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Original Article

Some trace elements in the water, sediments and muscles of three fish species along the Tigris River in Misan, southern Iraq

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Abstract: This study aimed to study the concentrations of some trace elements viz. Pb, Ni, Cd, Co, and Fe in the water, sediments and muscle of three fishes of *Liza abu*, *Mesopotamichthys sharpeyi* and *Carasobarbus luteus* in the Tigris River by selecting six stations distributed along the Misan Governorate, southern Iraq. The study was conducted during two seasons, winter and summer. The concentrations of the studied trace elements in water followed the following order: Fe > Ni > Cd > Co > Pb. Fe had the highest concentration in the water (28.748), while the lowest onewas Pb (0.0523). The results also recorded the trace elements in order of Fe > Ni > Pb > Cd > Co. The highest concentration of Fe in the sediments was 9690.39, and the lowest was cobalt (8.612). The bioconcentration factor (BCF) values in the studied fish species were much higher than the biosedimentation factor (BSF). We conclude that the concentrations of trace elements in the sediments were more than in the waters of the Tigris River, as a storage place of pollutants in the aquatic environments.

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Introduction

Several studies have been conducted on the pollution of rivers with trace elements, and the over-contamination of these elements has become a concern for the health of the aquatic ecosystem (Abdullah et al., 2020; Lazim et al., 2022). Because the trace elements are characterized by their high stability and remain for a long time, and are not affected by other environmental factors. It depends on its ability to form multiple complex compounds. Therefore, it is difficult to remove them (Agbozu et al., 2007; AL-Enazi et al., 2020). Thus, this pollution causes great environmental stress to aquatic organisms (Kapahi and Sachdeva, 2019).

Trace element pollution in aquatic environments has been increasing worldwide in recent years. This is because of human activities, which are the primary source of pollution in the environment, such as the dumping of industrial waste and chemical fertilizers, which play a significant role in the dissemination of trace elements in the aquatic environment (Huang et al., 2018; Algül and Beyhan, 2020). Most of these elements reach the ecosystem by dumping directly or indirectly, such as industrial waste dumped into river waters directly without treatment (Mulk et al., 2017; AL-Enazi et al., 2022). Or by dumping agricultural residues due to pesticides, chemical fertilizers, and wastewater (Al-Zubaidi, 2012; Salman, 2015; Khamar et al., 2018). These minerals are considered among surface water's most critical environmental pollutants because of their accumulation within these ecosystems and their high reliability. They are characterized by the inability to decompose by microorganisms and other life processes. Therefore, they constitute a significant threat to human health (Alkam and Jadan, 2010; Al-Naggar et al., 2018).

High levels of elements in water often lead to elevated concentrations in sediments that are storage places for pollutants (Juned et al., 2018). The elements are released from the sediments directly

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through their release and dissolution through the water column or indirectly by feeding the various benthic organisms or pelagic species, accumulating in these organisms' tissues (Al-Najjar, 2015). These elements may accumulate to very high toxic levels and cause multiple effects on aquatic organisms. Thus, they pose a potential health risk to consumers (Vanden Broek et al., 2002; Tabari et al., 2010).

Several studies have shown that trace elements are responsible for many severe and disastrous effects on fish and other aquatic animals (Gundogdu et al., 2016). Therefore, water and sediment quality monitoring must be performed periodically to assess the risks of these elements (Ali et al., 2016; Karikari et al., 2020). Their effect on aquatic organisms varies depending on their intensity, between chronic effects that symptoms appear after some time and acute effects that cause a reduction in a number of aquatics and change in environmental conditions by impacting the initial stages of growth. The impact of pollution with these elements on living organisms varies according to age, development, and other physiological factors, and also, according to the type of tissue where the metabolically active tissues are the target tissues of these trace elements (Olusola and Festus, 2015; Huseen and Mohammed, 2019). Many aquatic organisms, including fish, are useful bioindicators of trace element pollution in aquatic environments (Al-Khafaji and Lazim, 2013; Sobhanardakani et al., 2018; Farhood and Ali, 2020).

Tigris River receives many pollutants, especially trace elements, due to many human activities and factories that throw pollutants directly into the river without any treatment. Therefore, the current study aimed to study bioaccumulation of some trace elements (Pb, Ni, Cd, Co, and Fe) in water, sediments, and muscles of three species of fish found in the river, *Liza abu, Mesopotamichthys sharpeyi* and *Carasobarbus luteus* as bioindicators of the pollution along the Tigris River in the city of Misan.

Materials and Methods

The study was conducted on the Tigris River in Misan Governorate, southeast of Iraq. This city is characterized by its agricultural wealth, which derives its source from the Tigris River and its subsidiary rivers and contains many districts and sub-districts (Fig. 1). Six sampling sites were selected for the study characterized by different environmental characteristics (Fig. 1, Table 1).

Samples were collected from six stations as monthly in the winter and summer of 2021. Water samples were collected from the middle of the river using plastic (polyethylene) 5 L bottles with three replicates. A few drops of HNO_3 were added as a stabilizing agent to stabilize the elements in the water. For the sediment, the samples were collected from the middle of the river using a grab sampler of Van Veen. They were kept in nylon bags and stored in boxes according to the IMRP (2006). Fish samples were collected from the study area using gill nets (25 mm mesh) and then placed in an insulated cork container containing ice until they reached the laboratory.

The trace elements were extracted from the water after being digested using the method of APHA (2005). The trace elements in the sediments were extracted using the method of Yi et al. (2007). For fish samples, R.O.P.M.E. (1983) method was used to measure trace elements.

Preparation of blank solution: It was prepared by the same method for extracting trace elements but without adding any samples to understand the pollution problem resulting from using chemicals during working conditions in the laboratory as correction values.

Calculation of trace element: The trace elements were calculated using the calibration curve according to Usco (1992). Trace elements in water were calculated based on the equation of Econ. = A×B/C×1000, where Econ. = concentration of the element in water (µg/L), A = concentration of the element extracted from the calibration curve (µg/l), B = final volume of the filter sample (ml) and C = Initial volume of the filter sample (ml).

Trace elements in sediments and muscles of fish: They were measured according to the equation of Econ. = AB/ D, where Econ. = concentration of the

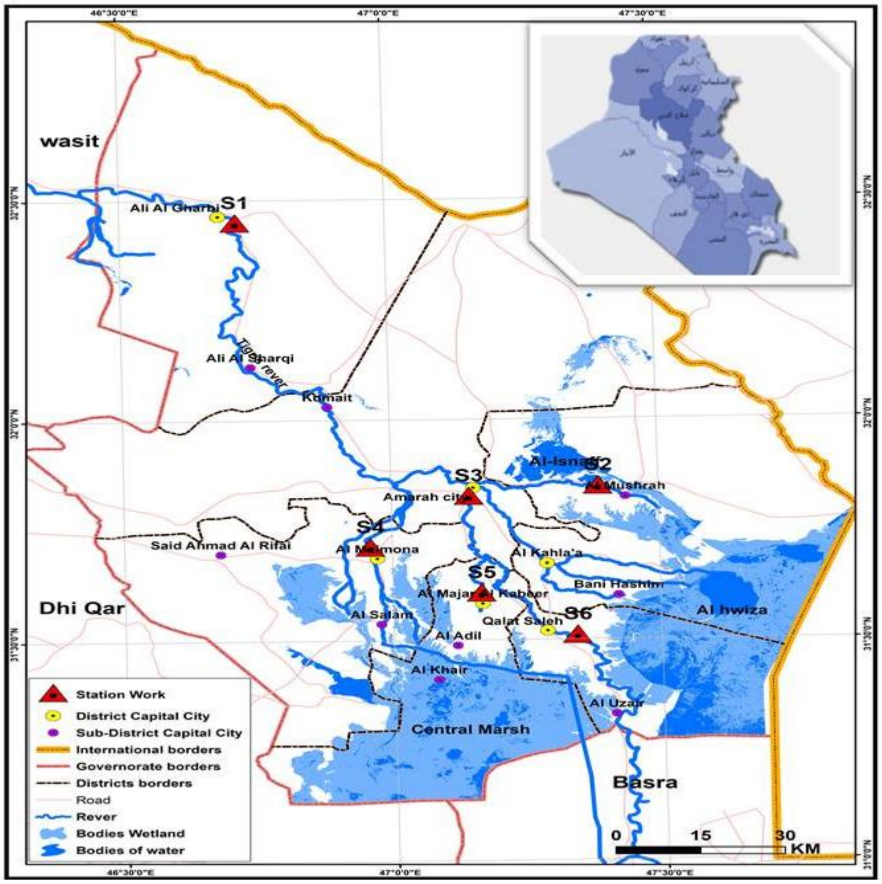

Figure 1. The study sites in the Tigris River, Misan Governorate.

Table 1. Coordinates of the geographical location of the study sites.

Name	Y	X
S1	32.4501	46.7187
S2	31.8481	47.3876
S3	31.8269	47.1456
S4	31.7126	46.9593
S5	31.6077	47.1649
S6	31.5113	47.3423

element in the sample (µg/g dry weight), A = concentration of the element extracted from the calibration curve (µg/l), B = final volume of the filter sample (ml), and D = dry weight of the sample (g).

Bioconcentration (BCF) and Biosedimentation factor (BSF): Since the purpose of this study is to understand transporting path of trace elements between water, sediments, and fish, the BCF and BSF were used to divide the total concentration rate of each element in fish (A) by its concentration in water (B) and sediment (C), respectively (Kumar et al., 2009) using the equations of BCF = A/B, and BSF = A/C, where A = the total concentration of the element in the fish muscles, B = the concentration of the same element in water and C = the concentration of the element in the sediment.

Statistical Analysis: The statistical program of SPSS was used to analyze the data. The significance of the differences between the means was tested using the least significant difference test (LSD) at the significance level of $P \leq 0.05$.

Results

Trace elements of water: The highest concentration of Pb was 0.16 µg/l in the summer at the third site, and its lowest record was 0.02 µg/l at the first site in the winter (Table 2). At the same time, the highest concentration of Ni was 0.89 µg/l in the fourth site in summer and below 0.09 µg/l at the same site in winter. The highest Cd was 0.69 µg/l in the third site during the summer and the lowest (0.003 µg/l) in the fourth site in winter. The highest Co is 0.42 µg/l recorded in the third station in the summer, and the

Table 2. Concentrations of the measured trace elements (µg/l) in water.

Season	Sites	Elements					
		Pb	Ni	Cd	Co	Fe	T
winter	S_1	0.02	0.46	0.04	0.04	16.89	17.45
	S_2	0.04	0.61	0.01	0.05	15.44	16.15
	S_3	0.05	0.63	0.31	0.09	63.95	65.03
	S_4	0.03	0.09	0.003	0.02	10.19	10.33
	S_5	0.05	0.22	0.018	0.076	17.66	18.024
	S_6	0.042	0.39	0.015	0.047	9.43	9.924
	T	0.232	2.4	0.396	0.323	133.56	
	AV	0.0386	0.4	0.066	0.053	22.26	
summer	S_1	0.04	0.29	0.32	0.03	28.88	29.56
	S_2	0.06	0.68	0.59	0.1	20.14	21.57
	S_3	0.16	0.71	0.69	0.42	80.92	82.9
	S_4	0.03	0.89	0.61	0.03	25.14	26.7
	S_5	0.08	0.24	0.22	0.4	23.18	24.12
	S_6	0.03	0.67	0.35	0.3	33.16	34.51
	T	0.4	3.48	2.78	1.28	211.42	
	AV	0.066	0.58	0.46	0.213	35.236	
Total Average		0.0523	0.49	0.263	0.133	28.748	

Table 3. Concentrations of the measured trace elements (µg/g dry weight) in sediment.

Season	Sites	Elements					
		Pb	Ni	Cd	Co	Fe	T
Winter	S_1	10.04	41.99	12.55	1.11	1120.43	1186.12
	S_2	33.12	115.31	12.66	5.44	1091.93	1258.46
	S_3	40.42	144.41	15.76	7.45	20442.5	20650.54
	S_4	29.44	76.41	2.33	4.96	1962.21	2075.35
	S_5	19.22	114.66	11.44	3.55	2081.11	2229.98
	S_6	16.99	95.22	13.81	6.12	11431.13	11563.27
	T	149.23	588	68.55	28.63	38129.31	
	AV	24.87	98	11.425	4.938	6354.885	
Summer	S_1	21.31	100.11	14.91	1.45	8779.16	8916.94
	S_2	31.94	116.14	15.54	16.18	23035.96	23215.76
	S_3	80.22	215.89	19.32	18.22	9435. 55	9769.2
	S_4	47.19	133.13	12.12	11.25	12562.11	12765.8
	S_5	48.88	224.16	18.14	16.29	10012.43	10319.9
	S_6	44.41	184.39	9.31	10.33	14330.16	14578.6
	T	273.95	973.82	89.34	73.72	78155.37	
	AV	45.658	162.303	14.89	12.286	13025.895	
Total Average		35.264	130.151	13.157	8.612	9690.39	

lowest (0.02 µg/l) at the fourth site in winter. The highest Fe was 80.92 µg/l in the third site in summer and the lowest (9.43 µg/l) at the sixth site in winter. The highest cumulative rate of iron among the studied elements in water was 28.748, while lead recorded the lowest cumulative rate of 0.0523 (Table 5). The concentrations of the studied trace elements appeared in the order: Fe > Ni > Cd > Co > Pb.

Trace elements in the sediment: The highest value of lead was 80.22 µg/g at the third site in summer, and the lowest one was 10.04 µg/g at the first site in the winter, and the highest value of nickel was

Table 4. Concentrations of the measure trace elements (µg/g dry weight) in the studied fishes.

Type	Season	Elements					
		Pb	Ni	Cd	Co	Fe	T
Liza abu	Winter	1.13	32.11	7.91	3.88	80.33	125.36
	Summer	1.87	34.77	9.44	4.19	101.55	151.82
AV		1.5	33.44	8.675	4.035	90.94	
Mesopotamichthys sharpeyi	Winter	1.99	29.66	7.99	3.98	98.66	142.28
	Summer	2.82	36.93	10.52	6.76	114.26	171.29
AV		2.405	33.295	9.255	5.37	106.46	
Carasobarbus luteus	Winter	3.44	43.12	14.32	5.76	132.17	198.81
	Summer	3.17	51.11	16.87	5.89	150.12	227.16
AV		3.305	47.115	15.595	5.825	141.145	
T		14.42	227.7	67.05	30.46	677.09	
Total Average		2.40	37.95	11.18	5.077	112.85	

Table 5. BCF and BSF for the trace elements studied in three types of fish during the study period.

Elements	Elements Conc. (µg/l) in Water	Elements Conc. (µg/g) d.w in Sediment	Elements Conc. (µg/g) d.w in *L. abu*	BCF	BSF	Elements Conc. (µg/g) d.w in *M. sharpeyi*	BCF	BSF	Elements Conc. (µg/g) d.w in *C. luteus*	BCF	BSF
pb	0.0523	35.264	1.5	28	0.	2.405	4	0.	3.305	63	0.
Ni	0.49	130.151	33.44	68	0.	33.295	6	0.	47.115	96	0.
Cd	0.263	13.157	8.675	32	0.	9.255	3	0.	15.595	59	1.
Co	0.133	8.612	4.035	30	0.	5.37	4	0.	5.825	43	0.
Fe	28.748	9690.39	90.94	3.	0.	106.46	3.	0.	141.145	4.	0.

224.16 µg/g at the fifth site is in summer and the lowest (41.99 µg/g) at the first site in winter. Cd had the highest concentration of 19.32 µg/g at the third site in summer and the lowest (2.33 µg/g) at the fourth site in winter. The highest CO was 18.22 µg/g at the third site in summer and the lowest (1.11 µg/g) at the first site in winter. The highest Fe in the sediments was 23035.96 µg/g in the second station in the summer and the lowest as 1091.93 µg/g in the winter (Table 3). The current study recorded the values of trace elements in the sediments of the study sites according to the following pattern: Fe > Ni > Pb > Cd > Co. The highest cumulative rate of Fe in the sediments was 9690.39 and the lowest cumulative rate was for CO (8.612) (Table 5).

Trace elements in fish muscle: The highest lead concentration was recorded in *C. luteus* as 3.44 µg/g in winter and the lowest as 1.13 µg/g in *L. abu* in winter. The highest Ni was 51.11 µg/g in *C. luteus* during summer and the lowest (29.66 µg/g) in *M. sharpeyi* during winter. At the same time, Cd recorded the highest concentration of 16.87 µg/g in *C. luteus* during summer and the lowest (7.91 µg/g) in *L. abu* during winter. For Co, the highest value was recorded at 6.76 µg/g in *M. sharpeyi* during summer, and the lowest value was 3.88 µg/g in *L. abu* during winter. For iron, the highest concentration was 150.12 µg/g in *C. luteus* during summer and the lowest (80.33 µg/g) in *L. abu* in winter (Table 4). Iron had the highest accumulative rate of 141.145 among the other studied elements in fish, and Pb recorded the lowest accumulative rate of 1.5 among the other elements (Table 5).

BCF and BSF: Table 5 shows the BCF values of the three fish species of *L. abu, M. sharpeyi*, and *C. luteus* that were higher than the BCF values.

Discussion

The results showed that the highest concentrations of the studied trace elements in the water occurred during summer. The reason for this may be because of the decrease in the dilution factor of these elements in the water due to the low water levels during the summer and the high temperatures leading to an increase in evaporation rates and an increase in the decomposition processes of organic matter, which causes an increase in the concentration of trace elements in the water (Obasohan, 2008; Mahmood, 2015). In contrast, the winter season showed the lowest concentrations of all measured elements. This may be attributed to the increase in water levels due to rain or as a result of the change in the activities of some living organisms, such as feeding and reproduction (Salman, 2015). Most studied elements increased in the summer, especially in the third site, 82.9 μg/l. This is due to the entrance of diverse pollutants in this site that represents the center of the city of Misan (Saeed, 2014), and the industrial wastewater from some oil facilities whose wastes pour into the Tigris River, and the high temperatures in the summer, which led to an increase in the evaporation of water (Salman, 2006).

The low concentrations of some trace elements in water in the current study may be due to their tendency to accumulate within aquatic organisms (Vardanyan et al., 2008) or through their adsorption on the surfaces of sediments, or the formation of complexes when interacting with sulfates and silicates (Dhir and Kumar, 2010). Considering that sediments are the final recipient of all the products of natural and human activities that are presented to the ecosystem and therefore represent the most important environmental indicators of pollution by trace elements that accumulate in them as a result of these activities (Saeed and Shaker, 2008). Increasing concentrations of trace elements in sediments directly or indirectly negatively affect aquatic and benthic organisms because they are in direct contact with the sediments (Vanden Broek et al., 2002). The concentrations of the studied trace elements in the sediments were higher than their concentrations in the water. This result agrees with Bazrafshan et al. (2015), as the concentrations of these elements on the surface are lower than in the deep layers (Aradpour et al., 2020).

According to the order of trace elements in the sediments, the cobalt had the lowest values (8.612 μg/g), while the highest values were for Fe (9690.39 μg/g), and niNi (130,151 μg/g). This indicates that these areas are polluted by sewage water from household, industrial and commercial wastes (Abaychi and Al-Saad, 1988; AL-Enazi, 2014). The reason may be due to trace elements' tendency to attach the suspended matter, including organic and clay particles, in sediments (Kaiser et al., 2004). Water's chemical and physical factors affect the sedimentation and adsorption of trace elements in sediments (Remoudaki et al., 2003). The presence of higher trace elements in the sediments of aquatic systems is because they represent the main reservoir of those elements and can move from the phase of their presence in the sediment to the phase of their presence in the water column (Al-Saad et al., 1996). Hence, the possibility of its transmission through the food chain by consumption through higher-level organisms such as humans is a crucial concern (Abdullah et al., 2007).

The accumulation of trace elements in fish negatively affects human health by consuming contaminated fish (Fergusson, 1990). According to the results, the concentration of trace elements in the muscles of the three fish species was higher than the permissible limits. Therefore, these species of fish can be used as bioindicators of pollution in the Tigris River, which agrees with the findings of Al-Sanjari (2009). The accumulation of trace elements in fish is generally higher than in surrounding waters (Olaifa et al., 2004). The high concentrations of trace elements in the muscles of three fish species in the summer are due to the high temperatures that increase their metabolic activities and feeding leading (Barsytelovjoy, 1999; Vanden Broek et al., 2002). Differences in the concentrations of trace elements in fishes may be due to differences in the species' ecological needs, metabolism, age, size, length, and swimming behaviors (Demark et al., 2006; Al-Ghanim et al., 2016).

The results indicated that BCF in the fish were higher than BSF, which indicates that the trace elements in the water have more impact on the organisms because they are bio-available and capable of accumulating and absorption within the bodies of living organisms, including fish more than sediments (Plessl et al., 2007). This supports the possibility of using these fishes as good bioindicators for pollution with this type of pollutants in the Tigris River (Otachi et al., 2015).

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