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STUDY OF CHEMICAL POLLUTION WITH HEAVY METALS IN THE TIGRIS RIVER IN SOME AREAS OF WASIT PROVINCE, IRAQ

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Abstract
The aim of study was to estimate the level of pollution with some heavy metals including copper (Cu), cadmium (Cd), lead (Pb), iron (Fe) and chromium (Cr), dissolved and particulate matter in water and the exchangeable fraction in sediments, and considering them as an indicator for monitoring pollution with heavy metals in some areas of Wasit Province. Five sites were selected and approximately 10 km from one site to another. It extended from Al-Numaniyah District, through Al-Ahrar District, and ended in Al-Kut District, with a total distance of 50 km.
The results showed that the concentrations of copper, cadmium, iron, lead, and chromium in the dissolved form of water have reached 0.49, 0.05, 2.97, 2.40, and 0.13 µg/L-1, respectively, while their rates in the particulate reached 27.42, 0.65, 1015.52, and 18.53. and 22.98 µg/g-1 dry weight, respectively, The exchange fraction of these metals in the sediment was 13.15, 0.58, 568.96, 31.43, and 30.67 µg/g-1 dry weight, respectively. The results also showed that the levels of heavy metals in their dissolved form were within the WHO limits, while in the particulate form the iron element was outside those limits. The rates of these metals in the sediments were high values in all study sites, with the values of the particulate form of these metals being superior to the dissolved form.

Keywords: pollution, heavy metals, Tigris River, copper, cadmium.

Introduction

Pollution is very important that began since the history of human existence on Earth, and research into it is one of the most difficult, most complex, and most hard matters to solve. The disasters that are occurring now in many countries have begun to threaten the foundations of life. It has been realized that these threats result from wrong practices towards the environment. Every action that human does cause some types of pollution including physical, psychological, or health. Pollution causes a change in the chemical, physical, and biological properties of the environment such as soil, water, plants, or air, which ends with harmful negative effects on humans and environment.
Recently, pollution is spread in various forms, which distorts the beautiful view of life and creates dangers. The only choice is to be alert about these dangers for the purpose of reducing them and overcoming their problems (Kar et al., 2008). It has become more complex when different industries and technologies have grown and the resulting chemical residues, toxins, and environmentally hazardous wastes have occurred. In addition, to the massive expansion in the use of pesticides, disinfectants, and sterilization materials, as well as the wastewater and industrial wastewater being released, the random spread of service workshops. All of these activities pollute water resources, especially rivers and streams in various types of pollutants, including heavy metals (Abdul Razzak and Sulayman, 2009).

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The most important sources of pollution with heavy metals are factory waste, fuel combustion, automobile exhausts, factory waste, metal smelting, and coal combustion. Pollution of soil or sediments with these metals leads to poor fertility and decreased productivity of agricultural crops (Singha et al, 2012). Therefore, it has become necessary to work to reduce the damage of heavy elements in soil, water and plants. Water sources available for drinking and domestic purposes must be of a high degree of purity and free of chemical contamination and microorganisms (Burul and Banmero, 2012). Pollution of the aquatic environment with heavy metals has become an important problem around the world because most of them have toxic effects on living organisms (Duruibe et al, 2007).

Some of them are harmful even in low concentrations and represent dangerous environmental pollutants because they are not biodegradable. So, they remain suspended or partially dissolved in the water and enter the body through Pollute food, air, or water and accumulate in it over time, causing various harms to the organism (Blance, 2005). The heavy metals are not dissolved for a long time in water. They appear in the form of suspended colloids or are stabilized by organic or mineral. The dissolved of the heavy elements are easy to attract and hold by clay or organic compounds, and iron and manganese hydroxides from minerals or carbons. Thus, they collect on the sediments or plants. It is evidence of water pollution with these metals, as sediments act as a potential source of pollution in the environment (Draver, 1988).

Therefore, the study aim was to determine the level of pollution with some heavy metals, such as copper (Cu), cadmium (Cd), iron (Fe), lead (Pb), chromium (Cr) dissolved in water and particulate matter and the exchangeable fraction in sediments. As well as, to consider it as an indicator for monitoring pollution with heavy metals in some areas of Wasit Province and for different time periods. Also, to provide a database in order to help decision makers to take the necessary decisions for protect the Tigris River.

Materials and Methods

Study area

Five sites were selected from the Tigris River, the distance between one site and another was 10 km, with a total distance of 50 km, as the distance extended from the Numaniyah district to the center of Kut in Wasit Province.

Collect the samples

Samples were collected from the five sites every two months for approximately one year, starting from 1/1/2023 to 11/1/2023. It was in three replicates for each sample, as follows:

-Water samples were collected to conduct chemical and heavy metal tests using clean polyethylene containers with a capacity of 5 L (Nollet, 2007) (Table 1).

-Sediment samples were collected using a Grab sample sediment collection device and stored in clean plastic bags until use.

Chemical tests of sediments and water

pH

The pH was measured using a pH meter according to (Page et al, 1982).

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Electrical connection

It was measured with an Ec meter according to the method (Page et al, 1982).

Total dissolved solids (TDS)

It was measured with a TDS device after being calibrated with standard solutions (APHA, 2003).

Total Suspended Solids (TSS).

It was measured by following the method described by the American Public Health Association (APHA, 2003), by filtering 100 ml of the sample through a filter paper after it had been weighed accurately. Then, this paper was dried in an oven at a temperature of 103-105°C for 24 hs, after that, it was weighed in mg/L.

Cations and anions

Cations and anions dissolved in water (Ca, Mg, Na, CL, HCO3) were measured according to (Page et al, 1982).

Table (1) Chemical characteristics of the water of the Tigris River in some areas of Wasit Province

sites	pH	Ec $Dsm.m^{-1}$	TDS $mg.L^{-1}$	TSS $mg.L^{-1}$	Ca^{+2} $mmol.L^{-1}$	Mg^{+2} $mmol.Ll^{1}$	Na^{+1} $mmol.L^{-1}$	HCO_3 $mmol.L^{-1}$	CL $mmol.L^{1}$	SAR
1	8.01	0.79	507.50	63.00	7.89	5.67	9.89	3.72	12.53	2.69
2	7.99	0.80	515.00	60.17	6.15	4.15	7.45	2.34	12.68	2.30
3	8.00	0.84	534.33	61.67	6.78	4.09	6.23	2.18	12.63	1.89
4	8.03	0.85	544.83	66.83	5.69	3.89	5.23	2.56	12.27	1.69
5	8.12	0.89	548.00	63.67	6.44	4.00	5.50	3.00	12.24	1.70

Determination of heavy metals in the water

Water samples were taken from the study sites. Two liters of each sample were filtered through 0.45 mm Millipore Filter Paper, which was previously washed with HNO3 (0.5 N), then with distilled water and dried at a temperature of 60°C for 12 hs. Then, add (1.5) ml of HNO3 Conc to every 1 L of filtered water samples for the purpose of preserving the metals in their ionic form. Then, take 100 ml of filtered water and evaporate at a temperature of 70 °C until dry, add 1 ml of HNO3 and 10 ml of distilled water and leave the solution to complete dissolution. After that, complete the final volume to 25 ml with ion free distilled water and store it in polyethylene containers until the concentrations of heavy metals are measured with an Atomic Absorption device according to the method described by (APHA, 2003).

Determination of particulate heavy metals

To determine the particulate heavy metals, the filter papers used to filter water samples were dried for 70 mm for 48 hs and then weighed for the purpose of extracting the amount of plankton in them. The metals ions were extracted by weighing 0.5 g of the dry sample and placing it in special Teflon containers. Six ml of Conc.HCL and Conc.HNO3 were placed in a ratio (1:1) and heated at 80°C and evaporated until almost dry. Then, add 4 ml of a mixture of concentrated perchloric acid HCLO4 and hydrofluoric acid HF in a ratio of (1:1). The solution is then evaporated until it is almost dry.

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The dissolve the precipitate with (20) ml 0.5 HCL and leave for 10 mins. Then, the sample was separated by centrifuge for 20 mins at a speed of 3000 rpm.
The solution was taken and placed in 25 ml volumetric containers, while the sediment was washed with distilled water free of ions, and the washing water was added to the volumetric containers after separating the sediment. The volume was increased to 25 ml, and the samples were stored in 25 ml plastic containers, as mentioned before (USEPA, 1999). Heavy metals were measured with an atomic absorption device in µg/g dry weight.

Extraction and estimation of exchangeable heavy metals from sediments

The sediment samples were mixed well after removing the solid and foreign parts. Then, it dried at a temperature of 60-70°C for 48 hs. It was ground with a ceramic mortar and passed through a sieve with a hole diameter of 65 µm and stored in special polyethylene containers. Elemental ions were extracted from the exchangeable portion of the sediment. One g of the dry sample was weighed and placed in a 50 ml Teflon container with a tight lid, and 20 ml of 0.5N HCL was added to it. Shake in a shaker for 16 hs, separate by centrifuge, and transfer the solution to special plastic containers. The elements were estimated using the Atomic Absorption device (Havay et al, 2004).

Statistical Analysis

The results were analyzed statistically using an analysis of variance (ANOVA) table and the least significant difference (LSD) test at the 0.05 according to (Al-Rawi and Khalaf Allah, 1980).

Results and Discussion

Dissolved heavy metals and particulate the Tigris River water

Dissolved particulate copper (Cu)

The results showed that the values of dissolved and particulate copper in water. The highest value of dissolved copper was achieved during November, which reaching 0.74 µg/L^{-1}, while the lowest value was achieved during July that was 0.24 µg/L^{-1}. The general average was 0.49 µg/L^{-1} for all sites. However, the highest value of particulate copper was achieved in March, it was 44.45 µg/L^{-1} (Tables 2, 3). The results indicated that there were significant differences between the months of the year in the amount of dissolved copper and particles, while they were not significant between the studied sites. These results are less than the specifications of the World Health Organization (WHO, 2011) (2.00) µg/L^{-1}.
The high values during November and January for the dissolved and in March for the particles may be attributed to the rainwater laden with clay, silt, and organic materials laden with heavy metals such as copper, and when present in high concentrations, it causes an increase in the concentrations of these elements in the water (Abida et al, 2009), or it is because to the discharge of sewage and industrial wastewater into the river water (Shah et al, 2005). Its decrease during the summer (July) may be due to the tendency of these metals to bioaccumulate in aquatic plants or aquatic organisms, or the tendency of these metals to absorb with sediments or form chelating complexes with organic materials (Kwan and Lee, 2001; Al-Saad et al., 2000).

Table (2) Concentration of dissolved copper (µg/L^{-1}) of the Tigris River water during different months in Wasit Province

Sites	Months						average
	January	March	May	July	September	November	
1	0.66	0.58	0.41	0.20	0.39	0.78	0.50
2	0.60	0.50	0.44	0.26	0.30	0.70	0.47
3	0.68	0.55	0.46	0.28	0.36	0.75	0.51
4	0.64	0.51	0.43	0.25	0.34	0.73	0.48
5	0.69	0.53	0.48	0.22	0.31	0.76	0.50
average	0.65	0.53	0.44	0.24	0.34	0.74	LSD 0.05
LSD 0.05	0.1						N.S

Table (3) Concentration of particulate copper (µg/g^{-1}) by dry weight of the Tigris River water during different months Wasit Province

Sites	Months						average
	January	March	May	July	September	November	
1	28.66	45.50	30.00	12.69	20.00	25.00	26.98
2	29.50	43.00	33.23	12.50	22.31	25.50	27.67
3	27.39	44.26	31.52	12.45	23.17	24.33	27.19
4	27.66	44.80	32.90	12.00	21.50	25.89	27.46
5	28.50	44.68	34.28	12.32	20.89	26.31	27.83
average	28.34	44.45	32.39	12.39	21.57	25.41	LSD0.05
LSD 0.05	3.25						N.S

Dissolved and particulate cadmium (Cd)

The results showed that the highest value of cadmium dissolved in water was achieved during January, that reaching 0.083 µg/L^{-1}, compared to July, which achieved the lowest value, reaching 0.015 µg/L^{-1}. The general average was 0.05 µg/L^{-1} (Tables 3, 4). For particulate cadmium, the highest value appeared in January, which amounted to 0.84 µg/g^{-1}dry weight, compared to March, which achieved the lowest value for particulate cadmium, which amounted to 0.44 µg/g^{-1} dry weight, with a general average of 0.65 µg/g^{-1}dry weight. The results of the statistical analysis (Tables 4 and 5) indicated that there were significant differences between the months of the year for the values of dissolved cadmium and particulate cadmium, while there were no significant differences between all the sites studied. The results showed that the values obtained for cadmium were less than the values of the World Health Organization 1996 standards. It is (3) µg/g^{-1}(Tables 4, 5).

The presence of dissolved cadmium in high levels during January compared to the other months studied may be due to the entry of rainwater laden with clay, silt, and organic materials laden with heavy metals such as cadmium, and when present in high concentrations, it causes an increase in the concentrations of these elements in the water (Abida et al, 2009). Heavy elements, such as cadmium, which are released into the aquatic environment do not remain in dissolved form, but rather bind or accumulate in aquatic plants and sediments, and are thus called particulate heavy metals (Edward et al, 2013). There are several factors that help the binding of heavy metals to suspended particles, including turbidity, suspended solids, and pH.

The study showed that heavy metals such as copper and cadmium in the particulate state recorded

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higher concentrations than in the dissolved state, which indicates the presence of high concentrations of particles or turbidity resulting from mixing processes or the water containing large quantities of plankton that have the ability to increase the concentrations of heavy metals.

Table (4) Concentration of dissolved cadmium (μg/L^{-1}) of the Tigris River water during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**0.080**	**0.065**	**0.043**	**0.011**	**0.038**	**0.075**	**0.052**
2	**0.086**	**0.060**	**0.040**	**0.019**	**0.035**	**0.071**	**0.052**
3	**0.082**	**0.068**	**0.048**	**0.016**	**0.031**	**0.078**	**0.054**
4	**0.084**	**0.064**	**0.046**	**0.013**	**0.033**	**0.073**	**0.052**
5	**0.085**	**0.062**	**0.047**	**0.014**	**0.036**	**0.076**	**0.053**
average	**0.083**	**0.064**	**0.045**	**0.015**	**0.035**	**0.075**	**LSD0.05**
LSD 0.05	**0.011**						**N.S**

Table (5) Concentration of particulate cadmium (μg/g^{-1}) by dry weight of the Tigris River water during different months Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**0.80**	**0.40**	**0.56**	**0.60**	**0.69**	**0.75**	**0.63**
2	**0.89**	**0.45**	**0.59**	**0.63**	**0.70**	**0.78**	**0.67**
3	**0.86**	**0.48**	**0.53**	**0.66**	**0.68**	**0.77**	**0.66**
4	**0.84**	**0.43**	**0.50**	**0.64**	**0.67**	**0.74**	**0.64**
5	**0.81**	**0.46**	**0.54**	**0.65**	**0.69**	**0.73**	**0.65**
average	**0.84**	**0.44**	**0.54**	**0.64**	**0.69**	**0.75**	**LSD .05**
LSD 0.05	**0.02**						**N.S**

Dissolved and particulate iron (Fe)

Tables (6 and 7) described that the values of dissolved and particulate iron in the water of the Tigris River. The results showed that the values differed according to the months and the study sites. The highest value of soluble iron appeared in January, which amounted to 4.21 μg/L^{-1}, compared to September, which achieved the lowest value, reached 1.57 μg/L^{-1}, with a general average of 2.97 μg/L^{-1}. For particulate iron, it achieved the highest values compared to dissolved iron, and its highest value was in July, which amounted to 1364.29 μg/g^{-1} dry weight, while its lowest value was in July, which amounted 540.74 μg/g^{-1} dry weight, with a general average of 1015.52 μg/g^{-1} dry weight. The results of the statistical analysis (Tables 6 and 7) indicated that there were significant differences between the months of the year in the amount of iron in both forms, while there were no significant differences between the study sites.

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Table (6) Concentration of dissolved iron (μg/L^{-1}) of the Tigris River water during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	4.25	3.11	2.75	2.00	1.58	3.33	2.84
2	4.35	3.25	2.83	2.15	1.62	3.38	2.93
3	4.00	3.55	2.73	2.25	1.52	3.77	2.97
4	4.28	3.67	2.79	2.35	1.60	3.75	3.07
5	4.18	3.50	2.80	2.40	1.55	3.66	3.02
average	4.21	3.42	2.78	2.23	1.57	3.58	LSD 0.05
LSD 0.05	0.45						N.s

Table (7) Concentration of particulate iron (μg/g^{-1}) by dry weight of the Tigris River water during different months Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	800.26	540.11	1190.36	1375.39	1160.00	1000.00	1011.02
2	833.16	548.76	1200.51	1365.00	1175.16	995.68	1019.71
3	825.66	538.69	1214.00	1360.18	1170.36	990.28	1016.53
4	813.27	542.66	1188.50	1350.22	1165.24	1015.49	1012.56
5	808.46	533.47	1210.23	1370.64	1158.67	1025.23	1017.78
average	816.16	540.74	1200.72	1364.29	1165.89	1005.34	LSD 0.05
LSD 0.05	**11.75**						**N.S**

The variation in the concentrations of heavy metals between the months of the year, including iron, may be due to variation in the characteristics of the water and its contents of organic and inorganic compounds and pollutants. Because of the dilution factor of water, life activities, the difference in the duration of lighting, and the activity of microorganisms, algae, aquatic plants, crustaceans, shellfish, and other organisms that use different amounts of minerals to activate metabolic activities and enzymes or to build the outer shell and body coverings, depending on the type of organism (Al-Saadi, 2013).

Dissolved and particulate lead (Pb)

The results indicate that the concentrations of dissolved and particulate lead. The values differed according to the months of the year and the study sites. The highest value of dissolved lead was achieved during November 3.53 μg/L^{-1}, while the lowest value was during March, which amounted 1.15 μg/L^{-1}, with a general average of 2.40 μg/L^{-1} (Tables 8, 9). Particulate lead has recorded the highest value was during September, which reaching 22.36 μg/g^{-1} dry weight, while the lowest value was in March, which amounted 15.29 μg/g^{-1} dry weight, with a general average of 18.53 μg/g^{-1} dry weight. The results of (Tables 8 and 9) indicated that there were significant differences between the months of the year in the amount of dissolved lead and particulate lead, while the effect was not significant between the study sites. The results in the current study showed that the values obtained were less than the World Health Organization (WHO), 1996), which was 10 μg/g^{-1}.

The difference in lead values, whether dissolved or particulate, during the seasons or months of the

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year may be due to several factors, including the difference in chemical, physical, and biological properties between the seasons of the year, such as pH, salinity, temperature, speed of water flow, water opacity, turbidity, total hardness, total dissolved salts, total suspended salts, and the amount of positive and negative ions (Salman, 2011).

Table (8) Concentration of dissolved lead (µg/L^{-1}) of the Tigris River water during different months in Wasit Province

Sites	Months						average
	January	March	May	July	September	November	
1	3.26	1.15	1.50	2.00	2.89	3.51	2.39
2	3.00	1.18	1.66	2.16	2.75	3.55	2.38
3	3.28	1.11	1.44	2.20	2.70	3.48	2.37
4	3.30	1.20	1.55	2.10	2.96	3.58	2.45
5	3.16	1.13	1.60	2.13	2.79	3.53	2.39
average	3.20	1.15	1.55	2.12	2.82	3.53	LSD 0.05
LSD 0.05	0.32						N.S

Table (9) Concentration of particulate lead (µg/g^{-1}) by dry weight of the Tigris River water during different months Wasit Province

Sites	Months						average
	January	March	May	July	September	November	
1	18.00	15.27	17.00	17.25	22.46	20.00	18.33
2	18.56	15.20	17.52	17.83	22.33	20.18	18.60
3	18.29	15.35	17.45	17.93	22.25	20.10	18.56
4	18.49	15.33	17.36	17.58	22.40	20.15	18.55
5	18.33	15.30	17.50	17.86	22.38	20.12	18.58
average	18.33	15.29	17.37	17.69	22.36	20.11	LSD 0.05
LSD 0.05	0.35						N.S

Dissolved and particulate chromium (Cr)

The results showed that the values of dissolved and particulate chromium, which differed according to the seasons of the year and the study sites. the highest value of chromium was achieved during September, which amounted 0.244 µg/L^{-1} compared to January and March. The values reached 0.035 and 0.071 µg/L^{-1} respectively, and the general average was 0.133. As for particulate chromium, the value was highest during the months of September and November, as the values reached 30.39 and 27.46 µg/g^{-1} in dry weight, respectively. However, the lowest value was achieved in January, which amounted 15.40 (µg/g^{-1}) dry weight. The general average was 22.98 µg/g^{-1} dry weight. The results of the statistical analysis indicated that there were significant differences in the amount of chromium, while the differences were not significant between the study sites (Tables 10, 11).

The results of the study showed that the values obtained were less than the specifications of the World Health Organization (WHO, 1996), which is 50 µg/L^{-1}. The variation occurring between the values of dissolved and fine chromium between the seasons of the year may be due to the difference in the chemical, physical and biological properties of the water between the months for all the sites studied (Table 1) and as mentioned previously.

Table (10) Concentration of dissolved chromium (μg/L^{-1}) of the Tigris River water during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**0.035**	**0.071**	**0.125**	**0.146**	**0.250**	**0.186**	**0.136**
2	**0.030**	**0.079**	**0.120**	**0.140**	**0.256**	**0.180**	**0.134**
3	**0.039**	**0.073**	**0.115**	**0.159**	**0.246**	**0.176**	**0.135**
4	**0.033**	**0.068**	**0.128**	**0.137**	**0.233**	**0.187**	**0.131**
5	**0.036**	**0.063**	**0.126**	**0.150**	**0.237**	**0.170**	**0.130**
average	**0.035**	**0.071**	**0.123**	**0.146**	**0.244**	**0.180**	**LSD 0.05**
LSD 0.05	**0.03**						**N.S**

Table (11) Concentration of particulate chromium (μg/g^{-1}) by dry weight of the Tigris River water during different months Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**15.69**	**18.25**	**21.39**	**24.22**	**30.75**	**27.68**	**23.00**
2	**15.00**	**19.37**	**21.00**	**24.00**	**30.00**	**27.37**	**22.79**
3	**15.37**	**18.00**	**21.83**	**24.73**	**30.21**	**26.79**	**22.82**
4	**15.50**	**19.00**	**21.57**	**25.33**	**30.53**	**28.57**	**23.42**
5	**15.40**	**18.22**	**21.33**	**24.86**	**30.46**	**26.89**	**22.86**
average	**15.39**	**18.57**	**21.42**	**24.63**	**30.39**	**27.46**	**LSD .05**
LSD 0.05	**3.00**						**N.S**

Heavy metals exchanged in sediments of the Tigris River

Exchange-Cu

Table (12) shows the values of exchangeable copper in the sediments of the Tigris River for some areas of Wasit Province and for different temperature months of the year. The results showed that the highest value of exchanged copper was achieved in July and May, which amounted 20.31 and 18.26 μg/g^{-1} dry weight, respectively, compared to September and November, which achieved the lowest values in the amount of exchanged copper, which was 6.64 and 8.33 μg/g^{-1} dry weight, with a general average of 13.15 μg/g^{-1} dry weight. The results of the statistical analysis indicated that there were significant differences between the months of the year for all study sites, while the differences were not significant between the study sites. The difference in the amount of copper exchanged between the seasons of the year may be due to the difference in thermal distribution, or as a result of the daily movement of aquatic animals, or due to water currents and other factors (Masaharu et al, 2006).

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Table (12) Exchangeable iron concentration (M.gm.gm^{-1}) by dry weight of Tigris River sediments during different months Wasit Province

Sites	Months						average
	January	March	May	July	September	November	
1	11.36	13.89	18.26	20.37	6.53	8.34	13.13
2	11.00	14.37	18.00	20.00	6.75	8.00	13.02
3	11.50	13.50	18.38	20.46	6.70	8.50	13.17
4	11.43	14.50	18.46	20.34	6.64	8.40	13.30
5	11.37	14.00	18.18	20.40	6.60	8.39	13.16
average	11.33	14.05	18.26	20.31	6.64	8.33	LSD 0.05
LSD 0.05	2.26						N.S

Cadmium Exchange-Cd

Table (13) indicate that the values of exchangeable cadmium in the sediments of the Tigris River for some areas of Wasit Province, which showed a clear variation between the months or seasons of the year. The results showed that the lowest value was achieved during May and July, which amounted 0.129 and 0.065 µg/g^{-1} dry weight, respectively, compared to September and November, which achieved the highest values, reaching 0.941 and 1.118 µg/g^{-1} dry weight, respectively, at an average It generally reached 0.58 µg/g^{-1}dry weight. This variation in the amount of heavy metals between the months of the year indicates that sediments play an important role in returning these pollutants to aquatic systems under appropriate environmental conditions. Therefore, they are produced either by chemical reactions or by the occurrence of biological activity, and these factors work to liberate these pollutants, including the heavy metals (Keenan et al, 2006).

Table (13) Exchangeable cadmium concentration (M.gm.gm^{-1}) by dry weight of Tigris River sediments during different months in Wasit province

Sites	Months						average
	January	March	May	July	September	November	
1	0.856	0.367	0.123	0.063	0.963	1.147	0.587
2	0.800	0.456	0.098	0..068	0.900	1.100	0.671
3	0.895	0.317	0.147	0.065	0.957	1.000	0.564
4	0.873	0.436	0.175	0.067	0.900	1.147	0.600
5	0.864	0.300	0.100	0.064	0.987	1.196	0.585
average	0.858	0.375	0.129	0.065	0.941	1.118	LSD 0.05
LSD 0.05	0.08						N.S

Exchange-Fe

Table (14) shows the concentration of iron in the river sediments, which showed a clear difference between the seasons of the year. The amount of iron exchanged in September and November reorded 808.43 and 785.96 µg/g^{-1} in dry weight, respectively. It was higher than March and May months, which amounted 355.76 and 376.10 µg/g^{-1} in dry weight, an overall average was 568.96 µg/g-1 dry weight. The results of the statistical analysis indicated that there were significant differences in the amount of iron exchanged between the seasons of the year, and non-significant differences between the studied sites. The results recorded that the presence of varying concentrations of the studied

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metals in the sediments, including iron, between the seasons of the year. As for the sites, there are clear differences. This may be due to the similarity in the nature of sediments and pollutants ( ).

Table (14) Exchangeable iron concentration (M.gm.gm^{-1}) by dry weight of Tigris River sediments during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**626.00**	**360.17**	**375.29**	**455.67**	**803.00**	**786.14**	**567.71**
2	**620.14**	**355.59**	**370.00**	**450.23**	**810.37**	**780.22**	**564.43**
3	**635.44**	**358.67**	**383.77**	**460.87**	**808.49**	**790.13**	**572.90**
4	**625.67**	**353.11**	**378.16**	**468.76**	**815.27**	**783.33**	**570.72**
5	**630.15**	**351.28**	**373.28**	**465.89**	**805.00**	**788.66**	**569.04**
average	**627.48**	**355.76**	**376.10**	**460.28**	**808.43**	**785.70**	**LSD 0.05**
LSD 0.05	**18.56**						**N.S**

Lead Exchange-Pb

Table (15) described the values of exchangeable lead for sediments of the Tigris River, as the values differed from one season to another and from one location to another. The results showed that the highest values appeared in September and November, which amounted 58.33 and 54.20 µg/g^{-1} dry weight, respectively, compared to the months of March and May (spring season), which amounted to 8.28 and 7.75 µg/g^{-1} dry weight, respectively, with a general average of 31.43 µg/g^{-1} dry weight. The results of the statistical analysis reported that there were significant differences between the months or seasons of the year in the amount of lead exchanged and non-significant differences between the study sites. It shows that the lead element in the exchanged case was high and may be due to the excretion of high concentrations of this element resulting from sources. Humans and oxides caused by transportation means or through wastewater containing organic materials that form complexes with this element and thus increase its concentration, or as a result of polluted rain and the high concentrations of this element that it carries to river water (Abdel-Satar, 2005).

Table (15) Exchangeable lead concentration (M.gm.gm^{-1}) by dry weight of Tigris River sediments during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**45.00**	**8.23**	**7.75**	**15.00**	**60.36**	**55.68**	**32.00**
2	**40.00**	**8.00**	**7.65**	**18.36**	**58.00**	**53.69**	**30.95**
3	**43.29**	**8.50**	**7.85**	**18.00**	**56.39**	**52.44**	**31.08**
4	**44.66**	**8.39**	**7.70**	**17.75**	**57.20**	**55.00**	**31.78**
5	**41.52**	**8.28**	**7.78**	**16.50**	**59.68**	**54.20**	**31.33**
average	**42.89**	**8.28**	**7.75**	**17.12**	**58.33**	**54.20**	**LSD 0.05**
LSD 0.05	**1.56**						**N.S**

Exchange chromium (Cr)

Table (16) estimates the values of exchangeable chromium in the sediments of the Tigris River for different months of the year and for different locations in Wasit province. The study showed that the highest values were recorded in March and May, which amounted 45.24 and 40.32 µg/g^{-1} dry weight, respectively, while the lowest values were recorded in July, which was 15.30 µg/g^{-1} dry weights, and an overall average of 30.67 µg/g^{-1} dry weights. The results of the statistical analysis indicated that there were significant differences between the months or seasons of the year in the amount of chromium exchanged and non-significant differences between the study sites. These differences in the amount of chromium between the months of the year may be due to the previously mentioned reasons for the concentrations of heavy metals (Table 16).

Table (16) Exchangeable chromium concentration (M.gm.gm^{-1}) by dry weight of Tigris River sediments during different months in Wasit Province

Sites	Months						average
	January	**March**	**May**	**July**	**September**	**November**	
1	**28.26**	**45.38**	**40.33**	**15.50**	**24.22**	**30.32**	**30.67**
2	**27.15**	**45.46**	**40.00**	**15.00**	**24.19**	**31.22**	**30.50**
3	**27.50**	**45.00**	**40.50**	**15.25**	**24.00**	**31.85**	**30.68**
4	**28.55**	**45.20**	**40.33**	**15.45**	**24.88**	**30.50**	**30.82**
5	**27.80**	**45.15**	**40.44**	**15.30**	**24.65**	**30.86**	**30.70**
average	**27.85**	**45.24**	**40.32**	**15.30**	**24.39**	**30.95**	**LSD 0.05**
LSD 0.05	**6.00**						**N.S**

Conclusion

The study concludes the rates of heavy metals in dissolved form were within the limits of the World Health Organization, while in the particulate form the iron metal was outside those limits. As for the rates of these metals in the sediments, they recorded high values in all study sites, with the values of the fine form of these elements being superior to those in the form. The values of the heavy metals dissolved in water exchanged in the sediments vary according to the seasons of the year with different temperatures and affect the chemical, physical and biological properties of the water and sediments in the Tigris River.

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