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ORIGINAL ARTICLE

EVALUATION OF SOIL POLLUTION WITH SOME HEAVY METALS FOR THE AREA AROUND THE AL-GHAF OIL FIELD

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Abstract: This study was conducted within the Al-Gharraf oil field area to evaluate the pollution status of some heavy metals (Pb, Co and Cu), which are the source of gases and vapors emitted from the Al-Gharraf oil field due to oil extractive operations in region. This study was conducted within the Al-Gharraf oil field area, which included cultivated and uncultivated lands at dimensions of (600, 1200 and 2400) m from the source of pollution and at two depths of (0-15) cm and (15-30) cm. Soil samples were collected from the study locations and the required analyzes were conducted on them. The results of the study showed an increase in the total concentration of heavy metals (Pb, Co, Cu) in the locations near the source of pollution (the first location) for cultivated and uncultivated lands compared to the far locations (the third location), the average concentration of these elements in the uncultivated lands increased in comparison with the cultivated lands, as their concentration in the uncultivated lands reached (233.31, 36.28 and 246.89) mg kg^{-1} soil sequentially, while the cultivated lands recorded a lower value of (187.68, 27.48, and 191.24) mg kg^{-1} soil, respectively. The results of the study showed an increase in the values of pollution standards (CF and PLI) for cultivated and uncultivated lands, which were caused by human activity in the region represented by oil extraction operations and the Contaminate factor value (CF) for the studied heavy elements was between medium to considerable pollution the pollution load index value $1 < PLI$ for cultivated and uncultivated lands and this means indicates deterioration of location quality.

Key words: Heavy metals, Contaminate Factor (CF), Oil field, Soil pollution.

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1. Introduction

Pollution is an environmental phenomenon that has taken a great deal of attention from world governments since the second half of the twentieth century, and the problem of pollution is one of the most pressing environmental problems that have begun to take on serious environmental economic and social dimensions especially after the industrial revolution in Europe [Khuwaidam *et al*. (2009)]. Pollution is defined as the change in the properties of soil, water, or any other natural resource in which an increase in the concentration of any chemical or physical substance occurs. It has been added to it at a level higher than the natural level, which is likely to represent harm to health and has a significant environmental impact on the financial and social capabilities and costs [Stavrianou (2007), Uruba *et al*. (2021)]. Oil pollution is one of the most important global problems that have emerged in recent times as a result of technological and industrial progress, as the pollution of land with oil materials makes the land unsuitable for agriculture. Thus, it reduces agricultural areas and oil pollution is one of the most serious problems to the environment natural and human environment as a result of its direct impact on living organisms because it contains toxic gases in addition to heavy elements, which are one of the most prominent and complex problems, and the presence of heavy elements in concentrations higher than the global

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Table 1: Some chemical and physical properties of the study soils.

Soils	pH (1:1)	$EC_{(1:1)}$ dS. m^{-1}	CEC cmol+Kg^{-1}	g Kg^{-1}				
				O.M	$CaCO_3$	Clay	Silt	Sand
Agricultural	8.17	4.60	28.96	20.42	293.20	492.93	322.85	184.22
Non-agricultural	8.07	7.45	22.45	13.85	350.50	492.88	320.20	186.92

determinants set by the World Health Organization (WHO) it leads to environmental pollution. Heavy metals are among the most important chemical pollutants affecting the ecosystem. It is constantly related to its cumulative nature and its toxic effect on all living organisms [Schow and Tjell (2003), Hassan *et al*. (2021)], whereas its transmission from the polluted source to the soil and then plants, and its transmission through the food chain of humans, leads to infection with many diseases [Vandecasteele *et al*. (2005), Hakanson (1980)]. This study was conducted in order to find out the extent of the impact of oil installations on soil pollution with heavy metals in the areas surrounding the Al-Gharraf oil field.

2. Materials and Methods

2.1 Field and laboratory procedures

Soil samples were collected from two agricultural and non-agricultural areas with three dimensions from the source of pollution 600, 1200 and 2400 m for each area, which represent A1, B1 and C1 for agricultural lands and A2, B2 and C2 for non-agricultural lands at two depths (0-15) cm and (15-30) cm from the surface layer of the soil and by three replicates for both dimensions and in the direction of the (northwest) winds prevailing in the region, which carry pollutants from the source of pollution (the Garraf field) to the neighboring lands. Soil samples were air dried, crushed and sieved through a (2) mm sieve. A soil sample was taken from the surface layer (0-15) cm for both agricultural and non-agricultural areas for the purpose of estimating some chemical and physical properties of soil the total concentration of heavy metals (Pd, Co and Cu) in the study soils was also estimated by atomic absorption device after digesting the soil with strong acids according to the method described in Sparks *et al*. (1996).

2.2 Pollution standards

Contamination Factor(CF): Contamination Factor (CF) was calculated based on the equation [Hakanson (1980)].

$$CF = \frac{\text{C Sample}}{\text{C background}}$$

where, C Sample: Total element concentration (mg kg^{-1}).

C background: The concentration of the total element in the comparison sample.

When the CF is less than 1, it means low contamination, when it is $1 \leq CF < 3$, it implies moderate contamination, $3 \leq CF < 6$ considerable contamination, and $CF \geq 6$, means very high contamination.

Pollution Load Index (PLI): Pollution load index was calculated based on an equation [Thomlinson *et al*. (1980)].

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

where, CF: Contamination factor

n: The number of studied element

when the PLI value is less than < 1, it indicates perfection, and when it is =1 it means that only baseline level of pollution is present, PLI > 1 indicates deterioration of location quality

3. Results and Discussion

3.1 Total concentration of heavy metals in soil (Pb)

The results of the study (Table 2) indicated that

Table 2: Total Pb concentration in the study soils (mg kg^{-1}).

Soil	Locat-ions	Distance from the source of pollution (m)	Depth (cm)		Moderate
			0-15	15-30	
Agriculture	A1	600	188.45	186.91	187.68
	B1	1200	111.32	102.99	107.15
	C1	2400	55.77	41.74	48.76
R.L.S.D $_{0.05}$		-	12.41		-
Non Agriculture	A2	600	256.14	210.49	233.31
	B2	1200	153.58	113.59	133.59
	C2	2400	66.93	50.09	58.51
R.L.S.D $_{0.05}$		-	14.89		-
Determinants [WHO (2007)]			100 mg kg^{-1}		

the proximity and distance from the source of pollution had a significant effect on the soil Lead content at the probability level (0.05), where it is noted that the soil content of lead has increased near the source of pollution and less in the far from the source of pollution for cultivated and uncultivated soils and for all depths (Table 2). The results of the study showed a decrease in the concentration of lead for soils planted at a depth of 0-15 cm for the second and third dimension by 41% and 70%, respectively compared to the soil content of lead in the first dimension (600) m the concentration of lead in the depth of 15-30 cm and in the two dimensions (1200 and 2400) m also decreased by 45% and 78%, respectively compared to the concentration of lead in the first dimension (600) m. As for non-agricultural soils the soil lead content also decreased significantly in depth 0-15 cm and for the second and third dimension (1200 and 2400) m by 41% and 70%, respectively compared to the concentration of lead in the first dimension (600) m also, the concentration of lead decreased for depth (15-30) cm for the second and third dimensions (1200 and 2400) m by 46% and 76%, respectively for the same soil it is noted from the results of the study that the soil content of lead decreased with increasing distance from the source of pollution (Al-Gharraf oil field) and that the nearby locations (the first location) of the sources of pollution, high values of lead were recorded that exceeded the permissible environmental limits set by 87% and 118% for the cultivated and uncultivated lands respectively. This is as a result of its proximity to oil activity, which leads to the release of gases and heavy metals, which are deposited in sites close to the source of pollution due to their transport by the prevailing winds in the region and its deposition on the soil surface, and the results of our study agreed with what was found by Miskowiec *et al*. (2015), Al-Mousawi and Mustafa (2016) and Al-Omar (2017).

Table 3: Total Cobalt concentration in the study soils (mg kg^{-1} soil).

Soil	Locat-ions	Distance from the source of pollution (m)	Depth (cm)		Moderate
			0-15	15-30	
Agriculture	A1	600	28.09	26.88	27.48
	B1	1200	18.36	16.99	17.68
	C1	2400	9.20	6.88	8.04
R.L.S.D $_{0.05}$		-	2.04		-
Non Agriculture	A2	600	37.31	35.25	36.28
	B2	1200	26.04	23.39	24.71
	C2	2400	11.04	8.26	9.65
R.L.S.D $_{0.05}$		-	2.45		-
Determinants [WHO (2007)]			100 mg kg^{-1}		

3.2 Cobalt element (Co)

The results of Table 3 showed that the total soil content of Cobalt varied according to the distance from the source of pollution, soil condition and depth, where the results of the study showed significant differences and below the level (0.05) in the total concentration of this element in the cultivated and uncultivated lands of the three depths and dimensions (600, 1200 and 2400) m from the source of pollution. It is noted from the results of the study that the concentration of Cobalt in the soil has increased in the sites close to the source of pollution compared to the sites far from the source of pollution, as the cobalt concentration reached 28.09 mg kg^{-1} soil for the first site 600 m and a depth of 0-15 cm while the soil content of the element was 9.20 mg kg^{-1} soil in the third position of 2400 m and for the same depth, where the cobalt decreased by 67% compared to the first site in the cultivated lands. As on the level for the depths, the depth (0-15) cm recorded the highest concentration of Cobalt in the soil compared to the depth (15-30) cm and for all dimensions, where a decrease in the concentration of Cobalt in the soil is noted with an increase in depth by (4%, 8% and 25%) for the first, second and third dimensions, respectively compared to the concentration of Cobalt in the first depth.

The results of the study showed that the Cobalt concentration in the soil was higher than the global determinants [WHO (2007)] for all locations and depths of cultivated and uncultivated soils, except for the third location of cultivated and uncultivated soils, and the results of our study are in agreement with Khuwaidam *et al*. (2009), Al-Omar (2017) and Alawsy *et al*. (2018).

3.3 Copper element (Cu)

Table 4 shows the significant effect of the distance from the source of pollution, soil condition and depth on the soil content of Copper, and the results showed that the distance from the pollution source had a significant effect under the probability level (0.05) on the soil Copper content of the cultivated and uncultivated lands of the three depths and dimensions from pollution source. It is noted from the results of the study that the

Table 4: Total Copper concentration in the study soils (mg kg^{-1} soil).

Soil	Locat-ions	Distance from the source of pollution (m)	Depth (cm)		Moderate
			0-15	15-30	
Agriculture	A1	600	203.29	179.20	191.24
	B1	1200	152.45	123.29	137.87
	C1	2400	61.35	35.92	48.64
R.L.S.D $_{0.05}$		-	13.65		-
Non Agriculture	A2	600	278.75	215.04	246.89
	B2	1200	166.94	135.95	151.44
	C2	2400	73.62	55.100	64.36
R.L.S.D $_{0.05}$		-	16.38		-
Determinants [WHO (2007)]			100 mg kg^{-1}		

concentration of Copper in the soil has increased in the sites close to the source of pollution compared to the locations far from the source of pollution the copper concentration reached 223.29 mg kg^{-1} in soil for the first location 600 m and a depth of 0-15 cm, whereas the element's soil content was 61.35 mg kg^{-1} soil in the third position at a depth of 2400 m, copper decreased by 72% compared to the first site in the cultivated lands . As on the level of depths , the depth (0-15) cm recorded the highest concentration of Copper in the soil compared to the depth (15-30) cm, and for all dimensions, where a decrease in the concentration of Copper in the cultivated soil is observed with an increase in depth (15-30) cm by (12, 19 and 41%) for the first, second and third dimensions, respectively compared with copper concentration in the first depth (0-15) cm.

The results of Table 4 indicated that the non-agricultural lands recorded an increase in the total Copper concentration by 18% compared to the agricultural lands for all dimensions, and depths, and that the concentration of Copper recorded an increase near the pollution location (first location), and decreased with increasing distance about the source of pollution, as the second and third sites recorded a decrease in the copper content of soil by 41% and 70%, respectively compared to the first location.

For the depths level, the concentration of copper increased in depth (0-15) cm compared to depth (15-30) cm, and for all dimensions from the source of pollution, and the results of Table 4 indicated an increase in the concentration of Copper in the soil in the locations close to the source of pollution for the cultivated and uncultivated lands, and this is attributed to the emission of gases and heavy elements to the atmosphere from sources of pollution as a result of combustion processes and oil industries and their deposition in a location close to pollution sources, and the results of our study agreed with Al-Mousawi and Mustafa (2016), and where they found an increase in the concentration of copper in the soil in the near and affected locations by the oil pollution of Majnoon and Al-Qurna fields, where the total concentration of copper reached an average of 201.66 mg kg^{-1} soil in the surface layer of the soil, and our results agreed with the findings of Al-Qargholi (2019), who obtained an increase in the copper element in the soil for the areas near the oil fields in Kut and Maysan, he attributed the reason for this to the pollutants secreted by the oil fields to the soil.

3.4 Pollution standards for heavy metals in study soils

Contamination Factor (CF): The equation for calculating the Contamination Factor (CF) for the three locations was applied according to the classification of Hakanson (1980) where the concentrations of heavy metals for the third location (2400) m were adopted for the cultivated and uncultivated lands as a location

Table 5: Contamination Factor (CF) for heavy metals in the soils of the studied locations.

*Locations	Soil condition	Distance (m)	Aver. Pb	CF (Pb)	Pollution situation	Aver. Co	CF (Co)	Pollution situation	Aver. Cu	CF (Cu)	Pollution situation
A1	Agriculture	600	187.68	3.84	High	27.48	3.41	High	191.24	3.74	High
A2	non Agriculture	600	233.31	3.98	High	36.28	3.75	High	246.89	3.84	High
B1	Agriculture	1200	107.15	2.19	Moderate	17.66	2.19	Moderate	117.87	2.30	Moderate
B2	non Agriculture	1200	133.59	2.28	Moderate	24.71	2.56	Moderate	151.44	2.35	Moderate
C1(Comparison) Agriculture		2400	48.76			8.04			51.13		
C2(Comparison) non Agriculture		2400	58.51			9.65			64.36		

Table 6: Pollution load index (PLI) for heavy metals in the soils of the studied locations.

*Locations	CF (Pb)	CF (Co)	CF (Cu)	PLI	Pollution situation
A1	3.84	3.41	3.74	3.61	Deterioration of location quality
A2	3.98	3.75	3.84	3.80	Deterioration of location quality
B1	2.19	2.19	2.30	2.21	Deterioration of location quality
B2	2.28	2.56	2.35	2.37	Deterioration of location quality
Moderate	3.07	2.98	3.06	3.00	Deterioration of location quality

comparison. The results of Table 5 indicate a variation in the values of the Contamination Factor (CF) for heavy metals (Pb, Co and Cu) in the study sites of agricultural and non-agricultural lands, and it is noted from the results of the study that the value of the contamination factor of these elements increased in the locations close to the source of pollution (the first location), which is 600 m away from the source of pollution.

Where the uncultivated lands recorded the highest value of the pollution factor, which amounted to (3.98, 3.75 and 3.84), respectively, while the value of the pollution factor for the cultivated lands decreased, as it recorded a value of (3.84, 3.41 and 3.74) sequentially, and through the results of the study, we note that the value of the pollution factor of heavy metals in cultivated and uncultivated lands indicates the occurrence of significant pollution with these elements, and this may be attributed to the oil extraction operations of the Garraf field and the accompanying emission of toxic gases and heavy metals and their deposition in places close to the source of pollution. They attributed the reason to the impact of industrial activities in the region on soil pollution with lead element, as well as with age [Al-Omar (2017)] from the high value of the pollution factor for heavy metals in the soils close to source of pollution.

Pollution Load Index (PLI): The results of Table 6 show the values of the Pollution Load Index (PLI) for heavy metals in agricultural and non-agricultural soils within the Al-Gharraf oil field, which was calculated through the equation of Thomlinson *et al*. (1980), where it was found that the value of the Pollution Load Index (PLI) was high for all sites near and far from the source of pollution and according to the results of the study indicates deterioration of location quality because the value of PLI > 1, and the results of our study were consistent with the findings of Obasi (2015), which found that the value of the pollution Load index (PLI) for heavy metals (Pb, Co, Ni, Cu, Zn) in the industrial areas was > 1, and the reason was attributed to the industrial activity in the region, and our results were in agreement with what was found by Al-Omar (2017) which indicated the value of the pollution Load index (PLI) for some heavy metals in the areas surrounding the brick factories greater than one and attributed the reason to the emissions of the brick factories and the heavy elements put into the soil.

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