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Research Article

Heavy metal accumulation in the muscles of three farmed cyprinid fish species in the City of Basrah

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Abstract
Water pollution may have a significant and negative impact on aquaculture because of heavy metal accumulation. This study aimed to determine the concentrations of heavy metals copper, cadmium, cobalt, iron, manganese, and nickel in the muscles of three cultured fish species viz. *Cyprinus carpio, Ctenopharyngodon idella,* and *Hypophthalmichthys molitrix*) in Basrah as well as in water and sediments. Between November 2020 and October 2021, the fish with an average length of 30.5cm and a weight of 379.5g were collected. Based on the results, the maximum concentrations of Fe, Ni, and Cu in common carp were 50, 19, and 10µg/g dry weight in November and December, respectively, while the lowest of Cd, Co, Cu, and Mn were non-sensitive in April. The greatest concentrations of Fe, Ni, and Cu in grass carp were also recorded, 35, 24, 11µg/g dry weight, respectively, in September and October, and the lowest Cd was in April at 1µg/g dry weight. The highest concentrations 53, and 27µg/g dry weight of Fe and Ni in silver carp were found in April, and the lowest in September and October. The heavy metals concentration levels in water varied for Co at 1.13 µg/g dry weight, in July and August for Fe and Ni at 28.87, and 14.93µg/l, respectively. The lowest concentrations were recorded in March for Cd and Mn 0.83, and 0.42µg/L, respectively, whereas Co was non-sensitive. Mn in sediments were highest in December and February at 209.0µg/g dry weight, whereas Cu was lowest in September and October at 21.46µg/g dry weight. The highest levels of heavy metal concentrations in the studied fishes were greater than the internationally permitted limits.

Keywords: Heavy metals, Bioaccumulation, Farmed fish, Contamination.

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Introduction

Fisheries and aquaculture play an important role in food security (Qian et al. 2020). Aquatic systems have been exposed to many pollutants, which may cause severe environmental damage. Industrial waste is a major cause of pollution in natural water, with some pollutants being thrown directly from industries and sewage treatment plants, while others come from agricultural run-off (Akhtar et al. 2021). Heavy metals are important contaminants, posing considerable environmental and health risks because of their toxicity, stability, bioaccumulation, and biomagnification features in water and fish tissues (Lipy et al. 2021). Not all heavy metals in aquaculture systems are created by human activities such as agriculture and industry (El Bahgy et al. 2021), but some are formed by the absorption of naturally occurring soil components, making it difficult to pinpoint their sources; also, pollution-free places are not entirely free of heavy metals (Hacisalihoglu 2020).

Some living species in the region are affected by toxic benthic sediments. Worms, crabs, and snails are exposed to harmful and hazardous compounds. However, depending on the element's toxicity, it can cause chemical or biological changes in the living organism (Habib et al. 2021). Some benthic organisms accumulate pollutants from sediments through oysters, crabs, and mollusks. These pollutants will be the food of fish, later the food of marine mammals, water birds, and humans. The food chain is upgraded and the accumulation process is increased, known as biomagnification. Pollutants in sediments may not always stay at the bottom of a water body, implying that when water flows and drifts, chemicals deposited at the bottom might be moved, and exposing organisms to hazardous pollutants directly (Vázquez & Rahman 2021). Chemical components that accumulate in silt and sediment at the bottom of bodies of water can re-enter the water, making silt a secondary source of heavy metal pollution (Valdelamar-Villegas et al. 2021). Heavy metal concentrations in fish muscle and tissue and water and sediment are now vital and useful as one of the most important indicators of pollution in aquaculture (Bawuro et al. 2018; Töre et al. 2021).

Many factors influence the intensity of heavy metal bioaccumulation in fish tissues, including fish species and eating patterns, the kind and concentration of pollutants, and season (Khallaf et al. 2018). Therefore, this study aimed to measure the concentrations of some heavy metals in the muscles of three high-demand farm fishes, including Common carp *Cyprinus carpio*, grass carp *Ctenopharyngodon idella*, silver carp *Hypophthalmichthys molitrix* in Basra Province during the year.

Materials and methods

A total of 30 samples of each species were collected monthly from fish cages (3*3*2m) in the Al-Haritha district. Fish were measured for their total length and weight. Between November 2020 and October 2021, the fish with an average length of 30.5cm and a weight of 379.5g were collected. Following sample collection and preparation, the procedure described by Ropme (1999) was used to digest fish muscle samples and assess their heavy metal concentration. For this purpose, 0.5g of lyophilized and crushed samples were placed in glass tubes, and 3ml of a concentrated combination of perchloric acid $HClO_4$ and nitric acid HNO_3 (1:1) was added. The tubes were submerged in a 70°C water bath for 30min before moving to a heating plate (until the mixture became clear) to finish the digesting process. During the filtering or separating process (fibers), a centrifuge was used to extract any remaining undigested components. The filtrate was collected, and the volume of 25ml with distilled deionized water was complete. Samples were kept in sealed plastic bottles until the examination using a flame atomic absorption spectrometer with wavelengths of 240.7, 248.3, 324.8, 232, 279.5, 228.8nm for Cu, Cd, Ni, Mn, Fe, and Co). The product in units, µg/g dry weight was measured. Because of the layer's stability, sediment samples were taken with a hand shovel at a depth of 5cm to determine the concentration of the heavy elements. Water samples at a depth of 10cm were collected.

The data was analyzed using SPSS version 22.0. One-way analysis of variance (One-way ANOVA) was used to compare the concentrations. The significant difference between means was examined by the least significant difference test (LSD test). All the differences were considered significant at $P<0.05$.

Results

Table 1 shows the environmental factors of the studied area, where the pH was the highest in winter as 8.7 and the lowest in summer at 7.3. In summer, the salinity reached the highest value at 9.33‰, and the lowest in spring at 5.50‰. Regarding DO, the highest level was found in winter at 10.60mg/liter and the lowest in summer at 8.27mg/liter. The highest temperature was recorded in summer at 28.2ºC, and the lowest was in winter at 13.7°C.

The highest concentrations of heavy metals in the muscles of the common carp fish were Fe, Ni, and Cu, with 50, 19, and 10µg/g dry weight, respectively, during September and October (Fig. 1). As for Cd, Co, and Mn, the highest concentrations were 2.74, 3,

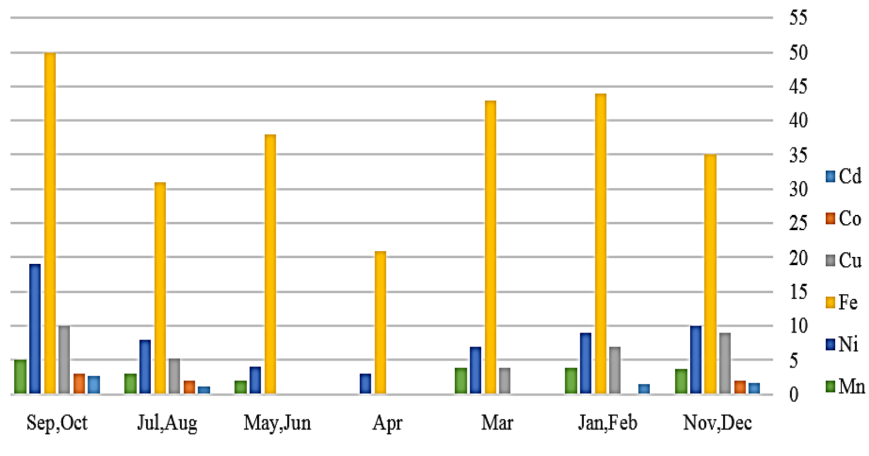

Fig.1. Concentration of elements in the muscles of the common carp during the study.

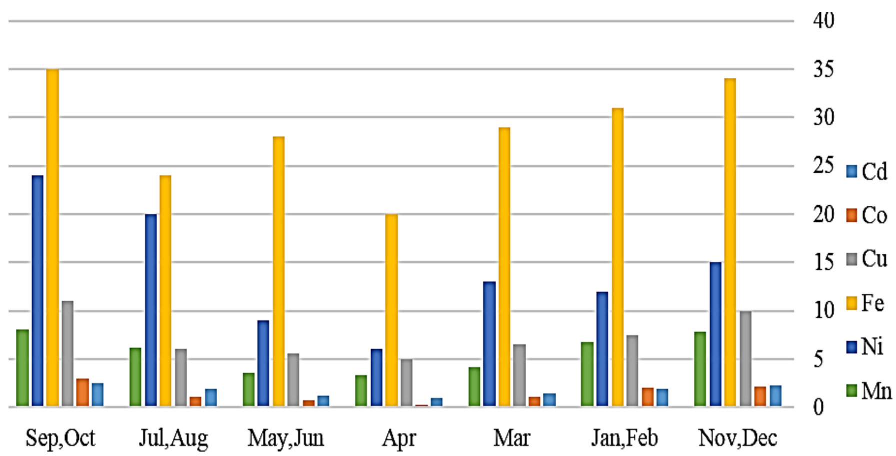

Fig.2. Concentration of elements in the muscles of the grass carp during the study.

and 5µg/g dry weight, respectively, in the same period. The lowest concentrations for Cd, Co, and Cu were during March, April, June, and May, and for Mn in April, and they were below the level of sensitivity of the device. The results also showed a significant difference (P<0.05) between the elements, where three groups were formed: Fe, Ni and Cu, and Cd, Co, and M groups.

Figure 2 shows the concentrations of elements in grass carp. Fe, Ni, and Cu had the highest values in September and October and 35, 24, and 11 µg/g dry weight, respectively. Mn was relatively high in the same period (8µg/g dry weight), with Cd and Co as 2.55, and 3µg/g dry weight, respectively. However, the lowest concentrations were found during April with 1, 0.23, 5, 20, 6, and 3.33µg/g dry weight for Cd, Co, Cu, Fe, Ni, and Mn, respectively. The results showed a significant difference (P<0.05) between the Cd and Ni group, Cu and Mn group, and Fe and Co group, but there was a significant difference between September, October, and April.

Heavy metal concentrations rose in the muscles of silver carp throughout April (Fig. 3), with Fe and Ni of 53 and, 27µg/g dry weight, respectively. Cu and Mn were 10, and 5.99µg/g dry weight, whereas Cd and Co were 3.9, and 5.55µg/g dry weight, respectively. The lowest concentration of Cd, Co, Cu, Fe, Ni, and Mn was reported in September and October, with 1.13, 1.54, 3.29, 17.44, 10, and 2µg/g dry weight, respectively. The results revealed a significant difference (P<0.05) between Cd, Co, Cu, and Mn with Ni. There were significant differences between March and the other months (Fig. 3).

The highest values in July and August for Cd, Co,

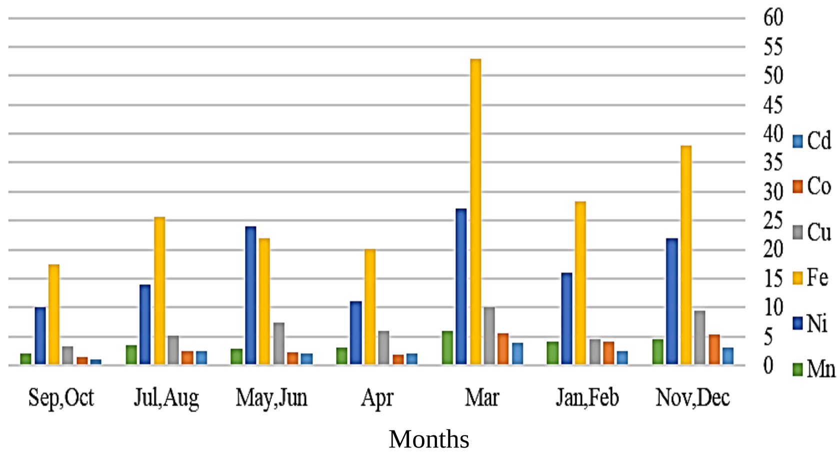

Fig.3. Concentration of elements in the muscles of the silver carp during the study.

Table 1. Environmental factors during the study period.

Stations	Season	pH	Salinity ‰	Dissolved oxygen mg/L	Water temperature°C
1	Autumn	8.2	8.29	9.9	15.30
	Winter	8.7	7.89	10.60	13.70
	Spring	7.4	5.50	10.50	21.19
	Summer	7.3	9.33	8.27	28.20

Cu, Fe, Ni, and Mn were 5.76, 2.73, 5, 28.87, 14.93, 2.72µg/l, respectively. The lowest values were noted in March for Cd, Cu, Fe, Ni, and Mn 0.83, 2, 5, 1.93, 0.42 µg/L, respectively, while the concentration of Co was below the sensitivity level. The results showed a significant difference (P<0.05) between April and June with the rest of the months. A significant difference between Fe and the other elements was found (Fig. 4).

The highest concentration of Mn was 209.82µg/g dry weight in December and February, and the lowest was 167.82µg/g dry weight in September and October. Iron had the highest value in sediments with 162.2g/g dry weight in November and December. Ni showed the highest concentration in November and December and the lowest in September and October. The highest concentration of Cd was in April and the lowest in September and October. Cobalt also recorded the highest concentration in November and December and the lowest in September and October. Copper recorded its lowest concentration in the same period and highest in April. Significant differences were found (P<0.05) between November and December and the rest of the year, and there were significant differences between Ni, Mn, and Fe and the rest of the elements (Fig. 5).

Discussion

Fishes can accumulate heavy metals in their tissues and move them to higher levels through the food chain (CCME 1998). The results of the current study showed high pH values. During fall and winter, the cause might be a lack of drainage from the Tigris and Euphrates rivers. This also applies to the salinity values that have increased during the two studied seasons (Al-Najare et al. 2020). Also, the dissolved oxygen recorded the highest values during winter and spring due to the decrease in temperature values that are inversely proportional to the amount of oxygen (Wu 2010). Temperature showed an increase in summer and a decrease in winter due to the region's climate (Power et al. 2000).

Heavy metals in farmed fish muscles are the most substantial indication of metal contamination in aquaculture. Fish may absorb metals and accumulate them biologically by swallowing polluted water

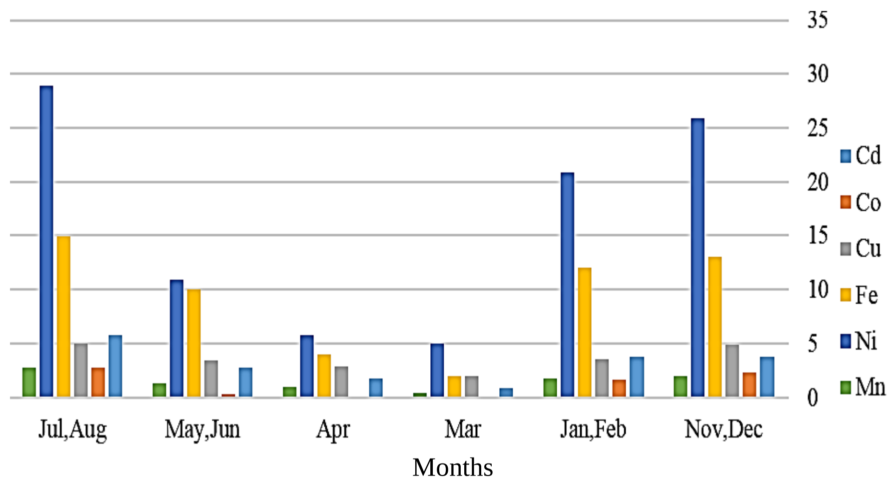

Fig.4. Concentration of elements in water during the months of the study.

Table 2. The permissible limits of heavy metals in fish (micrograms/g dry weight).

References	Pb	Cd	Fe	Mn	Ni
FAO (2009)	3.1	3.9	50	7.9	17.8
MFR (1985), (Swami et al. 2001)	4.0	1	55	4.5	20.0
FDA (2001), (Swami et al. 2001)	1.7	4	40	—	80

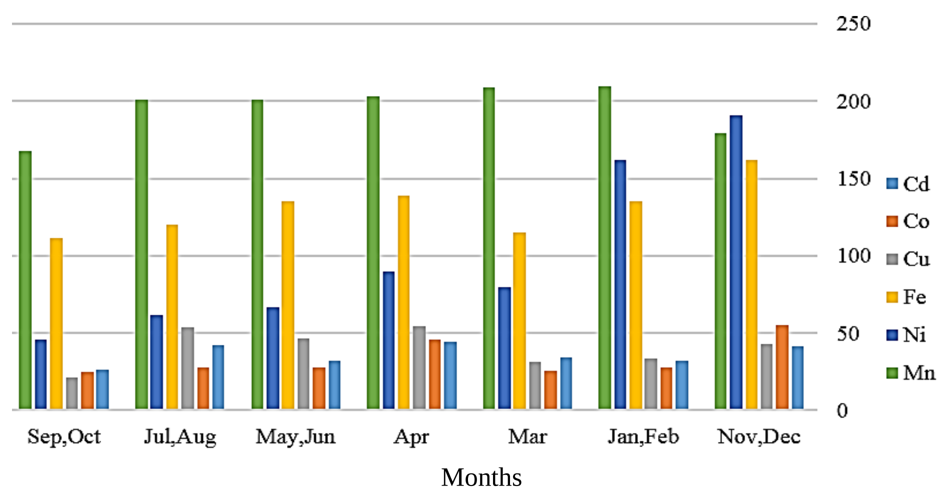

Fig.5. Concentration of elements in the sediments during the months of the study.

directly or through gills and skin (Rubalingeswari et al. 2021). It is critical to understand the concentrations of heavy metals in fish tissues that endanger human health (Chai et al. 2021). The present study found a high concentration of Fe and Ni in the muscles of the three carp species (common carp, grass carp, and silver carp) during the study period. It is due to the tendency of living organisms to concentrate Fe in their muscles to take advantage of it in growth processes (Al-Najare 2021). As for nickel, studies have indicated the tendency of its concentration in living things to be more than its concentration in the environment. These elements can accumulate through absorption or adsorption on the cell wall and affect the cellular system's structure (Danouche et al. 2021). Khallaf et al. (2018) noted that the degree of bioaccumulation of heavy metals in fish tissues and muscles depends on the type of pollutants and their concentration in the environment. Furthermore, heavy metals infiltrate fish tissues, such as fatty tissues, and with inadequate blood circulation in this area of the tissues, they are difficult to eliminate (Al-Najare 2012). According to the Malaysian Food Regulations 1985 (Table 2), the concentration of heavy metals in the muscles was higher than the permissible limits set by FAO/WHO (1984), while the rest of the concentrations were within the permissible limits.

In the muscles of fishes, there was a significant difference between Fe and Ni and the other elements investigated. The results showed the highest values are found in silver carp in all months of the year, except for Fe, which was highest in common carp, followed by grass carp, and silver carp. It may be due to the nature of these fish's feeding since they are fed the phytoplankton, which causes an increase in their concentration. It is diffusion through the absorption and buildup of chemicals found at the bottom of the food chain, such as phytoplankton and diatoms. Saleh (1997) reported that in *Liza subviridis* that fed diatoms and organic crumbs, heavy metals move from the intestines to the circulation and then to the various organs. The accumulation of heavy metals recorded in the present study is higher than that of Al-Najare (2012) in *L. subviridis*, and Nasir & Al-Najare (2015) on *Scomberoides commersonianus*, which are predatory fish at the top of the food pyramid.

The present study reveals that Metals concentrations in water might make it difficult to assess the environmental status. This work also revealed a fluctuation in heavy metal concentrations in the water of the culture ponds over the study period, as the heavy metals. The high concentrations of heavy metals in the present study might be because of irrigation water, sewage, and contaminants that enter the aquatic environment through agricultural operations, and household waste that is directly thrown without any treatment into the river (Mojoudi et al. 2013). Our findings outperformed those obtained by Al-Tai (1999) in his survey on some heavy metals in the waters of the Shatt Al-Hilla River, as well as those of Hussein & Fahd (2008) in their study on the monthly fluctuations of heavy metal concentrations in the waters of the Garraf Canal (one of the main tributary of the Tigris River).

According to the current study, there is approximate stability of the heavy elements in the sediments, with minor variations over the winter season due to the quantity of rain and absolute volumes of water. This is consistent with Fufeyin (1994) study on one of the tributaries of the Ravi River in Pakistan, where it was discovered that the average annual Cu, Cd, Ni, Mn, Zn, Pb, Fe, and Cr concentrations were higher in the rainy season than the dry season due to mineral release from sediments during the rainy and flood seasons and adsorption into sedimentary particles during the dry season (Obasohan et al. 2007).

References

Akhtar, N.; Ishak, M.; Ahmad, M.; Umar, K.; Yusuff, M.M.; Anees, M.; Qadir, A. & Almanasir, Y.A. 2021. Modification of the Water Quality Index (WQI) process for simple calculation using the multi-criteria decision-making (MCDM) Method: A Review. Water 13(7): 905.

Al-Nagar, G.A.; Douabul, A.A. & Al-Noor, S.S. 2020. Water Quality Index (WQI) as an indicator of the East Hammar marsh after sharpe salinity increase during summer 2018. Marsh Bulletin 15(1): 1-11.

Al-Najare, G.A. 2012. Concentration of metals in the fish *Liza subviridis* from the Iraqi Marine Estimation. Journal of King Abdulaziz University/Marine Sciences 23(1): 129-146.

Al-Saad, H.T. & Al-Najare, G.A. 2010. Estimation concentration of heavy metals in water, sediments and *Aspius vorax* fish, catching in southern Iraq marshes. Proceeding of the 3rd scientific conference for environmental pollution in Iraq. Iraq Environmental Protection Association 3(1): 1-14.

Al-Tai, M.M.S. 1999. Some trace elements in the water, sediments, fish and plants of the Shatt al-Hilla River. Ph.D. thesis. College of Science, University of Babylon. 129 p.

Bawuro, A.A.; Voegborlo, R.B. & Adimado, A.A. 2018. Bioaccumulation of heavy metals in some tissues of fish in Lake Geriyo, Adamawa State, Nigeria. Journal of Environmental and Public Health 2018: 1-7.

CCME. 1998. Canadian tissue residue guidelines for the protection of wildlife that consume aquatic biota.

Canadian Council of Ministers of the Environment. 18 p.

Chai, M.; Li, R.; Gong, Y.; Shen, X. & Yu, L. 2021. Bioaccessibility-corrected health risk of heavy metal exposure via shellfish consumption in coastal region of China. Environmental Pollution 273: 116529.

Danouche, M.; El Ghachtouli, N. & El Arroussi, H. 2021. Phycoremediation mechanisms of heavy metals using living green microalgae: Physicochemical and molecular approaches for enhancing selectivity and removal capacity. Heliyon 7: e07609.

El Bahgy, H.E.K.; Elabd, H. & Elkorashey, R.M. 2021. Heavy metals bioaccumulation in marine cultured fish and its probabilistic health hazard. Environmental Science and Pollution Research 28(30): 41431-41438.

FAO (Fisheries and Aquaculture Department). 2009. The state of world fisheries and aquaculture 2008. Food and agriculture organization of the United Nations. Electronic Publishing Policy and Support Branch, Rome. 176 p.

FAO/WHO. 1984. List of maximum levels recommended for contaminants by the Joint FAO/ WHO Codex Alimentarius Commission. Second series. CAC/FAL, Rome. 3: 1-8.

FDA. 2001. *Fish and Fisheries Products Hazards and Controls Guidance*. third ed.; Center for Food Safety and Applied Nutrition, US Food and Drug Administration.

Fufeyin, P.T. 1994. Heavy metal concentrations in the water, sediment and fish species of Ikpoba Reservior, Benin City. Ph.D. Thesis, University of Benin, Benin City, Nigeria. 112 p.

Habib, S.B.; Hossain, M.B.; Hossain, M.S.; Jolly, Y.N. & Sarker, S. 2021. Ecological risk evaluation in bottom-surface sediments and sub-surface water in the subtropical Meghna estuarine system. Heliyon 7(11): e08324

Hacisalihoglu, G. 2020. Zinc (Zn): The last nutrient in the alphabet and shedding light on Zn Efficiency for the future of crop production under suboptimal Zn. Plants 9(11): 1471.

Hussein, S.A. & Fahd, K.K. 2008. Monthly variations in concentration of trace elements of waters from Al-Garaf, one of the main branches of Tigris River, A special issue of the research of the Fourth Scientific Conference, Karbala University Scientific Journal pp: 167-175.

Khallaf, E.A.; Authman, M.M.N & Alne-Na-Ei, A.A. 2018. Contamination and ecological hazard assessment of heavy metals in freshwater sediments and *Oreochromis niloticus* (Linnaeus, 1758) fish muscles in a Nile River Canal in Egypt. Environmental Science and Pollution Research 25: 13796-13812.

Lipy, E.P.; Hakim, M.; Mohanta, L.C.; Islam, D.; Lyzu, C.; Roy, D.C.; Jahan, I.; Akhter, S.; Raknuzzaman, M. & Abu Sayed, M. 2021. Assessment of heavy metal concentration in water, sediment and common fish species of Dhaleshwari River in Bangladesh and their health implications. Biological Trace Element Research 199(11): 4295-4307.

MFR (Malaysian Food and Regulations). 1985. In Hamid Ibrahim ،Nasser and Yap Thiam Huat. Malaysian law on food and drugs. Kuala Lumpur, Malaysia Law Publisher.

Mojoudi, N.; Mojoudi, F. & Kafilzadeh, F. 2013. Investigate of accumulation the heavy metals Cd, Pb, and Zn in liver and muscle tissues *Capoeta trutta* fish from Dez River, southwest Iran. International Journal of Biosciences (IJB) 3(8): 325-331.

Mucha, A.P.; Vasconcelos M.T. & Bordalo, A.A. 2005. Spatial and seasonal variations of macrobenthic communities and metal concentration in Douro estuary (Portugal). Marine Environmental Research 60(5): 531-50.

Nasir, N.A. & Al-Najar, G.A. 2015. Seasonal variations of heavy metal concentrations in tissues of Talang Queenfish (*Scomberoides commersonianus*) from Iraqi marine and coastal waters, Northwestern Arabian Gulf. Mesopotamian Journal of Marine Science 30(2): 112-123.

Obasohan, E.E.; Oronsaye, J.A.O. & Eguavoen, O.I. 2007. Determination of post-dredging concentrations of selected trace metals in water, sediments and the freshwater mudfish (*Clarias gariepinus*) from Ikpoba River in Benin City, Edo State, Nigeria. African Journal of Biotechnology 6: 470-474.

Power, M.; At trill, M.J. & Thomas, R.M. 2000. Environmental factors and interactions affecting the temporal abundance of juvenile flatfish in the Thames Estuary. Journal of Sea Research 43(1):135-149.

Qian, Y.; Cheng, C.; Feng, H.; Hong, Z.; Zhu, Q.;

Kolencík, M. & Chang, X. 2020. Assessment of metal mobility in sediment, commercial fish accumulation and impact on human health risk in a large shallow plateau lake in southwest of China. Ecotoxicology and Environmental Safety 194: 110346.

ROPME. 2010. *Manual of Oceanographic Observation and Pollution Analyses Methods*. ROPME/ P.O Box 16388. Blzusafa, Kuwait.

Rubalingeswari, N.; Thulasimala, D.; Giridharan, L.; Gopal, V.; Magesh, N.S. & Jayaprakash, M. 2021. Bioaccumulation of heavy metals in water, sediment, and tissues of major fisheries from Adyar estuary, southeast coast of India: an ecotoxicological impact of a metropolitan city. Marine Pollution Bulletin 163: 111964.

Saleh, J.H. 1997. The biology and stock assessment of *Liza carinata* (Val., 1836) and *Liza subviridis* in the Northwest Gulf/Iraq. M.Sc. Thesis, College of Agriculture, University of Basrah. 74 p.

Swami, K.; Judd, C.D.; Orsini, J.; Yang, K.X. & Husain, L. 2001. Microwave assisted digestion of atmospheric aerosol samples followed by inductively coupled plasma-mass spectrometry determination of trace elements. Fresenius' Journal of Analytical Chemistry 369(1): 63-70.

Töre, Y.; Ustaoglu, F.; Tepe, Y. & Kalipci, E. 2021. Levels of toxic metals in edible fish species of the Tigris River (Turkey); threat to public health. Ecological Indicators 123: 107361.

Valdelamar-Villegas, J.; Gomez, J.; de la Rosa, J.D. & Olivero-Verbel, J. 2021. Multi-elemental composition and toxicity of bottom sediments from Panama Canal watershed. Ocean and Coastal Management 204: 105459.

Vázquez, O.A. & Rahman, M.S. 2021. An ecotoxicological approach to microplastics on terrestrial and aquatic organisms: A systematic review in assessment, monitoring and biological impact. Environmental Toxicology and Pharmacology 84: 103615.

Wu, M.-L.; Wang, Y.-S.; Sun, C.-C.; Wang, H.; Dong, J.-D.; Yin, J.-P. & Han, S.-H. 2010. Identification of coastal water quality by statistical analysis methods in Daya Bay, South China Sea. Marine Pollution Bulletin 60: 852-860.