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Assessment of Heavy Metal Contamination in Euphrates River Sediments from Al-Hindiya Barrage to Al-Nasiria City, South Iraq

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Abstract

The degree of contamination in the sediments of the Euphrates River (Shatt Al-Hindiya), for the metals As, Cd, Co, Cu, Cr, Mn, Ni, Pb, Sc Se, Sr, V and Zn has been evaluated using the index of geo-accumulation (I-geo), Enrichment factor (EF), Contamination factor (CF) and pollution load index (PLI), whereat the I-geo has been widely utilized as a measure of pollution in freshwater sediment. Enrichment factor (EF) is one widely used as approach to characterize the degree of anthropogenic pollution to establish enrichment ratios, while the pollution load index (PLI) represents the number of times by which the heavy metal concentrations in the sediment exceeds the background concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample. By using these numerical sediments indexes we found that the Sediments of Euphrates River in the study area are polluted by the metals of Nickel (maximum 194ppm) and Strontium (maximum 543ppm), and moderately polluted by the metals of Copper (maximum 47.9), Cobalt (maximum 22.8ppm), Chromium (maximum 111ppm) and Selenium (maximum 1.1ppm), while the sediments of Euphrates River are not polluted by the metals of Arsenic (maximum 10.2ppm), Cadmium (maximum 0.29ppm), Manganese (maximum 949ppm), Lead (maximum 14.8ppm), Scandium (maximum 8.96ppm), Vanadium (maximum 81ppm) and Zinc (maximum 91ppm).

Keywords: Assessment, Metal Contamination, Euphrates River, Iraq

تقييم تلوث رسوبيات نهر الفرات بالفلزات الثقيلة من سدة الهندية الى مدينة الناصرية

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الخلاصة

في السنوات الاخيرة كان هناك اهتمام متزايد في ما يتعلق بتلوث البيئات بالفلزات الثقيلة، وذلك بسبب سمية هذه الفلزات واستمرار تحسسها في الانظمة المائية. في النظام النهري، الرسوبيات قد استخدمت بشكل واسع كأدلة بيئية وتحاليلها الكيميائية اثبتت معلومات جديرة بالاهتمام في تقييم المؤثرات البشرية. حديثا" تطورت عدة مؤشرات رقمية لايجاد وسيلة لاثبات التلوث الكيميائي في الترب المختلفة. اكثر هذة الوسائل استخداما" هي دليل التراكم الجيولوجي (I–geo) وعامل الاغناء (EF) ودليل حمل التلوث (PLI). دليل التراكم الجيولوجي قد استخدم بشكل واسع كمقياس للتلوث في ترسبات المياه العذبة، بينما عامل الاغناء استخدم لتحديد درجة التلوث الناتج عن الفعاليات البشرية لاثبات نسبة او درجة الاغناء بالعنصر الملوث، ودليل حمل التلوث يمثل عدد المرات التي خرجت بها الفلزات الثقيلة قيد الدراسة عن الحدود المسموح بها وتعطي اشارة عن التلوث الكلي بعدة عناصر لمنطقة واحدة فيما اذا كانت ملوثة بمجموع هذه الفلزات ام لا. هدف هذا العمل هو تقييم درجة تلوث ترسبات نهر الفرات بواسطة العناصر الثقيلة قيد الدراسة. بواسطة استخدام هذه المؤشرات الرقمية وجد ان ترسبات نهر الفرات في المنطقة قيد الدراسة ملوثة بالفلزات (Ni) و (Sr) وملوثة بشكل متوسط

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بالفلزات (Cu)، (Co)، (Cr) و (Se) وغير ملوثة بالفلزات (As)، (Cd)، (Mn)، (Pb)، (Sc)، (V) و (Zn).

1. Introduction

Pollution of the natural environment by heavy metals is a universal problem because these metals are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded [1]. Heavy metals are either naturally or through anthropogenic sources introduced into river water. Metals that are naturally introduced into the river come primarily from sources such as rock weathering, soil erosion, and the dissolution of water-soluble salts. Naturally occurring metals (especially the heavy metals) move through aquatic environments independent of human activities and usually without any detrimental effects [2, 3]. Anthropogenic pollutants are discharged from industrial, domestic and agricultural wastewater into the river water system [4]. Sediment served as sinks for most of the metals in aqueous phase [5]. The concentrations of heavy metals in soils are varied according to the rate of particle sedimentation, the rate of heavy metals deposition, the particle size and the presence or absence of organic matter in the soils [6].The assessment of sediment enrichment with elements can be carried out in many ways; The most common ones are the index of geo-accumulation (I-geo), Enrichment Factor (EF) and pollution load index (PLI).

2. Materials and Methods

2.1. Study Area

Euphrates River is the longest in the Middle East and the largest in terms of area and the second basin feeding the rivers in the region from where the water contained. From Turkey the Euphrates flows through Syria's semi-desert plateau entering Iraq at Rumanah (AL Qaim); then it passes through the desert entering the Mesopotamian Plain at Fallujah. At Qurna, 60 km NNW of Basra, the Euphrates merges with the Tigris forming the Shatt AL-Arab. The Euphrates is 2700 km long (1213 km in Iraq) with a catchment area of 765000 km. The average flow rate of the Euphrates River is only 1100 m3/s. The flow of the Euphrates can reach 50000 m3/s, usually at the beginning of May. The Tigris has a much greater capacity than the Euphrates mainly because it does not flow through arid desert and because it is also fed within Iraq by numerous water courses flowing from the Zagros. **[7]**.The study area is bounded by latitudes (32°30'N to 31°00'N) and Longitudes (44°22'N to 46°25'E), Figure 1. The climate of Iraq in the summer, is dry and extremely hot with a shade temperature of 43°C or more during July and August, dropping at night to 26°C. The winter in Iraq is cold and rainy. The maximum monthly rate of rainfall for the period (2005-2015) was 20.97 mm in November, while the minimum rate was 0.00 mm in July. The maximum monthly rate of relative humidity in the study area of the Euphrates River for the period (2005-2015) was 66.2 % in January, while the minimum rate was 24.5% in July, the maximum evaporation value was 475.5 mm in July, while the minimum value was 71.1 mm in January, the rates of monthly temperatures for the duration of the year (2005-2015) between (11.19 C°) for the month of January (37.10 C°) for the month of August.

2.2. Sampling Collection and Analysis

Thirteen sampling sites were chosen for the collection of sediments along the Euphrates River Figure-1, Table-1. Sampling sites were localized exactly by GPS (Garmin) locator. The sediment samples were collected in October 2014. The River sediment samples were collected by using clean plastic scoop and stored in polyethylene bags. The concentrations of heavy metals were determined in all samples in the ALS Laboratory Group, SL, Spain, processed at ALS Loughrea-Ireland by Super Trace Aqua Regia (AR) by ICP-MS. The accuracy of the analytical method was evaluated using the standard reference materials GBM908-10, GEOMS-03, MRGEO-08 and SM1494-002.

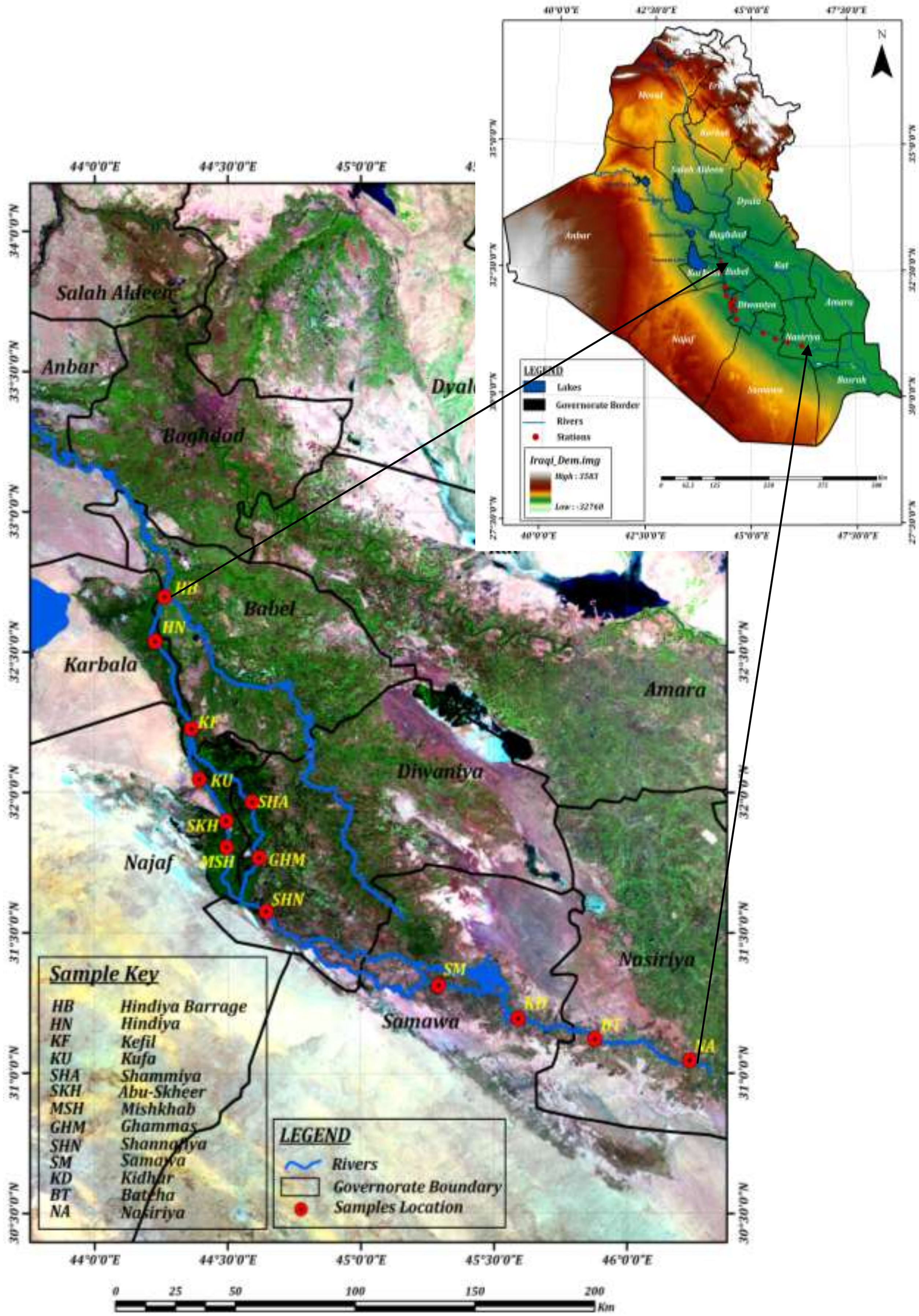

Figure 1- Location map of the study area.

Table 1- Details of sampling locations of Euphrates River

Stations	Symbol	E	N
Hindiya Barrage	HB	44.261	32.698
Hindiya	HN	44.228	32.538
Kifil	KF	44.363	32.228
Kufa	KU	44.393	32.048
Shamiya	SHA	44.592	31.966
Abu-Skheer	SKH	44.494	31.899
Mishkhab	MSH	44.497	31.805
Ghammas	GHM	44.618	31.768
Shanafiya	SHN	44.644	31.577
Samawa	SM	45.291	31.313
Kidhir	KD	45.590	31.194
Batha	BT	45.897	31.123
Nasiriya	NA	46.236	31.046

Table 2- Mean concentrations (ppm) of heavy metals in the Study area of Euphrates River sediments and their world surface soil average.

Stations/Element	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Sc	Se	Zn	Sr	V
Hindiya Barrage	6.4	0.16	24.6	19.8	86.2	544	152.5	7.05	6.14	0.9	55.1	239	74.6
Hindiya	4.9	0.09	10.8	16.3	60.9	425	116.5	5.28	4.04	0.6	34.7	155.5	69.7
Kifil	5.5	0.14	14.4	15.7	67.5	453	113.0	6.32	4.73	0.6	39.2	198.5	79.6
Kufa	6.7	0.16	26.5	20.6	78.1	572	138.0	9.94	6.59	0.8	56.7	543	59.7
Shamiya	8.9	0.20	31.7	20.6	93.3	615	160.0	10.40	7.94	0.7	68.0	342	67.6
Abu-Skheer	5.5	0.14	18.8	18.2	77.0	517	138.5	6.99	5.73	0.7	52.5	229	81.0
Mishkhab	10.2	0.29	47.9	21.2	94.4	655	149.5	14.80	6.78	1.1	91.0	342	67.8
Ghammas	8.3	0.21	31.7	22.8	99.6	673	179.5	8.96	8.27	0.9	63.7	329	78.2
Shanafiya	8.6	0.19	31.8	22.6	103.5	819	185.0	8.49	8.84	0.9	64.9	323	76.3
Samawa	8.7	0.21	33.8	21.5	103.0	802	180.5	9.71	8.67	0.8	69.2	343	69.9
Kidhir	9.1	0.20	33.0	22.7	111.0	949	194.0	8.80	8.96	0.9	70.9	346	72.8
Batha	8.3	0.19	33.0	22.1	111.0	828	190.5	9.08	8.88	1.0	68.3	349	71.8
Nasiriya	8.2	0.19	31.7	21.9	102.0	770	171.5	8.86	8.07	0.9	66.2	339	65.9
Maximum	10.2	0.29	47.9	22.8	111	949	194	14.8	8.96	1.1	91	543	81
Background (ppm)*	4.7	1.1	14	6.9	42	418	18	25	9.5	0.7	62	147	60

*** = Commonly reported mean background contents of heavy metals in surface soils (mg/kg) according to Kabata-Pendias and Pendias 1999-2001.**

2.3. Assessment of Heavy Metals Pollution

The Enrichment factor (EF), geo-accumulation index (I-geo) and pollution load index (PLI) were employed to assess the pollution of metals in the sediment of Euphrates river, as follow:

1. Enrichment Factor (EF)

Enrichment factor (EF) is one widely used approach to characterize the degree of anthropogenic pollution to establish enrichment ratios [8]. The enrichment factors (EF) were computed relatively to the abundance of species in source material and to that found in the Earth's crust [9].

$$\mathbf{EF = (C_m/C_X)\ sample\ /\ (C_m/C_X)\ Earth's\ crust} \quad \mathbf{(1)}$$

Where, C_M is the content of metal studied and C_X is the content of immobile element, immobile elements may be Fe and Ti [10], Mn [11] or Li, Sc, Zr [12]. In this Study Fe was selected as the reference element, due to its crustal dominance and its high immobility as in [13-16]. The reference value of Fe in Earth Crust is 5.0% and 3.5% as Median for World soils [17-19].

EF was classified into five grades, according to [20, 16] into:

EF Value	Pollution
EF < 2	Deficiency to Minimal Enrichment
2 ≤ EF ≥ 5	Moderate Enrichment
5 ≤ EF ≥ 20	Significant Enrichment
20 ≤ EF ≥ 40	Very High Enrichment
EF > 40	Extremely High Enrichment

Mean EF values of elements in Euphrates river sediments were in the order Ni> Sr >Co >Cr >Se >Cu >As >V >Mn > Sc> Zn >Pb >Cd. EF values for elements in Euphrates River Sediments are listed in Table-2, while Mean of EF values are shown in Figure-2.

Table 2- EF values of Heavy metals in the Study area of Euphrates River sediments

Station/Element	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Sc	Se	Zn	Sr	V
Hindiya Barrage	1.5	0.2	2.0	3.3	2.3	1.5	9.6	0.3	0.7	2.6	0.4	4.5	1.4
Hindiya	1.6	0.1	1.2	3.5	2.2	1.5	9.7	0.3	0.6	2.2	0.4	3.9	1.7
Kifil	1.6	0.2	1.4	3.1	2.2	1.5	8.5	0.3	0.7	2.0	0.4	4.5	1.7
Kufa	1.9	0.2	2.6	4.1	2.5	1.9	10	0.5	0.9	2.7	0.5	12	1.3
Shamiya	2.2	0.2	2.6	3.4	2.5	1.7	10	0.5	1.0	2.0	0.5	6.5	1.2
Abu-Skheer	1.5	0.2	1.7	3.3	2.3	1.5	9.5	0.3	0.7	2.2	0.4	4.7	1.6
Mishkhab	1.8	0.2	2.8	2.5	1.9	1.3	6.8	0.5	0.6	2.3	0.5	4.7	0.9
Ghammas	1.8	0.2	2.4	3.4	2.5	1.7	10	0.4	0.9	2.3	0.5	5.7	1.3
Shanafiya	1.9	0.2	2.4	3.4	2.6	2.0	11	0.4	1.0	2.3	0.5	5.6	1.3
Samawa	2.0	0.2	2.6	3.3	2.6	2.0	11	0.4	1.0	2.1	0.5	6.1	1.2
Kidhir	2.0	0.2	2.4	3.3	2.7	2.3	11	0.4	1.0	2.3	0.5	5.9	1.2
Batha	1.8	0.2	2.4	3.3	2.7	2.0	11	0.4	1.0	2.6	0.5	5.9	1.2
Nasiriya	2.0	0.2	2.5	3.6	2.7	2.1	11	0.4	1.0	2.5	0.5	6.4	1.2

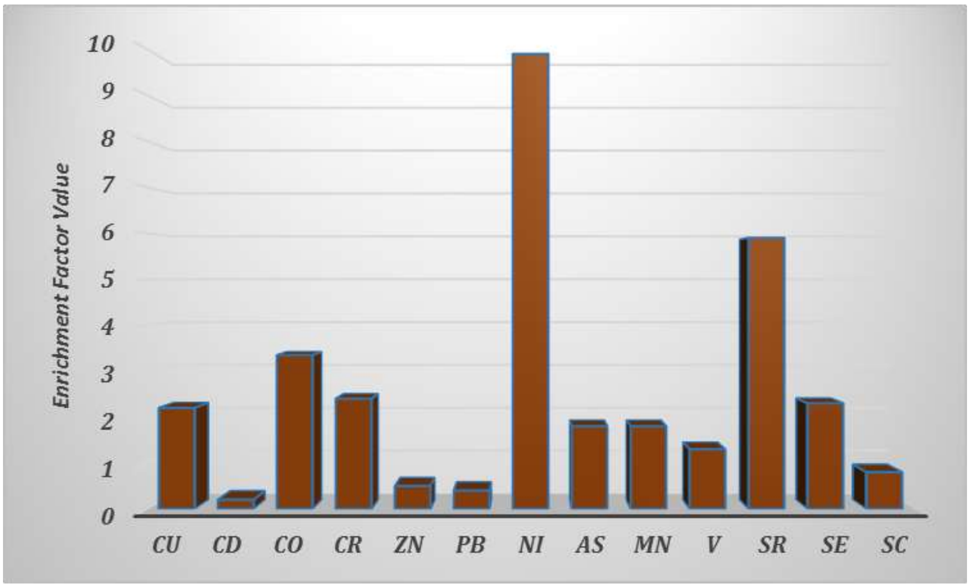

Figure 2- Mean of Enrichment Factor (EF) values of heavy metals in the study area of Euphrates River.

2. Geo-accumulation index (I-geo)

Enrichment of metal concentration above baseline concentrations was calculated using the method proposed by [21], termed the geo accumulation index (I_{geo}). Geo-accumulation index was determined by the following equation according to [21], which was described by [22].

$$\mathbf{I_{geo} = Ln\ (C_n / 1.5\ B_n)} \quad \textbf{(2)}$$

Where: C_n = Measured concentration of heavy metal in the Euphrates sediment.

B_n = Geochemical background value according to [9] of element n. The factor 1.5 is used for the possible variations of the background data due to lithological variations.

I-geo was classified into seven grades, according to [23]:

I_{geo}	I_{geo} grade	Pollution
< 0-0	0	Unpolluted
0-1	1	Unpolluted to Moderate
1-2	2	Moderate Polluted
2-3	3	Moderate to high Polluted
3-4	4	High Polluted
4-5	5	High to Extremely Polluted
5-6	>5	Extremely Polluted

Mean I_{geo} Accumulation Index values of elements in Euphrates river sediments were in the order Ni> Sr >Co >Cr >Cu >As >Mn >Se >V > Sc> Zn >Pb >Cd. I_{geo} value for elements in Euphrates River Sediments are listed in Table-3, while Mean of I_{geo} values are shown in Figure-3.

Table 3- I_{geo} values of Heavy metals in the Study area of Euphrates River sediments.

Station/Element	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Sc	Se	Zn	Sr	V
Hindiya Barrage	-0.1	-2.3	0.2	0.7	0.3	-0.1	1.7	-1.7	-0.8	-0.2	-1.4	1.0	-0.2
Hindiya	-0.4	-2.8	-0.7	0.5	-0.03	-0.4	1.5	-2	-1.3	-0.6	-1.8	0.5	-0.3
Kifil	-0.2	-2.5	-0.4	0.4	0.1	-0.3	1.4	-1.8	-1.1	-0.6	-1.7	0.8	-0.2
Kufa	-0.1	-2.3	0.2	0.7	0.2	-0.1	1.6	-1.3	-0.8	-0.3	-1.4	1.8	-0.4
Shamiya	0.2	-2.1	0.4	0.7	0.4	-0.02	1.8	-1.3	-0.6	-0.4	-1.2	1.3	-0.3
Abu-Skheer	-0.2	-2.5	-0.1	0.6	0.2	-0.2	1.6	-1.7	-0.9	-0.4	-1.4	0.9	-0.1
Mishkhab	0.4	-1.7	0.8	0.7	0.4	0.04	1.7	-0.9	-0.7	0.05	-0.9	1.3	-0.3
Ghammas	0.2	-2.1	0.4	0.8	0.5	0.1	1.9	-1.4	-0.5	-0.2	-1.2	1.3	-0.2
Shanafiya	0.2	-2.1	0.4	0.8	0.5	0.3	1.9	-1.5	-0.5	-0.2	-1.2	1.3	-0.2
Samawa	0.2	-2.1	0.5	0.7	0.5	0.2	1.9	-1.4	-0.5	-0.3	-1.2	1.3	-0.3
Kidhir	0.3	-2.1	0.5	0.8	0.6	0.4	2.0	-1.4	-0.5	-0.2	-1.1	1.3	-0.2
Batha	0.2	-2.1	0.5	0.8	0.6	0.3	2.0	-1.4	-0.5	-0.05	-1.2	1.4	-0.3
Nasiriya	0.2	-2.1	0.4	0.7	0.5	0.2	1.8	-1.4	-0.6	-0.2	-1.2	1.3	-0.3

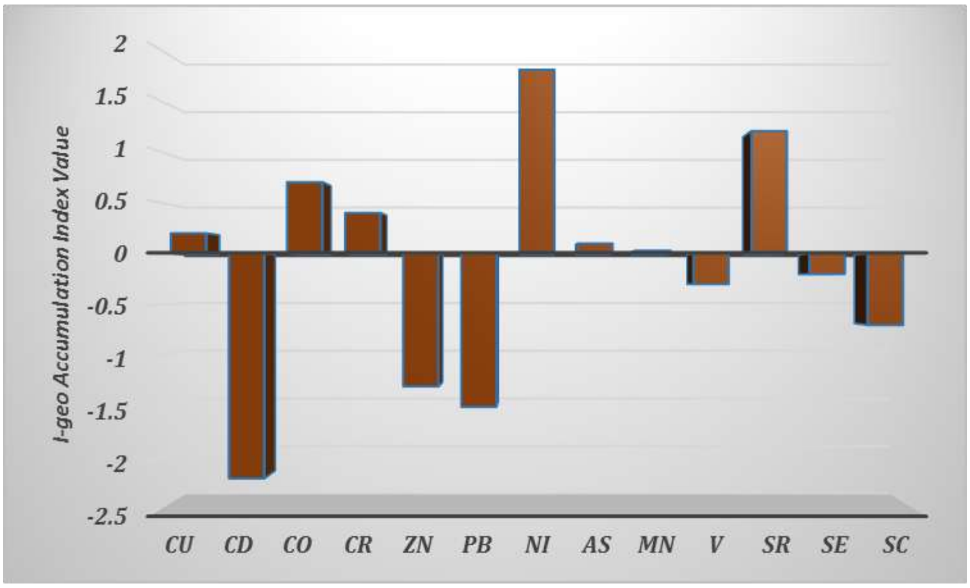

Figure 3- Mean of Geo Accumulation Index (I_{geo}) values of heavy metals in the study area of Euphrates River.

3. Pollution load index (PLI)

The Pollution Load Index (PLI) is obtained as Contamination Factors (CF). This CF is used to classify the level of contamination of metals in the soil and river sediment samples. The quotient obtained by dividing the concentration of each metals. The PLI of the place are calculated by obtaining the n-root from the n- CFs that were obtained for all the metals. With the PLI obtained from each place [24]. Generally pollution load index (PLI) as developed by Tomlinson et al [25], which is as follows:

CF = C metal / C background value **(3)**

PLI=n√(CF1xCF2xCF3x…xCFn) **(4)**

Where:

CF = Contamination factor, n = Number of metals.

C metal = Metal concentration in polluted sediments.

C Background value = Background value of that metal.

The Contamination Factor was classified according to [26] into:

CF Value	Pollution
CF < 1	Low
1 ≤ CF ≥ 3	Moderate
3 ≤ CF ≥ 6	Considerable
CF > 6	Very high

The PLI value was classified according to [27] into:

PLI Value	Pollution
0	Perfection
<1	Baseline Level
>1	Polluted

Pollution severity and its variation along the sites was determined with the use of pollution load index. This index is a quick tool in order to compare the pollution status of different places [28].
Mean CF values of elements in Euphrates river sediments were in the order Ni> Sr >Co >Cr> Cu >As >Mn >V >Se >Sc >Zn >Pb >Cd. CF values and PLI for elements in Euphrates River Sediments are listed in Table-4, while mean values of CF with PLI level are shown in Figure-4.

Table 4- CF values and PLI Value of Heavy metals in the Study area of Euphrates River sediments.

Station/Element	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Sc	Se	Zn	Sr	V	PLI
Hindiya Barrage	1.4	0.1	1.8	2.9	2.1	1.3	8.5	0.3	0.6	1.3	0.4	4.0	1.2	1.2
Hindiya	1.1	0.1	0.8	2.4	1.5	1.0	6.5	0.2	0.4	0.9	0.2	2.6	1.1	0.8
Kifil	1.2	0.1	1.0	2.3	1.6	1.1	6.3	0.3	0.5	0.9	0.3	3.3	1.3	0.9
Kufa	1.4	0.1	1.9	3.0	1.9	1.4	7.7	0.4	0.7	1.1	0.4	9.1	1.0	1.3
Shamiya	1.9	0.2	2.3	3.0	2.2	1.5	8.9	0.4	0.8	1.0	0.5	5.7	1.1	1.4
Abu-Skheer	1.2	0.1	1.3	2.6	1.8	1.2	7.7	0.3	0.6	1.0	0.4	3.8	1.3	1.1
Mishkhab	2.2	0.3	3.4	3.1	2.2	1.6	8.3	0.6	0.7	1.6	0.6	5.7	1.1	1.6
Ghammas	1.8	0.2	2.3	3.3	2.4	1.6	10	0.4	0.9	1.3	0.4	5.5	1.3	1.4
Shanafiya	1.8	0.2	2.3	3.3	2.5	2.0	10	0.3	0.9	1.3	0.4	5.4	1.2	1.5
Samawa	1.9	0.2	2.4	3.1	2.5	1.9	10	0.4	0.9	1.1	0.5	5.7	1.1	1.5
Kidhir	1.9	0.2	2.4	3.3	2.6	2.3	11	0.4	0.9	1.3	0.5	5.8	1.2	1.5
Batha	1.8	0.2	2.4	3.2	2.6	2.0	11	0.4	0.9	1.4	0.5	5.8	1.2	1.5
Nasiriya	1.8	0.2	2.3	3.2	2.4	1.8	9.5	0.4	0.8	1.3	0.5	5.7	1.1	1.4

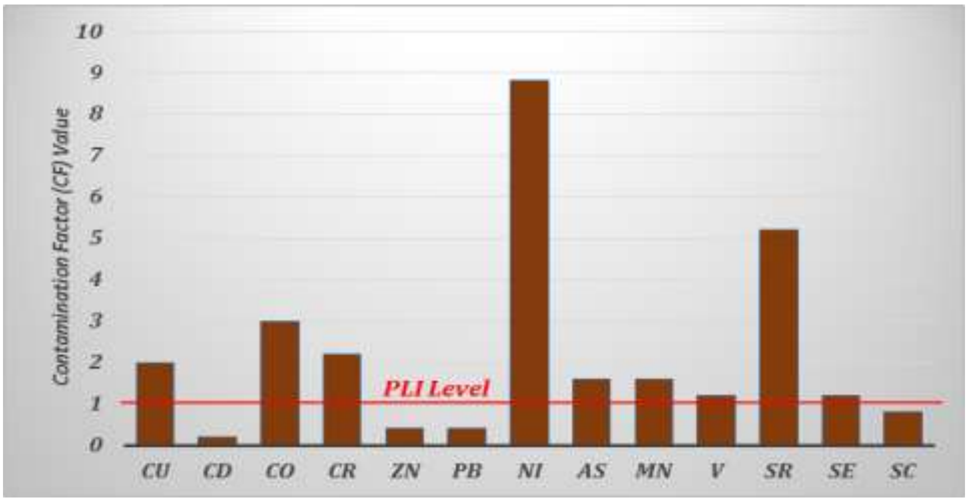

Figure 4- Contamination Factor (CF) values and PLI level of heavy metals in the study area of Euphrates River.

2.4 Results and Discussion

In order to assess the metal content in river sediments, it is important to establish the natural levels of these metals. Apart from natural contribution, heavy metals may be incorporated into the aquatic system from anthropogenic sources such as solid and liquid wastes of industries. Some degree of contamination may be caused from fall out of industrial emissions from the atmosphere.
Using the Enrichment Factor (EF) considered as an effective tool to evaluate the magnitude of metal contamination in soil [29], however, according to results of Enrichment factor listed in Table-5, the contamination factor of Ni and Sr in the sediments at (EF=9.90 and 5.90) respectively might be said to

come from Significant human influence, [10 and 11]. [30] suggested that EF values above 1.5 as in elements As, Cu, Co, Cr, Mn and Se have significant portion of the heavy metals delivered from non-crustal materials or from human influence, which therefore supposes that the contamination from these metals in the sediments are from Irrigation water (As, Cu and Se), Sewage sludge, mainly from municipal wastes (Cu, Co, Cr and Mn), Phosphate fertilizers (Only Cu). metals of V, Sc, Zn, Pb and Cd with EF value 1.30, 0.80m 0.50, 0.40 and 0.20 respectively having Deficiency to Minimal Enrichment which are reflect that no human influence on the River sediments by these metals. [31].

Table 5- Range and mean of EF values and Category for metals in Euphrates River Sediments

Heavy metals	EF value of River Sediments		EF Category
	Range	Mean	
Arsenic (As)	1.45-2.16	1.80	Deficiency to Minimal Enrichment
Cadmium (Cd)	0.13-0.22	0.20	Deficiency to Minimal Enrichment
Copper (Cu)	1.16-2.82	2.20	Moderate Enrichment
Cobalt (Co)	2.53-4.10	3.35	Moderate Enrichment
Chromium (Cr)	1.85-2.73	2.40	Moderate Enrichment
Manganese (Mn)	1.30-2.31	1.80	Deficiency to Minimal Enrichment
Nickel (Ni)	6.84-10.97	9.90	Significant Enrichment
Lead (Pb)	0.32-0.54	0.40	Deficiency to Minimal Enrichment
Scandium (Sc)	0.59-0.97	0.80	Deficiency to Minimal Enrichment
Selenium (Se)	2.0-2.73	2.30	Moderate Enrichment
Strontium (Sr)	3.90-12.40	5.90	Significant Enrichment
Vanadium (V)	0.90-1.75	1.30	Deficiency to Minimal Enrichment
Zinc (Zn)	0.35-0.53	0.50	Deficiency to Minimal Enrichment

Using the I_{geo} to find out the Enrichment of metal concentration above baseline concentrations Table-6, sediments were classified as Moderate polluted by Ni and Sr, while sediments are Unpolluted to Moderate polluted by As, Cu, Co, Cr and Mn and Unpolluted by V, Sc, Zn, Pb, Se and Cd. The results of I_{geo} value are confirm that in Enrichment factor as mentioned above.

Table 6- Range and mean of I_{geo} values and Grades for elements in Euphrates River Sediments

Heavy metals	$I\text{-}_{geo}$ value of Euphrates River Sediments		$I\text{-}_{geo}$ Grade
	Range	Mean	
Arsenic (As)	-0.35-0.36	0.10	Unpolluted to Moderate
Cadmium (Cd)	-2.84-1.72	-2.20	Unpolluted
Copper (Cu)	-0.66-0.82	0.20	Unpolluted to Moderate
Cobalt (Co)	0.42-0.80	0.70	Unpolluted to Moderate
Chromium (Cr)	-0.03-0.57	0.40	Unpolluted to Moderate
Manganese (Mn)	-0.39-0.41	0.03	Unpolluted to Moderate
Nickel (Ni)	1.43-1.97	1.80	Moderate polluted
Lead (Pb)	-1.96-0.93	-1.50	Unpolluted
Scandium (Sc)	-1.30-0.50	-0.70	Unpolluted
Selenium (Se)	-0.56-0.046	-0.20	Unpolluted
Strontium (Sr)	0.55-1.80	1.20	Moderate polluted
Vanadium (V)	-0.44-0.14	-0.30	Unpolluted
Zinc (Zn)	-1.85-0.90	-1.30	Unpolluted

Using the Contamination factor (CF), Table-7, to find out the polluted in each station by Pollution Load Index (PLI), whereat the elements of Ni and Sr with Contamination factor values of 8.84 (Very high pollution) and 5.23 (Considerable pollution) respectively show that these elements are above its background average in worldwide soil and reflect the influence of external discrete sources like industrial activities, agricultural runoff and other anthropogenic inputs. While the elements of Co, Cr, Cu, As, Mn, Se and V with contamination factor values of 2.97, 2.18, 2.03, 1.63, 1.59, 1.19 and 1.16 (Moderate pollution) show that these elements are slightly above its background average in worldwide soil and reflect both natural and anthropogenic sources. The elements of Sc, Zn, Pb and Cd reflect these elements are of lithogenic source. Degree of contamination by the 13 metals studied in the studied sites are of the order Mishkhab> Batha, Kidhir, Samawa and Shanafiya> Ghammas, Nasiriya and Shamiya> Kufa> Hindiya Barrage> Abu-Skheer, while the stations of Kifil and Hindiya are Unpolluted by the sum of Studied Heavy metals. Table-4.

Table 7- Range and mean of CF values and Grade for elements in Euphrates River Sediments

Heavy metals	CF value of River Sediments		CF Grade
	Range	Mean	
Arsenic (As)	1.05-2.16	1.63	Moderate Pollution
Cadmium (Cd)	0.09-0.27	0.17	Low Pollution
Copper (Cu)	0.78-3.42	2.03	Moderate Pollution
Cobalt (Co)	2.27-3.30	2.97	Moderate Pollution
Chromium (Cr)	1.45-2.64	2.18	Moderate Pollution
Manganese (Mn)	1.02-2.27	1.59	Moderate Pollution
Nickel (Ni)	6.28-10.78	8.84	Very High Pollution
Lead (Pb)	0.21-0.59	0.35	Low Pollution
Scandium (Sc)	0.43-0.94	0.76	Low Pollution
Selenium (Se)	0.86-1.57	1.19	Moderate Pollution
Strontium (Sr)	2.59-9.05	5.23	Considerable Pollution
Vanadium (V)	0.96-1.31	1.16	Moderate Pollution
Zinc (Zn)	0.24-0.62	0.42	Low Pollution

3. Conclusion

Anthropogenically impacted on the sediments of Euphrates River at the study area were assessed using enrichment factors, contamination factors, pollution load index and geo-accumulation index for the metals As, Cd, Co, Cu, Cr, Mn, Ni, Pb, Sc Se, Sr, V and Zn. Enrichment factor ratios showed that elements of As, Cd, Mn, Pb, Sc, V and Zn were deficiently to minimally enriched, while the elements of Cu, Co, Cr and Se were moderately enriched, and significant enriched for elements of Ni and Sr. The geo-accumulation index showed that sediments of Euphrates River are unpolluted by elements of Cd, Pb, Sc, Se, V and Zn, unpolluted to moderately polluted by the elements of As, Cu, Co, Cr and Mn, while the sediments are moderate polluted by elements of Ni and Sr. The measure of the degree of overall contamination (PLI) at a station indicated strong signs of pollution deterioration by the thirteen measured metals at all studied stations expect Hindiya and Kifil stations with PLI value 0.8 and 0.9 respectively, reflect that no overall contamination by the thirteen measured metals in these two station.

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