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Article

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ASSESSMENT OF HEAVY METALS IN EXCHANGEABLE SEDIMENTS SAMPLES FROM TIGRIS – EUPHRATES AND SHATT AL-ARAB RIVERS

The object of this study is the concentrations of heavy metals (cadmium, copper, iron, lead, manganese, nickel, and zinc) in sediment samples taken from the Tigris, Euphrates, and Shatt al-Arab rivers during the autumn 2021 to summer 2022. According to the analyses performed using the inductively coupled plasma atomic emission spectrometer, showed the seasonal average of heavy metal concentrations ranges between the lowest value (7.46 μg/g) for nickel in summer and the highest value (785.08 μg/g) for iron during winter in exchangeable phase. Measurements were made of variables that influenced how heavy metals were distributed in the sediments, as shown by (total organic carbon, and grain size analysis) which revealed a relationship between the concentrations of heavy metals in the sediments and these variables, suggesting that pollution from various human activities – the main cause of the high concentrations of some heavy elements in the study area's sediments above the global natural rates. Geo Accumulation Index (I-geo) for heavy elements in the sediments was also determined, and it showed that the yearly rate of the concentrations of the metals varied between the lowest value (–6.912) of Iron and the maximum value (6.767) for cadmium. Additionally, it was determined the enrichment coefficient (EF) for the heavy elements in the sediments, where the annual rate of the metals ranged between the lowest value (3.23) for manganese and the highest value (10406.58) for cadmium, and was accounted the contamination factor (CF) for the heavy metals in the sediments, where the annual average of the metals ranged between the lowest value (0.012) for iron and the highest value (163.4) for cadmium. If our findings are compared to those of previous study, this will be lies within previous data. This is very important data it can be used as a baseline for coming study, and also used as a reference in other countries.

Keywords: *heavy metals, sediment, Geo Accumulation Index, enrichment coefficient, Contamination factor, Tigris, Euphrates, Shatt al-Arab.*

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1. Introduction

The concept of pollution is always related to the concept of environment, because the concept of pollution cannot be approached in isolation from the environment that contains it, and it is not possible to define an environment without referring to the pollution that occurs in it [1]. Through land-based effluents, heavy elements assemble in coastal sediments [2]. The toxicity of heavy metals is determined by their chemical form and elemental composition, since most of these compounds are soluble in animal tissues and can cross biological membranes. As a result, sediments serve as a reservoir for elements that can be extracted [3]. Sediment contamination from heavy metals rose over time as the global economy developed, harming the ecosystem [4, 5]. According to several studies nickel, chromium, cadmium, cobalt, lead, and zinc are very poisonous and can harm the brain system and internal organs in addition to being carcinogenic [3].

Shatt al-Arab River, which has a length of 192 kilometers and 800 meters when at its mouth, defines the southern boundary between Iran and Iraq until it empties into the Arabain Gulf. It is 145,190 square kilometers in size. The eastern portion of the area is bordered by the Tigris and Shatt al-Arab rivers, while the Euphrates River separates the territory into its northern and southern half [6].

Thus, *the object of this study* is the concentrations of heavy metals (cadmium, copper, iron, lead, manganese, nickel, and zinc) in sediment samples taken from the Tigris, Euphrates, and Shatt al-Arab rivers during the autumn 2021 to summer 2022. And *the aim of this article* is assessment and measured concentrations of heavy metals (cadmium, copper, iron, lead, manganese, nickel, and zinc) in sediment samples taken from Tigris, Euphrates, and Shatt al-Arab rivers during the autumn 2021 to summer 2022.

2. Materials and Methods

Six sediments sampling sites were selected. for four seasons (fall, winter, spring, summer), where sediment samples were collected using plastic bags in order to measure heavy metals with full information recorded on each sample, which included Information: sampling site – date as shown in Fig. 1. The sediment samples were mixed well after removing the solid parts, then dried at a temperature of 60–70 °C for 48 hours, after that they were ground with mortar and sieved with a sieve with a hole diameter of (63 mesh) and kept in special polyethylene tubes that were clearly marked. After that, heavy metal ions were extracted in the sediment samples after the samples were digested with acids, and the measured elements included (cadmium, copper, iron, lead, manganese, nickel, zinc) and it was measured using a device ICP-OES (Inductively coupled plasma atomic emission spectroscopic). Heavy metal ions were extracted from the exchanged phase of the sediment, as fellow 1 g of the dry sample was weighed and placed in Teflon of 100 ml with a tight lid. 30 ml of hydrochloric acid 0.5 N was added carefully. Then placed in a vibrator for 16 hours, separated by a centrifuge at 3000 rpm for 20 minutes, the solution was transferred to special plastic bottles that were kept until measurement [7].

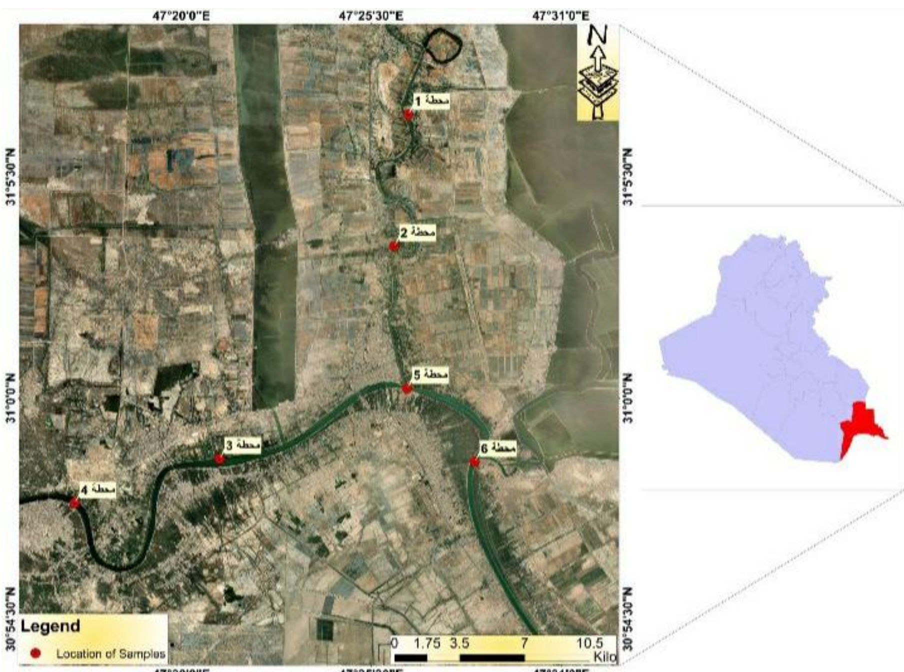

Fig. 1. Sample locations

The amount of total organic carbon (TOC, %) in the sediments was measured according to the incineration method used by [8]. The grain size analysis of the sediments of the study area was carried out using the pipette method, as described by [9].

3. Results and Discussion

The results showed that the concentrations of the Metals were high, except for nickel and cadmium, which were relatively few, the concentration arranged as fellow (Fe>Mn>Cu>Pb>Zn>Ni>Cd). The Tigris, Euphrates, and Shatt al-Arab rivers are subject to a variety of pollutants, which can be attributed to a number of factors, such as the population's growing disregard for public services, the region's history of wars, the increased use of fertilizers and pesticides to make up for the soil's loss of fertility, the rise in industrial activity, and a variety of other factors. Due to the city of Basra's recent population growth and the excessive usage of certain nearby companies, more domestic garbage has been discharged into the river, which has severely polluted the water and altered its ecology [10].

Cadmium (Cd). According to the study's findings, the concentration of cadmium in the exchangeable phase of the sediments samples was lowest (7.70 μg/g) during the summer at the first station and greatest (24.51 μg/g) during the winter at the sixth station as shown in Fig. 2. The study's findings also demonstrated that there was a rise in cadmium content, particularly in the sixth station where fossil fuel products are used for transportation since they have significant levels of heavy metals as Cd [11].

Copper (Cu). According to the study's findings, the concentration of copper in the exchangeable phase of the sediments samples was lowest (16.60 μg/g) during the summer at the first station and greatest (45.91 μg/g) during the winter at the sixth station as shown in Fig. 3. Due to the difference in clay concentration and dominant type across the stations, copper was present in greater concentrations in the sixth station. Numerous tests showed that copper was present, not from human inputs but from a mineral source [12].

Iron (Fe). According to the study's findings, the concentration of iron in the exchangeable phase of the sediments samples was lowest (625.71 μg/g) during the summer at the first station and greatest (784.86 μg/g) during the winter at the sixth station as shown in Fig. 4. This is due to the high natural concentration of iron in the earth's crust, as well as the sustainability processes of fishing boats, as well as human activities, especially the accumulation of iron waste, as well as iron oxides that enter the river that is loaded with them [13].

Lead (Pb). According to the study's findings, the concentration of lead in the exchangeable phase of the sediments samples was lowest (18.50 μg/g) during the summer at the first station and greatest (40.63 μg/g) during the winter at the sixth station as shown in Fig. 5. This is because of nearby transportation activity, which results in lead particles being released into the air as a result of the combustion of gasoline by moving vehicles. This activity traps a foggy suspension, which then spreads to other areas of the environment and increases pollution levels [14].

Manganese (Mn). According to the study's findings, the concentration of manganese in the exchangeable phase of the sediments samples was lowest (40.51 μg/g) during the summer at the first station and greatest (88.17 μg/g) during the winter at the sixth station as shown in Fig. 6. This is because human activity has increased, notably in recent years in agriculture, which can contribute to environmental pollution through the use of pesticides [15].

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Locations	autumn				winter				spring				summer			
	cd	Range	Mean	±SD	cd	Range	Mean	±SD	cd	Range	Mean	±SD	cd	Range	Mean	±SD
1	10.26 10.45 10.62	10.26-10.62	10.44	0.180	11.86 12.32 12.63	11.86-12.32	12.27	0.387	10.85 11.23 11.67	10.85-11.67	11.25	0.410	7.45 7.78 7.89	7.45-7.89	7.70	0.228
2	11.25 11.50 11.75	11.25-11.75	11.5	0.25	15.36 15.74 15.82	15.36-15.82	15.64	0.245	12.24 12.52 12.86	12.24-12.86	12.54	0.310	8.91 9.12 9.36	8.91-9.36	9.13	0.225
3	12.52 12.78 12.95	12.52-12.95	12.75	0.216	16.32 16.53 16.75	16.32-16.75	16.53	0.215	13.45 13.62 13.96	13.45-13.96	13.67	0.259	10.26 10.45 10.76	10.26-10.76	10.49	0.252
4	14.21 14.32 14.64	14.21-14.64	14.39	0.223	19.89 20.25 20.46	19.89-20.46	20.2	0.288	13.95 14.34 14.65	13.95-14.65	14.31	0.350	11.85 12.21 12.42	11.85-12.42	12.16	0.288
5	15.26 15.45 15.76	15.26-15.76	15.49	0.252	22.49 22.62 22.78	22.49-22.78	22.63	0.145	16.26 16.59 16.79	16.26-16.79	16.54	0.267	13.36 13.55 13.75	13.36-13.75	13.55	0.195
6	15.85 16.21 16.42	15.85-16.42	16.16	0.288	24.28 24.48 24.79	24.28-24.79	24.51	0.256	17.41 17.61 17.87	17.41-17.87	17.63	0.230	14.23 14.49 14.64	14.23-14.64	14.45	0.207

Fig. 2. Table of concentration of cadmium (μg/g) in the exchangeable phase

Locations	autumn				winter				spring				summer			
	Cu	Range	Mean	±SD	cu	Range	Mean	±SD	cu	Range	Mean	±SD	cu	Range	Mean	±SD
1	19.45 19.75 19.94	19.45-19.94	19.71	0.247	25.94 26.24 26.64	25.94-26.64	26.27	0.351	20.22 20.41 20.69	20.22-20.69	20.44	0.236	16.36 16.55 16.89	16.36-16.89	16.60	0.268
2	19.91 20.12 20.36	19.91	20.13	0.225	29.74 30.31 30.78	29.74-30.78	30.27	0.520	21.21 21.42 21.75	21.21-21.75	21.46	0.272	17.23 17.53 17.74	17.23-17.74	17.50	0.256
3	22.23 22.49 22.64	22.23-22.64	22.45	0.207	32.55 32.74 32.93	32.55-32.93	32.74	0.19	22.89 23.15 23.32	22.89-23.32	23.12	0.216	18.26 18.53 18.62	18.26-18.62	18.44	0.180
4	24.21 24.40 24.61	24.21-24.61	24.40	0.200	35.46 35.64 35.95	35.46-35.95	35.68	0.247	25.26 25.42 25.72	25.26-25.72	25.46	0.233	20.52 20.78 20.95	20.52-20.95	20.75	0.216
5	25.45 25.78 25.89	25.45-25.89	25.70	0.228	40.27 40.52 40.65	40.27-40.65	40.48	0.193	26.32 26.56 26.82	26.32-26.82	26.56	0.250	22.45 22.64 22.82	22.45-22.82	22.63	0.185
6	28.36 28.55 28.89	28.36-28.89	28.6	0.268	45.75 45.84 46.16	45.75-46.16	45.91	0.215	30.24 30.51 30.82	30.24-30.82	30.52	0.290	25.21 25.32 25.64	25.21-25.64	25.39	0.223

Fig. 3. Table of concentration of copper (μg/g) in the exchangeable phase

Locations	autumn				winter				spring				summer			
	Fe	Range	Mean	±SD	Fe	Range	Mean	±SD	Fe	Range	Mean	±SD	Fe	Range	Mean	±SD
1	631.95 632.32 632.65	631.95-632.65	632.30	0.350	657.31 657.49 657.62	657.31-657.62	657.4 7	0.155	651.85 652.30 652.65	651.85-652.65	652.26	0.401	625.45 625.75 625.94	625.45-625.94	625.71	0.247
2	634.42 634.78 634.92	634.42-634.92	634.70	0.257	660.32 660.55 660.78	660.32-660.78	660.5 5	0.23	675.27 675.52 675.75	675.27-675.75	675.51	0.240	629.86 630.22 630.41	629.86-630.41	630.16	0.279
3	642.22 642.42 642.79	642.22-642.79	642.47	0.289	750.28 750.48 750.77	750.28-750.77	750.51	0.246	720.32 720.59 720.85	720.32-720.85	720.58	0.265	642.22 642.42 642.79	642.22-642.79	642.47	0.289
4	650.25 650.65 651.12	650.25-651.12	650.67	0.435	772.29 772.46 772.76	772.29-772.76	772.50	0.237	752.28 752.46 752.79	752.28-752.79	752.51	0.258	650.42 650.78 650.92	650.42-650.92	650.70	0.257
5	662.23 662.45 662.65	662.23-662.45	662.44	0.210	779.55 779.70 779.95	779.55-779.70	779.73	0.202	773.46 773.70 773.92	773.46-773.92	773.69	0.230	665.23 665.53 665.74	666.23-665.74	665.50	0.256
6	674.94 675.23 675.64	674.94-675.64	675.27	0.351	784.86 784.12 785.28	784.86-785.28	785.08	0.211	782.23 782.44 782.75	782.23-782.75	782.47	0.261	6 72.55 672.65 672.75	672.55-672.75	672.70	0.070

Fig. 4. Table of concentration of iron (μg/g) in the exchangeable phase

Locations	autumn				winter				spring				summer			
	pb	Range	Mean	±SD	Pb	Range	Mean	±SD	pb	Range	Mean	±SD	pb	Range	Mean	±SD
1	20.78 21.12 21.36	20.78-21.36	21.08	0.291	29.92 30.16 30.28	29.92-30.28	30.12	0.172	22.21 22.45 22.78	22.21-22.78	22.48	0.286	18.23 18.53 18.74	18.23-18.74	18.50	0.256
2	26.45 26.64 26.82	26.45-26.82	26.63	0.185	32.65 32.84 33.21	32.65-33.21	32.9	0.284	26.42 26.74 26.89	26.42-26.89	26.68	0.240	21.42 21.78 21.92	21.42-21.92	21.70	0.257
3	26.92 27.23 27.49	26.92-27.49	27.21	0.285	34.95 35.24 35.42	34.95-35.42	35.20	0.237	27.82 28.23 28.55	27.82-28.55	28.2	0.365	23.36 23.55 23.75	23.36-23.75	23.55	0.195
4	29.23 29.53 29.74	29.23-29.74	29.5	0.256	36.75 36.86 37.14	36.75-37.14	36.91	0.201	30.24 30.53 30.76	30.24-30.76	30.51	0.260	26.22 26.47 26.65	26.22-26.65	26.44	0.215
5	30.82 31.20 31.39	30.82-31.39	31.13	0.290	37.91 38.23 38.44	37.91-38.44	38.19	0.266	31.79 32.20 32.36	31.79-32.36	32.11	0.293	29.26 29.45 29.76	29.26-29.76	29.44	0.252
6	33.74 34.12 34.44	33.74-34.44	34.1	0.350	40.25 40.75 40.89	40.25-40.89	40.63	0.336	35.32 35.75 35.94	35.32-35.94	35.67	0.317	30.45 30.64 30.82	30.45-30.82	30.63	0.185

Fig. 5. Table of concentration of lead (μg/g) in the exchangeable phase

Locations	autumn				winter				spring				summer			
	Mn	Range	Mean	±SD	Mn	Range	Mean	±SD	mn	Range	Mean	±SD	mn	Range	Mean	±SD
1	42.92 43.23 43.42	42.92-43.42	43.19	0.252	53.26 53.49 53.78	53.26-53.78	53.51	0.260	46.74 46.94 47.18		46.95	0.220	40.26 40.46 40.82	40.26-40.82	40.51	0.283
2	46.71 46.94 47.15	46.71-47.15	46.93	0.220	54.92 55.09 55.25	54.92-55.25	55.08	0.165	48.43 48.66 48.87		48.65	0.220	43.22 43.43 43.75	43.22-43.75	43.46	0.266
3	52.91 53.12 53.35	52.91-53.35	53.12	0.220	59.88 60.16 60.36	59.88-60.36	60.13	0.241	55.92 56.16 56.35		56.12	0.215	50.46 50.73 50.92	50.46-50.92	50.70	0.231
4	60.26 60.56 60.75	60.26-60.75	60.52	0.247	70.65 70.85 71.22	70.65-71.22	70.90	0.289	61.72 61.99 62.25		61.98	0.265	55.23 55.46 55.64	55.23-55.64	55.44	0.205
5	65.22 65.43 65.75	65.22-65.75	65.52	0.0.266	79.23 79.34 79.52	79.23-79.52	79.36	0.146	69.25 69.50 69.75		69.5	0.25	64.91 65.12 65.35	64.91-65.35	65.12	0.220
6	70.91 71.27 71.45	70.91-71.45	71.21	0.274	87.92 88.13 88.46	87.92-88.46	88.17	0.272	74.85 75.18 75.36		75.13	0.258	68.26 68.56 68.75	68.26-68.75	68.52	0.247

Fig. 6. Table of concentration of manganese (μg/g) in the exchangeable phase

Nickel (Ni). According to the study's findings, the concentration of Nickel in the exchangeable phase of the sediments samples was lowest (7.46 μg/g) during the summer at the first station and greatest (16.40 μg/g) during the winter at the sixth station as shown in Fig. 7. The use of pesticides and fertilizers, irrigation and sewage operations, industrial waste, as well as spills and leaks of liquid materials from loading trucks, is some of the factors that contribute to the contamination of sediments with sewage and agricultural waste, was causes increased nickel [16].

Zinc (Zn). According to the study's findings, the concentration of Zinc in the exchangeable phase of the sediments samples was lowest (9.42 μg/g) during the summer at the first station and greatest (32.63 μg/g) during the winter at the sixth station as shown in Fig. 8. The study's findings revealed that transportation and fuel combustion, as well as the effects of human activity, increased the concentration of zinc in the stations, particularly the sixth station. Other findings included an increase in the proportion of clay granules in other stations, which aid in the element's absorption. The rise may be caused by the area's high concentration of silt and sand sediments, closeness to a wastewater treatment facility that receives its water untreated, proximity to landfill regions, as well as other factors [17].

The results of the grain size analysis of the sediment samples also showed that the sediments of the study area have a clay or silty clay character where was the clay rate is 44.31 %, while the silt rate is 39.77 % and the sand rate is 15.91 % as shown in Table 1. The Shatt al-Arab region's surface sediments are recent deposits made up primarily of silt and clay with some sand [18].

As for the total organic carbon of the sediment samples, it was found that there are seasonal and local changes in the values of organic carbon. The results of the study showed that the lowest value was in the first station in the summer (2.0) and the highest value in the sixth station in the winter (5.06) as shown in Table 2. The findings of the present study revealed that the region had a high proportion of organic materials since there were plants and animals there as well as because of the local environment. According to the findings of the current study, the greatest values were obtained during the winter due to the high percentage of rainfall as well as the presence of dead aquatic plants in the area [3].

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Locations	autumn				winter				spring				summer			
	Ni	Range	Mean	±SD	Ni	Range	Mean	±SD	Ni	Range	Mean	±SD	Ni	Range	Mean	±SD
1	9.49 9.70 9.92	9.49- 9.92	9.79	0.215	10.85 11.15 11.39	10.85- 11.39	11.13	0.270	10.55 10.70 10.95	10.55- 10.95	10.73	0.202	7.21 7.44 7.75	7.12- 7.75	7.46	0.270
2	10.23 10.46 10.64	10.23- 10.64	10.44	0.205	11.92 12.18 12.24	11.92- 12.24	12.11	0.170	11.26 11.46 11.82	11.26- 11.82	11.51	0.283	8.91 9.12 9.35	8.91- 9.35	9.12	0.220
3	10.87 11.11 11.45	10.87- 11.45	11.14	0.291	13.74 13.92 14.25	13.74- 14.25	13.97	0.258	11.86 12.11 12.32	11.86- 12.32	12.09	0.230	10.22 10.42 10.79	10.22- 10.79	10.47	0.289
4	12.46 12.73 12.92	12.46- 12.92	12.70	0.231	13.95 14.34 14.55	13.95- 14.55	14.28	0.304	13.45 13.73 12.92	13.45- 12.92	13.7	0.236	11.23 11.42 11.63	11.23- 11.63	11.42	0.200
5	13.56 13.87 14.25	13.56- 14.25	13.89	0.345	14.86 15.25 15.49	14.86- 15.49	15.20	0.317	13.83 14.30 14.57	13.83- 14.57	14.23	0.374	12.23 12.46 12.64	12.23- 12.64	12.44	0.205
6	14.26 14.46 14.82	14.26- 14.82	14.51	0.283	16.22 16.35 16.65	16.22- 16.65	16.40	0.220	15.28 15.46 15.78	15.28- 15.78	15.50	0.253	13.32 13.64 13.89	13.32- 13.89	13.61	0.285

Fig. 7. Table of concentration of nickel (µg/g) in the exchangeable phase

Locations	autumn				winter				spring				summer			
	zn	Range	Mean	±SD	zn	Range	Mean	±SD	zn	Range	Mean	±SD	zn	Range	Mean	±SD
1	10.56 10.90 11.16	10.56- 11.16	10.90	0.225	13.25 13.53 13.79	13.25- 13.79	13.52	0.270	11.65 11.90 12.23	11.65- 12.23	11.92	0.290	9.23 9.42 9.63	9.23- 9.63	9.42	0.200
2	10.73 11.12 11.46	10.73- 11.46	11.10	0.365	14.97 15.34 15.68	14.97- 15.68	15.33	0.355	11.95 12.12 12.36	11.95- 12.36	12.14	0.205	10.26 10.56 10.75	10.26- 10.75	10.52	0.247
3	13.32 13.64 13.89	13.32- 13.89	13.61	0.285	15.92 16.23 16.52	15.92- 16.52	16.22	0.300	14.42 14.64 14.79	14.42- 14.79	14.61	0.186	11.23 11.42 11.63	11.23- 11.63	11.42	0.200
4	15.22 15.34 15.75	15.22- 15.75	15.43	0.277	18.63 18.89 19.15	18.63- 19.15	18.89	0.26	15.21 15.34 15.64	15.21- 15.64	15.39	0.220	12.23 12.46 12.64	12.23- 12.64	12.44	0.205
5	16.62 16.87 17.12	16.62- 17.12	16.87	0.25	20.89 21.34 21.74	20.89- 21.74	21.32	0.425	17.59 17.87 18.12	17.59- 18.12	17.86	0.265	15.46 15.73 15.92	15.46- 15.92	15.70	0.231
6	19.23 19.42 19.63	19.23- 19.63	19.42	.200	32.42 32.61 32.86	32.42- 32.86	32.63	0.220	20.22 20.42 20.75	20.22- 20.75	20.46	0.267	17.32 17.64 17.89	17.32- 17.89	17.61	0.285

Fig. 8. Table of concentration of zinc (µg/g) in the exchangeable phase

Table 1

Grain size analysis of sediment samples

Locations	Clay, %	Silt, %	Sand, %	Texture
1	44.26	46.28	9.46	Silty clay
2	44.38	40.1	15.52	Silty clay
3	46.04	38.32	15.64	Clay
4	48.42	32.02	19.56	Clay
5	42.36	42.12	15.52	Silty clay
6	40.4	39.79	19.81	Clay
Mean	44.31	39.77	15.91	–

Table 2

TOC values for stations in the study area, %

Dept (cm)	Autumn	Winter	Spring	Summer
1	2.5	2.9	2.2	2.0
2	3.0	3.5	2.6	2.2
3	3.7	4.6	3.1	2.8
4	4.5	5.8	4.2	3.9
5	5.8	6.4	5.3	5.0
6	6.9	7.2	6.2	5.8
Mean	4.40	5.06	3.93	3.61

The results of the study showed the evidence of the geochemical accumulation of heavy elements in the study area, according to the classification of [19] as shown in Fig. 9. The sediments of each of the Tigris and Euphrates and the confluence of the Shatt al-Arab were unpolluted to highly polluted, as cadmium exceeded the maximum levels of pollution degrees (<5). As for lead, which gave a non-polluting to medium pollution degree in the remaining phase of some study areas, this is due to the use of pesticides and fertilizers in agricultural lands, as well as sewage and human and health waste as. Thus, the result of the geochemical accumulation factor took the following order: Cd>Pb>Cu>Zn>Ni>Mn>Fe.

The results of the enrichment coefficient for heavy metals in the study area were shown according to the classification [20] as shown in Fig. 10. Let's observe that the lead and cadmium elements were richer than the other elements as a result of the pollution sources represented by the burning of car fuel and the burning of wastes created by government buildings, hospitals, power plants, and other sources. The sediments of the study area range from moderate to very severe and the result of the arrangement was taken as follows: $EF^{Cd}>EF^{Pb}>EF^{Cu}>EF^{Zn}>EF^{Ni}>EF^{Mn}$.

Stations	season	I-geo Cd	I-geo Cu	I-geo Fe	I-geo Pb	I-geo Mn	I-geo Ni	I-geo Zn
Stations 1	autumn	5.536	-2.191	-6.895	-0.092	-5.158	-3.69	-3.47
	winter	5.768	-1.780	-6.834	0.321	-4.836	-3.50	-3.18
	spring	5.643	-2.139	-6.846	-0.043	-5.011	-3.55	-3.33
	summer	5.096	-2.442	-6.912	-0.340	-5.210	-4.32	-3.68
Stations 2	autumn	5.675	-2.164	-6.885	-0.061	-5.011	-3.60	-3.44
	winter	6.119	-1.573	-6.828	0.526	-4.795	-3.38	-3.05
	spring	5.800	-2.070	-6.795	0.028	-4.965	-3.45	-3.30
	summer	5.342	-2.365	-6.895	-0.268	-5.158	-3.79	-3.52
Stations 3	autumn	5.824	-2.005	-6.878	0.084	-4.836	-3.50	-3.18
	winter	6.198	-1.461	-6.643	0.632	-4.643	-3.18	-2.94
	spring	5.924	-1.965	-6.702	0.137	-4.756	-3.99	-3.04
	summer	5.542	-2.293	-6.878	-0.200	-4.921	-3.59	-3.39
Stations 4	autumn	5.998	-1.883	-6.849	0.214	-4.643	-3.32	-3.05
	winter	6.488	-1.336	-6.601	0.757	-4.411	-3.14	-2.73
	spring	5.990	-1.826	-6.702	0.275	-4.608	-3.21	-2.96
	summer	5.755	-2.120	-6.816	-.0.029	-4.795	-3.47	-3.27
Stations 5	autumn	6.105	-1.810	-6.823	0.286	-4.539	-3.18	-2.83
	winter	6.652	-1.155	-6.588	0.941	-4.265	-3.05	-2.55
	spring	6.199	-1.761	-6.599	0.333	-4.442	-3.15	-2.75
	summer	5.912	-1.994	-6.816	0.097	-4.539	-3.35	-2.94
Stations 6	autumn	6.166	-1.657	-6.795	0.443	-4.411	-3.12	-2.64
	winter	6.767	-0.971	-6.578	1.124	-4.107	-2.94	-1.88
	spring	6.291	-1.560	-6.587	0.536	-4.321	-3.02	-2.55
	summer	6.004	-1.826	-6.802	0.263	4.473	-3.21	-2.83

Fig. 9. Table of the geochemical accumulation coefficient (I-geo) of heavy metals concentration

Stations	season	EF-Cd	EF-Cu	EF-Pb	EF-Mn	EF-Ni	EF-Zn
Stations 1	autumn	5503.71	25.97	119.06	3.41	9.21	10.77
	winter	6220.81	33.29	163.61	4.06	10.07	12.85
	spring	5749.24	26.11	123.09	3.59	9.79	11.42
	summer	4102.00	22.10	105.59	3.23	7.09	9.40
Stations 2	autumn	6039.59	26.42	149.08	3.69	9.79	10.93
	winter	7892.41	38.18	177.88	4.16	10.91	14.50
	spring	6187.91	26.47	141.05	3.60	10.14	11.23
	summer	4829.46	23.14	122.98	3.44	8.04	10.43
Stations 3	autumn	6615.09	29.11	151.25	4.13	10.32	13.23
	winter	7341.67	36.35	167.50	4.00	11.07	13.50
	spring	6323.60	26.73	139.76	3.89	9.98	12.61
	summer	5442.53	23.91	130.91	3.94	9.70	11.10
Stations 4	autumn	7371.88	31.24	161.92	4.65	11.61	15.01
	winter	8716.28	38.48	170.64	4.58	11.00	15.28
	spring	6338.78	28.19	144.80	4.11	10.53	12.78
	summer	6229.18	26.57	145.11	4.26	10.44	11.94
Stations 5	autumn	7794.41	32.32	167.83	4.94	12.48	15.91
	winter	9674.28	43.26	174.92	5.08	11.60	17.08
	spring	7126.02	28.60	148.22	4.49	10.94	14.42
	summer	6786.87	28.33	157.99	4.89	11.12	14.74
Stations 6	autumn	7977.05	35.29	180.35	5.27	12.79	17.97
	winter	10406.58	48.73	184.83	5.57	12.43	25.97
	spring	7150.40	32.50	162.80	4.80	11.79	16.34
	summer	7160.20	31.45	162.61	5.09	12.04	16.36

Fig. 10. Table of enrichment factor (EF) of heavy metals

The results of the heavy metal Contamination factor in the study area showed according to the classification [21] as shown in Fig. 11. Copper, iron, manganese, nickel and zinc appeared in the study sites as having low pollution, while lead appeared in the study sites as medium pollution, while cadmium in the study sites was highly polluted. This is consistent with the study [22]. Several factors contributed to the increase in the concentration of heavy metals in the sediments, including the increase in transport vehicles and the burning of gasoline and the increase in the release of pollutants from government facilities such as hospitals, electric power plants, oil and gas companies, paper mills, etc., as well as the use of fertilizers in agricultural areas. Thus, the result of the pollution coefficient took the following order: $CF^{Cd}>CF^{Pb}>CF^{Mn}>CF^{Cu}>CF^{Zn}>CF^{Ni}>CF^{Fe}$.

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If to compare our data with the previous study, it is possible to see that our data lies in some of this study as shown in Table 3. Where the sediments of the study area of the Tigris, Euphrates and Shatt al-Arab receive large quantities of minerals resulting from industrial waste resulting from human activity and other sources such as sewage.

The difference in metal concentrations and metal pollution index value in exchangeable sediment this gave an idea about the contamination of these metals in rivers was considered as low contaminated with not permissible limits set by Rivers due to State ministry of environment, Federal Environmental Protection Agency and World Health Organization and therefore not serious environmental concern. Abandoned metals parts and effluents from industrial and commercial activities such as fishing (nets, hooks, etc.) shipping, timber processing and outboard engine boats influenced the levels of metals along the rivers while domestic activities (such as building materials, solid wastes), run-offs, tidal and wave actions influenced the metal levels along the rivers [33].

According to [34] Permissible limits of heavy metals in sediment as shown in Table 4 indicated that Sediment pollution in the research locations is classified as moderate pollution.

Stations	season	CF-Cd	CF-Cu	CF-Fe	CF-Pb	CF-Mn	CF-Ni	CF-Zn
Stations 1	autumn	69.6	0.32	0.012	1.50	0.043	0.11	0.13
	winter	81.8	0.43	0.013	2.15	0.053	0.13	0.16
	spring	75.00	0.34	0.013	1.60	0.046	0.12	0.14
	summer	51.33	0.27	0.012	1.32	0.040	0.08	0.11
Stations 2	autumn	76.66	0.33	0.012	1.90	0.046	0.12	0.13
	winter	104.26	0.50	0.013	2.35	0.055	0.14	0.19
	spring	83.6	0.35	0.013	1.90	0.048	0.13	0.15
	summer	60.86	0.29	0.012	1.55	0.043	0.10	0.13
Stations 3	autumn	85.01	0.37	0.012	1.94	0.053	0.13	0.17
	winter	110.2	0.54	0.015	2.51	0.060	0.16	0.20
	spring	91.13	0.38	0.014	2.01	0.056	0.14	0.18
	summer	69.93	0.30	0.012	1.68	0.050	0.12	0.14
Stations 4	autumn	95.93	0.40	0.013	2.10	0.060	0.15	0.19
	winter	134.66	0.59	0.015	2.63	0.070	0.17	0.23
	spring	95.4	0.42	0.015	2.17	0.061	0.16	0.19
	summer	81.06	0.34	0.013	1.88	0.055	0.13	0.15
Stations 5	autumn	103.26	0.42	0.013	2.22	0.065	0.16	0.21
	winter	150.86	0.67	0.016	2.72	0.079	0.18	0.26
	spring	103.37	0.44	0.015	2.29	0.069	0.16	0.22
	summer	90.33	0.37	0.013	2.10	0.065	0.14	0.19
Stations 6	autumn	107.73	0.47	0.013	2.43	0.071	0.17	0.24
	winter	163.4	0.76	0.016	2.90	0.088	0.19	0.40
	spring	117.53	0.50	0.015	2.54	0.075	0.18	0.25
	summer	96.33	0.42	0.013	2.18	0.068	0.16	0.22

Fig. 11. Table of Contamination factor (CF) of Heavy metals

Table 3

Heavy metals concentrations in sediments sampling (μg/g) in the present study as compared with the other previous studies

Studied Areas	Cd	Cu	Fe	Pb	Ni	Mn	Zn	References
Shatt al-Arab River – Shatt al-Basra	5.81	30.15	4170.33	40.13	53.80	–	–	[23]
Euphrates River	11.22	14.14	661.70	0.59	0.37	–	67.66	[24]
Euphrates River	0.30	30.40	2034	11.17	–	–	24.05	[25]
Shatt al-Arab River	–	26.69	1911.03	83.78	–	–	75.56	[26]
Shatt al-Hilla River	–	21.8–8.21	629.0–1228.9	27.06–18.5	1114.5–140.5	–	–	[27]
Shatt al-Arab River	13.08	44.11	20485.79	104.97	234.64	–	106.21	[28]
Shatt al-Arab River	693.245–1159.254	–	–	–	40.942–134.375	–	–	[29]
Shatt al-Arab River	5.01–13.32	9.17–26.49	950.78–4987.92	15.20–54.37	30.07–93.65	–	23.34–43.13	[30]
Abu al-Kasaib River – Iraq	0.0001–0.009	0.1118–3731	1118–3731	0.015–0.256	–	–	–	[31]
Shatt al-Basra	–5.59–80.18	27.23–1.7	103.5–900	4.19–0.5	–1.4–38.15	–	41.15–0.3	[32]
Tigris – Euphrates – Shatt al-Arab	24.51–7.70	45.91–16.60	785.08–625.71	40.63–18.50	16.40–7.46	88.17–40.51	32.63–9.42	Study present

Table 4

Permissible limits of heavy metals in sediment (mg/kg) as proposed by international agencies

Permissible limits for sediment		Present Study	Reference
Cd	0.70	7.70–24.51	[34]
Cu	18.70	16.60–45.91	
Fe	–	625.71–785.08	
Pb	30.20	18.50–40.63	
Mn	–	7.46–16.40	
Ni	35	40.51–88.17	
Zn	124.00	9.42–32.63	

The presence of these metals can indicate diversity in the sources of pollutants between natural weathering and anthropogenic, whereas the areas of the rivers are affected by strong winds, in addition to heavy rain in winter. The direction of the water drainage is in the direction that goes towards the Arabian Gulf. This makes weathering an important role in transferring heavy metals to the sediments. At the same time, it cannot neglect the many and varied human activities in the total study area, such as commercial and industrial activities, in addition to the presence of ports, and the population. Due to the fact that such research helps to lessen the obvious shortage of information regarding such pollutants in Iraqi rivers, and gives a valuable information for coming research.

4. Conclusions

The results obtained for the concentrations of sediment samples were high except cadmium and nickel, which were relatively low. And according to the following order: Fe>Mn>Cu>Pb>Zn>Ni>Cd.

The results showed the pollution factors for heavy metals in the study area copper, iron, manganese, nickel and zinc appeared in the study sites as having low pollution, while lead appeared in the study area as medium pollution, while cadmium in the study sites was highly polluted and this agrees with the study [22].

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

The manuscript has associated data in a data repository.

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