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Estimation of Some Heavy Elements Transported in the Suspended River Load of the Tigris and Euphrates Rivers

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Abstract
This study was conducted to determine the contamination level of suspended sediments coming from Tigris and Euphrates rivers with heavy metals namely Zn, V, Ni, Co, Mn, Fe, Cr, Cu, Cd, and Pb, within Iraqi alluvial plain area in Baghdad, Wasit, and Misan Babel and Diwaniyah governorates during the year 2023, suspended sediment samples were collected using pumps to suction the samples and passing them through filters to catch the sediment. The sediments were dried, grind, and sieved. Heavy metals were extracted using the digestion method and then determined using a spectrophotometer. Contamination indices were including Contamination Degree, Enrichment Factor, Pollution Load Index, Geo Accumulation Index. The results showed that the total concentrations of heavy metals in suspended sediment samples of the Tigris and Euphrates rivers were higher than the background values, and most of the concentrations values in the Tigris River were higher than in the Euphrates River and increase in the concentrations of polluting elements in the sediments also with the distance mileage through the river. The contamination factor (CF) values sediments were according sequence: CF= Ni > Cr > Sr > Cu > Co > V > Zn > Cd > As > Mn > Fe > Pb. The most of the CF values for the elements were within moderate contamination. The values of the contamination degree (Cdeg) indicate were as follows: Cdeg = Misan > Waist > Diwanya > Baghdad > Babel. That most of the values of the contamination degree (C_{deg}) were within the considerable degree of contamination. The pollution load index (PLI) values were greater than 1 in all sites, which indicates the presence of pollution in all sites. These values differed from one site to another, and were sequence: PLI = Misan > Waist > Diwanya > Baghdad > Babel. The enrichment factor (EF) for the (V, Zn, Pb, Mn, Co, Cd, As) were within deficiently to minimal enrichment. and the enrichment factor (EF) for the (Cu, Cr, Sr) were within the moderate enrichment index. the enrichment factor (EF) for the (Ni) were within the Significant enrichment. The Geo accumulation index that each value in most of the sites was less than 1 and is within Uncontaminated to moderately.
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1. Introduction

The Tigris and Euphrates rivers are the main source of water on which Iraq depends mainly for drinking, irrigation and other uses. These rivers originate in Turkey, passing through Syria and then Iraq, where they pass through many cities and agricultural lands and near factories and Sewage treatment plants, carrying with them many diverse sediments, the source of which are erosion processes. Transport and sedimentation. (Al-Ansari et al 2019).

River sediments play a role in transporting mineral pollutants as they flow in the river, as pollutants are transported from the source area of these sediments through various riverine environments, from city waste, drainage channels to agricultural lands, and what factories release, whether in the form of dust, solid, liquid or gaseous waste, as they may contribute to Soil particle pollution transported through the river. Butler et al.,2023).

Pollution of the river network has extremely harmful effects on humans and the environment. In addition, it paves the way for the spread of dangerous diseases through water (Shilsar et al, 2023). In addition, these polluted river sediments, especially suspended ones, are deposited on the surface of agricultural lands after irrigation, which may add fertilizers and pollutants to agricultural soils. (Al-Shihmani,2022).

Heavy elements are created in the sediments carried in the river as a result of natural processes that take place on the rocks. At the forefront of these processes are weathering, both physical and chemical, and the process of erosion and transport, and what wind sediments add the rivers. Human activities come in second place, whether industrial activity or agricultural activity, as they contribute to the disposal of solid waste, liquid and gaseous in rivers, which increases their pollution (Mondal et al,.2018)

The sediments carried in rivers, bottom sediments, and sediments deposited on river banks all have a role in capturing and isolating passing pollutants, especially heavy metals. These heavy elements may be generated naturally as a result of weathering processes or generated by human activity (May et al,. 2023).

These sediments, which are transported with river water, may be deposited later, especially on agricultural lands after irrigation, which may add mineral or organic pollutants to the surface of the soil. The concentrations and quality of pollutants in these sediments vary as the distance and time period of their stay within the river load increases, as these carried sediments may pass through pollutant-generating areas, especially where solid and liquid wastes are thrown away without being properly treated. This situation occurs in developing countries without warning of pollution problems. (Wang et al,.2023).

During recent years, there has been an increase in population numbers, and despite scientific development, the problems of environmental pollution with heavy metals have increased. Climate changes and global warming have affected the amount of rain and drought, in addition to the increased demand for water and the construction of dams and reservoirs in the areas of river sources, which has affected the decrease in the water shares of the rivers. In turn, it affected the speed of water flow, the content of the river load of these sediments, the nature of the mineral content, and the concentration of pollutants in it. (Xu et al,.2019).

High levels of heavy elements in water sediment, especially cadmium (Cd), arsenic (As), chromium (Cr), mercury (Hg), nickel (Ni), copper (CU), and cobalt (Co), have a significant impact on the lives of most living organisms because they are incredibly harmful environmental pollutants that can travel and biomagnify through food chains and seriously threaten human health (Zaynab et al, 2022).

Many studies were conducted to estimate the percentage of pollution with heavy metals in different locations of Iraqi soil. Most of the studies targeted cities, factories, electric power plants, oil facilities, and brick factories. Studies were conducted regarding river sediments (Mahmmoud et al, 2023; AI-Shawi et al, 2022; Issa et al,.2020; Kadhum et al,.2020 However, there is little research in the field of river sediment pollution, especially suspended sediments, which represent fine-sized particles that have a role in adsorption of pollutants to their surfaces.

There has been water scarcity and a decrease in water releases in recent years due to climate change, in addition to the role of human activities in storing water by building dams and reservoirs along river channels. There have been changes in the quantity and quality of sediments as well as water-borne pollutants (Adamo et al., 2020). Therefore, the current study aims to estimate the levels of pollution with heavy elements in suspended river load sediments transported by the Tigris and Euphrates rivers within the Iraqi alluvial plain region, in addition to estimating pollution indicators with these elements and the extent to which natural and human factors contribute to increasing pollution levels. Where this may lead to contamination of agricultural lands with heavy metals as a result of irrigating them with water that contains sediments in the long term.

2. Materials and methods

A laboratory experiment was carried out in 2023, which included collecting samples of the suspended river load sediments of the Tigris and Euphrates rivers in Iraq. The samples were collected during the month of January at the peak of the river load, after identifying sites to take samples of the suspended river load sediments. The samples were collected from the Tigris River in the governorates of Baghdad, Waist, and Misan. and in the Euphrates River in the governorates of Babel and Diwaniyah. Samples were collected by drawing water samples loaded with suspended sediments and passing them through filters to catch the suspended sediments. Several pumps were used to withdraw samples from the river within the specified locations and from different distances within the same channel (from the middle of the river, near the river bank, between the river bank and the middle of River) and at different depths (1 m, 2 m, 4 m), and water samples were passed through several filters for the purpose of capturing sediments. Collecting samples took a long period of time in addition to making an effort to obtain them. After collecting the sediment samples, they were dried, separated, and then sieved using a sieve with a hole diameter of 2 mm to conduct laboratory tests on them.

For estimating the total concentration of heavy metals in suspended river sediments. Taking 100 grams of suspended river load sediment samples for the purpose of conducting analyzes and estimating the total concentrations of the following heavy elements (Zn, V, Ni, Co, Mn, Fe, Cr, Cu, Cd, and Pb) by following Energy Dispersive X-ray Fluorescence (EDXRF) technique by using the SPECTRO XEPOS device .The device performs two types of analysis: a qualitative analysis that determines the type of element present in the sample, and a quantitative analysis that shows the amount of the element in the sample, according to Moseley's law. Qualitative analysis is the basis for quantitative analysis (Yao et al,.2015) , after obtaining the results, it converted the elements from percentages to ppm, and their formulas were converted from oxides to elements (Essington ,2015).

After obtaining the results, mathematical methods were used to find indicators of environmental pollution for river sediments and were compared with mean background contents of heavy metals in surface soils(ppm) mentioned in (Kabata-Pendias and Pendias 1999-2001). were calculated the Contamination Factor (CF), Contamination Degree (C_{deg}), Enrichment factor (EF), geo-accumulation index (I-geo) and pollution load index (PLI) as environmental to pollution indicators of river sediments in Tigris and Euphrates river, as follow.

1- Contamination Factor (CF): The Contamination Factor (CF) is necessary to classify the level of contamination of metals in the soil and sediment samples of river (Hakanson,1980).

$$C_f^i = {C_s^i}/{C_r^i} \quad \ldots\ldots\ldots(1)$$

Where: C_f^i= Contamination Factor, C_s^i= concentration of the element in the sample mg kg^{-1} , C_r^i= concentration of the element in the reference sample mg kg^{-1} .

2- Contamination Degree (C_{deg}): (Hakanson ,1980)

$$\mathbf{C_{deg}} = \sum_{i=0}^{n} \boldsymbol{C_f^i} \text{ ....(2)}$$

Where : C_{deg} = Contamination Degree C_f^i= Contamination Factor

3- Enrichment Factor (EF): is one of the mathematical relations used globally to describe the degree of pollution due to human activity to determine the enrichment ratios (Zakir et al., 2008).

EF= ((X/Fe) sample)/(X/Fe) background)) ....(3)

Where:(X/Fe) sample= concentration of the element divided by concentration of iron in the sample mg kg^{-1}.

(X/Fe) background= concentration of the element divided by concentration of iron in the background sample mg kg-1.

4 -Pollution Load Index (PLI) (Tomlinson et al,.1980)

$$\mathbf{PLI}=\left(C_f^1 * C_f^2 * C_f^3 * C_f^4 * C_f^5 * \ldots\ldots\ldots.* C_f^n\right)^{1/n} \text{ ....(4)}$$

Where: PLI= Pollution Load Index , C_f^1 , C_f^3 , C_f^2.= Contamination factor for the first, second and third elements...etc. and n = The number of contaminated items.

5 -Geo Accumulation Index (I_{geo}): (Muller, 1969)

$$\boldsymbol{Igeo = log\,2}\left[\boldsymbol{C_s^i sample} \Big/ \left(\mathbf{1.5} * \boldsymbol{C_r^i Background}\right)\right] \text{ ....(5)}$$

C_s^i = concentration of heavy metal in the sample (ppm), C_r^i = background value concentration of heavy metal ,1.5= Factor used for the some variations of the background data due to lithological variations.

All results were compared with Pollution indices values for soil and river sediments listed in Table 1.

Table 1. Pollution indices values for soil and river sediments

Contamination factor value		
CF Value	Contamination class	
CF < 1	low contamination	
1≤CF<3	moderate contamination	
3 ≤ CF < 6	considerable contamination	
CF ≥ 6	very high contamination	
Contamination Degree		
Cdeg<8	Low degree of contamination	
Cdeg<168<	Moderate degree of contamination	
Cdeg<3216<	Considerable degree of contamination	
32 >Cdeg	Very high degree of contamination	
Enrichment factor		
EF Value	Pollution	
EF < 2	Deficiently to minimal enrichment	
2 < EF < 5	Moderate enrichment	
5 < EF < 20	Significant enrichment	
20 < EF < 40	Very high enrichment	
EF > 40	Extremely high enrichment	
Pollution load index		
PLI < 1	Indicate uncontaminated site	
PLI =1	Pollutants are present only at baseline level	
PLI > 1	Indicate deterioration of site quality	
Geo accumulation index		
Class	Igeo value	Interpretation
0	Igeo < 0	Practically uncontaminated
1	10 < Igeo <	Uncontaminated to moderately contaminated
2	1 < Igeo < 2	Moderately contaminated
3	2 < Igeo < 3	Moderate to strongly contaminated
4	3 < Igeo < 4	Strongly contaminated
5	4 < Igeo < 5	Strongly to very strongly contaminated
6	Igeo > 5	Very strongly contaminated

3. Results and discussion

It is clear from Table 2 of the total concentrations of heavy metals in suspended sediment samples of the Tigris and Euphrates rivers that the concentrations of heavy metals were: arsenic (AS) ranging from 5.3 to 8.4 ppm, cadmium (Cd) ranging from 0.6 to 3.8 ppm, and copper (Cu). It ranged from 20.2 to 43.1 ppm, cobalt (Co) ranged from 8.5 to 18.3 ppm, chromium (Cr) ranged from 77.8 to 230.4 ppm, manganese (Mn) ranged from 425 to 723 ppm, and nickel (Ni) ranged from 97 to 164 ppm. Lead (Pb) ranged from 10.8-51.2 ppm, Zinc (Zn) ranged from 50.3-198 ppm, Strontium (Sr) ranged from 289-504 ppm, and Vanadium (V) ranged from 75-134 ppm, finally, iron (Fe), the value ranged from 3596 to 4298 ppm.

Table 2. Total concentrations (ppm) of heavy metals in suspended sediment samples of the Tigris and Euphrates rivers

Location	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Zn	Sr	V	Fe
Baghdad	5.3	1.6	26.8	8.5	142.2	425	97	28.4	81.0	290	95	3674
Waist	6.9	2.2	38.4	15.7	230.4	548	150	15.3	93.2	345	107	3965
Misan	8.4	3.8	43.1	17.1	119.0	723	164	51.2	198.0	504	134	4298
Babel	6.1	0.6	20.2	15.5	77.8	432	111	10.8	50.3	289	75.	3596
Diwanya	8.3	0.8	33.1	18.3	98.2	656	156	14.7	79.4	311	86.	3851
Background	4.7	1.1	14	6.9	42	418	18	25	62	147	60	3500

It is clear that most of the values were higher than the background values, and most of the values in the Tigris River were higher than in the Euphrates River, these results are consistent with what Rabee, and Al-Fatlawy (2009) found. It notices an increase in the concentrations of polluting elements in the sediments also with the distance traveled through the river, due to sewage pipes, pesticides, and fertilizers for the agricultural lands adjacent to the river, and some factory wastes along the river. These results are consistent with Li et al (2023) found, as they found an increase in the concentration of heavy elements (zinc, lead, cadmium) in the suspended sediments of the river load compared to what is found in the earth's crust. They indicated that the sources of pollution are from factories and agricultural lands, which contributed to an increase in the concentrations of the elements. Heavy in river sediments.

It is clear from Table 3 of the contamination factor (CF) values for the suspended river sediments that their values for the heavy elements were according to the following sequence:

CF= Ni > Cr > Sr > Cu > Co > V > Zn > Cd > As > Mn > Fe > Pb

Table 3. Contamination Factor (CF), Contamination degree (C_{deg}) and Pollution Load Index (PLI) value

Location	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Zn	Sr	V	Fe	C_{deg}	PLI
Baghdad	1.12	1.45	1.91	1.23	3.38	1.02	5.39	1.14	1.31	1.97	1.58	1.05	**22.55**	**1.62**
Waist	1.46	1.83	2.74	2.27	5.48	1.31	8.33	0.61	1.50	2.34	1.78	1.13	**30.78**	**2.00**
Misan	1.78	3.45	3.07	2.47	2.80	1.72	9.11	2.04	3.19	3.42	2.23	1.23	**36.51**	**2.65**
Babel	1.29	0.54	1.14	2.24	1.85	1.03	6.16	0.43	0.81	1.96	1.25	1.03	**19.73**	**1.27**
Diwanya	1.76	0.72	2.36	2.65	2.33	1.57	8.66	0.59	1.28	2.11	1.43	1.10	**26.56**	**1.71**
Min	1.12	0.54	1.14	1.23	1.85	1.02	5.39	0.43	0.81	1.96	1.25	1.03	**19.73**	**1.27**
Max	1.78	3.45	3.07	2.65	5.48	1.72	9.11	2.04	3.19	3.42	2.23	1.23	**36.51**	**2.65**
Mean	1.48	1.60	2.24	2.17	3.17	1.33	7.53	0.96	1.62	2.36	1.65	1.11	**27.23**	**1.85**

According to Hakanson (1980), the contamination factor (CF) values for nickel were within very high contamination, while the CF values for chromium were within significant contamination - moderate contamination, but most of the CF values for the elements were within moderate contamination. The increase in the values of both nickel and chromium may be due to the role of what is released by laboratories, factories, and electric power generation stations, especially those located near rivers, which increases levels of pollution beyond global limits with these two elements (Yang et al,.2023). Likewise, throwing liquid waste, fertilizers, agricultural pesticides, and urban waste may contribute to Increased pollution with heavy metals. Yuan et al (2015) have shown that the passage of rivers in urban areas, in addition to a decrease in the intensity of water currents due to water scarcity or due to their passage through dams, leads to a decrease in their flow, which may contribute to giving more opportunity to increase the concentration of pollutants in the sediments carried in the rivers.

The values of the contamination degree (C_{deg}) indicate the degree of total pollution according to the site, as it is clear from Table 3 that its values for the study sites were as follows.

C_{deg} = Misan > Waist > Diwanya > Baghdad > Babel

It is clear that most of the values of the contamination degree (C_{deg}) according to Hakanson (1980) were within the considerable degree of contamination. The reason may be due to the lack of water releases into the rivers, which may reduces the contribution to washing out or reducing the concentration of pollutants in the rivers and displacing pollutants to the sea, in addition to an increase in the quantity and sources of pollutants, in river water in recent years , Yue-Fang et al (2022) stated that this is also due to local industries, including textile printing and dyeing, electroplating, chemical manufacturing, agriculture, and metal manufacturing, all of which are causes of heavy metal pollution. Among all this, textile dyeing and printing factories, and metal manufacturing factories are the main causes of pollution. In addition, the suspended river load of sediments with fine particles, especially clay, has the ability to adsorb pollutants on the surfaces of the clay particle charges (Chen et el,.2016). It is also evident that most values of the contamination degree C_{deg} increase with the distance traveled by rivers from one location to another. On the other hand, the increase in values of the contamination degree can also be explained by an increase in the concentration of heavy elements in the rainy seasons and the flow of water laden with sediments and pollutants due to industrial/agricultural/domestic runoff that flows into the river. (Gaur et al 2005). It is clear from Table 3 that the pollution load index (PLI) values were greater than 1 in all sites, which indicates the presence of pollution in all sites. These values differed from one site to another, and were in the following sequence:

PLI = Misan > Waist > Diwanya > Baghdad > Babel

It is clear that the pollution load index (PLI) values increase with the distance that the sediments travel during their flow in the river. This is due to the fact that the majority of these sediments are fine particles that have the ability to adsorb pollutants on their surfaces, which increases the concentrations of pollutants on the surfaces of the particles with distance, (Chen et el,.2016).

It is clear from Table 4 that the values of the enrichment factor (EF) for the arsenic element (AS) were in the range of 1.07 - 1.60, and according to the enrichment factor (EF) index, it is within deficiently to minimal enrichment. As for the cadmium element, the enrichment factor (EF) was in the range of 0.53 to 2.82, which is within the deficiently to minimal enrichment index in all governorates, except for the Misan site, where it was within the moderate enrichment index. As for the copper element, the enrichment factor values ranged from 1.40-2.51, where it was within the deficiently to minimal enrichment index. enrichment, with the exception of the Wasit, Misan and Diwanya sites, where they were included in the moderate enrichment index. cobalt enrichment factor values ranged from 1.17 to 2.41, where they were included in the moderate enrichment index.

Table 4. Enrichment Factor (EF)

Location	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Zn	Sr	V
Baghdad	1.07	1.39	1.82	1.17	3.23	0.97	5.13	1.08	1.24	1.88	1.51
Waist	1.30	1.77	2.42	2.01	4.84	1.16	7.36	0.54	1.33	2.07	1.57
Misan	1.45	2.82	2.51	2.02	2.31	1.41	7.42	1.67	2.60	2.79	1.82
Babel	1.26	0.53	1.40	2.19	1.80	1.01	6.00	0.42	0.79	1.91	1.22
Diwanya	1.60	0.66	2.15	2.41	2.13	1.43	7.88	0.53	1.16	1.92	1.30
Min	1.07	0.53	1.40	1.17	1.80	0.97	5.13	0.42	0.79	1.88	1.22
Max	1.60	2.82	2.51	2.41	4.84	1.43	7.88	1.67	2.60	2.79	1.82
Mean	**1.34**	**1.43**	**2.06**	**1.96**	**2.86**	**1.20**	**6.76**	**0.85**	**1.42**	**2.11**	**1.48**

In all sites except the Baghdad site, where they were included in the deficiently to minimal enrichment index. The enrichment factor for chromium ranged between 1.80-4.84 and was within the moderate enrichment index, except for the Babel site, where it was within the deficiently to minimal enrichment index. It is noted that the values of the enrichment factor for manganese were in the range of 0.97-1.43, and in all locations it was within the deficiently to minimal enrichment index. As for the nickel element, it was in the range of 5.13 - 7.88, and the value in all sites was within the Significant enrichment index. The values of the enrichment factor for the element lead ranged between 0.42 - 1.67, as it is clear that every value in all sites is within the deficiently to minimal enrichment index.

The values of the enrichment factor for the element zinc was in the range of 0.79 - 2.60, which was a value in all sites within the deficiently to minimal enrichment index, except for the Misan site, which was a value within the moderate enrichment index. It is clear that the values of the enrichment factor for the element strontium were in the range of 1.88-2.79, as every value was within the deficiently to minimal enrichment index, with the exception of the wasit and Misan sites, where they were within the moderate enrichment index. As for the values of the enrichment factor for the element vanadium (V), it was a value in the range of 1.22 - 1.82, and it was in all locations within the deficiently to minimal enrichment index. (Sutherland et al,.2000) showed that enrichment factor values that are greater than 1.5 indicate the role of human activities in contributing to increasing the values of polluted elements in the soil, while enrichment factor values that are less than 1.5 indicate that the source of pollution is due to weathering processes resulting from natural conditions without human intervention in them. It is clear from the table 4 that the enrichment factor values for the sediments of the Tigris river are higher than the Euphrates river in most of the contaminated elements, these results are consistent with what Rabee, and Al-Fatlawy (2009) found, with the exception of arsenic (AS), cobalt and nickel, where the enrichment factor values were higher in the Euphrates river. This may be due to the difference in human activity between the two rivers in terms of the nature of the sources to which humans contribute to increasing their activity, as well as the type of human activity, whether laboratories, Sewage treatment plants, factories, facilities that generate electricity or others, which are located near the rivers.

It is noted that there is a variation in the enrichment factor in the same river, especially with distance, which may be attributed to the increase in concentrations of heavy elements in the sediments of the suspended river load due to the increase in water returned from urban areas, factories and agricultural lands and its leakage into the rivers (Al Obaidy et al,.2014). Since these sediments are in the form of fine particles, they have the ability to adsorb these heavy elements and hold them over distance.

from Table 5 for the Geo accumulation index we can see that each value in most of the sites was less than 1 and is within Uncontaminated to moderately, as the I_{geo} values for the arsenic element (AS) ranged between 0.18-0.38 and is within Class 1 (Uncontaminated to moderately). The I_{geo} for the cadmium element was in the range of -0.14-0.66, which is in Class 1 (Uncontaminated to moderately) in all locations except for Babel and Diwaniyah Governorates, which are in Class 0 (Practically uncontaminated). As for the copper element, the I_{geo} values were in the range of 0.28 - 0.61, which is in Class 1 (Uncontaminated). to moderately) in all sites. I_{geo} values for cobalt ranged from 0.21 to 0.54 and are within class 1 (Uncontaminated to moderately) in all sites. I_{geo} values for chromium ranged from 0.39 to 0.86 and are within class 1 (Uncontaminated to moderately) in all sites.

Table 5. I_{geo} value

Location	As	Cd	Cu	Co	Cr	Mn	Ni	Pb	Zn	Sr	V	Fe
Baghdad	0.18	0.29	0.41	0.21	0.65	0.13	0.86	0.18	0.24	0.42	0.32	-0.16
Waist	0.29	0.43	0.56	0.47	0.86	0.24	1.05	-0.09	0.30	0.50	0.38	-0.12
Misan	0.38	0.66	0.61	0.51	0.58	0.36	1.08	0.44	0.63	0.66	0.47	-0.09
Babel	0.24	-0.14	0.28	0.47	0.39	0.14	0.91	-0.24	0.03	0.42	0.22	-0.16
Diwanya	0.37	-0.01	0.50	0.54	0.49	0.32	1.06	-0.11	0.23	0.45	0.28	-0.13
Min	0.18	-0.14	0.28	0.21	0.39	0.13	0.86	-0.24	0.03	0.42	0.22	-0.16
Max	0.38	0.66	0.61	0.54	0.86	0.36	1.08	0.44	0.63	0.66	0.47	-0.09
Mean	0.29	0.25	0.47	0.44	0.59	0.24	0.99	0.04	0.29	0.49	0.33	-0.13

The I_{geo} values for manganese ranged from 0.13 to 0.36, which is within Class 1 (Uncontaminated to moderately) in all locations. The I_{geo} values for nickel ranged from 0.86 to 1.08, which is within Class 1 (Uncontaminated to moderately), while it was within Class 2 (Moderately contaminated).in Wasit, Misan and Diwaniyah governorates. The I_{geo} values for lead ranged between -0.24 - 0.44, and it was in Class 1 (Uncontaminated to moderately) in Baghdad and Misan Governorates, while it was in Class 0 (Practically uncontaminated) in Wasit, Babel, and Diwaniyah Governorates. The I_{geo} values for zinc ranged from 0.03 to 0.63 and are within class 1 (Uncontaminated to moderately) in all sites. The I_{geo} values for Strontium (Sr) ranged between 0.42-0.66 and are within class 1 (Uncontaminated to moderately) in all locations. I_{geo} values for Vanadium (V) ranged from 0.22 to 0.47 and are within class 1 (Uncontaminated to moderately) in all sites. The I_{geo} values for iron ranged from -0.09 - -0.16 and are in class 0 (Practically uncontaminated).

From Table 5 that the I_{geo} values are in the category 0 (Practically uncontaminated), which includes the elements iron, lead, and cadmium. This category (0) indicates that the soil is not contaminated with the previous elements due to the contribution of earthly elements and the absence of a geological source in the ground that contributed to the pollution. The I_{geo} values within Class 1 (Uncontaminated to moderately) were all of the elements arsenic, copper, cobalt, chromium, manganese, zinc, Strontium, and Vanadium. This class indicates (1) that soil contamination with these elements was among the uncontaminated. And moderate pollution, meaning that there is a weak role in soil pollution due to the mineral composition of the geological origin. As for the element nickel, the I_{geo} values for it were in category 2 (Moderately contaminated), meaning there is a moderate contribution in some locations, which may be close to weak. In other words, there is a contribution due to the mineral composition of the geological origin in soil contamination with the element nickel. Most of the previous results for the values of I_{geo} agree with the findings of Rabee et al,.2011; Kamel et al,.2023. These results are an indicator of the nature of the mineral composition of the rocks that generated these deposits and the polluting elements they contain that are part of their composition and may some contribute to the pollution of nature.

Conclusion

The pollution of suspended river load sediments in the Tigris and Euphrates rivers in the Iraqi alluvial plain region was estimated with heavy elements (Zn, V, Ni, Co, Mn, Fe, Cr, Cu, Cd, and Pb). The pollution indicators were calculated by the Contamination Factor (CF), Contamination Degree (Cdeg), Enrichment factor (EF), geo-accumulation index (I-geo) and pollution load index (PLI) as environmental to pollution indicators of river sediments in Tigris and Euphrates river. The results showed that there is pollution in these sediments due to human activities in All study sites were polluted with heavy elements. Pollution increased with the distance traveled by sediment in the river, because suspended river sediments are fine particles, they have the ability to absorb heavy elements. It is clear that there is an increase in the concentrations of most polluting elements in the Tigris River compared to the Euphrates River, and this is due to a difference in the nature of human activity in terms of type and size. There was a major role in the contribution of climate change, water scarcity, and the lack of water releases in the Tigris and Euphrates rivers in increasing sediment pollution with heavy elements, in addition to the increase in human activities due to population increase and expansion, which contributed to the rise in pollutants at a rate exceeding the permissible limits for some polluting elements.

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References

Adamo, N., Al-Ansari, N., & Sissakian, V. K. (2020). Global climate change impacts on Tigris-Euphrates Rivers basins. Journal of Earth Sciences and Geotechnical Engineering, 10(1), 49-98.

AI-Shawi, S. R., Kadhim, H. A., & Al-Saad, H. T. (2022). Assessment of heavy metals in exchangeable sediments samples from Tigris–Euphrates and Shatt al-Arab rivers. Technology audit and production reserves, 6(3 (68)), 6-14.

Al Obaidy, A. H. M. J., Talib, A. H., & Zaki, S. R. (2014). Environmental assessment of heavy metal distribution in sediments of Tigris River within Baghdad City. International Journal of Advanced Research, 2(8), 947-952.

Al-Ansari, N., Adamo, N., & Sissakian, V. (2019). Water shortages and its environmental consequences within Tigris and Euphrates Rivers. Journal of Earth Sciences and Geotechnical Engineering, 9(4), 27-56.

Al-Shihmani, L. S. S. (2022). A study of the distribution of the Tigris River sediments and the variation of their chemical, physical and mineral properties and the effect caused by Kut Dam. Sarhad Journal of Agriculture, 38(5), 130-142.

Butler, M. J., Yellen, B. C., Oyewumi, O., Ouimet, W., & Richardson, J. B. (2023). Accumulation and transport of nutrient and pollutant elements in riparian soils, sediments, and river waters across the Thames River Watershed, Connecticut, USA. Science of The Total Environment, 899, 165630.

Chen, Y. M., Gao, J. B., Yuan, Y. Q., Ma, J., & Yu, S. (2016). Relationship between heavy metal contents and clay mineral properties in surface sediments: Implications for metal pollution assessment. Continental Shelf Research, 124, 125-133.

Essington, M. E. (2015). Soil and water chemistry: an integrative approach. CRC press.

Gaur, V. K., Gupta, S. K., Pandey, S. D., Gopal, K., & Misra, V. (2005). Distribution of heavy metals in sediment and water of river Gomti. Environmental monitoring and assessment, 102, 419-433.

Hakanson, L .1980. An ecological risk index for aquatic pollution control. Asediment -logical approach, Water Res. 14. 975–1001. Doi :10.116/043 -1354 (80) 90143-8.

Issa, M. J., Al-Obaidi, B. S., & Muslim, R. I. (2020). Evaluation of some trace elements pollution in sediments of the Tigris river in Wasit governorate, Iraq. Baghdad Science Journal, 17(1), 9-22.

Kabata-Pendias A., Pendias H.: Trace elements in soil and plants, Boca Raton, CRC Press 2001, 65-87, 310-317.

Kadhum, S. A., Abed, S. A., Ewaid, S. H., Chabuk, A., Al-Ansari, N., & Jassim, A. K. (2020). Multivariate analysis and geochemical assessment of heavy metals pollution in surface sediment from Euphrates River, Iraq. Pollution Research, 39(November Suppl. Issue), S262-S267.

Kamel, L. H., Mahmood, M. B., & Al-zurfi, S. K. (2023). Applying Geoaccumulation Index and Enrichment Factor for Assessing Metal Contamination in the Sediments of Euphrates River, Iraq. Iraqi Journal of Science, 1093-1108.

Li, D., Yang, T., Zhou, R., Zhu, Z., & An, S. (2023). Assessment and sources of heavy metals in the suspended particulate matter, sediments and water of a karst lake in Guizhou Province, China. Marine Pollution Bulletin, 189, 114636.

Mahmmoud , R. H., Najam, L. A., Wais, T. Y., & Mansour, H. (2023). Assessment of the Pollution of some Heavy Metals in the Sediments of the Tigris River in the City of Mosul-Northern Iraq. Pollution, 9(2), 646-659.

May, H., Rixon, S., Gardner, S., Goel, P., Levison, J., & Binns, A. (2023). Investigating relationships between climate controls and nutrient flux in surface waters, sediments, and subsurface pathways in an agricultural clay catchment of the Great Lakes Basin. Science of The Total Environment, 864, 160979.

Mondal , P.; R. A. Mendes ; M.P. Jonathan ; J. K. Biswas ; K. Murugan and S.K. Sarkara .2018. Seasonal assessment of trace element contamination in intertidal sediments of the meso-macrotidal Hooghly (Ganges) River Estuary with a note on mercury speciation . Marine Pollution Bulletin 127, 117–130.

Müller, G. .1969. Index of geo - accumulation in sediments of Rhine River. Geochem. J. 2,108–118.

Rabee, A. M., & Al-Fatlawy, Y. F. (2009). Seasonal variation and assessment of heavy metals pollution in sediments from selected stations in Tigris and Euphrates Rivers, central Iraq. Iraqi Journal of Science, 50(4).

Rabee, A. M., Al-Fatlawy, Y. F., & Nameer, M. (2011). Using Pollution Load Index (PLI) and geoaccumulation index (I-Geo) for the assessment of heavy metals pollution in Tigris river sediment in Baghdad Region.

Journal of Al-Nahrain University, 14(4), 108-114.

Shilsar, M. J. F., Mazaheri, M., & Samani, J. M. V. (2023). A semi-analytical solution for one-dimensional pollutant transport equation in different types of river networks. Journal of Hydrology, 619, 129287.

Sutherland R.A ; C.A. Tolosa ; F.M.G. Tack and M.G. Verloo .2000. Characterization of selected element concentrations and enrichment ratios in background and anthropogenically impacted roadside areas. Arch Environ Contam Toxicol 38: 428-438.

Tomlinson, D.C.; J.G. Wilson; C.R. Harris and D.W. Jeffrey .1980. Problems in the assessment of heavy metals in estuaries and the formation pollution index. Helgol. Mar. Res. 33, 566–575.

Wang, J., Lu, X., Jing, Q., Zhang, B., Ye, J., Zhang, H., ... & Zhang, J. (2023). Spatiotemporal characterization of heavy metal and antibiotics in the Pearl River Basin and pollutants removal assessment using invasive species-derived biochars. Journal of Hazardous Materials, 454, 131409.

Xu, J., Xu, L., Zheng, L., Liu, B., Liu, J., & Wang, X. (2019). Distribution, risk assessment, and source analysis of heavy metals in sediment of rivers located in the hilly area of southern China. Journal of Soils and Sediments, 19, 3608-3619.

Yang, Z., Wang, M., Dong, Z., Tan, Z., & Guo, X. (2023). Potentially toxic elements contamination, risk and source analysis in sediments of Beiyun River supplied with reclaimed water, China. Ecological Indicators, 154, 110622.

Yao, M., Wang, D., & Zhao, M. (2015). Element analysis based on energy-dispersive X-ray fluorescence. Advances in Materials Science and Engineering, 2015.

Yuan, J., Li, M., Yang, Y., 2015. Analysis of characterization, nutrient content and pollution status of sediment in Yankou reservoir, Yiwu city. J. Zhejiang Ocean Univ. (Natural Science). 34, 255–262.

Yue-Fang, C. H. E. N., Qing-Yun, S. H. I., Jin-Yan, Q. U., Meng-Xue, H. E., & Qian, L. I. U. (2022). A pollution risk assessment and source analysis of heavy metals in sediments: A case study of Lake Gehu, China. Chinese Journal of Analytical Chemistry, 50(5), 100077.

Zakir, H. M., Shikazono, N., & Otomo, K. (2008). Geochemical distribution of trace metals and assessment of anthropogenic pollution in sediments of Old Nakagawa River, Tokyo, Japan. American Journal of Environmental Sciences, 4(6), 654.

Zaynab, M., Al-Yahyai, R., Ameen, A., Sharif, Y., Ali, L., Fatima, M., ... & Li, S. (2022). Health and environmental effects of heavy metals. Journal of King Saud University-Science, 34(1), 101653.