The concentration of Some Heavy Metals in the Water, Sediment, and Fish Muscles of Tilapia Fish in Two Different Natural Water Southern Iraq

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Abstract

The concentration of certain heavy metals (Pb, Zn, Cu, Mn, and Cd) was determined in the water, sediments, and tilapia fish (Coptodon zilli, and Oreochromis niloticaus) from the Tigris River and the fish ponds of Marine Science Centre, University of Basrah, Southern Iraq, during the period April-June 2019. Pb and Zn have the highest concentrations (0.51466 mg/100L) in fish ponds and (0.63 mg/100L) in the Tigris River. Heavy metal concentrations were generally higher in sediment samples than in water samples. Zn recorded a high level of heavy metals in fish pond sediments and the Tigris River. Lead (Pb) has been the most abundant heavy metal identified in the fish muscles. It varied from 0.3010 to 0.8560 mg/100 g in the muscles of C. zilli , and O. niloticus in the Tigris River, respectively. Cd, not detected in all samples of fish. The results showed significant differences (P<0.05) in the bioconcentration of metals in the muscles of O. niloticus and C. zilli fish. Pb shows the highest bioconcentration (8.7622 and 4.2016) in the O. niloticus and C. zilli fish muscles respectively in the waters of the Tigris River. Fish can accumulate heavy metals from their environment and act as bioindicators for these metals. Fish can therefore be considered as ideal organisms in the study of certain long-term variations in the heavy metal concentrations in their environments.

Keywords: *Coptodon zilli, Fish ponds, heavy metals, Oreochromis niloticus, Tigris River*

INTRODUCTION

Environmental pollution is among the issue of the main threat facing human society, environmental destruction and pollution from heavy metals pose a risk to the environment which are of great concern (Ali *et al*., 2019). Heavy metals are a general collective concept that refers to a category of metals and metalloids with an atomic density greater than 4 g /cm^3 (Duruibe, et al., 2007). Besides, heavy metals are also known as trace metals because they exist at low concentrations in biological systems. Concentrations of heavy metals in aquatic ecosystems are commonly controlled by assessing their concentrations in water, sediment, and biota (Camusso *et al*., 1995). The presence of metals in the ecosystem is mostly due to environmental processes such as volcanic activity and degradation, but mainly due to industrial waste (Turkmen *et al.*, 2009). Heavy metals have been studied in some fish from Iraqi fresh and marine water resources (Al-Shamary *et al*., 2015; Nasir and Al-Najar, 2015; Jaafar, *et al*., 2018), as they cause significant harm to human health and other organisms. Heavy metals have high contamination potentials that might be assessed with the use of fish (Adakole, 2000). Monitoring the quality of both water and fish is very critical to increasing the yield of aquaculture. Higher concentrations of heavy metals above the fish tolerance limit impact the fish population, reduce their growth and reproduction (Mohamed and Gad, 2008; Omar *et al*., 2008). Water quality is a significant factor that directly affects the wellbeing, reproduction, and economic and public health of fish. Most heavy metals are toxic to living organisms, and even those considered to be important can be toxic if they are present in abundance. Metal contamination assessment is a significant component of most of the water quality assessment program. The present study was therefore aimed at assessing the concentration levels of Pb, Cu, Zn, Mn, and Cd in the muscles of the red belly tilapia *Coptodon zilli* and *the* Nile tilapia *Oreochromis niloticaus* in the fish ponds of the Marine Science Center-University of Basrah and those in the Tigris River in Basrah, Southern Iraq. The red belly Tilapia *C. zillii*

(Gervais, 1848) is widely distributed in the tropical and subtropical regions of Africa and Eurasia (El-Shazly, 1993). The Nile tilapia, *O. niloticus* (Linnaeus, 1758) is native to Africa, the two species have been introduced for aquaculture and vegetation management purposes in many parts of the world (Negassa and Getahun, 2004). *Tilapia zillii* was recorded by Al-Sa'adi (2007), at Al-Musaib, on the river Euphrates, in Iraq. Mutlak and Al-Faisal (2009), recorded two species *Tilapia zillii* (= *Coptodon zillii*) and *O. aureus* from Basrah's main outfall drain. The Nile tilapia *O. niloticus* is the third exotic cichlid fish that has been introduced to the inland waters of Iraq (Al-Faisal and Mutlak, 2014). Attempts were made to introduce tilapia in the Tigris River basin in Iraq but were unsuccessful (Coad, 1996).

MATERIALS AND METHODS

The study took place in the province of Basrah. It included the Tigris River and the fish ponds of the Marine Science Center of the University of Basrah. Samples of heavy metals in water, sediments, and fish have been obtained from April to June 2019. Water was collected from each fish pond and the Tigris River and stored in separate plastic bottles for further testing with a water sampler. Vertical sampling core (0 cm-15 cm depth) was used to collect sediment samples. The samples were transported to the laboratory and dried immediately at room temperature. After drying, the sample ground and screened to pass a 2.00 mm sieve and placed in plastic bags. Tilapia fish (*O. niloticus* and *C. zillii*) weighing between 150 and 200 g were collected using a cast net. Immediately after collection, the fish samples were placed in the icebox and stored in the laboratory deep freezer (-18 ° C) to avoid decay before further testing. Fish was held for 24 hours in an oven at 70 ° C and ground into a fine powder. Heavy metals (Pb, Zn, Cu, Mn, and Cd) were analyzed by Shimadzu atomic absorption spectrophotometer using different cathode lamps with acetylene flame system (AOAC, 2005). Samples prepared for the study of heavy metals have been stored in a single vial for study of heavy metals. For digestion, 0.2 g-0.5 g of each dry sample was taken into a separate glass beaker and digested with a mixture of nitric acid (HNO3)- perchloric acid (HClO4) at a 3:1 ratio and a temperature of 150 ° C at 3 h and then filtered and finally marked with 50 ml volume with laboratory distilled water.

Besides, the study was expanded to determine the bioconcentration of heavy metals in fish muscles. In this study, the bioconcentration of contaminants BCFs was estimated using the following equation according to Kalfakakour and Akrida-Demertzi, (2000).

BCF = concentration of metals in fish / concentration of metals in water.

All statistical analyses were performed with IBM SPSS version 22 (Arlington, Virginia). and complete randomized design (CRD), at a significant level of ≤ 0.05, and the least significant difference (LSD) was used to compare different treatments.

RESULTS

Heavy metals in water

The results of dissolved heavy metals (Pb, Zn, Cu, Mn, and Cd) concentration in the water samples from the fish ponds and Tigris River are shown in Figure 1. The results showed that there were significant differences ($P< 0.05$) in the content of heavy metals between water in fish ponds and the Tigris River. The Pb (0.51466mg/L) and Zn (0.6300 mg/L) show the highest concentration in the water of fish ponds and Tigris River respectively. Cd was not detected in water samples of fish ponds.

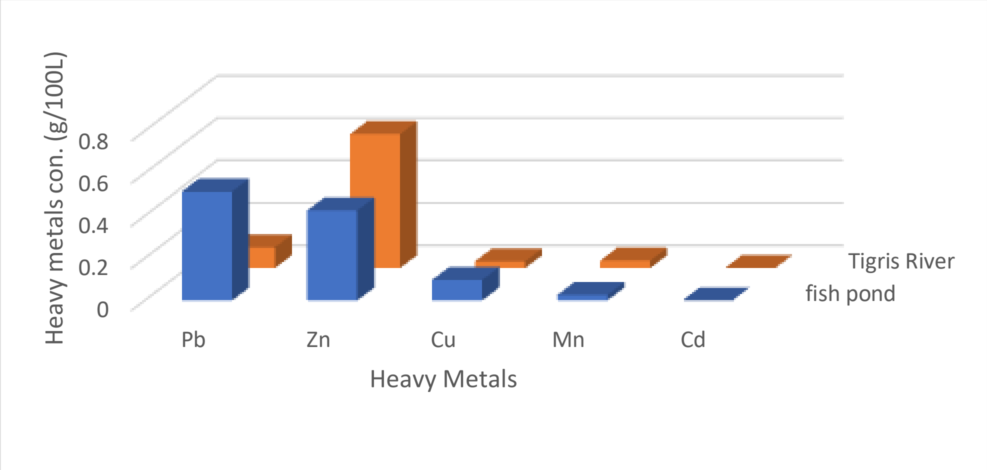

Fig 1. Level of Heavy metals in water (mg/100L)

Heavy metals in Sediments

Figure 2. shows the results of determining the concentration of heavy metals in the sediment samples from the fish ponds and Tigris River, there were significant differences (P< 0.05) in the content of heavy metals between sediments in fish ponds and Tigris River. The Zn shows the highest concentration (2.36554, and 2.35438 mg/100g) in the sediments of fish ponds, and the Tigris river respectively. followed by Cu (1.25200 mg/100g) in the sediments of fish ponds.

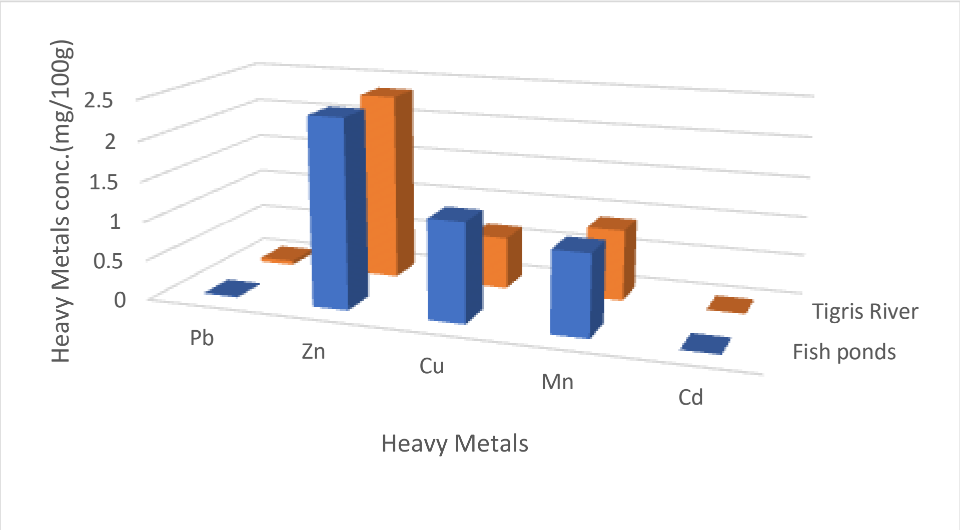

Fig 2. Level of Heavy metals in sediments (mg/100g)

Heavy metals in fish muscles

Lead (Pb) was the most abundant heavy metals detected in the fish muscles. It ranged between 0.4110 to 0.8560 mg/100g in the muscles of *C. zilli* , and *O. niloticus* at Tigris River respectively, and between (0.301 to 0.5233mg/100g) in the muscles of *O. niloticus* and *C. zillii* at fish ponds respectively. The muscles of tilapia fish differed significantly (P<0.05) in terms of their content of heavy metals. Cd is not detected in all samples of fish (Figure 3).

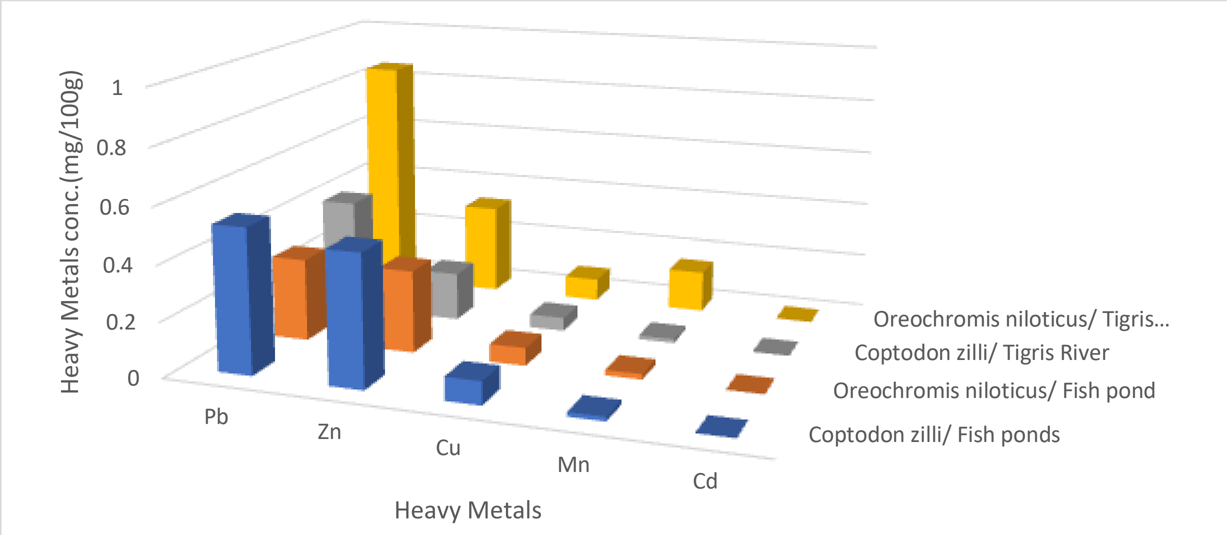

Fig 3. Level of Heavy metals in fish muscles (mg/100g)

Bioconcentrations (BCFs) of Heavy metals in fish muscles

The results showed significant differences ($P<0.05$) in the content of the heavy metals bioconcentration in the muscles of the *O. niloticus* and *C. zilli* fish (Figure 4). Pb shows the highest bioconcentration (8.7622 and 4.2016) in the muscles of *O. niloticus* and *C. zilli* respectively in the waters of the Tigris River. Mn was recorded high bioconcentration in the muscles of *O. niloticus* in the Tigris River (4.3442).

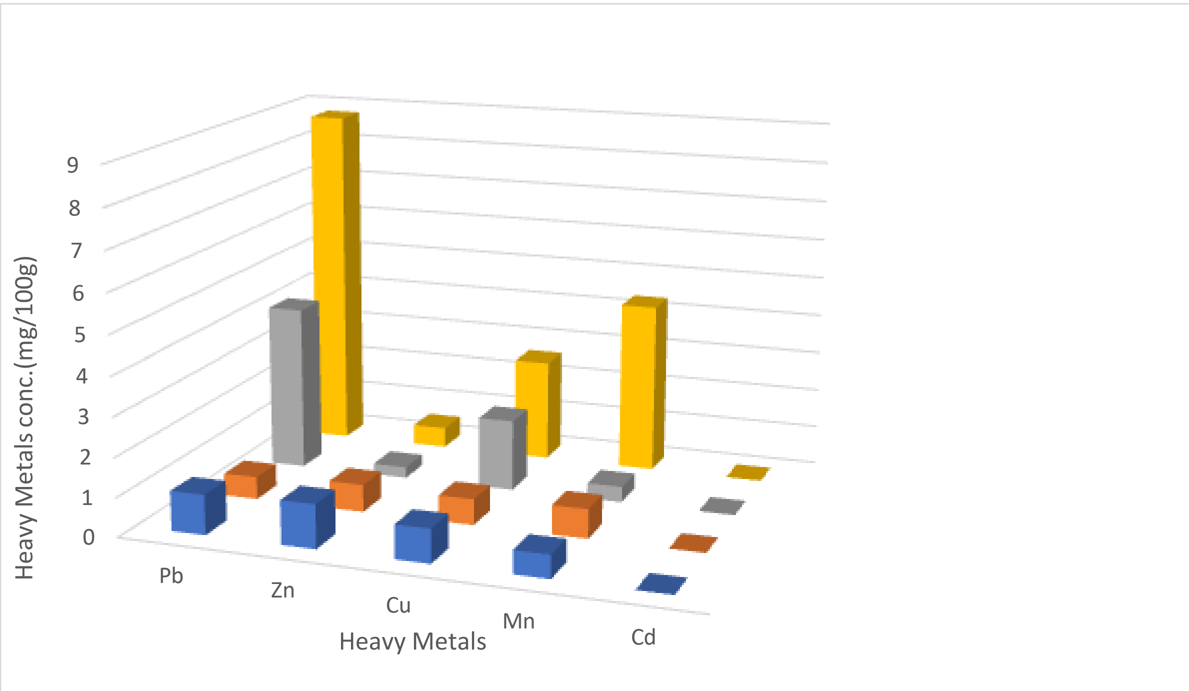

Fig.4. Bioconcentration (BCFs) of Heavy metals in fish muscles

DISCUSSION

The physical and chemical properties of freshwater environments are highly variable due to local geological and climate variations. All metals are natural compounds and can be present in all surface and ground waters at varying levels (Martin and Coughtrey, 1982). Sanders (1997) stated that it is important to carefully monitor heavy metal contamination levels in aquatic environments to obtain rough measurements of the potential threat. The levels of heavy metals detected in the water of fish ponds are observed in the following order: Pb > Zn > Cu > Mn > Cd, and in the water of the Tigris river were in the order of Zn > Pb > Mn > Cu > Cd. Increased use of metal-containing fertilizer could lead to continuing increases in metal pollutant concentration in freshwater as a result of the water runoff (Nagajyoti, 2010). Chemical weathering of minerals are the primary natural sources of metals in water, and anthropogenic sources are mostly associated with industrial and domestic effluent (Zarazua *et al*., 2006). In the present study, the heavy metal concentrations in fish ponds and Tigris River were generally greater in the sediment samples than water samples. Zn recorded a high concentration of heavy metals in the sediments of fish ponds and Tigris River (2.365544 and 2.354389 mg/ 100g) respectively. The high zinc level may be due to the natural contribution of soil, human activity, and soil weathering (Egila and Nimyel, 2002). The order of heavy metal in sediments of fish ponds was: Zn > Cu > Mn > Pb > Cd, and in the sediments of the Tigris River were in the order of Zn > Mn > Cu > Pb > Cd. Metal mobilization is dependent on changes in the sediment-water interface to physicochemical water. Pb, Cu, Mn, and Zn can result from alkaline pH in insoluble hydroxide, oxide, and carbonate precipitation (Ahmad *et al*.,2010). Metals such as Cu has interacted with organic matter in the aqueous phase and settled, resulting in a high concentration of these metals in the sediment. In comparison, the results showed that sediments accumulated heavy metals higher than water. This may be because both pollutants and the dead organic matter are deposited in the sediments (Saeed & Shaker, 2008). Contact with polluted water, sediment, and the ingestion of polluted feed exposes fish to pollutants. The heavy metals in fish muscles from fish ponds and Tigris River were found in the following order: Pb> Zn > Cu > Mn > Cd. Lead (Pb) recorded the highest mean values of 0.52333 and 0.30100 mg/100g in the muscles of *C.zilli*, and 0.41100 and 0.8560mg/100g in the muscles of *O. niloticus* at fish ponds and Tigris River respectively. Whereas Cd is not detected in all samples of fish. The amount of heavy metals in the fish gives insight into the amount that can finally get to a human.

Aquatic organisms bioaccumulate Pb from water and diet, although there is confirmation that Pb accumulation in fish is more likely to derive from polluted water rather than diet (Cretì *et al*., 2010). Pb is listed as potentially dangerous and hazardous for most ways of life by the United States Environmental Protection Agency (USEPA, 1986). Fish can accumulate metals that enter their bodies either directly through water and sediment or indirectly through the food chain (Abdel-Khalek *et al*., 2016). Ibrahim *et a*l. (2000), and Ibrahim and El-Naggar (2006) have observed a strong relationship between concentrations of heavy metals in aquatic organisms and sediments. Also, Singh *et al*. (2017) stated that heavy metals could be fixed in sediment for a limited period and that a small quantity of these fixed heavy metals will be re-entered in the overlying water body and consumed by aquatic biota. According to EPA guidelines, BCF is identified as the ratio of the chemical concentration in the body to that in the surrounding water. Bioconcentration happens only by the absorption and retention of material from water, gill membranes, or other external surfaces of the body. The bioconcentration levels of metals in muscle tissues have been detected in the order: Pb > Zn > Cu > Mn > Cd, and Pb > Cu > Mn > Zn > Cd in the *C. zilli* muscles at both fish ponds and Tigris River respectively, whereas the bioconcentration of metals in the muscles of *O. niloticus* was in the order of Mn > Zn > Cu > Pb > Cd, and Pb > Mn > Cu > Zn > Cd respectively. Pb and Mn recorded the highest bioconcentration in the muscles of *C. zilli* (4.2016, and 1.8163 respectively) at Tigris River, while Pb, Mn, and Cu, recorded the highest bioconcentration in the muscles of *O. niloticus* (8.7622, 4.3342, and 2.5967 respectively) at Tigris River too. The findings of this study are consistent (Al-Imarah *et al*., 2017, Al-Najar *et al*., 2018). which showed that the bioaccumulation of metals in tissues differs from metal to metal is due to the nature of the tissue and physiological structure of the organ and the amounts of fat within the tissue and the presence of enzymes that can combine with heavy elements and remove them outside the tissue and thus out of the body. Also, Koca *et al.* (2005) concluded that the patterns of accumulation of pollutants in fish and other aquatic organisms depend on the rate of uptake and removal of pollutants.

CONCLUSION

The present study indicates some relationships between fish and their environment, especially sediment and water. Fish are more likely to be affected by environmental pollution than land animals. Fish can accumulate heavy metals from their environment and act as bioindicators for these elements. Fish can therefore be considered as ideal organisms in the study of certain long-term increases in the concentrations of heavy metals in their habitats. This study provides useful information on heavy metals in water, sediments, and fish muscles.

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