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Assessment of Soil Pollution in the Ishaqi Project Area- Salah Al-Dean Governorate, Iraq

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ABSTRACT

Ten soil samples were collected from Ishaqi project area, Salah Al-Dean Governorate, and analysed for chemical elements (Fe₂O₃, Al₂O₃, CaO, K₂O Na₂O, Co, Zn, Cu, and Pb) to detect the pollution in the study soil using the indices of geo-accumulation (I-geo), contamination factor (CF), and pollution load index (PLI). The results of I-geo indicate that the soil of Ishaqi project area is unpolluted with Pb, Co and slightly polluted with Zn and Cu. The results of CF for Zn, Cu, and Co showed class 2 of moderate contamination and class 1 of low contamination in some samples while those for Pb demonstrated class 1 –of low contamination. The Pollution Load Index (PLI) values for Co, Zn, Cu, and Pb showed class 2 of local pollution.

Keywords: Geo-accumulation, Contamination factor, Pollution load index, Ishaqi soil.

تقييم تلوث التربة في مشروع الاسحاقى محافظة صلاح الدين العراق

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الخلاصة

تم اختبار عشر عينات من التربة من مشروع الاسحاقى ، محافظة صلاح الدين ، وتم تحليلها للعناصر الكيميائية Fe₂O₃ و Al₂O₃ و CaO و K₂O و Na₂O و Co و Zn و Cu و Pb للكشف عن التلوث في تربة باستخدام المؤشرات. التراكم الجغرافي (I-geo)، عامل التلوث (CF)، ومؤشر حمل التلوث (PLI)، ((تمثل نتائج I-geo الموجودة في مشروع الاسحاقى رواسب غير ملوثة بـ Pb و Co ، وملوثة قليلاً بالزنك والنحاس. تُعرف الفئة (CF) الخاصة بالزنك والنحاس والصلب (CO) بالصف الثاني الذي يمثل تلوثاً معتدلاً والفئة 1 تمثل تلوثاً منخفضاً في بعض العينات. بينما Pb المعترف بها الفئة 1 تمثل انخفاض التلوث. يمثل مؤشر حمل التلوث (PLI) الخاص بـ Co و Zn و Cu و Pb الفئة 2 من التلوث المحلي.

Introduction

High probability of heavy elements contamination is expected from exhaust gases of vehicles, emissions from factories, regional / local sand and dust storms. Toxic heavy elements affecting the ecosystems could lead to geo-accumulation and bioaccumulation [1]. Pollutants enter the environment in many ways , such as by industrial discharge, municipal waste discharge and others; also by land runoff mainly by rivers, tributaries, agricultural canals and by the atmospheric fallout of pollutants transferred by the air mass onto the land- surface [2]. Many authors studied the heavy elements as a

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polluted indicator using the traditional analytical methods [3], but neither one used the proposed indices to evaluate the pollution and the degree of weathering of study area soil, central Iraq. Ishaqi project area is located about 100 km to the north of Baghdad within Salah al-Din Governorate and its geographical position lies between the longitude 43° 55' 12"- 44°28' 05"E and the latitude 33°30' 28"- 34°03'07''N (Figure-1).The study area is composed of recent and quaternary sediments of Pleistocene-Holocene of the Mesopotamian plain alluvium which consists of thin layers of sand, clayey silt, and silty clay with a succession of clay, sand, and mud, and some gravel within deeper layers. The study area has been heavily used for agricultural purposes[4].The objective of this research is to calculate the heavy elements distribution in the soil of Ishaqi project area using the geo-accumulation index (I-geo), contamination factor (CF), and Pollution load index (PLI).

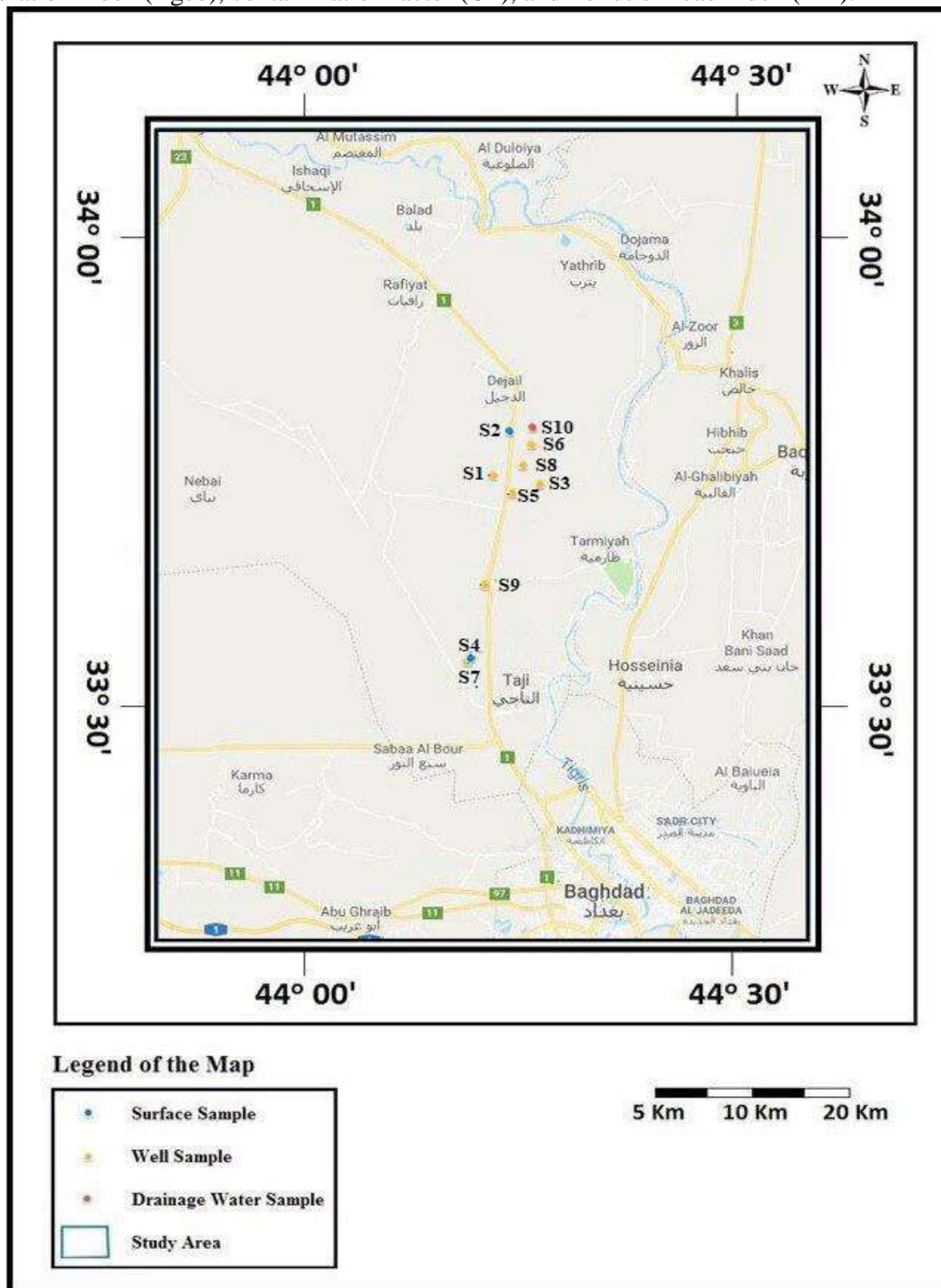


Figure 1-Location map of the soil samples for the study area.

MATERIALS AND METHODS

Ten soil samples were selected at depths range of 0 – 15 cm. from -Ishaqi area during 2018 to evaluate some oxides and heavy elements in the sediments. The selected samples were investigated for Co, Zn, Cu, and Pb elements using three indices; geo-accumulation index (I-geo), contamination factor (CF), and pollution load index (PLI) to detect soil pollution. The natural levels of these chemical constituents were established according to Taylor and McLennan (1985)[5]. All samples were transferred to the Geochemical prep lab – School of environment & technology /University of Brighton / United Kingdom and laboratory of Geology Department/ University of Baghdad . and subjected to drying processes by an oven at a temperature of 60°C. Thereafter, five grams of the sediments were powdered to detect Al₂O₃, CaO, Na₂O and K₂O as well as heavy metals Co, Zn, Cu, and Pb by XRF Methods[6].

The measured heavy metals were used to indicate the pollution by using the mentioned indices. The oxides were used to investigate the intensity of weathering by calculating the Chemical Index of Alteration (CIA) using the formula of Nesbitt and Young (1982)[7]:

$$CIA = \frac{(Al_2O_3 / Al_2O_3 + CaO + Na_2O + K_2O) \times 100}{}$$

RESULTS AND DISCUSSION

The results of the measured oxides (Fe₂O₃ %, Al₂O₃%, CaO%, Na₂O%, and K₂O%) and heavy metals concentrations (Co, Zn, Cu, and Pb) for Ishaqi area are shown in Tables- (1 and 2). Discussion of these chemical constituents is as follows:

A- Heavy Metals and Oxides

Cobalt: Cobalt is an important and essential element for living organisms and is associated with clay minerals [8]. It was found that the mean value of Co concentration was 18.76 ppm in study area. Cobalt is present in the same chemical family with Fe and shows a similar geochemical behaviour so that there is a direct relation of Co with Fe₂O₃. Cobalt with Al₂O₃, CaO, Zn, Cu, and Pb may be adsorbed on the surface of clay and carbonate minerals[9].

Zinc: The agricultural practice is considered as an important source of Zn. Zinc is directly related to Fe and with clay minerals as one host[9]. It was found that the mean value of Zn concentration was 114.9ppm in the study area.

Nickel and zinc are present in the same chemical family of Fe and show similar geochemical behaviour, so that there is a direct relation with Fe₂O₃. The positive relation with Al₂O₃, CaO, Cu, and Pb may be due to the adsorption of these two elements on the surface of clay and carbonate minerals [9].

Copper: Cu is a component of several enzymes and is necessary for the utilization of iron[10]. The mean value of Cu concentration was 51.78 ppm in Ishaqi area. The sediment content of copper depends on the source rocks, organic matter, clay concentration and PH value [11]. The correlation of copper with the other elements in the samples of the study area showed that it has positive relations with each of Al₂O₃, Fe₂O₃, and CaO. These relations may be due to copper adsorption on the surface of clay, iron and carbonate minerals. The direct relation with Co and Pb elements may reflect the same source rocks for these elements (mafic rocks).

Lead: The anthropogenic source of Pb is leaded gasoline. Lead may be found in carbonates, Fe – Mn oxides, inorganic matter and clay minerals [9]. Pb is a toxic metal that is harmful to human health; there is no safe level for lead exposure. The degree of exposure depends on the concentration of lead and route of exposure (air, water, and food)[12]. It was found that the mean value of Pb concentration was 14.25 ppm in the study area.

Iron oxide: The concentration of Fe oxides (Fe₂O₃) in the sediment is related to parent material, degree of weathering, and pedogenic accumulation or depletion processes. Iron is present in opaque minerals and in the clay mineral structures such as chlorite, montmorillonite and kaolinite minerals, as well as in the iron minerals[13]. It was found that the mean value of Fe₂O₃ was 6.11% in the study area.

Aluminum oxide: Aluminum is a common element in primary silicate minerals, from which it may be released by weathering[13]. Alumina element is present in the clay minerals structure. In addition, it is found as Al (OH)₂ between the layers of montmorillonite or adsorbs on clay minerals[14]. It was found that the mean value of (Al₂O₃) was 8.75% in the study area.

Calcium oxide: Calcium oxide is common in primary carbonate minerals, from which it may be released by weathering. There is a correlation of CaO with the other oxides in the sediments; it has

direct relations with Fe_2O_3 and Al_2O_3 , and these relations may be attributed to the association of these metals in the clay minerals. It was found that the mean value of (CaO) was 17.18% in the study area.

Sodium oxide: Sodium oxide content in the samples is due to its relation with clay minerals especially montmorillonite [15]. Navratilova and Kula (2000) showed that sodium element was considered as a major element in the montmorillonite minerals [16]. Also, Gregor (1976) reported that sodium element is fixed in the clay minerals by substitution of potassium by sodium element. This study also mentioned the ability of sodium element to adsorb on clay minerals in the basic condition [17]. It was found that the mean value of Na_2O was 1.26% in the study area.

Potassium oxide: It was found that the mean percent of K_2O was 1.44 % in the study area. The correlation of K_2O with the other oxides in the sediments of the study area reflected an indirect relation with Fe_2O_3 , and Na_2O , due to the lack of potassium element and carbonate minerals in the clays.

Table 1-Results of oxides and heavy elements in the soil of the study area

No	Fe_2O_3	Al_2O_3	CaO	Na_2O_3	K_2O	Co	Zn	Cu	Pb
1	6.39	9.257	17.99	0.769	1.444	23.4	109.1	55.1	13.1
2	6.477	9.324	17.15	1.014	1.527	25	112	51.5	13
3	6.02	8.701	16.17	0.875	1.43	18.2	118	49.6	13.6
4	6.097	8.456	19.26	0.723	1.299	12.9	103.7	54	12.9
5	6.394	9.454	16.76	1.23	1.511	22.9	117	53.2	13.8
6	6.433	9.385	15.74	0.969	1.645	32.5	117.6	54.9	15.5
7	6.077	8.606	18.56	1.153	1.403	15.2	103	49.7	12.8
8	5.029	7.343	17.13	2.534	1.332	9.3	140.8	46.2	19.8
9	6.003	8.334	16.45	1.906	1.491	10.8	112.1	51.6	15.3
10	6.252	8.725	16.67	1.503	1.41	17.4	115.7	52	12.7
Mean	6.1172	8.7585	17.188	1.2676	1.4492	18.76	114.9	51.78	14.25
Min	5.029	7.343	15.74	0.723	1.299	9.3	103	46.2	12.7
Max	6.477	9.454	19.26	2.534	1.645	32.5	140.8	55.1	19.8

B- Assessment of contamination:

In this research, three soil pollution indices were selected to assess the contamination level of Co, Zn, Cu, and Pb in the soil of study area. These are the Geo accumulation index (I-geo), contamination factor (CF) and Pollution Load Index (PLI) (Tables- 2 and 3).

1- Geo-accumulation index (I-geo)

This index is used for comparing the levels of the analysed heavy elements to the background level. I-geo was determined by the following equation according to Taylor and McLennan (1985) Muller (1969):

$I\text{-geo} = \log_2 (C_n/1.5 B_n)$ Where:

C_n = the analysed value of the heavy elements in the samples and

B_n = the crustal average background concentration of the heavy elements (Taylor and McLennan, 1985; Lu et al., 2009).

Lu et al (2009)[18] defined the constant 1.5 as a constant introduced to minimize the effect of possible variations in the background values which may be attributed to lithological variations in the sediments. Muller (1969)[19] designed a classification for the Geoaccumulation index. This application was considered by many researchers like Huu et al (2010)[20]. The values of this index vary from sub-zero to more than 5 having 7 grades (Table- 3). The highest grade (6) reflects a 100-fold enrichment and (0) reflects the background concentration according to Table-3. The values of this index have seven grades and the results reflected the following: The value for Pb was found negative in study area, ranging from - 0.20 - -0.9 (Table-3). The result indicates that the study area is unpolluted by Pb. I geo values of Cu in Ishaqi area ranged from 0.2 to 0.5 indicating slightly polluted

sediments by Cu. the I-geo value of Zn in the study area ranged from -0.0 to 0.1, indicating that these samples are slightly polluted. I-geo value for Co were in Ishaqi area ranged from -0.0 to -1.4 and were considered as unpolluted sediments by Co.

2- Contamination factor (CF)

The contamination factor (CF) was determined according to Thomilson et al. (1980) equation.

$$CF = C_m \text{ Sample} / C_m \text{ Background}$$

Where:

CF: contamination factor.

C_m Sample: metal content in the sample.

C_m Background: background level of metal.

The contamination factor (CF) for Co, Zn, Cu, and Pb was calculated in the Ishaqi area (Table-3). The values of pb in the ten sites ranged from 0.7 to 1.2, reflecting low to moderate contamination with. Lead is known to come from the use of high lead gasoline[9]. CF for Cu in Ishaqi area ranged from 1.8 to 2.2 indicating moderate contamination (class 2). Zn in the study area was classified as class 2, representing moderate contamination ranging from 1.4 to 1.9. Zn originates from toxic waste from industrial sources[21]. Cobalt (Co) in the study area is represented low to moderate contamination, as class 2, ranging from 0.5 to 1.9. (Table-3).

It is believed that a considerable part of heavy elements find its way into the environment as a result of the burning of diesel oil and may be due to the disposal of heavy elements -containing wastewater.

3- Pollution load index (PLI) The pollution load index (PLI) was determined according to Thomilson et al. (1980) [22] equation, where (PLI) is expressed as follows:

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times \dots \times CF_n}$$

Where:

n = the number of analyzed metals in each site.

The Pollution Load Index (PLI) for Co, Zn, Cu, and Pb was calculated, and the samples were classified as class 2 (Deterioration on-site quality), indicating local pollution. PLI values in the study area ranged from 1.1 to 1.6 (Table-3). Higher values of PLI factor may result from the effects of untreated toxic waste that discharges to the drainage from the domestic areas, along with some anthropogenic activities that contaminate the soil by heavy metals.

Table 2-Results of the soil pollution indices; geo-accumulation (I-geo), contamination factor (CF), and pollution load index (PLI) values of the study area.

Sample no	PLI	Co (ppm)	I geo	CF	Zn (ppm)	I geo	CF	Cu (ppm)	I geo	CF	Pb (ppm)	I geo	CF
1	1.40	23.4	-0.12	1.38	109.10	0.03	1.54	55.10	0.55	2.20	13.10	-0.87	0.82
2	1.40	25	-0.03	1.47	112.00	0.07	1.58	51.50	0.45	2.06	13.00	-0.88	0.81
3	1.32	18.2	-0.49	1.07	118.00	0.15	1.66	49.60	0.40	1.98	13.60	-0.82	0.85
4	1.18	12.9	-0.98	0.76	103.70	-0.04	1.46	54.00	0.52	2.16	12.90	-0.90	0.81
5	1.42	22.9	-0.16	1.35	117.00	0.14	1.65	53.20	0.50	2.13	13.80	-0.80	0.86
6	1.61	32.5	0.35	1.91	117.60	0.14	1.66	54.90	0.54	2.20	15.50	-0.63	0.97
7	1.20	15.2	-0.75	0.89	103.00	-0.05	1.45	49.70	0.40	1.99	12.80	-0.91	0.80
8	1.26	9.3	-1.46	0.55	140.80	0.40	1.98	46.20	0.29	1.85	19.80	-0.28	1.24
9	1.19	10.8	-1.24	0.64	112.10	0.07	1.58	51.60	0.45	2.06	15.30	-0.65	0.96
10	1.29	17.4	-0.55	1.02	115.70	0.12	1.63	52.00	0.46	2.08	12.70	-0.92	0.79

Table 3-Classified grades of I-geo, CF and PLI indices (after Thomilson *et al.*, 1980)

I-geo	CF contamination factor	PLI
≤ 0 (class 0), Practically unpolluted		<1 Perfection (class 0)
$0 < \text{to} \leq 1$ (class 1), slightly polluted	<1 Low contamination (Class 1).	$=1$ Baseline level (Class 1)
$1 < \text{to} \leq 2$ (class 2), Moderately polluted	$1 \leq \text{CF} < 3$ Moderate contamination (class 2).	>1 Deterioration on site Quality (class 2)
$2 < \text{to} \leq 3$ (class 3), moderately severely polluted	$3 \leq \text{CF} \leq 6$ Considerable Contamination (class 3).	
$3 < \text{to} \leq 4$ (class 4), Severely polluted	>6 Very high Contamination (class 4).	
$4 < \text{to} \leq 5$ (class 5), Severely extremely polluted		
> 5 (class 6), Extremely polluted		

CONCLUSIONS

The concentrations of heavy metals (Co, Zn, Cu, and Pb) found in the study area can mainly be due to the relatively high percentages of clay contamination. Moreover, pollution with these heavy elements is thought to be due to different sources such as urban wastes, fertilizers, etc. It is clear that the pollutants affected Ishaqi area soil that have relatively high clay.

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