Ann. For. Res. 65(1): 2123-2136, 2022
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
https://www.e-afr.org/

The effect of the Garraf oil field on soil pollution with some heavy metals (Pb, Cd, Cr, Co, Ni) for the surrounding area of the field

Murtada Suhail Abed Al-Rikabi and Mahdi Wasmi Sahib Al-Aydi
Department of Soil Sciences and Water Resources, College of Agriculture, Wasit University, Iraq

Abstract

To estimate the state of pollution with some heavy metals (lead, cadmium, nickel, chromium and cobalt), a study was applied to find out the effect of Al-Gharraf oil field in Dhi Qar governorate on soil pollution with heavy metals in the surrounding areas of the field. Soil samples were collected from three sites, which are 500, 1000 and 1500 m away from the source of pollution, in addition to the fourth (control) site in the northeastern part of the oil field. Samples were collected at depths of 0-20 and 20-40 cm and from the southeastern and northwestern northeastern parts. The results of the study have been showed a high total concentration of heavy metals lead, cadmium, nickel, cobalt and chromium in the soil of the study sites in the southeastern part of the field at depth 0- 20 cm, which is 500 m (first site) from the oil field. It has been recorded 347.40, 11.09, 116.56, 68.78, and 98.45 mg kg^{-1} soil, respectively, which is higher compared to its concentration in the soil of the fourth site, where was 50.87, 1.25, 12.76, 5.77 and 5.98 mg kg^{-1} soil, respectively. The concentration of heavy metals in northwestern part of the field has the same depth, the nearby sites were recorded. However, it has been reached 116.28, 3.08, 62.70, 22.56 and 37.54 mg kg^{-1} soil, respectively, which is higher compared to the second depth and in both directions. The concentration of heavy metals in the soils of the study sites close to the source of pollution has increased above the international limits allowed by the World Health Organization (WHO, 2007) in the southeastern part of the oil field, except for chromium, which did not exceed the permissible limits. The study showed that human activity is the main source of high pollution standards (CF, PLI, I_{geo}). The mean values of the CF pollution factor for lead, cadmium, nickel, cobalt and chromium in the soils of the nearby sites (the first site) of the oil field and in the southeastern part were 6.83, 8.87, 9.13, 11.92 and 16.46, respectively. The value of the CF pollution factor indicates that a considerable contamination occurred to very high contamination. In the northern part, the CF pollution factor recorded low values for soil close and far sites compared to the southeastern part of the Al-Gharraf oil field. The average values of the Pollution Load Index (PLI) for the soil of the sites near the field and in the southeastern part reached the highest value of 10.16, which is higher compared to the far sites, which is recorded 3.98. In the northwestern part, the pollution load index (PLI) values decreased compared to the southeastern part. The values of the PLI <1 for the study soil sites indicated a state of deterioration in the soils of the study sites and for the northwestern and southeastern parts and the deep pasture.

Key word: Garraf oil field, soil pollution, heavy metals, Pb, Cd, Cr, Co, Ni

Introduction

The pollution issue is the most important environmental problem that has taken on serious economic and social dimensions, especially after the industrial expansion supported by modern technologies, which is accompanied by serious pollution that leads to the deterioration of the ecosystem. The quantitative or qualitative changes that occurs in the composition of the elements of this system leads to the imbalance and the inability of the ecosystem to accept this matter. The products of human, agricultural, industrial and military processes, such as toxic and radioactive materials that affect human health, which should raise awareness of the study of pollutants and ways to treat them because it is a big and very serious problem (kabir et al., 2010).

The concentration of industry in cities and the increase in means of transportation have led to the creation of a polluted environment. One of these pollutants is heavy elements, which are among the most chemical pollutants that constantly confront environmental issues due to their cumulative nature and their toxic effect on organisms, especially humans, thus affect the humans with many diseases (Kabata and Mukherjee, 2007). As well as, its stability in the environment and its spread over long distances from the sources of its emergence due to wind, storms and rain (Gulfraz et al., 2001; Feng et al., 2008). The most important sources of pollution with heavy metals are factory waste, fuel combustion, car exhaust, metal smelting and coal combustion, and soil pollution with these elements leads to low fertility and lower productivity of agricultural crops (Singh et al., 2011). Therefore, it became necessary to work to reduce the damage of the heavy metals in the soil. Oil pollution is considered one of the most important global problems that have recorded recently as a result of the expansion of oil extraction as it is an important economic resource for many countries, including Iraq.

The pollution of lands with oil and its derivatives makes these lands unsuitable for agriculture, which reduces agricultural areas as a result of the continuous subtraction of pollutants throughout the production process of oil, starting from exploration operations to use operations. In addition, it was one of the most serious problems on the natural and human environment as a result of its direct impact on the environment. It contains toxic gases in addition to heavy metals, which are among the most prominent and complex problems. In order to find out the extent of the impact of oil installations on soil, water and plant pollution with heavy metals in the surrounding areas of the Al-Gharf oil field. This study aims were the effect of emissions from the Al-Gharraf oil field on the accumulation of heavy metals in the soil and water of the surrounding areas of the field. Also, to assessing the level of soil pollution with heavy metals including (Ni, Cd, Pb, Co and Cr) as a resulting from oil extraction and associated gas combustion in two different directions from pollution sources and comparing them with global determinants. In addition, to estimate some pollution indicators to assess the state of deterioration of the soil affected by the Al-Gharraf oil field.

Materials and methods

Study area

The study included the surrounding area of the Al-Gharraf oil field, which is 85 km from the center of Dhi Qar governorate and located in the northern part of it and 5 km northwest of Al-Rifai District.

The study area was divided into two parts, the northwestern part and the southeastern part of the Al-Gharraf oil field. Soil samples were collected on 5/11/2021 from the northwestern and southeastern parts, in the direction of the wind movement in the area. Three dimensions from the source of pollution were taken: 500, 1000 and 1500 m for each part, which represented A1, B1 and C1 for the northwestern part: A2, B2 and C2 for the southern part. The eastern as well as from the fourth site (control D) in the northeastern part, which is 5000 m away from the field, at two depths (0-20) cm and (20-40) cm, with three models for each site. Soil samples were dried, crushed and sieved from a 2 mm sieve and some chemical and physical properties were estimated (Table 1).

Table 1: chemical and physical characteristic of the soil

$SO_4^{=}$	$CO_3^{=}$	HCO_3^-	Cl^-	Na^+	K^+	Mg^{+2}	Ca^{+2}	EC	pH	texture	sand	silt	clay	Depth (cm)	site
mmole^{-1}								ds^{-1}			%				
15.10	Nil	1.78	31.01	19.34	1.15	6.34	7.95	5.15	7.41	SiC	19.2	40.5	40.3	-0 20	A1
13.07	Nil	1.23	28.89	17.56	1.09	5.21	6.78	4.55	7.87	SiC	14.1	40.2	45.7	-21 40	
15.23	Nil	1.48	30.76	16.98	0.98	7.09	8.13	4.94	7.65	SiC	17.5	40.3	42.2	-0 20	B1
10.05	Nil	1.11	30.44	13.77	0.71	6.15	6.98	4.77	7.73	SiC	13.2	41.7	45.1	-21 40	
21.56	Nil	1.66	34.56	21.54	1.22	7.98	9.87	5.35	7.42	CL	18.4	39.1	42.5	-0 20	C1
11.45	Nil	1.34	29.72	15.99	1.12	6.34	8.43	4.85	7.28	SiC	13.5	41.2	45.3	-21 40	
19.15	Nil	1.88	33.23	19.87	0.89	8.21	9.45	5.33	7.74	CL	19.4	38.4	42.2	-0 20	A2
12.23	Nil	1.45	24.88	12.39	0.88	5.31	7.63	4.58	7.24	CL	16.3	39.2	44.5	-21 40	
19.87	Nil	1.43	36.60	23.89	1.01	7.49	9.22	6.18	7.66	CL	20.1	38.7	41.2	-0 20	B2
10.49	Nil	1.35	32.09	18.11	0.76	5.89	7.08	4.88	7.33	SiC	15.6	40.1	44.3	-21 40	
15.93	Nil	1.09	34.43	14.37	0.69	8.34	9.98	5.82	7.59	SiC	17.1	42.7	40.2	-0 20	C2
17.25	Nil	1.05	25.53	12.15	0.58	7.98	8.20	4.66	7.22	SiC	16.3	41.1	42.6	-21 40	

Heavy metals determinate

The heavy metals in the soil (Cr, Co, Pb, Cd, Ni) were estimated by wet digestion method by using the acidic mixture of sulfuric and pyrochloric acid using the Atomic Absorption Spectrophotometer (AAS) according to the method of (Davies, 1992).

Calculation of indicators of environmental pollution of the soil

Contamination factor (CF): Tomlinson et al., (1980).

CF = Cm Sample / Cm background

CF = Contamination Factor, Cm Sample the total concentration of the heavy metals in the soil sample mg kg^{-1}

Cm background = the total concentration of the heavy metals in the control soil, mg kg^{-1}

Table 2: Contamination Factor Index values (CF)

Classification	**CF Value**
Low contamination	≤ 1
Moderate contamination	1 ≤ CF < 3
Considerable contamination	3 ≤ CF < 6
Very high contamination	CF ≥ 6

Pollution Load Index (PLI): 1980,(Hakanson, 1980)

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

PLI = pollution load index, CF: pollution factor for the first metal, second, third, etc., etc., n = the number of studied heavy metals.

Table 3: Pollution load index (PLI)

Classification	**PLI Value**
Not pollution	PLI < 1
pollution	PLI = 1
degraded	PLI > 1

Results and Discussion

Total concentration of heavy metals in the soil

The Total lead (Pb)

The results of the study have been showed in that there are highly significant differences for the effect of distance and proximity to the source of pollution in increasing the soil content of total lead (table 4). In the southeastern part of the Al-Gharraf field, the sites close to the source of pollution (sites 1 and 2) recorded the highest value of lead concentration in the soil, which amounted to (347.40 and 305.40) mg kg^{-1} soil, respectively, while the third site and the control were (168.90 and 50.87 mg kg^{-1} soil), respectively. This may be attributed to the proximity of these sites to the oil-industrial activity represented by extractive wells, isolation stations and oil incinerators that directly dump their wastes and products into the surrounding environment, which results from the accumulation of pollutants, including heavy elements (Fakher, 2022). The study results indicated an increase in the concentration of lead metal in the soil for the sites close to the source of pollution.

The northwestern part of the Al-Gharraf oil field, the depth, distance and proximity to the source of pollution were affected in the total lead concentration in the soil. The lowest values were recorded (73.78 and 50.87) mg Pb kg^{-1} soil, respectively. As for the depth level, the concentration of lead in the soil and depth (20-40) cm decreased by 10% compared to the first depth (0-20) cm. In general, it is noted from the results of the study that the total lead concentration in the soil of the study sites has been increased in the southeastern part of the Al-Gharraf oil field and for all depths and dimensions compared to the northwestern part of the oil field. This might be attributed to the nature of the (north-western) winds prevailing in the region, which transferring pollutants from their sources to the next areas. This result is agreed with Wajda Al-Qargoli (2019) which found an increase in the concentration of heavy metals, including lead, with the direction of the north-west winds in the soil of sites near the oil fields in Wasit and Maysan governorates. It is clear from the results of the study that the concentration of lead has decreased in depth 20-40 cm compared by depth 0-20, in both directions.

Table (4) total concentration of heavy metals (mg^{-1} kg soil)

Depth/cm	site	Distance from the source of pollution (m)	Pb	Cd	Ni	Co	Cr
0-20	southeast	500	347.40	11.09	116.56	68.78	98.45
		1000	305.40	9.73	98.22	45.89	77.45
		1500	168.90	3.75	38.30	32.19	30.00
	Northwest	500	116.28	3.08	62.70	22.56	37.54
		1000	102.00	2.37	58.30	16.67	24.74
		1500	73.78	1.33	28.10	9.04	12.26
20-40	southeast	500	330.00	10.55	99.67	35.57	75.76
		1000	248.30	7.75	86.98	32.76	64.80
		1500	90.90	3.06	18.00	28.97	22.30
	Northwest	500	102.97	2.08	59.30	14.66	28.54
		1000	86.54	1.78	53.20	13.37	12.72
		1500	68.45	1.08	21.10	5.37	8.02
control	0-20		50.87	1.25	12.76	5.77	5.98
	20-40		48.98	0.98	7.15	2.45	5.77

Total Cadmium (Cd)

The results have been detected that there were high differences between the distance and proximity to the source of pollution for the Garraf oil field in the total cadmium concentration in the soil samples. In the southeastern part, cadmium has been recorded the highest value of (11.09) mg $Cdkg^{-1}$ in the soil of the first and second sites. The highest value for the concentration of lead metal in the soil were (11.09 and 9.73) from the source of pollution compared to the third dimension and the control, which recorded the lowest values of 3.75 and 1.25 mg Cd^{-1} kg soil (Table 4). This is because the gases and fumes of the oil industries and the heavy metals that carry, which leads to soil pollution in the sites surrounding these facilities (Abbas, 2018).

The northwestern part of the Al-Gharraf oil field, the results of Table (4) has been showed that there are high differences in distance and proximity from the source of pollution in the total cadmium concentration in the soil samples, as the first and second sites reached 3.08 and 2.37 mg Cd kg^{-1} soil, while third dimension and the control have been reached 1.33 and 1.25 mg Cd kg^{-1} soil. The results of this study agreed with Abdul Latif (2020) which found the increase of cadmium in agricultural lands in the Dora region. The reason was to the gases emitted from power and the excessive use of chemical fertilizers and agricultural pesticides.

The results of this study agreed also with Farhan (2020) which mentioned the increase in the total cadmium concentration in the soil at the first depth (0-30) cm for brick factories in the Al-Hay district which release gases and associated heavy elements to the surrounding environment. The results of the study also showed that the total cadmium concentration in the study soil varied spatially, as the sites near the source of pollution in the southeast recorded values that exceeded the permissible limits for cadmium concentration according to (WHO, 2007; Kabata-Pendias, 2011). Khuwaidam et al. (2009) have been found of an increase in the concentration of cadmium and chromium over global determinants in soil samples that collected from residential, agricultural and industrial areas. The reason of this to the proximity of these sites to oil facilities such as the Shuaiba refinery and the oil fields in Basra. In the northwestern part, the cadmium concentration in the soil of the study sites and for all dimensions from the source of pollution was below the permissible limits according to (WHO, 2007) and (Kabata-Pendias, 2011). It is noted from the results of the study that the concentration of cadmium has decreased in depth 20-40 cm, compared to depth 0-20 and both directions.

Total Nickel (Ni)

The results have been recorded that there are high differences in the depth and distance from the source of pollution in the concentration of total nickel in the soil samples of the studied sites in the southeastern part of the Al-Gharraf oil field. The first and second sites recorded the highest value of nickel concentration in the soil amounted to (116.56 and 98.22) mg Ni kg^{-1} soil, while the third site and the control sample were (38.30 and 12.76) mg Ni kg^{-1} soil (Table 4). The results of our study agreed with of Al-Omar (2017) which found the increase in the concentration of nickel in the soil of the sites near the source of pollution for the Nasiriyah brick factories, attributing the reason to the emissions of the brick factories that emit gases. The northwestern part of the oil field, the results recorded a decrease in the concentration of nickel in the soil of the studied sites. It has been reached in the first and second sites 62.70 and 58.30 mg Ni kg^{-1} soil compared to the third site and the control sample, which gave less which reached 28.10 and 12.76 mg Ni kg^{-1} soil.

In general, it is noted that the concentration of nickel in the study soils has increased in the locations close to the source of pollution in the southeastern and northwestern parts at a depth of 0-20 cm compared to a depth of (20-40) cm. The values with the permissible limits according to (WHO, 2007) and (Kabata-Pendias, 2011). Our results find that the concentration of nickel in the soil has exceeded the permissible limits in the sites near the Al-Gharraf oil field especially in the southeastern part. In the northwestern part, the concentration of nickel in the soil was higher than the permissible limits according to (WHO, 2007) and less than the permissible limits according to (Kabata-Pendias, 2011) for sites near the oil field. It is clear that the concentration of nickel has decreased in depth 20-40 cm compared to depth 0-20 and both directions.

Total cobalt (Co)

The results have been showed that there were high differences in the distance from the source of pollution in the values of the total cobalt concentration in the soil samples for the study sites.the first site has been recorded 68.78, 45.89 mg Co kg^{-1} soil, compared to the third site and the control sample, which recorded the lowest values 5.77 and 32.19 mg Co kg^{-1} soil (Table 4). These results agreed with with Al-Baydani et al. (2015) who found an increase in the concentration of cobalt in the soil of the South Gas Company site in Basra and attributed the reason to the residual pollutants resulting from the volatile fumes from the company that are deposited in the soil. As well as with Wajdah Al-Qarghouli (2019) which mentioned the increase of the cobalt metal in the soils of the Maysan and Wasit cities in the locations near the oil fields. It was clear from the results of the study that the concentration of cobalt in the surface depths of the soil increased compared to the depths below the surface (Farhan, 2020).

The northwestern part of the Al-Gharraf oil field, the distance from the source of pollution was lower. The total cobalt concentration in the soil decreased compared to the southeastern part. At the level of distance from the source of pollution, the first and second dimensions recorded the highest value of cobalt, which was 22.56 and 16.67 mg Co kg^{-1} soil, compared to the third dimension and the control samples, which recorded the lowest values 9.04 and 5.77 mg Co kg^{-1} soil (Table 4). In general, it is noted from the results of the study that the total cobalt concentration in the soil of the study sites has increased in the southeastern part of the Al-Gharraf oil field and for all depths and dimensions compared to the northwestern part of the oil field. This is due to the same reasons that were mentioned previously for the lead mental. If we compare these values with the permissible limits according to WHO, 2007 and Kabata-Pendias, 2011, we find that the concentration of cobalt in the soil has exceeded the permissible limits in the sites near and far from the Garraf oil field in the southeastern part.

Total chromium (Cr)

There were high differences in depth in the concentration of chromium in the studied soil samples. In the southeastern part of the Al-Gharraf oil field, the first and second sites recorded the highest value of chromium were 98.45 and 77.45 mg Co kg^{-1} soil compared to the third site and control sample, which recorded the lowest values 30.00 and 5.98 mg Co kg^{-1} soil (Table 4). This is because the accumulation on the surface of the soil and the increase in its concentration, as well as the lack of rain, which may wash the heavy metals to the lower horizons in the event of their increase. Also, the gases and vapors accompanying the oil industries and the heavy elements, which leads to the pollution of the area close to the oil field.

In the northwestern part of the oil field, the level of distance from the source of pollution, the first and second dimensions recorded the highest value of chromium, which were 37.54 and 24.74 mg

Co kg^{-1}soil, compared to the third dimension and the control treatment, which recorded the lowest values 12.26 and 5.98 mg Co kg^{-1} soil (Table 4). The results have been also showed a decrease in the concentration of total chromium in the soil compared to the southeastern part. The results of the study agreed with Khuwaidam and others (2009) who found that the increase of heavy metals, including chromium, in the areas west of Basra. They attributed the reason to its proximity to oil facilities such as the refinery Basra is in the Shuaiba region, as the products of industrial processes contain a high concentration of some heavy metals.

In general, it is noted from the results of the study an increase in the concentration of chromium in the soil in the southeastern part, compared to the northwestern part of the oil field. When comparing the concentration of chromium in soil samples with the permissible limits according to Kabata-Pendias, 2011, we find that the concentration of chromium in the soil was below the permissible limits in the near and far sites of the Al-Gharraf field oil and for both southeastern and northwestern parts. It is noted from the results of the study that the concentration of chromium has decreased in depth 20-40 cm compared to depth 0-20 and both directions.

In the northwestern part, the cobalt concentration was below the limits according to Kabata-Pendias (2011) and higher than the critical limits according to WHO (2007).

Contamination standards for heavy metals

One of the main objectives of the results of our study is to know whether the content of the soil surrounding the Al-Gharf oil field of heavy metals is within the few, critical or toxic levels. To achieve this goal, a number of indicators were adopted on which to base the classification of the study soil from heavy metals, and these indicators or criteria used in the assessment:

Contamination factor (CF)

Table 5: Contamination Factor values (CF)

Depth/cm	site	Distance from the source of pollution (m)	Pb	Cd	Ni	Co	Cr
0-20	southeast	500	6.83	8.87	9.13	11.92	16.46
		1000	6.00	7.78	7.70	7.95	12.95
		1500	3.32	3.00	3.01	6.65	5.02
	Northwest	500	2.29	2.46	6.18	3.91	6.28
		1000	2.01	1.90	4.57	2.89	4.14
		1500	1.45	1.06	2.20	1.57	2.05
20-40	southeast	500	6.74	8.30	8.40	7.38	13.13
		1000	5.07	6.74	7.32	6.80	11.23
		1500	1.86	2.66	1.51	6.01	3.86
	Northwest	500	2.10	1.81	4.99	3.04	4.95
		1000	1.77	1.54	4.48	2.77	2.20

		1500	1.40	1.03	1.78	1.11	1.39
CF value	Low pollution CF ≤1	3>CF>1 medium pollution		6>CF>3 severe pollution	CF>6 Very severe pollution		

Contamination factor (FC) for lead element (Pb)

Table (5) showed the values of the pollution factor of lead for the soils of the studied sites in the southeastern and northwestern parts of the Al-Gharraf oil field. In the southeastern part, the first site gave the highest value of 6.83 compared to the third site, which recorded the lowest value of 3.32 at a depth of 0-20 cm, while the values of the pollution factor decreased at a depth of 20-40 cm compared to a depth of 0-20 cm. The values of the pollution factor index in the first site indicate a very high pollution, while the values of the pollution factor in the third site of the Al-Gharf oil field indicate that there has been a severe pollution Considerable Contamination with lead, according to the classification of (Tomlinson et al., 1980).

In the northwestern part of the Al-Gharraf oil field, the results of the study showed a decrease in the pollution index values at a depth of 0-20 cm for the soil of the studied sites compared to the southeastern part (Table 5). It is noted that the pollution index value for the first, second and third dimensions was 2.29, 2.01 and 1.45. This indicates moderate contamination with lead. As for the increase in the values of the pollution factor in the soils of the sites near the Al-Gharraf oil field, it is due to the high concentration of heavy metals, including lead. The results of our study agreed with Abdul Latif (2020) which found increase in the pollution factor value of lead in the sites near the Dora refinery, as well as with Al-Omar (2017) and attributed the reason to the effect of brick factories on soil pollution. The results of the study have been also showed an increase in the pollution factor values in the southeastern part compared to the northwestern part of the oil field. This is due to the nature of the north-western winds prevailing in the region, which carry pollutants resulting from industrial activities to the southeastern part of the Al-Gharraf oil field.

Contamination Factor (FC) for Cadmium (Cd)

The values of the pollution factor index (CF) for cadmium for the soil of the study sites found that the highest value in the first site was 8.87, and the lowest value in the third site recorded 3.00 at the depth 0-20 cm compared to the depth 20 - 40 cm, which gave lower values compared to the first site. The value of the pollution factor index in the first site indicates the occurrence of a very high pollution according to the classification of (Tomlinson et al., 1980). In the northwestern part of the oil field, the pollution factor recorded lower values compared to the southeastern part, where the dimension the first had the highest value of the pollution factor amounting to 2.46 compared to the third site, which recorded the lowest value of 1.06, according to the classification of (Tomlinson et al., 1980) (Table 5).

This indicates moderate contamination with cadmium for the far sites and close to the oil field. From the results of the study, we note that the values of the pollution factor for the near and far sites and for the southeastern and northwestern parts are classified between moderate contamination and very high contamination. This is because to the oil activity in the field. This agrees with Achadu et al (2015) who found that the pollution factor of cadmium increased along one of the roads in Nigeria. The reason for that to the movement of transport and industrial activity in the region. The highest value of the cadmium pollution factor was in the soils adjacent to power and brick factories.

Contamination Factor (FC) for nickel (Ni)

Table (5) indicate that the value of the CF pollution factor for nickel differed according to the proximity and distance from the source of pollution, as well as according to the location of soil sampling in the northwestern and southeastern parts of the oil field. In the southeastern part of the oil field, the highest value of the pollution factor in the first site was 9.13 compared to the third site, which recorded a value of 3.01. It is noted that the value of the pollution factor at the site indicates the occurrence of severe pollution to very severe pollution and moderate pollution in the third site according to (Tomlinson classification et al., 1980).

In the northwestern part, the value of the pollution factor decreased compared to the southeastern part, where the first site recorded a value of 6.18, while the value of the pollution factor decreased in the third site, which gave a value of 2.20. The results indicate that very large pollution occurred in the first site, Very High Contamination and Moderate pollution. Contamination at the third site of nickel in the northwestern part of the field according to the classification of (Tomlinson et al., 1980). It is noted from the results of the study that the value of the pollution factor has increased in the locations close to the source of pollution and this may be attributed to the combustion processes of the gases associated with the process of oil extraction and its facilities from the accumulation of heavy elements in the locations near the source of pollution.

these results are in agreement (Al-Jubouri, 2016 and Al-Omar, 2017; Abdul Latif, 2020; Al-Hakkak, 2021), which found that the value of the pollution factor has been increased in places close to the source of pollution and according to pollution sources, whether they are electric power stations or laboratories or oil installations. In general, it has been noted that the values of the pollution factor have increased at the depth of 0-20 cm compared to the depth of 20-40 cm for all dimensions and in both directions.

Contamination Factor (FC) for Cobalt (Co)

The results were clarified by applying the (Tomlinson et al., 1980) to the total cobalt concentration in the soil of the studied sites and in the southeastern part of the field (Table 5). The value of the cobalt pollution factor in the first site close to the source of pollution was 11.92 and in the third site 6.65 at a depth of 0-20 cm, according to the value of the cobalt pollution factor for the soil of the studied sites, the soil is classified between very high pollution according to the classification of (Tomlinson et al., 1980) (Table 5). The results agreed with Al-Baydani et al. (2015) which found that the high CF values of the cobalt metal in the soil of the site west of Basra represented by the South Gas and Petrochemical Company, whose residues are dumped without treatment to the neighboring soils.

In the northwestern part, the values of the pollution factor decreased compared to the southeastern part and at both depths, where the pollution factor in the first site scored 3.91 and in the third site it was 1.57. Soil is classified as highly polluted in the first site and moderately polluted in the third site. Obasi (2015) has been found an increase in the value of the pollution factor in the soils of sites near the source of pollution in southwestern Nigeria and attributed the reason to the industrial activity in the region. Farhan (2020) has been detected an increase in the pollution factor in the sites near the Dora refinery and the power plant, and the reason for that to the type of fuel used in these facilities, which leads to pollution by some heavy metals, including cobalt.

Contamination factor (FC) for chromium (Cr)

The results have been indicated that the values of the pollution factor CF of chromium in the soil of the studied sites. In the eastern part of the oil field and in the first site, which is 500 m away from the source of pollution, the highest value of the pollution factor was recorded at 16.46 and the lowest value of 5.02 in the third site, which is 1500 m away. The soil of the studied sites has been classified according to the standard (Tomlinson et al., 1980) as highly contaminated, considerable to very high contamination. This is because to the high concentration of total chromium in the soil of the sites near the Al-Gharf oil field as a result of gaseous emissions containing heavy metals, which are transfer by air and fall on the soils close to the source of pollution. Al-Ghalbi indicated (2016) found that the high values of the pollution factor for heavy metals in soil sites near industrial facilities.

In the northwestern part of the oil field, the pollution factor recorded low values compared to the southeastern part of the field, where the first site recorded a value of 6.28, while the third site recorded a value of 2.05 according to the (Tomlinson et al., 1980). The soil is classified as medium pollution Moderate Contamination to highly polluted soil. It is noted from the results of the study that the values of the pollution factor have decreased in depth 20-40 cm compared to depth 0-20 cm in both directions. The values of the pollution factor in the southeastern part compared to the northwestern part, and this is due to the nature of the north-western winds prevailing in the region, which carry pollutants from the sources of pollution to the southeastern side of the oil field, which is in the direction of wind movement, which leads to an increase in pollutants compared to the areas located in the opposite direction of the wind, which indicates that the soils located in the direction of the wind are more susceptible to pollution (Mohammed, 2008).

Pollution Load Index (PLI)

This indicator expresses the pollution status of the soil at a particular site. The pollution load index was applied by (Hakanson, 1980) which represents the product of the pollution factor CF for each pollutant metal raised to the power of 1 and divided by the number of studied heavy metals. The results indicate that the variation in the PLI pollution load index values for the studied heavy metals lead, cadmium, nickel, cobalt and chromium. In the southeastern part of the Al-Gharraf oil field, the highest value of the PLI index in the first site was 10.16, and the lowest value in the third site was 3.98, for a depth of 0-20 cm compared to a depth of 20-40 cm. In the northwestern part, the first site recorded the highest value of 3.85 compared to the third site, which recorded the lowest values of 1.61 (Table 5).

Table 6: Pollution Load Index (PLI) values

Depth (cm)	Distance from the source of pollution (m	Southeast	Northwest

0-20	500	10.16	3.85
	1000	8.19	2.91
	1500	3.98	1.61
20-40	500	8.54	3.09
	1000	7.18	2.36
	1500	2.80	1.31
Pollution load indicator (PLI)	1 > PLI Site not pollute	PLI=1 Site is edge of degradation	PLI > 1 Degrade of site quality

It is noted from the results of the study that the average values of the index in the northwestern and southeastern parts of the soil of the studied sites were higher PLI > 1 and this indicates a state of deterioration in the soil of the studied sites. This is because the gases and vapors emitted from the oil field as a result of oil extraction operations, which contain quantities of heavy metals. These results agreement with (Al-Jubouri, 2016), which found that the values of the index PLI < 1 in the soil of the sites near the industrial facilities and attributed this to the increase in the proportion of heavy metals in the studied site as a result of gases and fumes emitted from power stations, which contain quantities of heavy metals. Our study has been also agreed with (Al-Saad and Karem, 2018) who mentioned the increase in the index values in the soils of urban sites and they attributed the reason to various human activities, power stations, oil fields and electric power generators, and the pollutants they put into the environment without treatment, all of which led to soil pollution with heavy metals.

Conclusion

The study conclude that the northern part, the CF pollution factor recorded low values for soil close and far sites compared to the southeastern part of the Al-Gharraf oil field. In the northwestern part, the pollution load index (PLI) values decreased compared to the southeastern part. The values of the PLI <1 for the study soil sites indicated a state of deterioration in the soils of the study sites and for the northwestern and southeastern parts and the deep pasture. The concentration of heavy metals in the soils of the study sites close to the source of pollution has increased above the international limits allowed by the World Health Organization (WHO, 2007) in the southeastern part of the oil field, except for chromium, which did not exceed the permissible limits. The study showed that human activity is the main source of high pollution standards (CF, PLI, I_{geo}).

References

1- Abbas, A. Karim (2018). Effect of fumes and gases for Al-Furat Chemicals and Al-Siddah Cement Labs in Babil Governorate on soil, water and plant pollution with lead, nickel and cadmium elements. PhD thesis. Faculty of Agriculture. Baghdad University
2- Abdel, A. Akram (2020). Pollution with heavy and radioactive elements of the soil and plants of the city of Baghdad. PhD thesis. Faculty of Agriculture. Baghdad University .

3- Achadu , O. J. ; E.Goler ; O. Ayejuyo and I. Ochimana(2015). Assessment of heavy metals (Pb , Cd , Zn and Cu) concentration in Soil along a major highway in Wukari , North – Eastern Nigeria J. of Biodiversity and Enevi.Sci.(JBES) Vol.6,No.2 , p 1-7.

4- Al- Saad , Hamid T and Duha S. Karem.2018. Environmental Assessment of Heavy Metals in Soil of West Quarna -2 Oil field at Basrah-Southern Iraq. J. of Pet. Res. and Stu., No.19.

5- Al-Baydani, A. Hamid and Hawra R. Younes and Hamed T. Al-Saad (2015). Assessment of the geochemical pollution of some heavy metals in the soil of Basra Governorate. Dhi Qar Science Journal, Volume (5) 2: 34-41.

6- Al-Ghalbi, Dai M. Saleh (2016). The role of some industrial establishments in the city of Baghdad in the pollution of soil, water and plants with some heavy metals, Master's thesis, College of Agriculture, University of Baghdad.

7- Al-Hakkak, W. Hadi (2021). The effect of Wasit thermal power station on soil, water and plant pollution with some heavy metals (Cr, Co, Pb, Cd, Ni). Master's thesis, College of Agriculture. Wasit University.

8- Al-Jubouri, Donia A. Abbas (2016). Study of the different quantitative standards of pollution with cadmium, lead, zinc and nickel elements of soil and roadside plants in Baghdad governorate. PhD thesis. Faculty of Agriculture. Baghdad University.

9- Al-Moussawi, Nasr A. and Suha W. Mustafa (2016). Geographical distribution of oil pollutant concentrations in the soils of the districts of Qurna and Medina. Basra Studies Journal. Issue (22)

10- Al-Omar, Hassan J. Noman (2017). The effect of Nasiriyah brick factories on soil, water and plant pollution with some heavy metals. Higher Diploma. Faculty of Agriculture. Baghdad University

11- Al-Qargoli, Zahraa M. Saleh (2019). The effect of oil field residues on the soil properties of Wasit and Maysan governorates (a study in environmental geography). PhD thesis. Geographical department. College of Literature. Al-Qadisiyah University.

12- Davies, B. E. .1992. Inter-relationships between soil properties and the uptake of cadmium, copper, lead and zinc from contaminated soils by radish (Raphanus sativus L.). Water, air, and soil pollution, 63 (3-4): 331-342.

13- Farhan, B. Hussein (2020). Study of soil, water and plant pollution with some heavy metals from industrial waste in Wasit Governorate. PhD thesis. College of Agricultural Engineering Sciences. Baghdad University.

14- Feng, L.; Wen, Y. M.; Zhu, P.T. 2008. Bioavailability and toxicity of heavy metals in a heavily polluted river, in PRD, china. B. Environ. Contam. Toxicol., 81: 90- 94.

15- Gulfraz, M.; Ahmad, T.; Afzal, H. 2001. Concentration level of heavy and trace metals in the fish and relevant water from Rawal and Mangla lakes. Online J. Bio. Sci., 1 (5):414-416.

16- Hakanson, L .1980. An ecological risk index for aquatic pollution control. Asediment - logical approach, Water Res. 14. 975–1001. Doi :10.116/043 -1354 (80) 90143-8.

17- Islam, S.; K. Ahmed; H. Al-Mamun and S. A. Islam .2017. Sources and Ecological Risk of Heavy Metals in Soils of Different Land Uses in Bangladesh. Pedosphere, ISSN 1002-0160/CN 32-1315/P doi:10.1016/ S1002-0160(17)6394-1.
18- Kabata, Alina –Pendias and Mukherjee, Arun B.2007.Trace Elements from Soil to Human.ISBN-10 3-540-32713-4 Springer Berlin Heidelberg New York Library of Congress Control Number: 2007920909.
19- Kabata-Pendias, A .2011. Trace elements in soils and plants, Fourth Edition. by Taylor and Francis Group, LLC. ISBN 978-1-4200-9368-1
20- Kabir M. ; M. Z. Iqbal ; M. Shafiq and Z. R. Farooq . 2010. Effects of lead on seedling growth of Thespssia populnea L. Plant Sci. Environment . 56 (4) : 194 – 199.
21- Khuwaidam, K. Hussein; Habib R. Al-Ansari and Khaldoun S. Al-Bassam.2009. Study of the distribution of some heavy metals in the soil of Basra city - southern Iraq. The Iraqi Journal of Science, 50 (4):542-53.
22- Muhammad, H. Shamran (2008). Study of the effect of the soils adjacent to the asphalt and brick factories located on the main road Diwaniyah - Afak on the precipitation of those factories. Al-Qadisiyah Journal of Pure Sciences, 13 (1): 395-403.
23- Muhammad, H. Shamran (2008). Study of the effect of the soils adjacent to the asphalt and brick factories located on the main road Diwaniyah - Afak on the precipitation of those factories. Al-Qadisiyah Journal of Pure Sciences. 13 (1): 395-403.
24- Obasi , R.A.2015. Vertical Dispersion ,Contamination Potentials of Heavy metals and Rare Earth Elements in Soil of Ode Aye Bitumen rich Area , Ondo State, Southwest , Nigeria , Scientific Research .J. Vol.III. 7 ISSN 2201 – 2796.
25- Singh , A. ; Kumar , C. S. and Agarwal ,A.(2011). Phytotoxicity of cadmium and lead in Hydrilla verticillata (IF) .Rolye .J.of Phytology ,3(8), 1-4.
26- Tomlinson , D.L., Wilson , J.G. ,Harris , C.R. and Jeffrey , D.W.(1980).Problems in the Assessment of Heavy Metals Levels in Estuaries and the formation of Pollution Index .
27- WHO / FAO. 2007. Joint WHO/FAO. Food standard programme codex Alimentarius commission 13th session .