Eco. Env. & Cons. 27 (October Suppl. Issue) : 2021; pp. (S253-S258)
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ISSN 0971–765X

A comparative study of the accumulation of heavy elements in two species of fish in the Eastern channel of the Euphrates River (Al Haffar), Southern Iraq

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(Received 25 December, 2020; accepted 19 March, 2021)

ABSTRACT

Chemical water pollution is a critical issue nowadays as it results in the bioaccumulation of toxic metals in the aquatic creatures mainly in fish. In this study, the fish samples were collected quarterly for a whole year along the eastern channel of the Euphrates River called Al-Haffar. Concentrations of heavy metals zinc, lead, chromium, and copper determined in the gills, skin, and muscles of two species of fish (i.e, *Tilapia zilli* and *Liza abu*) using an Atomic Absorption Spectrophotometer. According to the results, it observed that heavy elements concentrations magnified in general, but zinc and copper were the most accumulated elements, while the least concentrated were lead and chromium. Heavy elements were more accumulated in the skin, while the gills were the least attractive to heavy elements for both species. Heavy metals in *Liza abu* were as follows (Zn, Cu, Pb and Cr) while, in *Tilapia zilli*, it was as follows (Zn, Pb, Cu and Cr). The statistical analysis showed that there are significant differences between the two species and between tissues of the same species during the study period, as $p \leq 0.05$. In general, *L. abu* fish was more tendencies to accumulate metals than *T. zilli*. The results showed that the fish of this area was not suitable for human consumption, as the level of the elements exceeded the limits set by food organizations. Besides, both studied species could be biomarkers of contamination as the level of accumulation was extreme.

Key words : *AL-Haffar, Tilapia zilli, Liza abu, Heavy metals, Bio magnification, Iraq*

Introduction

Water contamination considered a serious environmental issue on our planet at present, in particular, pollution with heavy elements, which either result from natural sources, such as erosion processes of rocks and the mineral crust of the earth (due to rain, wind, and harsh environmental factors) or may result from human activities such as agricultural waste containing chemical fertilizers and pesticides, industrial activities that include mining and drilling, fuel-burning in factories and electric power plants that use oil and gas, as well as household and animal wastes (Ansari, 2014).

Nanotechnology, which includes the production of small metal particles of 20 nanometers or less for scientific or commercial purposes, is another source of contamination with the elements, when the wastes containing these elements with their various sources reach the water bodies (rivers, ponds, pits, etc. ... Etc) it causes a change in water properties on the one hand and on the other hand it accumulates in the bodies of organisms that live in water (CDCP, 2012).

Water is considered a medium for the transmission, accumulation and decomposition of pollutants,

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and the increase in the concentrations of these pollutants, including heavy elements, poses a threat to the survival and abundance of fish and then to human health, which urges intensified efforts to protect water resources from the risk of pollution (Zelenakova, 2018). The negative impact of these elements on aquatic systems is due to their ability to accumulate in the bodies of aquatic organisms and then pass through the food chain to humans and this poses a real danger, especially for the population of developing countries for which fish represent a major source of food security. These elements are characterized by their ability to last for several years, as it is difficult to get rid of them because they do not degrade chemically or biologically as they are not perishable with the passage of time.

The quality of water will ultimately decrease if human activities continue to be practiced without supervision or legal and special determinants. With the problem of population inflation and the possibility of increasing the population of 9.7 by 2050 (Gao, 2019).

this directly affects the fish that make up about 40% of the vertebrates on the planet and are of commercial and environmental importance and are linked by complex relationships with the water environment that includes feeding, respiration and excretion, Reproduction, migration, and others, as any change in water characteristics directly affects these important activities (Tundisi, 2011) Fish are an available and renewable source of animal protein, vitamins, and elements necessary for human health. Inedible parts are also invested in various purposes, including commercial and industrial such as animal feed (Hicks, 2019) as well as the advantage of fish.

It is also rich in fatty acids that have positive effects on cardiovascular health, improving vision, immunity, protecting against kidney disease, infections, blood pressure, high harmful cholesterol and strokes (Hua, 2019). There are many local studies on the accumulation of heavy elements in fish, including *Liza abu*, but there is little related to Tilapia (Iman Al-Sarraj, 2014; Afaq, 2015).

The Euphrates is one of the most polluted rivers in the Middle East, where many factories or different sources of pollution are established near the river, which exposes it to high levels of pollution directly as a result of throwing various wastes into the river without treatment.

There is no doubt that the drainage (AL-Haffar) gets its share of this pollution; This situation represents an increasing environmental catastrophe that carries serious impacts on the abundance of aquatic organisms, the most important of which is fish, as it suffers from bio magnification of pollutants, as well as on the health of consumers.

Al-Khashni (*Liza abu* as it called in Iraq) fish are among the dominant and endemic fish in southern governorate of Iraq such as Basra, Nasiriyah and Qadisiyah; *Tilapia* fish is an invasive species in the water environment in Iraq and its presence was recorded for the first time in the city of Al-Musayyab in 2007, where it is believed that it came accidentally from the Euphrates River in Syria, but it was able to resist the harsh environmental conditions and rapidly reproduce, which caused an imbalance in the ecological system due to its sovereignty over The rest of the species and in the study area (Al-Haffar) have been observed to have a bad effect on biodiversity by the village residents and fishermen who authorized the invasion of *Tilapia* fish 6 years ago from now in an unknown manner.

This study aims are measure the concentration of heavy elements (Zn, Pb, Cu, Cr) in the gills, skin, and muscles of each of the *Liza* and *Tilapia* fish, verifying the presence of any difference in the accumulation of these elements between the two mentioned species, and finaly, Calculation of bioaccumulation factors of heavy metals for mentioned groups.

Methods and Materials

Site description

Al-Haffar drainage channel is existed at the entrance to the township of Shafeia, in the province of Qadisiyah, southern Iraq. The length of the study area is approximately 12 km and is about 26 km away from the city center. It is situated on 31°57′48.2 N and 44°40′58.6 E and representing the eastern channel of the Euphrates River, which dug in 1942. There are enormous agricultural lands, populated villages on both sides of the canal, there is a gas-powered electricity generation station and fuel filling stations nearby the study area.

Liquid waste drains off the city of Shamiya and Hilla, as well as surplus irrigation water from agricultural lands, are all poured into this drainage. Drainage water is considered saline and polluted, unfit for drinking or irrigation purposes except for some crops (wheat, barley). Residents of the area mainly consume the fish caught from this channel.

Water, fish sampling

Water samples were collected using sterile polyethylene bottles, drops of nitric acid added to preserve it until measurement. Fish samples were gathered separately along the drainage canal from October 2019 until July 2020, helped by professional fishermen being in the area. 30-40 Tilapia (9-16 cm.) 100-120 *Lisa abu*, (11.5 - 20.5 cm) were collected. Samples were put in a heat-insulated box full of ice to keep low temperature, then brought into a laboratory fish were cleaned by water to remove any impurities. The common individuals (male genus of *Tilapia*, female genus of *Liza abu*) specified, dissected. Gills, skin, muscles isolated for each species, organs remained freezing until samples prepared for heavy metals analysis.

Samples preparation and analysis

Water samples are prepared for testing heavy metals using the method mentioned by (Rodger B. Baird, 2017). Previously isolated tissues of fish dried in an electric oven at a temperature of 105, then they grounded (using a pestle and mortar made of porcelain) and sifted. Approximately (0.5) g dry weight of the sample was taken and placed into Teflon container and added 6 ml of each of Hydrochloric and nitric acid in a ratio of 1: 1 and put on a hot plate at a temperature of 150 and left to close to drying, remove the container and leave to cool slightly, then 4 ml of both perchloric and hydrofluoric acid in a 1: 1 ratio add, repeat to a hot plate as they dried, The digested sample was diluted with the addition of 20 ml of acidified water (N 0.5 HCL) and gently stirred until it was mixed and became homogeneous, then filtered using filter paper. The concentrations of heavy elements were measured using an Atomic Absorption Spectrophotometer (SHIMADUZ, AA-6300). This method is a modification of those mentioned in (Tabassum, 2016).

Statistical analysis:

Data obtained were analyzed statistically one-way (ANOVA) utilizing the SPSS statistical program. The average and standard deviations of heavy elements in tissues of two fish species i.e. *Tilapia zilli*; *Liza abu* calculated, as well as the significant variations if $p < 0.05$ estimated statistically between the organs of two mentioned species.

Bioaccumulation factor:

The accumulation factor of heavy elements (Zn, Cu, Cr, Pb) was calculated for three tissues gills, skin, and muscles, using the previously mentioned equation (Authman, 2007), where it represents the ratio between the value of each heavy element in fish and water, as in the following equation:

$$BAF = \frac{\text{[illegible]}}{\text{[illegible]}}$$

Results

Table 1, 2 shows the concentrations of heavy elements (zinc, chromium, lead, copper) in the gills, skin, and muscles of *Tilapia zilli* and *Liza abu*, however, level of Cr in Gills, Skin and Muscles were 8.7 ± 6.3, 10.24 ± 0.7 and 12.1 ± 3.6 respectivily, wherever, level of Pb in Gills, Skin and Muscles were 23.8

Table 1. Annual average of heavy elements concentration of *Liza abu* (µg/g, dry weighs)

Tissues	Elements (mean ± SD)			
	Cr	Pb	Zn	Cu
Gills	8.7±6.3	23.8±3.6	678.1±436	23.4±4.8
Skin	10.24±0.7	20.6±5.3	1071.3±294	33.1±18.1
Muscles	12.1±3.6	23.4±3.2	1036±714	16.6±2.8

Table 2. Annual average of heavy elements concentration of *Tilapia zilli* (µg/g, dry weighs).

Tissues	Elements (mean ± SD)			
	Cr	Pb	Zn	Cu
Gills	10.2±4.5	20.9±1.6	877±262	21.2±21
Skin	9.5±3.01	19.1±2.3	1260±342	20.2±31
Muscles	12.5±1.8	18.3±4.5	1036±714	16.6±2.8

± 3.6, 20.6 ± 5.3 and 23.4 ± 3.2 respectivily, however, level of Zn in Gills, Skin and Muscles were 678.1 ± 436, 1071.3 ± 294 and 1036 ± 714 respectivily, wherever, level of Cu in Gills, Skin and Muscles were 23.4 ± 4.8, 33.1 ± 18.1 and 16.6±2.8 respectivily.

While, Table 3 shows the concentrations of heavy elements in water, and Table 4 shows the bioaccumulation index values in fish tissues, look at Figure 1.

Table 3. Heavy metals availability in water(mg/L).

Elements	Range	Mean±SD
Cr	5.47.3	6.5±0.8
Pb	23.125.8	24.5±1.1
Zn	459.6926.1	684.4±190.8
Cu	29.530.6	30±0.43

Discussion

In this study, the results showed that the heavy elements in *Liza abu* were in order: Zn, Cu, Pb and crin *Tilapia Zilli*, as Zn, Pb, Cu and Cr. The highest concentrations of copper, lead, and chromium was in liza *Abu fish*, while the highest concentration of zinc was in *Tilapia zilli*.

Liza abu fish was more attractive to zinc and copper, while *Tilapia zilli* was more attractive to both zinc and lead. The chromium concentration was lower compared to the rest of the elements in both types. At the tissue level, the skin was more attractive to Zn and Cu and less affinity for Cr in both species *Tilapia zilli* and *L. abu*. The order of elements in the skin was as follows: Zn, Cu, Pb andcr into both species.

It found that the highest concentrations of the elements Zn, Cu, and Pb in *L. abu* and *T. zilli* in the skin, It was must be due to the high rates of lipids in the skin. The accumulation of chemicals, including heavy elements in an organism's tissues accretion along with organ lipid content (Geyer, 2000).

Zn and Pb were the most concentrated elements in gills of *Liza abu*, while in *Tilapia zilli* gills were more attractive to Cu and Zn. As for muscles, zinc and lead were the highest concentrations. The concentration of chromium in the muscles of two species was higher than in the skin and gills, meaning that the muscles are more enticing to chromium than the rest of the organs.

Copper was the highest in the skin and gills in *Liza abu* and *Tilapia zilli*, respectively, and lowest in muscle. zn was the highest in the skin and lowest in the gills for both types, as follows: Skin, Muscles and Gills. Pb was the higher in gills and lower in the skin for *Liza abu*, and as for gills> muscles> skin, as for *Tilapia zilli*, Muscles were less attracted to lead than other organs, as follows: gills, skin and muscles.

Statistical analysis showed significant differences found in the concentrations of heavy elements among the studied tissues of the same species and

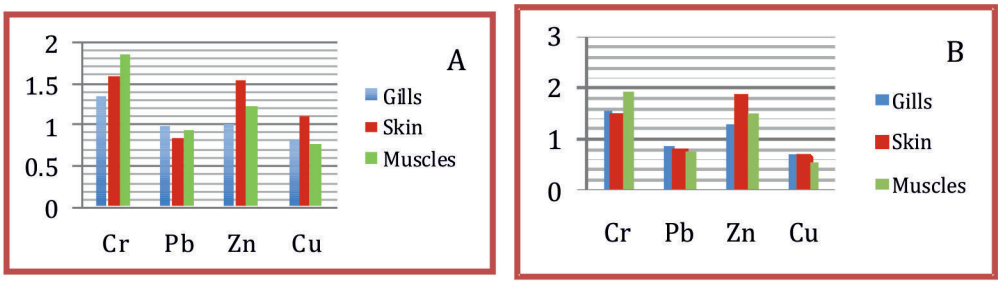

Fig. 1. Bioaccumulation Factor in (A) *Liza abu*, (B) *Tilapia zilli*.

Table 4. Bioaccumulation factors of heavy elements in fish tissues

Species	Tissues	(BAF)			
		Cr	Pb	Zn	Cu
L .Abu	Gills	1.34	0.97	0.99	0.78
	Skin	1.6	0.84	1.56	1.104
	Muscles	1.86	0.95	1.24	0.76
T. zilli	Gills	1.57	0.85	1.28	0.7
	Skin	1.46	0.77	1.84	0.67
	Muscles	1.92	0.74	1.51	0.55

between the two groups where $p \leq 0.05$. The element chromium is widespread as one of the products of factories as rubber, stainless steel, tanning, wood, textile, mining, as well as the pharmaceutical industry (Vutukuru, 2007).

Cr (VI) is one of toxic elements due to its high solubility in aqueous media; Fish muscles contain a high percentage of moisture. In this study, Muscles were more chelated for chromium compared to skin and gills in both species. Gills are the portal through which chromium can reach the cytoplasm (Vinodini, 2009).

Chromium penetrates the cell wall and binds with protein plasma, as well it is concentrated in fish tissues (Dhara, 2014). Several factors affect chromium toxicity in the organism as species, sexual maturity, age, as well as the surrounding environment factors such as temperature, pH, salinity, and turbidity.

Chromium is one of the most abundant elements in the earth's crust. Many epidemiological studies conducted on humans showed that exposure to chromium causes genetic mutations, As well as it is an acute carcinogen that has a particular effect on the respiratory system and can cause ulcers and inflammation of the bronchi and lungs.

Lung cancer is one of the complications associated with exposure to chromium by miners and laborers, As production of dyes, tanning, glass, paper, rubber, and wood (Braadl, 2005). Heavy elements are a crucial part of the cycles in the ecosystem as consumers who are at the top of the food chains obtain the most. Although there is some heavy elements such as Zn and Cu are vital and performs essential functions for organisms such as metabolism, strengthening immunity, growth, enzyme activity, neurotransmitters, and cell structure, they should receive in a given dose.

Zinc helps build proteins, form DNA and cell proliferation, the process of transcription, and formation of RNA. Cr is performing a vital role in hemoglobin synthesis and disease resistance. As for zinc deficiency, it may cause birth-defects. Increasing the concentration of the two elements leads to symptoms such as anemia, liver and kidney diseases, intestinal irritation in humans, as well as bio magnification in fish (Ansari, 2014).

Zinc is toxic if its concentration increases in living cells and some of its compounds, such as zinc oxide, create free radicals from fat cells and cause inflammatory complications and then cell death (Sharma, 2012) it is possible copper promotes the recurrence of carcinomas, leukemia, and lymphoma, and weakens the immune system in high doses and a long period of time (Lansdown, 2014). There is a risk of death when the daily quaff exceeds 250.

An increase in the incidence of lung cancer among workers has recorded in copper extraction mines; however, this is related to inhaling the elements nickel and zinc. Some of the heavy elements are harmful even with low concentrations as lead, mercury, cadmium, and chromium. Pb is one of the most dangerous metals on environmental systems and living organisms as it characterized by its toxicity and ability to interact with living tissues and its negative effect on enzyme functions, as it impedes the absorption of some essential elements such as iron and zinc, which cause anemia, damage in the nervous system and the kidneys.

Furthermore, causes limit the ability of children to develop mentally and may cause birth-defects (laws, 2018) as well as the emergence of complications in the intestinal tract, impaired metabolism, and absorption of vitamin D, high blood pressure, growth problems Reduced intelligence and memory loss are all associated with elevated lead concentrations in the body (USDH and HS, 2019).

Conclusion

The heavy elements in *Liza abu* fish were more than *Tilapia zilli*, while zinc in *T. zilli* fish more than *Liza abu* fish. Skin was the most attractive to the heavy elements Cu and Zn. The chromium in muscles were higher than in the rest of the organs, while the gills were more attractive to lead than the rest of the organs. heavy metals of two species were high. Bioaccumulation of chemicals is obtained from gills, the skin or through the food ingestion. *Zilli* and *L. abu* fish considered bio-indicators for pollution of the surrounding waters. No doupt, high level of the toxic heavy metals have critical effects on human health.

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