Pollution Assessment of Slabiat Soil Depression Southwestern Iraq

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Abstract

Slabiat is one of the main depressions in Iraq, located between Al-Muthanna and Di Qar Governorate. The depression is to be a natural storage area for the excess water of the Euphrates River in times of floods. The heavy metals Ni, Co, Cr, Fe, Pb, As, Cu, Cd, Zn, Mn and B were measured soil samples using Inductively coupled plasma optical emission spectrometry (ICP-OES), a grain size analysis of soil showed the predomant of sand and silt, the acidity of functions was between basic and natural, and the electrical conductivity and total organic carbon were analyzed. The concentrations of above heavy metals are (82, 8, 47, 4887, 2.5, 4, 23.5, 0.034, 24, 215.9) ppm, respectively. The pollution indices (geochemical aggregation coefficient, concentration coefficient and enrichment coefficient) indicate that the soil of the study area is not polluted with heavy metals in comparison. with global soils except for boron, arsenic and nickel which were pollutants caused by human activity in the area, the specific PLI (pollution of the load index) values were higher than zero but less than 1 indicating minimal soil degradation. The results were compared with the specific levels of soil pollutants provided by the US Department of Environment.

Keywords: Slabiat depression, pollution of the load index, heavy metals, southwestern Iraq

1. Introduction

Slabiat Depression is one of the biggest depressions in the southern Iraqi desert. It is 65 km long and goes from the south to the southwest of the city of Di Qar. Its width ranges from 30 to 5.32 km (Zaini & Abdul Jab'bar, 2015) The depression has an area of 905.021 km^2, The Euphrates river is the main feeder of the slabiat depression. The slabiat Depression with the Al Qadisiyah river and the springs Al-Wahshya water group that emerges through a group of breaks and faults from groundwater aquifers form the water drainage system in the study area, the geological structure of the depression was reflected in the nature of the lake water, in which its feet describe an increase in the salt concentration of sodium, potassium and gypsum ions (Al-Khafaji & Kamel, 2016).

Pollution of the environment is defined as "the pollution of the physical and biological components of the Earth/atmosphere system to the extent that normal environmental processes are affected." Pollutants may be chemicals or natural energies and are defined as substances that exceed their natural limits. Air, water and soil. The introduction of toxins into the natural environment leads to undesirable changes. According to a study (Mohiuddin *et al.*, 2012) of all chemical pollutants, heavy metals are of particular environmental, biological and health importance.

Heavy metals in soil causes a major problem because they are toxic and their ability to accumulate in living organisms is very dangerous to the food chain. Heavy metals are naturally present in soil due to weathering of parent material through genetic processes at levels considered negligible (1000 mg/kg) and rarely toxic (Wuana & Okieimen, 2011). Most soils in industrial, rural, and urban areas can pick up at least one heavy metal. Sources of heavy metals in soil that were created by humans tend to be more mobile and, therefore, more bioavailable than sources that were created by plants or stones (Basta, *et al.*, 2005).

Metal-containing soils at contaminated sites can come from many different of human activities, such as metal mine tailings. High-metal waste dumped in poorly protected landfills, leaded gasoline, lead paint, and fertilizer use in Land, animal dung, Compost, pesticides, coal combustion byproducts, petrochemicals, atmospheric sediments, biosolids (sewage sludge), and (Wuana & Okieimen, 2011), (Aday *et al.*, 2017). Repeated use of pesticides causes their accumulation in the soil, and their effect varies according to the soil texture (Abdel-Rasoul, 2009).

The study's goals are to determine the extent to which heavy metals have contaminated the soil in the slabiat depression (Ni, Co, Cr, Fe, Pb, As, Cu, Cd, Zn and Mn).

2. Materials & Methods

Sample collection and preparation: Eleven of the surface soil samples (0-20 cm depth) were taken on February 2020, (Fig. 1) Using a stainless-steel hand shovel, the sample was placed in plastic bags. Human-derived materials (Glass, plastic cuts and plant remains) were carefully removed from samples, and then dried at room temperature The samples were taken to a lab so they could be analysis.

Physicochemical properties of soil: PH, EC, and

TOC were measured of the lab of university of Basrah according to method of (Page et al ,1982). The electrical conductivity (EC) was measured by EC meter equipment (Jenway 4510 Conductivity/TDS Meter) (1982). Total organic carbon, (TOC), was quantified according to (Walkey & black, 1934), used (folk ,1974) method to determine the grain size of the soil samples. stainless-steel sieves (2, 1, 0.5, 0.250, 0.125, and 0.63 mm), then the pipette method was employed to calculate the percentages of silt and clay were used to separate sand and mud fraction, table (1) represents the concentrations of heavy elements, sedimentary volumes, pH, electrical conductivity and total carbon in the study area. ten heavy metals were analyzed using (ICP-OES) at Amir Kabir University in the Islamic State of Iran.

Pollution assessment methods for heavy metals: Geoaccumulation Index (Igeo):In order to measure the concentration of metals in soil, (Müller,1979) developed the Geoaccumulation Index (Igeo). Following is how this index is written:

Igeo = log2(Cn/1.5Bn)

where Cn is the concentration of metal (n) found in the study area's soils, Bn is the background value for that metal (n), and the constant 1.5 allows us to analyze naturally occurring differences in the amount of a given substance in the environment and detect very minute anthropogenic affects. standard classes of Igeo for heavy metals are given according to Müller (1969) listed in table (3)

Contamination Factor (CF): Contamination factor (CF): The contamination factor was determined using (Pekey *et al.*, 2004), where CF (mineral) is the ratio between the amount of each metal present in soil samples from the research area and that metal's background value Eqn (1)

CF = C (metal) / C (background) ------ 1

To enhance the credibility of the evaluation results, several total content indicators have been proposed to assess the impact of the pollution level of heavy metals in the study area (PLI) Pollution Load Index is used as the square root of the multiplication of the pollution factor (CF) for metal (Eqn 2) (Nkinda *et al.*, 2020). This indicator makes it simple to show how soil conditions have gotten more severe as a result of the buildup of heavy metals (Varol ,2011). As a geometric mean of PI, PLI is determined using the following formula:

PLI = (CF1 x CF2 xCF3 x….x CFn) 1/n ….. 2

where (n) is the number of samples, standard classes of Contamination factor for heavy metals are given according to (Pekey *et al.*, 2004) listed in table (3)

Enrichment Factor(EF): (EF) A metals indicator is used to determine whether and how much anthropogenic soil pollution is present (Sutherland, 2000). Following is how the enrichment factor is expressed:

EF = (Metal/RE) soil/(Metal/RE) background

RE stands for the value of metal, which has been chosen as the Reference Element. standard classes of Enrichment Factor for heavy metals are given according to (Sutherland, 2000) listed in table (3)

3. Results & Discussion

Physicochemical properties of soils: The results of the grain size analysis showed that sand and silt are the predominate components in soil of study area Table (1). The sediments classified as Sandy silt according to (Fuchtbauer,1974), with exception of sample (No.11) which have higher percentage of sand in comparison with other component.

fine size fractions are able to adsorbed on the surface of sediments (clay sizes). Where some elements showed a correlation with the percentage of clay in the study area such as nickel, cobalt and manganese. The acidic function of the soil system is a very important parameter, since it directly affects solubility, absorption, adsorption, and oxidation - reducing reactions and complex formation. The soil of the region was characterized by a moderate to alkaline indicator The pH values were between (8.1) and (8.7) table (1). Only under alkaline circumstances are all heavy metals deposited, taking the forms of oxide hydroxide phosphate and carbonate phases (Al-Khafaji & Jalal, 2020).

The electrical conductivity of the soil changes according to the amount of moisture retained by the soil particles. Thus, EC is strongly related to the size and texture of soil particles (Al-Halfi & Al-Khafaji, 2022). Salinity reaches its high levels in the study areas (8.33) ms, this indicates the impact of the bed rock over which the Qadisiyah river runs and effect the geological formation on the properties the of Slabiat depression. Soil texture influences pollution. Soft soils such as clay are able to absorb more heavy metal such as Cd, Pb, and Ni (Meuser, 2013). The topsoil is more susceptible to both natural and human changes since it is subject to persistent changes as a result of human activity. The average rate of organic materials (TOC) (0.45) in study area. The area is rich in organic materials as it is a marsh environment. Zinc, lead, and manganese showed an effect with the organic carbonate content of the soil in each of (7, 9, and 10) samples. Figure 3 represents the ratios of each of sand, silt and clay, figure 4 such as the ratios of acidity, electrical conductivity and total organic carbon

Concentrations of heavy metals in soil

Concentrations of Ni, Co, Cr, Fe, Pb, As, Cu, Cd, Zn, Mn and B in soils of slabiat depression indicate the area high averages of nickel, arsenic and boron. Nickel in some samples reached (115) ppm, where the increase was associated with both clay and total organic carbon in sample 9this increase may come from the fuel that used in fishing boats for the residents of the area. The values of arsenic were also high, where the highest value reached (6) ppm. The noticeable increase of arsenic resulted from the use of agricultural pesticides and inorganic fertilizers for farms adjacent to Al-Qadisiyah river. Boron is considered one of the most important compounds and the most widespread in the study area, where the value of boron reached (57) ppm, a value that exceeds the natural average of the element boron in the earth's crust (10) ppm, table (2) shows a comparing the levels of heavy metals in soil of the study area with some local and international studies. Boron can be available in nature either in the form of dissolved borate salts or boric acid, or in the form of minerals such as borax. Among the well-known borate minerals in addition to borax are kernite, colimanite, alexite, as well as borcite (Al-Khafaji *et al.*,2010). It was mentioned (Al-Khafaji & Kamel, 2016) that there is filtering of groundwater and a contribution to feeding the depression, and it is likely that the increase in boron is due to that. The average concentration of zinc (29.9) ppm and cadmium (0.02) ppm was close to their background value. While Co, pb, Cr, Cu, and Mn averages are often lower than their background values, as demonstrated in (table 1).

Geo-accumulation index (Igeo): The geochemical accumulation index is used to assess the presence and intensity of deposition of anthropogenic pollutants on the soil. All numerical values for the treatment of geochemical accumulation in the study area were within the range (0 < Igeo < 1), meaning that they are not polluted to medium polluted soils. Except for the boron in sample (5) and (11), the Igeo was higher than 1 (1 < Igeo), table (3) (Muller, 1979) which is considered as one of the average polluted of study area as shown in the table (4), fig. (5). In general, the soil is less polluted with bromine, nickel and arsenic and is not contaminated with the rest of the elements because it is far from areas of congestion and emission of gases and vapors, which means that the study area is less affected by human pollutants. Igeo has the following order: Fe >B >As>Ni > Cr > Pb>Co > Zn > Mn > Cu>Cd.

Concentration factor: It is a tool for tracking individual metal contamination by contrasting its level with background values (Pekey *et al.*, 2004). The values in all samples were recorded as unpolluted in the study area except for (boron, arsenic and nickel), boron in soil comes from groundwater and agricultural fertilizers that use boron as a basic material in soil fertilization processes, the arsenic increase is due to the use of fertilizers and agricultural pesticides, which led to the emergence of pollution in the area (Al-Khafaji & Jalal ,2020). As for the increase in nickel, related to the use of petroleum fuels for transportation and fishing purposes in the boats that used by the people who lived in study area table (5). The increase in the iron as a result of its high occurrence in the earth's crust, which is a natural major element and is not considered a pollutant that enters the process of soil degradation.

Specific PLI values were more than 1 which is an indicator of soil degradation with both boron and arsenic, while the rest of the elements less than 1 which indicate minimal soil degradation. Fig. (6) represents the concentration coefficient values for the study area samples. The elements for the pollution factor were taken the following order: B >As>Ni > Cr > Pb> Zn > Mn > Co > Cu>Cd.

Metal enrichment factor

(EF): (EF) an indicator that is utilized in the process of determining the presence and concentration of anthropogenic pollutants on the surface of soil. Iron has been used as a constant in the enrichment factor equation, Iron has similar geochemical behavior to that of many trace elements in an oxidizing and hypoxic environment, as it has been employed by many authors working in marine and estuarine sediments. Table (3) shows a different range of EF from EF <2 minimal enrichment) to EF >40 (extremely high enrichment) deficiency (Sutherland, 2000) Through table (6) of the values of the enrichment coefficient in the soil samples, we find their The enrichment coefficient values for heavy metals (Cu, Cd, Zn, Mn, Co, Cr, Pb) in study area were less than 2 it is mean a minimal enrichment the content of these trace metals is likely to be entirely due to natural weathering processes.

The principal source of heavy metals in the soil of the study area is the interaction between soil structure and weathering processes. While the values of arsenic and nickel ranged between 2, 5, 5 and 20, respectively, they have a medium to large enrichment in the soil, as an indication of the non-human pollution in the study area that it comes from non-human sources such as some types of agricultural treatments and the fertilization process for plants.

Boron enrichment coefficient ranged from 40 to 20 in the study area, it is located between a high to a very high percentage of enrichment, the groundwater in the study area of this element is one of the most important of these sources of this element (Al-Khafaji & Kamel, 2016), in addition to the agricultural fertilizers used for boron as a soil fertilizer (Aftab *et al.*,2022). Fig. (7) represents. B> As> Ni> Cr> Pb> Co> Zn> Mn> Cu> Cd> Fe is the set of the enrichment factors of heavy metals in the study area.

Conclusion: In the soils of the study area, silt and sand are the predomination. The pH and EC value indicate that the soil is neutral to alkaline and highly salinity. The high organic matter is due to sources of natural origin linked to the nature of the marshes, as they are areas where reeds, papyrus, and short grasses abound. Each of the heavy metal concentrations (Cr, Cu, Cd, Zn, Co, Fe, and Mn) was within acceptable limit limits. While the element (B, As, and Ni) showed high concentrations and more than their geochemical background values.

The Geo-accumulation index (Igeo), concentration factor(CF) and enrichment factor (EF) studies confirmed the presence of pollution in each of the metals nickel and arsenic in a small extent and polluted with the metal bromine in a large extentt, indicating the dominance of human sources, such as the movement of fishing boats, the use of pesticides and the use of agricultural fertilizers. Where the metal took the following order for all pollutants: B> As> Ni> Cr> Pb> Co> Zn> Mn> Cu> Cd, the iron was not included in the sequence in the soil pollutant metals, as it has a naturally high percentage.

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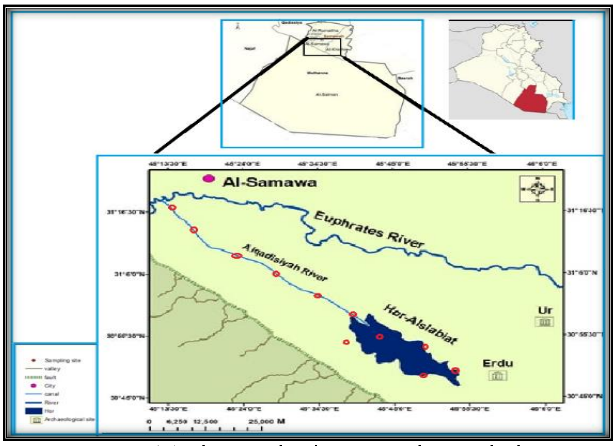

Fig. (2) The studied area and sample locations.Fig. (1) The studied area and sampling locations.

Table (1) of concentration of heavy metals ,volumetrec analysis and physicochemical properties of soil

Sample	Ni	Co	Cr	Fe	Pb	As	Cu	Cd	Zn	Mn	Sand	Silt	Clay	PH	EC(ds/m)	T.O.C
1	72	10.5	59	9505.5	6	4.5	15.5	0.037	27	325.3	22	66	12	8.6	1.4	0.8
2	102.5	14.5	84.5	11650.5	7	6	22.5	0.045	36	419.7	27	63	10	8.1	5.8	0.4
3	67.5	10	60.5	9357	5.5	4	14.5	0.042	26	366.3	37	42	21	8.1	11.3	1.3
4	80	11.5	66	9811	5.8	4	17.5	0.015	29.5	363.08	26	65	9	8.1	20.22	0.6
5	98.5	14	81	11643	8	5.5	22	0.035	36	459.8	33	58	9	8.2	8	1.3
6	35	6.5	43	6807.5	7	2.5	6.5	0.011	16.5	300.4	23	70	7	8.7	1.66	1.8
7	90.5	12	68.5	10389.5	6.8	5	21	0.027	32.5	361.9	25	59	16	8.4	3.09	2.1
8	104	14.5	83	11444.5	6.5	5.5	24	0.034	36	388.6	34	58	8	8.5	7.4	1.1
9	115	14.5	87	11478	7.5	4	30	0.028	40.5	384.7	11	69	20	8.2	8.7	2.2
10	81.5	12	64	9621	6.5	4	19.5	0.02	31.5	360.9	19	63	18	8.4	2.9	3.5
11	33	6.5	40	6763.5	5.6	2	7.5	0.019	17.5	243.9	77	19	4	8.7	13.5	0.4
MIN	33	6.5	40	6763.5	5.5	2	6.5	0.011	16.5	243.9	11	19	4	8.1	1.4	0.4
MAX	115	14.5	87	11650.5	8	6	30	0.045	40.5	459.8	77	70	21	8.7	20.22	3.5
Range	82	8	47	4887	2.5	4	23.5	0.034	24	215.9	66	51	17	0.6	18.82	3.1
STD	26.86	2.94	16.06	1764.6	0.79	1.23	6.98	0.01	7.68	57.6	17.1	14.84	5.68	0.23	5.7	0.93
AV.	79.95	11.5	66.95	9861	6.56	4.27	18.2	0.02	29.9	361.3	30.36	57.45	12.18	8.3	7.6	1.4

Table 2 Compared the average concentration of heavy metals in soil of study area with different standards and previous studies

Studies	Ni	Co	Cr	Fe	Pb	As	Cu	Cd	Zn	Mn	B	Location
USEPA,1997	50	_	400	_	300	_	50	3	200	_	_	International Soil
VROM 2000	35	9	100	_	85	29	36	0.8	_	_	_	Natural safte limit
FOREGS 2005	37	10.4	94.8	_	32	11.6	17.3	0.28	68.1	524	_	Topsoil of Europe
ASTM,2007	210	_	_	220	530	_	190	12	230	_	_	International Soil
Manea etal,2019	28.9	30.3	18.2	1021	32	6.29	59	4.8	77.3	43.7	_	Soil (Shatt-Al-Hilla)
Kabata-Pendias 2011	20	10.5	155.5	5E+05	15	1.8	26	1.05	66	488	_	World soil
AL-Taie etal 2013	83.95	_	70.85	5148	33.3	_	21.14	_	_	_	_	Hor al-Azim
Al-Sabah,2013	_	_	_	2465	7.06		5.79	_	7.1	_	_	South Iraq
FAO/WHO Guidelines (Chiroma,2014)	50	50	100	_	100	20	100	3	300	_	_	International Soil
Al - Anbari et al - 2015	206.6	_	149.19	_	106.09	_	33.07	4	108.05	_	_	Baghdad (Soil Industrial)
Li , D. , and Liao Y. -2018	23		66.1		147.6	10.9	24	0.22	47.5		_	China
Present study	79.9	11.5	66.9	9861	6.5	4.2	18.2	0.02	29.9	361.3	39.27	Slabiat depression

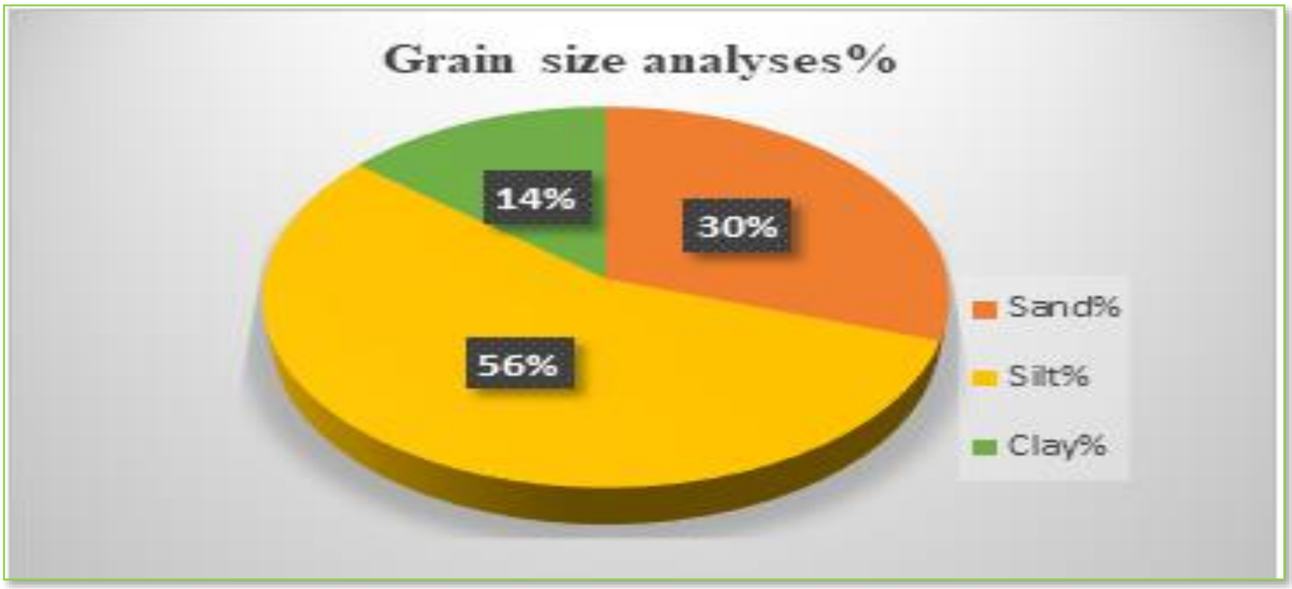

Fig (3) The percentages of sand, silt and clay in soils of study area.

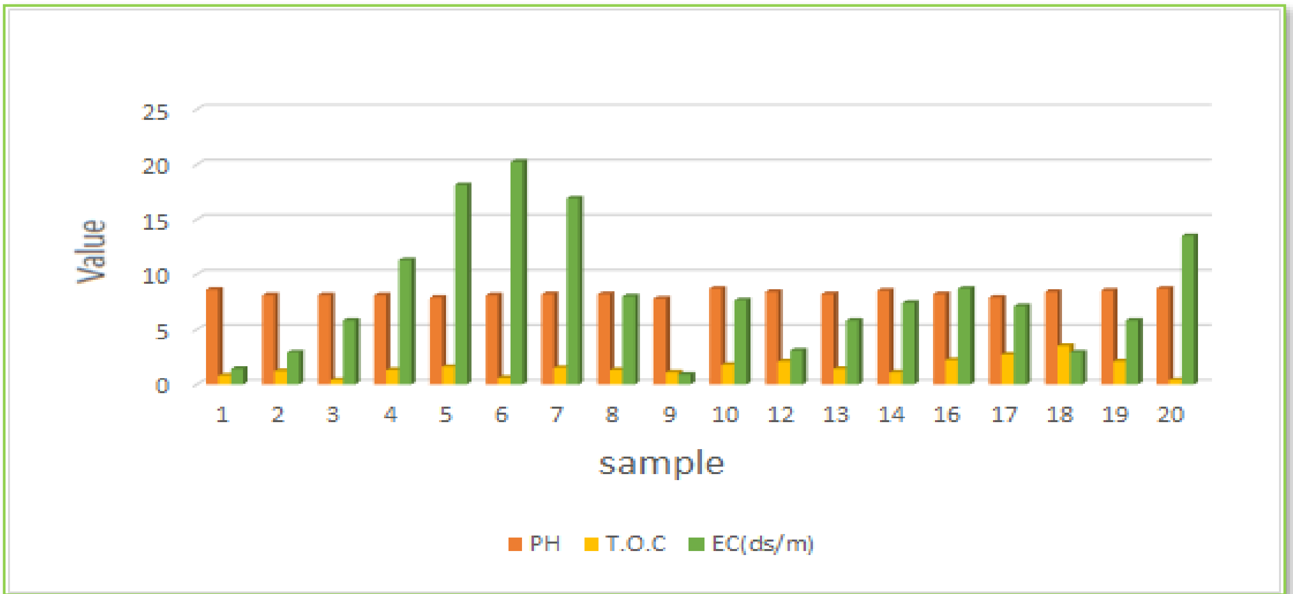

Figure (4) Changes in EC, TOC and pH of soil samples in the study area.

Table 3 The classification of indexes ((Müller ,1979;Pekey et al, 2004;Sutherland,2000)

Index	Category	Description
Geo-accumulation	Igeo≤0	Uncontaminated
index (Igeo)	0< Igeo <1	Uncontaminated to moderatelly contaminated
	1< Igeo <2	Moderately contaminated
	2< Igeo <3	Moderately to heavily contaminated
	3< Igeo <4	Heavily contaminated
	4< Igeo <5	Heavily to extremely contaminated
	Igeo≥5	Extremely contaminated
Concentration	CFi < 1	Low
Factor (CF)	1 ≤ CFi < 3	Moderate
	3 ≤ CFi < 6	Considerable
	CFi ≥ 6	Very high
Pollution Load	<0<	No Pollution
Index (PLI)	0_1	Low degree of Pollution
	1_2	Moderate degree of Pollution
	2_4	High degree of Pollution
	4_8	Very High degree of Pollution
	8_16	Extremely High degree of Pollution
Enrichment	EF<2	Deficiency to minimal enrichment
Factor(EF)	2< EF <5	Moderate enrichment
	5< EF <20	Significant enrichment
	20< EF <40	Very high enrichment
	EF>40	Extremaly high enrichment

Table 4 geochemical index (Igeo) in soil of study area

Sample	igeo(Ni)	igeo(Co)	igeo(Cr)	igeo(Fe)	igeo(Pb)	igeo(As)	igeo(Cu)	igeo(Cd)	igeo(Zn)	igeo(Mn)	igeo(B)	igeo(Fe)
1	0.172	0.084	0.116	33.8	0.086	0.501	0.051	0.049	0.077	0.068	0.65	33.8
2	0.244	0.116	0.166	41.5	0.1	0.668	0.075	0.06	0.103	0.088	0.72	41.5
3	0.161	0.08	0.119	33.3	0.078	0.445	0.048	0.056	0.074	0.077	0.56	33.3
4	0.191	0.092	0.129	34.9	0.083	0.445	0.058	0.02	0.084	0.076	0.74	34.9
5	0.235	0.112	0.159	41.5	0.114	0.613	0.073	0.046	0.103	0.097	1.03	41.5
6	0.083	0.052	0.084	24.2	0.1	0.278	0.021	0.014	0.047	0.063	0.45	24.2
7	0.216	0.096	0.134	37	0.097	0.557	0.07	0.036	0.093	0.076	0.72	37
8	0.248	0.116	0.163	40.7	0.093	0.613	0.08	0.045	0.103	0.082	0.84	40.7
9	0.274	0.116	0.171	40.9	0.107	0.445	0.1	0.037	0.116	0.081	0.82	40.9
10	0.194	0.096	0.125	34.2	0.093	0.445	0.065	0.026	0.09	0.076	0.93	34.2
11	0.078	0.052	0.078	24.1	0.08	0.222	0.025	0.025	0.05	0.051	1.13	24.1
MIN	0.07	0.05	0.078	24.1	0.078	0.22	0.02	0.01	0.04	0.05	0.45	24.1
MAX	0.27	0.11	0.17	41.5	0.11	0.66	0.1	0.06	0.11	0.09	1.13	41.5
STD	0.06	0.023	0.031	6.29	0.01	0.13	0.02	0.01	0.02	0.012	0.19	6.29
AV	0.19	0.092	0.13	35.1	0.093	0.47	0.06	0.037	0.08	0.075	0.78	35.1

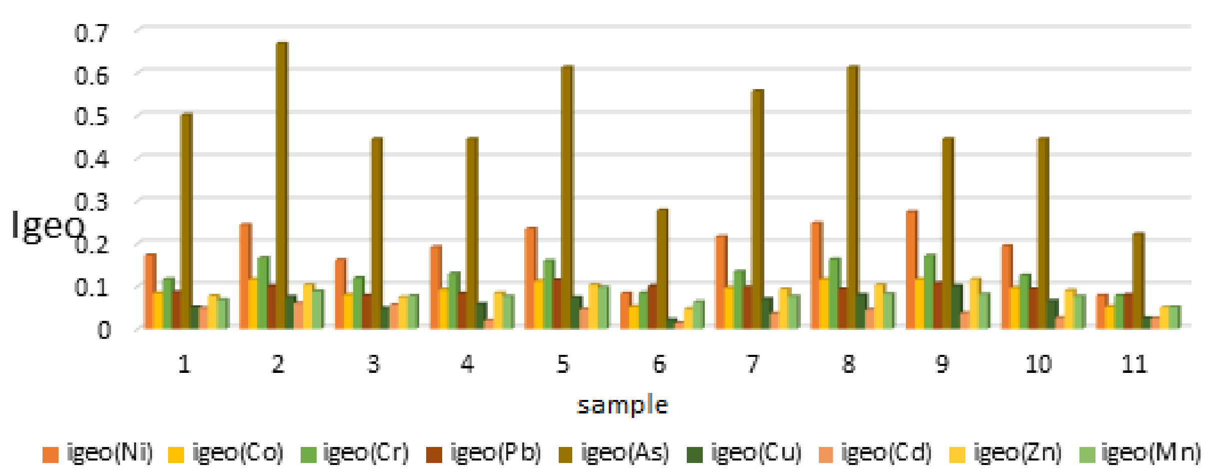

Fig. (5) Igeo distribution of heavy metals in soil of study area

Table 5 Concentration factor(CF) index in soils of study area

Sample	CFI (Ni)	CFI (Co)	CFI (Cr)	CFI (Fe)	CFI (Pb)	CFI (As)	CFI (Cu)	CFI (Cd)	CFI (Zn)	CFI (Mn)	CFI (B)
1	0.8	0.35	0.59	168.8	0.42	2.14	0.25	0.24	0.38	0.36	32.5
2	1.1	0.48	0.8	206.9	0.5	2.85	0.375	0.3	0.51	0.46	36
3	0.75	0.33	0.6	166.1	0.39	1.9	0.24	0.28	0.37	0.4	28
4	0.88	0.38	0.66	174.2	0.41	1.9	0.29	0.1	0.42	0.4	37
5	1.09	0.46	0.81	206.8	0.57	2.61	0.36	0.23	0.51	0.51	51.5
6	0.38	0.21	0.43	120.9	0.5	1.19	0.1	0.07	0.23	0.33	22.5
7	1	0.4	0.68	184.5	0.48	2.38	0.35	0.18	0.46	0.4	36
8	1.1	0.48	0.83	203.2	0.46	2.61	0.4	0.22	0.51	0.43	42
9	1.27	0.48	0.87	203.8	0.53	1.9	0.5	0.18	0.57	0.42	41
10	0.96	0.4	0.64	170.8	0.46	1.9	0.325	0.13	0.45	0.4	46.5
11	0.36	0.21	0.4	120.1	0.4	0.95	0.125	0.12	0.25	0.27	56.5
MIN	0.36	0.21	0.4	120.1	0.39	0.95	0.1	0.07	0.23	0.27	22.5
MAX	1.27	0.48	0.87	206.9	0.57	2.85	0.5	0.3	0.57	0.51	56.5
STD	0.29	0.09	0.15	31.33	0.057	0.58	0.11	0.07	0.1	0.06	9.94
AV.	0.88	0.38	0.66	175.1	0.46	2.03	0.3	0.18	0.42	0.39	39.04
PLI	0.34	0.003	0.09	1.98995E+12	0.014	38.1	0.00081	0.00006	0.0072	0.0058	478284389.6

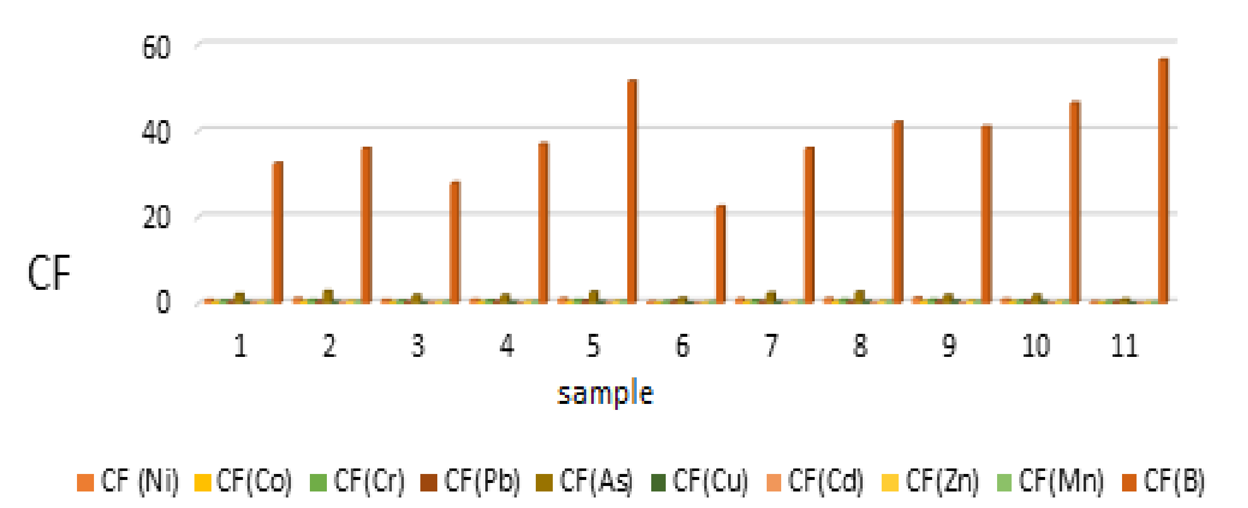

Fig. (6). Concentration factor(CF) of heavy metals in soils of study area

Table 6 Enrichment factor in soil of study area

Sample	EF(Ni)	EF(Co)	EF(Cr)	EF(Fe)	EF(Pb)	EF(As)	EF(Cu)	EF(Cd)	EF(Zn)	EF(Mn)	EF(B)
1	5.04	2.47	3.4	1	2.52	14.72	1.52	1.45	2.27	2.01	19.14
2	5.86	2.78	3.98	1	2.4	16.02	1.8	1.44	2.47	2.12	17.3
3	4.8	2.39	3.54	1	2.35	13.29	1.44	1.67	2.22	2.3	16.75
4	5.43	2.62	3.69	1	2.36	12.68	1.66	0.57	2.4	2.18	21.1
5	5.64	2.69	3.81	1	2.74	14.69	1.76	1.12	2.47	2.32	24.77
6	3.42	2.13	3.46	1	4.11	11.42	0.89	0.6	1.93	2.6	18.5
7	5.8	2.58	3.61	1	2.61	14.97	1.88	0.97	2.5	2.05	19.4
8	6.05	2.83	3.98	1	2.27	14.95	1.95	1.1	2.51	2	20.55
9	6.67	2.82	4.16	1	2.61	10.84	2.43	0.91	2.82	1.97	20
10	5.64	2.79	3.65	1	2.7	12.93	1.89	0.77	2.61	2.2	27.06
11	3.25	2.15	3.24	1	3.31	9.19	1.03	1.04	2.06	2.1	46.78
MIN	3.25	2.13	3.24	1	2.27	9.19	0.89	0.57	1.93	1.97	16.75
MAX	6.67	2.83	4.16	1	4.11	16.02	2.43	1.67	2.82	2.6	46.78
STD	1.06	0.25	0.27	0	0.54	2.09	0.43	0.35	0.25	0.18	8.5
AV	5.23	2.56	3.68	1	2.72	13.24	1.65	1.05	2.38	2.16	22.85

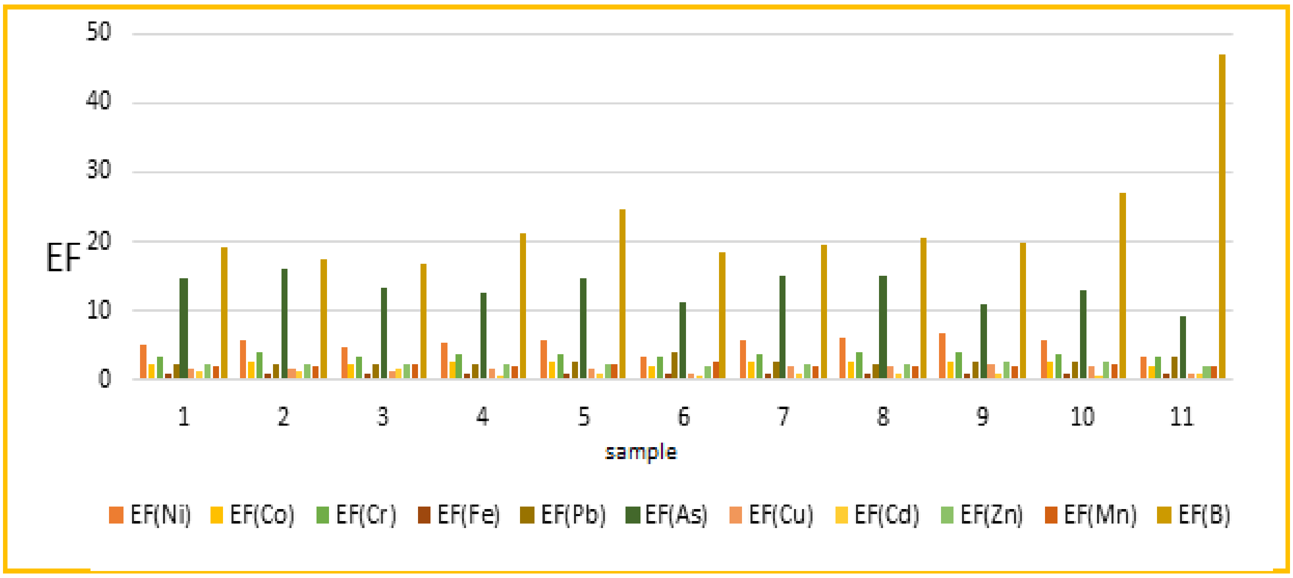

Fig. (7). enrichment factor of heavy metals in soils of study area