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Trace Metals in Exchangeable Soil from the Oil Fields in Basrah Governorate, Iraq

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Abstract. Soil samples were collected from eleven locations (Seba, Safwan, Majnoon, Ratawi, Bergezia, West Qurna 2, West Qurna 1, Shuaaba, South Rumaila, North Rumaila, and Al Zubair) were selected in the oil fields at Basrah city .And measured of trace metals by Inconductivity Coupled Plasma (ICP). The analysis of trace element concentrations based on CF, EF , and Igeo reveals the following that Lead (Pb): Significant contamination is observed in West Qurna 2, with extremely high values across all indices. This indicates severe anthropogenic influence and requires immediate investigation and monitoring, Cadmium (Cd): Slight contamination is noted in West Qurna 1 and West Qurna 2, though the levels are generally within acceptable limits in other stations, And other Elements (Fe, Cu, Zn, Mn, Cr): These elements show natural concentrations across all stations, with no signs of significant enrichment or contamination.

Highlights:

1. Sampling: Soil collected from 11 Basrah oil field locations.
2. Findings: High Pb in West Qurna 2; Cd slight contamination.
3. Other Metals: Fe, Cu, Zn, Mn, Cr at natural concentrations..

Keywords: Basra , Basra oil fields, Exchangeable , Trace metals , Soil , ICP.

Introduction

The Basrah Governorate, located in southern Iraq, is known as the primary oil-producing region in the country [1] . It is home to three key oil fields: North Rumaila, South Rumaila, and North Zubair [2] . Various human activities, including industrial and military operations, have a continuous impact on the environment[3] . In recent times, the focus has been on studying oil fields as potential sources of heavy metal pollution in the environment [4]. Excessive levels of these trace metals can pose health risks to humans. This has led to researchers seeking to establish safe limits for these metals in different environmental components such as soil, water, and plants[5]. However, limited attention has been given to determining the levels of metals in exchangeable soil samples from oil fields, which could help predict the concentration of trace metals and their impact on biological activity in the soil[6]. Industrial activities, particularly in oil regions,

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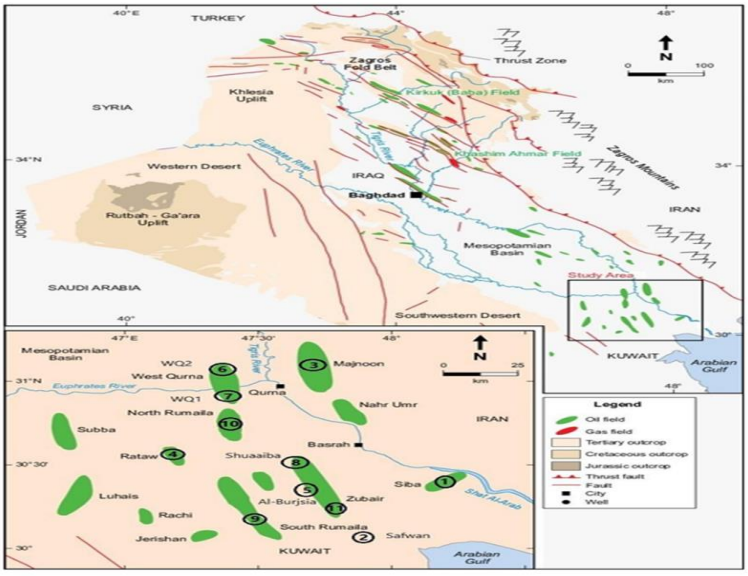
have increased over time, resulting in anthropogenic trace metals that can become an environmental issue if not properly managed , To address this, it is important to monitor and control trace metals in the soil. plant growth [7]. heigh levels of metals can be harmful to both people and animals, as well as the environment [8]. Both natural occurrences and human activities can lead to the contamination of natural resources with metals, which can then spread from one area to another [9]. Trace metals, in particular, can cause a wide range of negative effects [10]. Many studies have been carried out to investigate the health risks associated with trace metals. It is well known that metallic elements in the environment can eventually make their way into aquatic organisms, posing risks to human health [11]. Petroleum products contain a variety of organic substances and metallic elements that can build up on particles in bodies of water [12].

Methods

Study Area:

Eleven locations (Seba, Safwan, Majnoon, Ratawi, Bergezia, West Qurna 2, West Qurna 1, Shuaaba, South Rumaila, North Rumaila, and Al Zubair) were selected in the oil fields at Basrah city as shown in Fig(1).



(Fig1): Maps of The Study Area

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Heavy Metals Analysis

The Exchangeable:

The exchangeable heavy metal ions will be determined according to the method of [13]. Details are shown below. One gram of the dry sample is placed in a 50 ml Teflon test tube with a tight cover. Then, 20 ml of 0.5N Hydrochloric acid is added, and the mixture is shaken for 16 hours. After that, the sample is separated by centrifugation at 3000 rpm for 20 minutes. The solution is then placed in a plastic (polyethylene) vial until it is measured by inductively Coupled Plasma (ICP).

Determination of Contamination Factor (CF)

Contamination Factor was used to determine the contamination status of soil in this study. CF was calculated by the equation described below:

$$CF=Mc/Bc$$

Where…

Mc :The measured concentration of the metal.

Bc : the background concentration of the same metal.

Table(1) : [14] The classification of contamination factor.

CF	Indicate of Contamination Factor
CF<1	low contamination
1≤CF≤ 3	moderate contamination
3≤CF<6	considerable contamination
CF>6	very high contamination

Determination of Enrichment Factor (EF)

To evaluate of source material found in the Earth's crust

[15] , EF was calculated by the equation described below:

$$EF = (CM / CFe)sample / (CM / CFe)Earth's\ crust$$

Where,

(CM / CFe):the sample ratio of concentration of trace metal

(CM / CFe) Earth's crust: is the same reference ratio in the Earth's crust; the reference value of Fe is 5% was selected as the reference element, due to its crustal dominance and its high immobility .

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Table(2): The classification of enrichment factor(EF).

EF	Indicates of Enrichment Factor
EF <1	no enrichment
EF = 1-3	minor enrichment
EF = 3-5	moderate enrichment
EF = 5-10	moderate to severe enrichment
EF = 10-25	severe enrichment
EF 25-50	very severe enrichment
EF >50	extremely severe enrichment

Determination of Geo Accumulation Index (Igeo)

Geo accumulation index (Igeo) values were calculated of different metals, (Igeo) was calculated by the equation that introduced by [16] as described below:

$$\textbf{I-geo} = \log_2 (Cn / 1.5\ Bn)$$

Where,

Cn: The measured concentration of element n in the soil .

Bn: The geo accumulation background for the element n .

Table(3) : The classification of (Igeo).

Igeo	Soil Pollution Case
<1	practically unpolluted- Background sample
1-2	unpolluted to moderately polluted
2-3	moderately polluted to polluted
3-4	strongly polluted
4-5	strongly to extremely polluted
>5	extremely polluted

Pollution Load Index (PLI)

Soil pollution load index was calculated using the equation:

$$\textbf{PLI} = \sqrt[n]{(CF1 \times CF2 \times CF3 \times \ldots\ldots CFn)}$$

Table(4) : [17] The classification of (PLI).

PLI	The Indicates
value > 1	Pollution
value < 1	no pollution

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Result and Discussion

Results of the this study are shown in Table (5) and Fig(2). The concentrations of Zn was lowest (0.882 ug/g dry weight) in Majnoon field and the highest (20.887 ug/g dry weight) in West Qurna 2 field that shown in Table(5) and Fig(2). The concentrations of Cd was lowest (0.038 ug/g dry weight) in Safwan field and the highest(0.253 ug/g dry weight) in West Qurna 2 field , Table (5) and Fig(2). The concentrations of Mn was lowest (22.304 ug/g dry weight) in Safwan field and highest(196.567 ug/g dry weight) in West Qurna 2 field , Table (5) and Fig(2).The concentrations of Pb was lowest (0.004 ug/g dry weight) in Al-Zubair field and highest(1789.281 ug/g dry weight) in West Qurna 2 field , Table (5) and Fig(2). The concentrations of Fe was lowest (0.189 ug/g dry weight) in Majnoon field and highest(582.983 ug/g dry weight) in South Rumaila field , Table (5) and Fig(2).The concentrations of Cu was lowest (0.213 ug/g dry weight) in Majnoon field and highest(10.888 ug/g dry weight) in West Qurna 2 field , Table (5) and Fig(2). The concentrations of Cr was lowest (0.008 ug/g dry weight) in Al-Zubair field and highest(15.330 ug/g dry weight) in West Qurna 2 field , Table (5) and Fig(2). The presence of high levels of trace metals in the soil of certain oil fields can be attributed to the continuous discharge of oil production waste, which contains up to 10 different trace metals [18]. These waste materials are introduced into the soil through various components of the oil production process, such as well bores, storage tanks, and processing equipment [19]. The waste includes metallic components like pipes, pumps, and electrical equipment, all of which come into contact with oil, gas, and water [20]. In addition, the drilling process also contributes to the buildup of waste materials in the soil, including sand, scale, and corrosion wear [21]. This waste is produced as a byproduct of drilling activities and contributes to the overall environmental impact of oil production [22].

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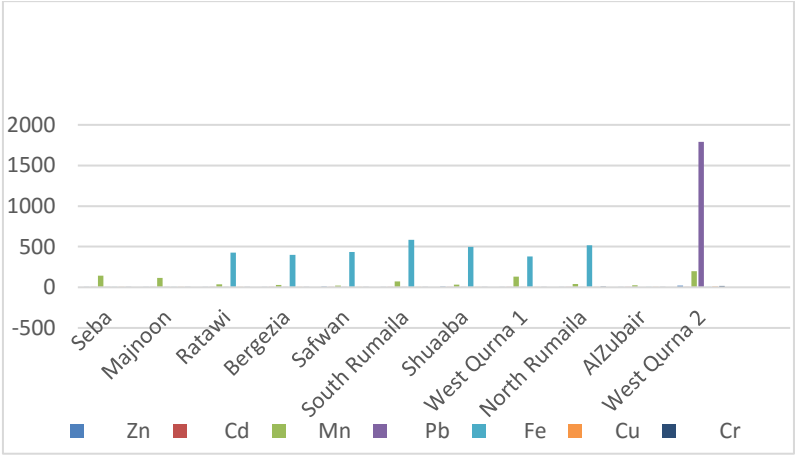
Table5)) concentration of exchangeable trace metals (ug/g)dry weight

Fields	Zn	Cd	Mn	Pb	Fe	Cu	Cr
Seba	1.431	0.061	142.383	0.218	2.021	0.245	0.149
Majnoon	0.882	0.067	116.691	2.232	0.189	0.213	0.011
Ratawi	3.765	0.047	36.368	1.007	425.382	1.224	5.808
Bergezia	4.600	0.042	27.069	1.417	400.724	1.257	4.509
Safwan	7.789	0.038	22.304	0.783	435.051	2.289	4.453
South Rumaila	4.048	0.071	71.031	0.980	582.983	1.916	4.515
Shuaaba	10.332	0.052	32.132	2.691	496.897	1.870	4.081
West Qurna 1	5.360	0.173	129.858	1.377	378.420	1.760	2.862
North Rumaila	3.526	0.056	39.985	0.732	517.884	1.581	9.058
AlZubair	0.937	0.049	23.187	0.004	0.497	0.358	0.008
West Qurna 2	20.8872	0.253	196.567	1789.381	2.484	10.888	15.330



Fig(2) concentration of exchangeable trace metals (ug/g)dry weight

The analysis of trace element concentrations based on CF (Table6), EF (Table7), Igeo (Table8) and PLI(Table 9) reveals the following:

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1.Lead (Pb): Significant contamination is observed in West Qurna 2, with extremely high values across all indices. This indicates severe anthropogenic influence and requires immediate investigation and monitoring. The study indicated that lead recorded the highest levels of contamination at the "West Qurna 2" station, with pollution values (CF > 119.292) according to the CF index(table6), reflecting significant anthropogenic influence .This contamination can be attributed to industrial and oil-related activities, such as chemical spills or the use of metallic equipment .Lead accumulation in soil disrupts biological processes in plants and may leach into groundwater, posing health risks to humans[23].

2.Cadmium (Cd): Slight contamination is noted in West Qurna 1 and West Qurna2, though the levels are generally within acceptable limits in other fields.This indicates limited leakage from human-related sources, such as industrial waste. Cadmium is a toxic metal that can hinder plant growth and increase toxicity within food chains[24].

3.Other Elements (Fe, Cu, Zn, Mn, Cr): These elements show natural or below-background concentrations across all fields, with no signs of significant enrichment or contamination. The limited increase could result from natural sedimentation or chemical interactions caused by industrial activities[25].

Increased concentrations of heavy metals degrade soil fertility, hindering plant growth and threatening biodiversity .Soluble trace metals can leach into groundwater, increasing the risk of contaminating drinking water sources .Exposure to lead and cadmium through contaminated soil can result in serious health effects, including nervous system disorders and kidney diseases[26].

Table(6) Contamination factor (CF) of trace metals

Fields	CF_Zn	CF_Cd	CF_Mn	CF_Pb	CF_Fe	CF_Cu	CF_Cr
Seba	0.021	0.406	0.134	0.014	0.004	0.009	0.001
Majnoon	0.013	0.446	0.110	0.148	0.003	0.008	0.0001
Ratawi	0.057	0.313	0.034	0.067	0.008	0.047	0.058
Bergezia	0.069	0.280	0.025	0.094	0.008	0.048	0.045
Safwan	0.118	0.253	0.021	0.052	0.008	0.088	0.044
South Rumaila	0.061	0.473	0.067	0.065	0.011	0.073	0.045
Shuaaba	0.156	0.346	0.030	0.179	0.009	0.071	0.040
West Qurna 1	0.081	1.153	0.122	0.091	0.007	0.067	0.028
North Rumaila	0.053	0.373	0.037	0.048	0.010	0.060	0.090

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AlZubair	0.014	0.326	0.021	-0.0003	0.009	0.013	0.0001
West Qurna 2	0.316	1.686	0.185	119.292	0.035	0.418	0.153

Table(7) enrichment factor (EF) of trace metals

Fields	EF_Zn	EF_Cd	EF_Mn	EF_Pb	EF_Fe	EF_Cu	EF_Cr
Seba	0.538	0.783	0.281	0.028	0.007	0.179	0.028
Majnoon	0.328	0.861	0.224	0.289	0.007	0.155	0.002
Ratawi	1.111	0.603	0.063	0.129	0.163	0.881	1.118
Bergezia	1.180	0.539	0.043	0.182	0.154	0.899	0.868
Safwan	1.387	0.487	0.037	0.101	0.167	1.746	0.856
South Rumaila	1.204	0.914	0.135	0.130	0.224	1.419	0.866
Shuaaba	3.065	0.666	0.057	0.358	0.190	1.380	0.782
West Qurna 1	1.796	2.220	0.216	0.183	0.145	1.356	0.551
North Rumaila	1.090	0.720	0.075	0.098	0.199	1.216	1.743
AlZubair	0.320	0.631	0.41	-0.001	0.001	0.275	0.002
West Qurna2	7.207	4.060	0.652	23.929	0.690	3.271	2.950

Table(8) the geochemical accumulation coefficient (I-geo) of trace metals concentration

Fields	Igeo_Zn	Igeo_Cd	Igeo_Mn	Igeo_Pb	Igeo_Fe	Igeo_Cu	Igeo_Cr
Seba	-7.45	-3.95	-3.34	-9.10	-11.28	-9.08	-9.07
Majnoon	-7.90	-3.84	-3.45	-5.57	-18.01	-9.23	-14.04
Ratawi	-6.13	-4.35	-4.38	-6.36	-3.67	-6.77	-4.09
Bergezia	-5.64	-4.38	-4.71	-6.00	-3.59	-6.73	-4.48
Safwan	-4.67	-4.66	-4.91	-6.62	-3.73	-5.80	-4.50

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South Rumaila	-5.95	-3.68	-3.85	-6.50	-3.01	-6.12	-4.47
Shuaaba	-3.74	-4.10	-4.52	-5.41	-3.15	-6.17	-4.58
West Qurna 1	-5.48	-1.14	-3.49	-6.01	-3.49	-6.25	-5.19
North Rumaila	-6.30	-4.09	-4.18	-6.79	-3.10	-6.44	-3.55
AlZubair	-7.75	-4.31	-5.06		-16.68	-7.96	-18.73
West Qurna 2	-2.33	-0.32	-2.33	2.17	-1.50	-3.90	-0.65

Table (9): Pollution Load Index (PLI) of trace metals for this study

Fields	PLI
Seba	0.041
Majnoon	0.023
Ratawi	0.235
Bergezia	0.223
Safwan	0.252
South Rumaila	0.310
Shuaaba	0.265
West Qurna 1	0.207
North Rumaila	0.28
AlZubair	0.023
West Qurna 2	0.803

Table(10) Trace metals concentrations (µ g/g dry weight) in the present study as compared with the other previous studies.

Location	Zn	Cd	Mn	Pb	Fe	Cu	Cr	References
Khor Al-Zubair	27.41 - 58.48	-	353.7-570.6	-	6676.0 - 7398.3	7.56-27.73	-	[27]
Southern Iraq	-	-	506.3-408.6	-	-	38.3-16.63	-	[28]
Northern Iraq	-	9.79-19.65	91.65-111.5	-	-	6.18-14.42	-	[29]

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Southern Iraq	39.89	5	361.29	25	298.14	17.71	-	[30]
Shatt Al-Arab River	-	5.8	-	40.13	4170.89	30.15	-	[31]
Basrah oil fields	0.882 - 20.887	0.038 - 0.253	22.304 - 196.567	0.004-1789.381	0.189-582.983	0.213 - 10.888	0.008 - 15.330	Present study

Table(10) In general, the difference in the concentration of heavy elements for the present study with other studies is attributed to the difference in the quality of the selected soils in addition to the volume of household and health waste and the amount of industrial pollutants and others.

Conclusion

The analysis of trace element concentrations in this study appears the Lead (Pb) Significant contamination is observed in West Qurna 2, with extremely high values across all indices. This indicates severe anthropogenic influence and requires immediate investigation and monitoring. Cadmium (Cd) Slight contamination is noted in West Qurna 1 and West Qurna2, though the levels are generally within acceptable limits in other fields.Other Elements (Fe, Cu, Zn, Mn, Cr) These elements show natural or background concentrations across all fields, with no signs of significant enrichment or contamination. In Basrah, at least, the effect should be specified. In recognizing the effects and dimensions of elemental content in the exchangeable setting of soil revealed in Basrah, researchers increasingly need to ensure their attention adheres to certain necessary outcomes of expected value

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