



DOI: <http://dx.doi.org/10.31759/mej.2026.9.1.0056>

Evaluation the concentrations of some heavy metals in the dissolved and particulate phase in Hilla River , Iraq

Nuha Falih Kadhim¹

Mohammed Ali Shalab Gaaed¹

¹Department of Biology, College of Science, University of Babylon, Iraq.

ORCID: 000-00003-3101-2891

Corresponding author: sci.nuha.falih@uobabylon.edu.iq

Received date: 5/3/2026

Accepted date: 1/5/2026

Published date:5/5/2026

To cite this article:

Kadhim ,N.F.. and Gaaed , M.A.S. Evaluation the concentrations of some heavy metals in the dissolved and particulate phase in Hilla River , Iraq . *Mesop. environ. j.*, 2026, Vol. 9, No.1, pp. 42-56 .

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).



Abstract:

This research was carried out in the Shat Al-Hilla River in central of Iraq where Samples selected from three locations along Al-Hilla River for the period from (October 2018) to (June 2019). The study included the assessment of certain heavy metals' content and distribution in water's dissolved and particle phases

Dissolved Heavy Metals were as follows: Iron (1.28- 115.6 µg/l), Cadmium (non detected -1.061µg/l) and Copper (non detected -5.199 µg/l) .Particulate Heavy Metals are as follows: Iron (507- 3596.1 µg/g), Cadmium (non detected - 6.258 µg/g) And Copper (1.8-19.58 µg/g) .The distributed of dissolved heavy metals in water in the all studied sites were as following order: Fe >Cu> Cd. Results study recorded a significant variation in the concentrations of elements among different sites, also the results show there was a seasonal difference in the concentrations of trace elements. Furthermore, the summertime concentrations of these metals are higher than the other seasons. The present study found the particle trace elements have a higher concentration than the dissolved form. The results also show seasonal variation in the concentration of heavy metals in particulate phase where high concentrations were recorded in summer and winter, while a low concentrations were recorded in spring.

Key words: Dissolved Heavy metals, Particulate Heavy metals , water pollution, Hilla river,

Introduction

Heavy metals are metallic elements whose density exceeds that of water, Heavy metals are metals having large atomic weights and densities, they are found in the crust of the earth naturally as oxides, carbonates, and sulfurides. (1,2,3)

These metals, are non-biodegradable by nature and are broadly distributed across the earth's crust. They are absorbed by the body through water, food, and the air. In small amounts, a tiny number are vital to human and animal metabolism, but in larger concentrations, they can be poisonous and pose health risks. (4). There are several chemical characteristics of heavy metals. and are frequently used in electronics and other technical industries, machinery, and other objects. Because of this, they can penetrate soil and rock through natural geochemical weathering mechanisms in addition to various human sources, including aquatic environments and animal food chains. The main sources of contamination are wastewaters from industries, especially those involved in electroplating, electronics, and metal-finishing industries, municipal wastewaters, landfill leaches, mining wastes, and urban runoff. (5) .These metals can enter the aquatic environment through a variety of man-made and natural sources, including home and industrial sewage, landfill leaching, storm runoff, shipping, harbor activities, and atmospheric emissions (6,7). Metals are naturally bioaccumulative. The term "bioaccumulation" describes the gradual build-up of a material, particularly a contaminant (such a heavy metal or pesticide) in a living organism. These substances are accumulated in living organisms more quickly and are difficult to metabolize or excrete (8) .Phase association, temperature, adsorption, sequestration, and other physical components affect the bioavailability of heavy metals. In addition, it is influenced by chemical factors that affect complexation kinetics, lipid solubility, octanol/water partition coefficients, and speciation at thermodynamic equilibrium (9). Biological components, such as trophic relationships, species traits, and biochemical/physiological adaptability, are also important (10).

Therefore, this study was aimed to study the forms of heavy metals, which are important pollutants in the study area, as a comprehensive understanding of the forms of heavy metals is crucial for taking the necessary measures to address excessive exposure to them.

Material and Methods

Description of The Study Area

Three sites were selected in Shat Al-Hilla River to study some Heavy metals con. (Fe, Cd and Cu) in water and *Ceratophyllum demersum* during the study period from October 2018 to July 2019. The first site (S1) is located in the Sinjar region, approximately 7.2 km from the center of Hilla city, in an agricultural area. The second site is located in the center of Hilla city, near the main market and the third site is located south of the city in an agricultural area with numerous fish farms.

Estimate dissolved Heavy metals in water

Water samples was collected monthly from the middle of river at depth of 20-50cm. collected in polyethylene containers with volume of 10 liters approximately 20–30 cm below the water's surface then kept at 15°C in refrigerator. to estimate the Dissolved Heavy metals Two liters of water sample were filtered through Millipore filter paper 0.45µm. 0.5N of nitric acid was used to wash these filter papers. Follow by deionized water, then dried at 60°C for 24 hour and weighted. 2liters of filtered water pass through Ion exchange column (2x50) cm containing Chelating Resin kind chelex-100 in sodium form with mesh size 50-100 provided by Bio-Rad Company at speed no more than 5ml/min. Then 80 ml of nitric acid (2N) were added to wash the ions of heavy metals from the column to the container of volume (80) ml, then vaporized

at 70°C. before crystals dried 1ml of concentrated nitric acid and (10) ml of deionized water was added to dissolved the crystals, then the final volume was completed to 25ml with deionized water. Then the samples were kept in sterile polyethylene containers washed by HNO₃ (0.5N) and deionized water, and kept in refrigerator for the measurement by using Atomic absorption spectrophotometer (11).

Estimate particulate Heavy metals in water

To estimate Particulate Heavy Metals , 0.5g dry wt. of filtered particles, then 6ml of Nitric acid HNO₃ and Hydrochloric acid HCl at ratio 1:1 was added. Then heated at 80°C till vapor to dried, then 4ml of Perochloric acid HClO₄ and HNO₃ at ratio 1:1 was added and dried again. The precipitate dissolved in 20ml of HCl (0.5N) then transferred to the centrifuge for 20min. at 3000r/min. The volume of solution was completed to 25ml by adding deionized water and storing in a plastic container for atomic absorption spectrophotometer examination later. (12).

Statistical Analysis

SPSS V 23 program used for calculating the significant difference ($P \leq 0.05$) with Means and Standard Deviation by using Duncan test.

Results and Discussion

The concentration of heavy metals (iron, cadmium, and copper) in water (dissolved and particulate phases) were shown in Tables (1-6), Figures (1-6).

Dissolved Heavy Metals showed seasonal variation among study months. There was a fluctuation in the levels of heavy metals during study period. Fe con. ranged (1.28- 115.69 µg/l) at site 3 during Oct(Autumn 2018) and Jun (Summer2019) at the same site1 (Fig.1) ,while Cd con. has a highest value (1.016 µg/l) at site 3 during Jan (Winter 2019) and lowest value (ND) at site 1 during Oct ,Dec , Jan, and Jun .at site2 during Oct, Nov , and Mar , and at site 3 during Oct, Nov , and Jun. (Fig.2). Cu ranged between (ND-5.199 µg/l) at site1 during Mar ,and at site3 during Dec, while high value recorded at site 2 during May(Summer 2019) at site2 (Fig.3) . According to statistical analysis results show some significant differences among study months and among sites during significant differences among sites ($P < 0.05$). All measured metals followed this order (Fe > Cu > Cd).

Particulate heavy metals show monthly and seasonal variation during study period. Fe con. ranged (507- 3596.1 µg/g) in site 2 during Oct (Autumn 2018) and in the site1 during Feb(Winter 2019) respectively (Fig.4),while Cd con. has a highest value (6.258 µg/g) in site 1 during Feb (Winter 2019) and lowest value (ND) in site 3 during Nov (Autumn 2019) (Fig.5). Cu ranged between (1.8-19.58 µg/l) in site2 during Nov (Autumn 2018) and Jun (Summer2019) at site1 respectively (Fig.6). According to statistical analysis results showed some significant differences among study months and among sites($P < 0.05$). All measured metals followed this trend (Fe > Cu > Cd).

Table (1): Monthly Variation of heavy metal concentrations of water in site 1 during study period (2018- 2019) (Mean±S.D).

Parameters Months	2018			2019					
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Dissolved Fe (µg/L)	11.17±0.01 b	6.53±0.00 a	34.6±0.1 f	39.15±0.07 g	14.83±0.008 d	13.47±0.09 c	26.18±0.011 e	114.89±0.509 h	40.65±0.011 i
Dissolved Cd (µg/L)	0±0 a	0.3±0.01 f	0±0 a	0±0 a	0.2406±0.01005 g	0.3467±0.01528 e	0.209±0 d	0.159±0 c	0±0 a
Dissolved Cu (µg/L)	0.3848±0.00785 d	1.7255±0.00477 g	0.026±0.001 e	0.1579±0.00088 a	0.0832±0.0076 b	0±0	2.0275±0.0015 h	1.3385±0.00132 f	2.1413±0.00041 i
Particle Fe µg /g	631.5±0.8459 a	1157.9±0.58531 b	3019.4±1.41827 f	1831.2±1.07152 c	3596.1±3.50132 i	2928.5±1.80278 d	3393.4±1.93221 g	3459±1.45539 h	3010±0.93115 e
Particle Cd µg /g	0.102±0.001 a	3.755±0.019 d	0.9572±0.00139 b	0.6736±0.00151 f	6.258±0 c	0.566±0.002 e	0.7906±0.01005 g	0.9533±0.01528 i	0.91±0.001 h
Particle Cu µg /g	10.02±0.157 bc	6.13±4.706 a	10.94±0.151 c	5.65±0.062 a	13.72±0.107 d	8.18±0.001 bc	7.41±0.006 ab	6.14±0.01 a	19.58±0.015 e

different letters referred to significant different (P≤0.05)(Duncan)

Table (2): Monthly Variation of heavy metal concentrations of water in site 2 during study period 2018- 2019) (Mean±S.D).

Parameters Months	2018			2019					
	Oct	Nov	Dec	Jan	Feb	Ma	Apr	May	Jun
Dissolved Fe (µg/L)	7.076±0.001 b	37.648±0.018 g	97.4±0.1 i	37.413±0.082 f	13.083±0.011 d	6.087±0 a	11.282±0.008 c	24.644±0.017 e	78.461±0.01 h
Dissolved Cd (µg/L)	0±0 a	0±0 a	0.307±0.006 e	0.026±0.002 b	0.131±0.01 c	0±0 a	0.005±0.001 a	0.126±0 c	0.281±0.001 d
Dissolved Cu (µg/L)	0.769±0.001 a	0.652±0.001 a	0.652±0.002 a	0.425±0.002 a	0.693±0.002 a	0.687±0.002 a	1.529±0.002 b	5.199±0.564 c	1.247±0.015 b
Particle Fe µg /g	507±1 a	1093.26±1.118 b	2669.78±0.255 d	2328.86±1.214 c	3130.43±1.765 e	3217.66±1.163 e	2918.68±519.482 de	3115.32±3.026 e	2925.36±2.711 de
Particle Cd µg /g	0.9±0.001 d	0.77±0.116 c	1.02±0.001 e	0.62±0.002 ab	1.35±0.068 f	1.28±0.001 f	0.69±0.008 bc	0.58±0.001 a	0.96±0.01 de
Particle Cu µg /g	12.09±0.001 h	1.8±0.002 a	9.67±0.153 f	6.4±0.009 b	9.15±0.018 e	7.08±0.001 c	7.94±0.023 d	10.72±0.015 g	18.59±0.008 i

different letters referred to significant different (P≤0.05)(Duncan)

Table (3): Monthly Variation of heavy metals concentrations of water in site 3 during study period (2018- 2019) (Mean±S.D).

Parameters Months	2018			2019					
	Oct	Nov	Dec	Jan	Feb	Ma	Apr	May	Jun
Dissolved Fe (µg/L)	1.287±0.002 a	7.887±0.01 5 c	44.536±0.0 15 h	29.026±0.00 1 f	16.421±0.0 09 d	6.693±0.00 7 b	21.393±0 .007 e	30.014±0.0 02 g	115.697±0 .072 i
Dissolved Cd (µg/L)	0±0 a	0±0 a	0.011±0.00 1 c	1.016±0.003 f	0.69±0.01 d	0.003±0 b	0.192±0. 001 a	0.143±0.00 1 e	0±0 a
Dissolved Cu (µg/L)	4.468±0.001 i	1.831±0.00 5 g	0±0 a	3.095±0 h	0.693±0.00 4 c	0.772±0.00 1 d	0.616±0 b	1.152±0.00 2 e	1.797±0.0 01 f
Particle Fe µg /g	737.3±0.819 a	1941.27±0. 929 c	2649.69±0. 688 g	2210.08±0.8 78 d	2574.99±2. 106 d	2610±1 e	1623.82± 1.281 f	2751.48±1. 191 h	3486.34±0 .893 i
Particle Cd µg /g	0.9±0.015 e	0±0 a	0.24±0.015 b	1.16±0.011 f	0.08±0.001 d	0.44±0.314 c	0.19±0.0 01 b	0.46±0.001 c	4.29±0.00 9 g
Particle Cu µg /g	5.84±0.014 b	7.92±0.002 e	7.41±0.002 d	8.18±0.001 f	6.65±0.006 c	5.84±0.008 b	4.62±0.0 03 a	11.16±0.01 1 h	9.17±0.00 7 g

different letters referred to significant different (P≤0.05)(Duncan)

Table (4): Seasonal Variation of Environmental parameters and heavy metals concentrations of water in site 1 during (2018-20192) (Mean±S.D).

Parameters Seasons	2018	2019		
	Autumn	Winter	Spring	Summer
Dissolved Fe ug/L	8.85±2.55 a	29.53±11.2 a	19.83±6.96 a	77.77±40.66 b
Particle Fe ug/g	894.7±288.37 a	2815.55±779.34 b	3160.95±254.64 b	3234.48±245.92 b
Dissolved Cd ug/L	0.15±0.16 b	0.08±0.09 a	0.27±0.2 b	0.075 a
Particle Cd ug/g	0.57±0.24 b	2.629±2 c	0.678±0.03 a	0.93±3.13 a
Dissolved Cu ug/L	1.06±0.73 ab	0.088±0.42 a	1.01±1.11 ab	1.74±0.44 b
Particle Cu ug/g	8.08±3.66 a	10.1±3.55 a	7.79±0.42 a	12.86±7.36 a

N.D = non detected
Different letters referred to significant different (P≤0.05)(Duncan)

Table (5): Seasonal Variation of Environmental parameters and heavy metals concentrations of water in site 2 during(2018-20192) (Mean±S.D).

Parameters Seasons	2018	2019		
	Autumn	Winter	Spring	Summer
Dissolved Fe ug/L	22.36±16.75 a	49.3±37.58 b	8.69±2.85 a	51.55±29.48 b
Particle Fe ug/g	800.13±321.11 a	2709.69±348.38 b	3016.17±367.1 b	3020.34±104.08 b
Dissolved Cd ug/L	nd	0.16±0.12 a	nd	0.2±0.09 a
Particle Cd ug/g	0.77±0.21 a	1±0.32 a	0.83±0.1 a	0.98±0.32 a
Dissolved Cu ug/L	0.71±0.06 a	0.59±0.13 a	1.11±0.46 a	3.22±2.19 b
Particle Cu ug/g	6.94±5.64 a	8.41±1.52 a	7.51±0.47 a	14.65±4.31 b

N.D = non detected
Different letters referred to significant different (P≤0.05)(Duncan)

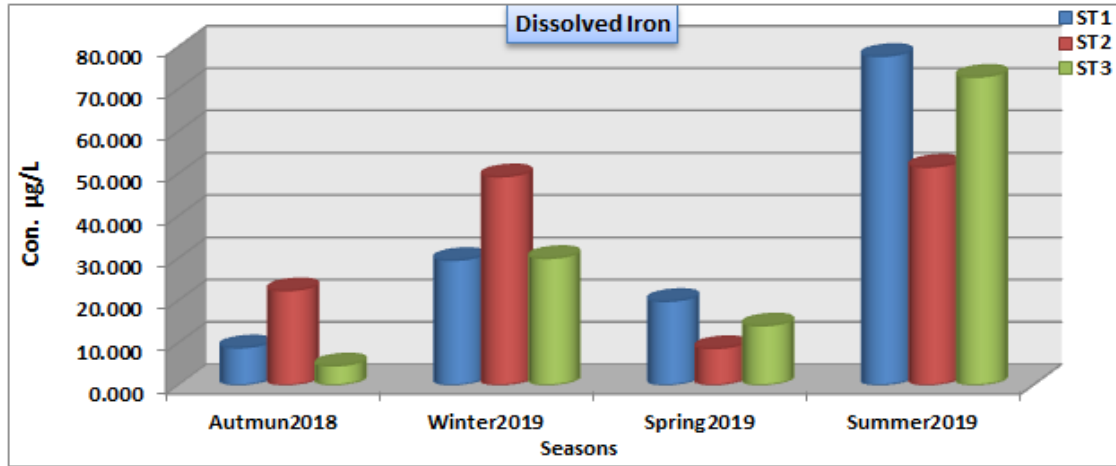


Fig. (1) : Seasonal Variation of Dissolved Fe concentrations (µ g/L) of study sites during 2018/2019.

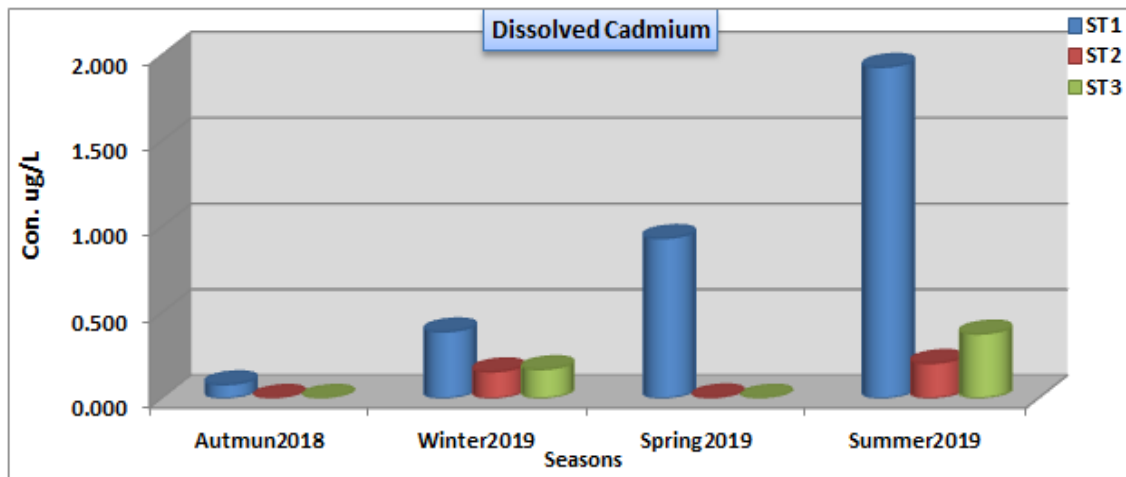


Fig. (2) : Seasonal Variation of Dissolved Cd Concentrations (ug/L) of study sites during 2018/2019

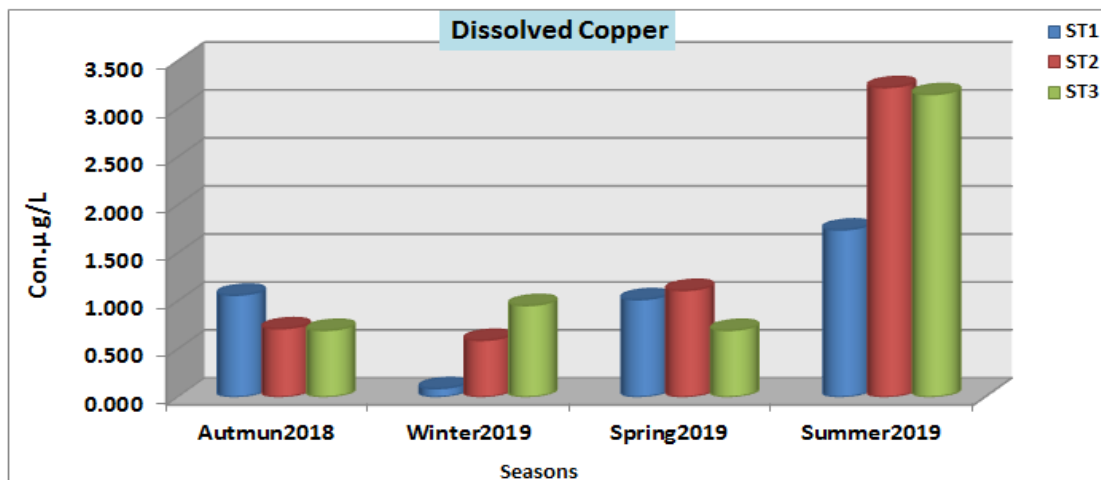


Fig. (3) : Seasonal Variation of Dissolved Cu Concentrations ($\mu\text{g/L}$) of study sites during 2018/2019.

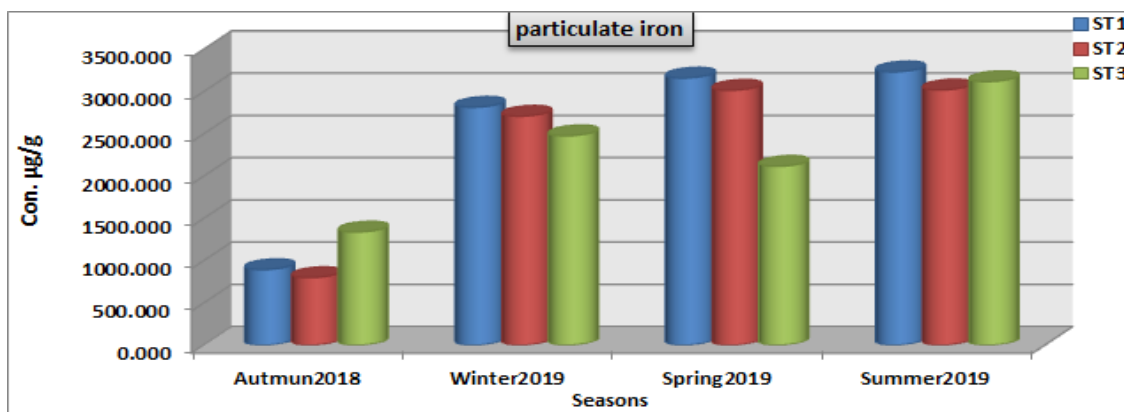


Fig. (4) : Seasonal Variation in Particle Fe Concentrations ($\mu\text{g/g}$) of study sites during 2018/2019.

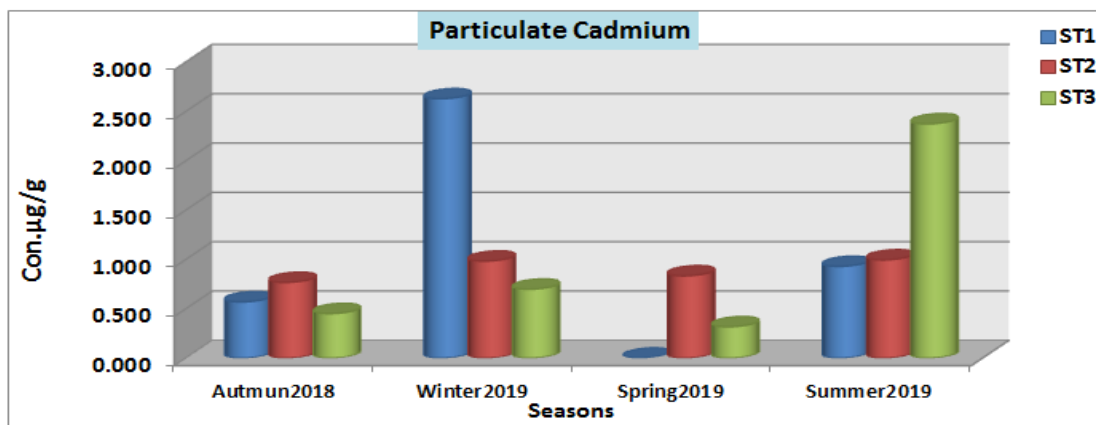


Fig. (5) : Seasonal Variation in Particle Cd Concentrations ($\mu\text{g/g}$) of study sites during 2018/2019

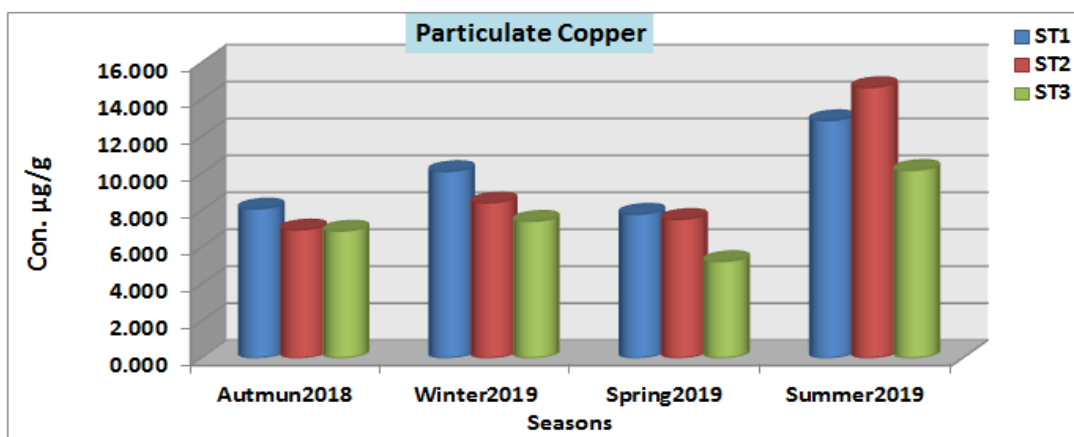


Fig. (6) : Seasonal Variation in Particle Cu Concentrations ($\mu\text{g/g}$) of study sites during 2018/2019

Rivers Consider important transport pathways for heavy metals on a national and regional scale (13). Heavy elements are characterized by being the most surviving in different habitats because they do not transform or decompose, but they may combine to be different complex compounds, which increases the risk of spreading over long distances from the places of origin and subtraction (14). The environmental impact of heavy elements in the water system is associated with their distribution between the dissolved and particle phases of the aquatic ecosystem(15).

distributed of dissolved trace elements in water in the three studied sites were as following order : Fe >Cu> Cd. The cause of the low concentration in the dissolved phase compared to other phases is due to the effect of various physical and chemical factors such as salinity, temperature and pH which leads to adhesion of metals with suspended materials, thereby reducing the concentrations of metals in the dissolved phase (16). results study recorded a significant variation in the concentrations of elements among different sites, this may be due to the diversity in the pollution sources of these elements or to the difference in the amount of pollutants ,The results also show that there was a seasonal variation in the concentrations of trace elements as high concentrations were in the summer, while autumn and spring show the lowest concentrations of elements. This may be due to change in the life activities of some organisms which are affected by several factors that including the amount of food , reproduction and the length of the lighting period (17).

As well, the higher concentrations of these metals in the summer compared with the other seasons may be related to several physical and chemical factors, for example increased in temperatures which led to increased evaporation of water and this led to increased concentrations of heavy metals. In addition, increasing rains in the winter diluted the heavy metal concentrations. (18),while low concentrations of some trace elements in autumn and spring seasons may be due to the removed by some organisms and the ability of these elements to accumulate within the bodies of organisms or to be absorbed by particulate matter and thus precipitate (19). or adsorbed by sediments, or creating complexes with organic matter (20). dissolved phase of metals with water temp. where con. are reduced by low water temperature, this may be due to the deposition of these heavy elements from the water column to sediment due to low temperature (21).

The results of the study showed that the concentrations of dissolved trace elements in the water are within the acceptable limits that fall within the Iraqi determinants mentioned in the draft Iraqi specifications for drinking water for 1986 and within the limits of the international determinants of drinking water for the World Health Organization (22). results of the present study are compared with a number of local studies conducted on the Euphrates, and Shatt al-Arab for Previous periods, results of the comparison found that the concentrations of the trace elements under study were higher than study results higher than the study by (23) on Shatt Al-Arab river except con. Cd was recorded higher than present study, and study by (24) on Al-Hammar marsh south of Iraq, while percent study results recorded less than study results by (25,26) on the Euphrates river and study by (27) on the same river .This difference may be attributed to the decrease in the flow of some industrial activities in the Shatt Al-Hilla and to the increase in water levels of the river.

The increased concentrations of suspended matter in water lead to the transfer of metals from the dissolved phase to the particulate phase (28).The present study found that the particle trace elements have a higher concentration than the dissolved form. This may be due to the high tendency of these elements to adsorption and binding on the surfaces of particulate matter, organic matter and clay in the water column(29). The results also show seasonal variation in the con.of heavy metals where high concentrations were recorded in summer and winter, while a low concentrations were recorded in spring ,The reason for the decrease may be that the growing season occurs in spring and therefore plants absorb most of the trace elements ,but In summer, they increase due to high temperature which leads to an increase in evaporation rates and decomposition of organic materials especially the dead parts of organisms and decrease in the absorption of these elements in addition to increase activity of anaerobic bacteria which analyzes the organic materials mixed with it. (30).

Conclusions

The results showed a seasonal variations in the concentrations of dissolved heavy metals as high concentrations were in the summer, while autumn and spring show the elements' lowest concentrations. The particle trace elements have a higher

concentration than the dissolved form. Also there is a seasonal variation in the concentration of particulate heavy metals where high concentrations were recorded in summer and winter, while a low concentrations were recorded in spring.

Author Contribution

All research stage: laboratory work, collection and analysis of data, research write were done by the author.

Declaration of competing interest

The author confirms that there was no competing interest with others.

Acknowledgment

We glad to knowledge the staff of biology department /collage of science in Babylon university specially those who helpe we in this work.

References

- 1- Ashraf, S., Ali, Q., Zahir, Z. A., Ashraf, S., & Asghar, H. N. (2019). Phytoremediation: Environmentally sustainable way for reclamation of heavy metal polluted soils. *Ecotoxicology and environmental safety*, 174, 714-727. doi: 10.1016/j.ecoenv.2019.02.068. Epub 2019 Mar 14.
- 2- Vareda, J. P., Valente, A. J., & Durães, L. (2019). Assessment of heavy metal pollution from anthropogenic activities and remediation strategies: A review. *Journal of environmental management*, 246, 101-118. doi: 10.1016/j.jenvman.2019.05.126.
- 3- Hou, S., Zheng, N., Tang, L., Ji, X., Li, Y., & Hua, X. (2019). Pollution characteristics, sources, and health risk assessment of human exposure to Cu, Zn, and Cd and Pb pollution in urban street dust across China between 2009 and 2018. *Environment international*, 128, 430-437. doi: 10.1016/j.envint.2019.04.046.
- 4- Gautam, R. K., Sharma, S. K., Mahiya, S., & Chattopadhyaya, M. C. (2014). Contamination of heavy metals in aquatic media: transport, toxicity and technologies for remediation. DOI:10.1039/9781782620174-00001
- 5- Abadin, H., Ashizawa, A., Stevens, Y. W., Lladós, F., Diamond, G., Sage, G., & Swarts, S. (2007). Agency for Toxic Substances and Disease Registry. Toxicological Profile for Lead. <https://doi.org/10.15620/cdc:95222>
- 6- Yilmaz, A. B. (2003). Levels of heavy metals (Fe, Cu, Ni, Cr, Pb, and Zn) in tissue of *Mugil cephalus* and *Trachurus mediterraneus* from Iskenderun bay, Turkey. *Environmental research*, 92(3), 277-281. DOI: 10.1016/S0013-9351(02)00082-8
- 7- Marcovecchio, J. E. (2004). The use of *Micropogonias furnieri* and *Mugil Liza* as bioindicators of heavy metals pollution in La Plata river estuary, Argentina. *Science of the Total Environment*, 323(1-3), 219-226. doi: 10.1016/j.scitotenv.2003.09.029.
- 8- Baby, J., Raj, J. S., Biby, E. T., Sankarganesh, P., Jeevitha, M. V., Ajisha, S. U., & Rajan, S. S. (2010). Toxic effect of heavy metals on aquatic environment. *International Journal of Biological and Chemical Sciences*, 4(4). DOI:10.4314/IJBCS.V4I4.62976
- 9- Hamelink, J., Landrum, P. F., Bergman, H., & Benson, W. H. (1994). *Bioavailability: physical, chemical, and biological interactions*. CRC press.
- 10- Verkleij, J. A. (1993). The effects of heavy metal stress on higher plants and their use as biomonitors. pp. 415–424.
- 11- Riley, J. P., and Taylor, D. (1968). Chelating resins for the concentration of trace elements from sea water and their analytical use in conjunction with atomic absorption spectrophotometry. *Analytica Chimica Acta*, 40, 479-485. doi.org/10.1016/S0003-2670(00)86764-1

- 12- Sturgeon, R.E.; Desaulincrs, J.A.; Berman, S.S. and Russell, D.S. (1982). Determination of trace metals in estuarine sediment by graphite furnace atomic absorption spectrophotometry. *Anal. Chem. Acta.*, 134: 288-291. [https://doi.org/10.1016/s0003-2670\(01\)84198-2](https://doi.org/10.1016/s0003-2670(01)84198-2).
- 13- UNEP, United Nations Environmental Programme UNEP. 2008. Interim review of scientific information on Cadmium- version of March, 2008.
- 14- Gangaiya, P., Tabudravu, J., South, R., Sotheeswaran, S., (2001). Heavy metal contamination of the Lami coastal environment, Fiji. *S. Pac. J. Natural Sci.* 19: 24–29. <https://doi.org/10.1071/SP01005>
- 15- Linnik, P. M.; Zubenko, I. B., (2000). Role of bottom sediments in the secondary pollution of aquatic environments by heavy metal compounds, lakes and reservoirs. *Res. Manage.*, 5 (1), 11 – 21 (11 pages). DOI:10.1046/j.1440-1770.2000.00094.x
- 16- Al-khafaji, B. Y., and Al-Awady, A. A. M. (2014). Concentration and accumulation of some trace elements in water, sediment and two species of aquatic plants collected from the Main outfall drain, near the center of AlNassiriya city/Iraq. *Jornal of Biotechnology Research Center*, 8(2): 19-27. DOI:10.24126/jobrc.2014.8.2.321
- 17- Salman , J.M. (2011). The Clam *Pseudodontopsis euphraticus* (Bourguignat, 1852) as a Bioaccumulation Indicator Organism of Heavy Metals in Euphrates River – Iraq , *J. of Babylon University* ,19 (3) .
- 18- Fang, TH. And Lin, CL. 2002, 'Dissolved and particulate trace metals and their partitioning in a hypoxic estuary: the Tanshui estuary in northern Taiwan', *Estuaries and Coasts*, vol. 25, no. 4, pp.:598-607. <https://doi.org/10.1007/BF02804893>.
- 19- Al-Hayali, A. K. (2001) "Study of the toxic effect of lead and cadmium on the growth of algae *Microcystis aeruginosa* kuetz" Master Thesis - University of Babylon.
- 20- Kaiser, E.; D.B. Arcott; K. Tochner and B. Sulzberger. (2004) Source and distribution of organic carbon and nitrogen in the Tagliamento River, Italy. *Aquat. Sci.* 66: 103-116. DOI: 10.1007/s00027-003-0683-4.
- 21- Goher ME (2002). Chemical studies on the precipitation and dissolution of some chemical elements in Lake Qarun. Ph.D. Thesis, Fac., of Sci., Azhar Univ. Cairo, Egypt. p. 330.
- 22- UNEP/WHO, United Nations Environment Programme and the World Health Organization (1996). A practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programme. Edi. By Jamie and Bartram and Richard Isbn 0419 22320 7(Hbk) 0 419 21730 4 (Pbk).
- 23- Al-Imarah, F.J.M. (2002). Levels of trace metals in the water of Shatt Al-Arab River Marina Mesopotamia. 16 (1): 257-265.
- 24- Al-Khafaji, B.Y. (2010). Distribution Pattern of Selected Heavy metals in Water, Sediments and two species of fish from Al-Hammar Marsh south of Iraq. The 5th Scientific Conference 2011-college of Science- Babylon Univ., 5: 115-124.
- 25- Salman, J.M. (2006). Environmental study of possible pollutants in Euphrates River from Al-Hindiya Barrage to Al-Kufa –Iraq. Ph.D. Thesis, College of Science. Univ. of Babylon. 197 pp.
- 26- Salman, J. M., and Hussain, H. A. (2012). Water quality and some heavy metals in water and sediments of Euphrates River, Iraq.*Journal of Environmental Science and Engineering. A*, 1(9A), 1088.
- 27- Al-Shammery, A. O. S. (2014). A study of Aquatic plants Biodiversity and applications Of water quality indices in Hilla River, IRAQ (Doctoral dissertation, Thesis, University of Babylon-College of Science):125-131.

- 28- Thanh-Nho, N., Strady, E., Nhu-Trang, T. T., David, F., and Marchand, C. (2018). Trace metals partitioning between particulate and dissolved phases along a tropical mangrove estuary (Can Gio, Vietnam). *Chemosphere*, 196, 311-322 .
DOI:10.1016/j.chemosphere.2017.12.189
- 29- Demina, L.L.; Galkin, S.V. and Shumilin, E.N. (2009). Bioaccumulation of some trace elements in the biota of hydrothermal fields of the Guaymas Basin (Gulf of California). *Boletin De LA Sociaeded Geologica Mexicana*, 61(1): 31– 45.
- 30- Park, D.; Lim, S. R.;Yun, Y. S. and Park, J. M. (2008). Development of a new Cr (VI)-biosorbent from agricultural biowaste. *Bioresource Technology*, 99(18): 8810-8818.