. The southeastern part of the asphalt plant found that the high value of Pollution Load Index was at the first site (350) m and for the first depth (0-35) cm, which amounted to (11.85) compared to the third site (1500) m and the second depth (35-70) cm in the northwest direction, which recorded the low values of the Pollution Load Index, which was (2.39). From the result, the average value of the Pollution Load Index in the southeastern, and northwestern parts of the studied soil were greater than 1, and this indicates the state of deterioration of the studied soils. The reason for this is attributed to the gases, and the vapours emitted from the asphalt industrial as a results of their work, which contains large amounts of heavy metal that contribute to the deterioration of the soil surrounding those industrial.

Table 5. Pollution Load Index (PLI) value for the studied metals.

Depth (cm)	Distance from pollution source (m)	Southeast	Northwest
	350	11.85	5.67
0-35	700	9.88	4.44
	1400	5.96	3.07
	350	10.63	4.64
35-70	700	8.54	3.50
	1400	4.72	3.39
Pollution Load Index	1>PLI Site is unpolluted	PLI=1 Site is on the verge of deterioration	PLI >1 quality deterioration

The results agreed with [14], as they found an increases in the value of the pollutions load index in the soil of urban sites, and attributed reason for this to different human activity as well as power station, electric power generator and oil fields and the untreated pollutants they release into the soil that contribute to increasing the amount of heavy metals in the soil and its deterioration.The study also agreed with what was found by (Duong & Lee,2011) in a study of the soil of sites near industrial facilities, as the results of the pollutions load index were greater than 1 and attributed the reason for this to the gases, and the vapours emitted from power stations that contribute to increasing the percentage of heavy metal in the studied sites.

Conclusions

The study concludes that the CF values indicated the occurrence of large to very large pollution, especially in southeastern compared to the northwestern parts, which recorded lower values. For PLI values, it indicated the occurrence of deterioration of the studied soil, especially in the southeastern of soils close to the laboratories.

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