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Heavy metals in some tissues and organs of Common Carp (Cyprinus carpio L., 1758).fish species in relation to body size, age, sex and seasons from Taqtaq Region of Little Zab River, Northern Iraq

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***Abstract*— *Heavy metals (Zn, Pb, Cu, Fe, Cd, and Ni) were measured seasonally in three different tissues (gonads, gills, and muscle) of common carp (Cyprinus carpio L., 1758) from the Taqtaq Region of the Little Zab River in Northern Iraq from March 2008 to February 2009. After wet digestion using the MALAIYANDI and BARETTE methods, heavy metals in fish samples were analyzed using atomic absorption spectrophotometry. To compare the data between seasons, age, sex, and size one-way ANOVA and principal component analysis were used (level of 0,05). In the sequence of Cyprinus carpio samples, mean concentrations decreased in the gonads and gills as Zn > Fe > Pb > Ni > Cu > Cd, and in the muscle as Zn> Pb > Fe > Ni > Cu > Cd. Heavy metal concentrations in the samples exceeded the tolerable limits set by international organizations (AIEA-407). Gills had the highest metal concentrations, followed by gonads and muscle. In the winter, the levels of heavy metals in carp tissues decreased. The average values of Zn (80,30 21,00 mg.kg) and Ni (6,95 0,19 mg.kg) were at their highest levels in spring, according to the results. In the winter, the highest Pb, Cu, and Fe levels were found to be 7,53 214, 5,31 0,03, and 22,12 16,06 mg.kg, respectively. Summer had the highest Cd levels, which were 3,29 0.69 mg.kg. Significant differences between seasons were found for each metal (P 0.05).*

Keywords*— *Little Zab River, Heavy metal, Cyprinus carpio L., 1758, Taqtaq Region, Northern Iraq.

I. INTRODUCTION

Metal contamination of aquatic ecosystems (e.g., dams, lakes, rivers, streams, etc.) has gotten more attention around the world, and there are numerous publications on the subject (Bawuro, et al., 2018). Fish species are commonly used to biologically monitor changes in anthropogenic pollutant levels in the environment (Bulut, et al., 2021). Fish are frequently at the top of the aquatic food chain, and they can concentrate large amounts of metals in the water (Abarshi, et al., 2017). Heavy metal toxicity can affect physiological functions, individual growth rates, reproduction, and mortality in fish (Paschoalini & Bazzoli, 2021). Heavy metal concentrations in tissues are the result of uptake and release processes with distinct kinetics for the elements and biological halftimes, which are influenced by individual age and size, species feeding habits, life cycle and life history, and seasons (Rashid, et al., 2021). Heavy metals can enter fish bodies through three routes: the skin, the gills, or the digestive tract (Salam, et al., 2019). The gills are thought to be the most important site for direct water uptake (Rajeshkumar & Li, 2018), while the body surface is thought to play a minor role in fish heavy metal uptake (Ali & Khan, 2018). Food may also be a source of heavy metal accumulation (Rashid, et al., 2018), which could lead to biomagnification, or the spread of pollutants up the food chain (Rashid & Basusta, 2021). The target organs for measuring metal accumulation were muscle, gills, and gonads. Metal concentrations in gills are similar to those in the water. The metal content of the dorsal muscle, as well as that of the gonads, was studied because of its importance for human consumption. The river was built to help alleviate the Isser basin's water problems, and many residents of the area also fish in the Taqtaq Region of the Little Zab River in Northern Iraq. Agriculture and humane activities have both degraded the ecosystem's quality. To the best of our knowledge, no research has been done on the river's environmental quality biota, based on a literature review (Abalaka, et al., 2020). Since this fish is an important component of the humane diet in this zone, the current study was conducted to determine zinc, lead, copper, iron, cadmium, and nickel concentrations in three different tissues (muscle, gonads, and gills) of cyprinus carpio L., 1758 from the Taqtaq Region of the Little Zab River, Northern Iraq. The findings of this study will be used to determine the background levels of metals in the river's common fish species.

II. MATERIALS AND METHODS

Area descriptions

The Taqtaq Region of Northern Iraq is home to the Little Zab River. It stretches for about 400 kilometers (250 miles) and drains about 22,000 square kilometers (8,500 sq mi). Rainfall and snowmelt feed the river, resulting in a peak discharge in the spring and low water in the summer and early fall. On the Little Zab, two dams have been built to control river flow, provide irrigation water, and generate hydroelectricity. The Zagros Mountains have been inhabited since the Lower Palaeolithic, but Barda Balka, the earliest archaeological site in the Little Zab basin, dates from the Middle Palaeolithic. Since then, human occupation of the Little Zab basin has been documented at various times.

Sample Size

Using a motorized boat provided by the river management as well as a tri mesh net, 60 specimens of fish species (Cyprinus carpio) were collected from the Taqtaq Region of the Little Zab River in Northern Iraq. The fish were kept in a cooler and transported to the lab, where their age, total body length, and total wet weight were measured (Table 1).

Scales were removed from the left side between the posterior end of the pectoral fin and the anterior end of the dorsal fin to determine the age of the carp. Gills, gonads, and muscle were removed with a plastic knife, weighted, and stored in polyethylene bags that were closed and labeled at room temperature until digestion. Following the dissection, the sex (males or females) is determined.

The Malaiyandi and Barette techniques of digestion were used [23]. A gram of each organ was placed in a ball containing a volume of concentrated nitric acid ($HNO3$) (1N). A temperature of 95°C was applied to the ball. After digestion, the contents of the ball were cooled to room temperature, diluted to 20 ml with double-distilled water, filtered through a 0.45 m porosity filter paper and a swinex, then packed in polyethylene bags and stored in the refrigerator until analysis. A Rayleigh wfx-130 atomic absorption spectrometer was used to analyze the metal content of samples (Zn, Pb, Cu, Fe, Ni, and Cd). Heavy metal concentrations are measured in milligrams per kilogram of wet tissue weight. Zn absorption wavelengths were 211,87 nm, Pb absorption wavelengths were 272,01 nm, Cu absorption wavelengths were 299,71 nm, Fe absorption wavelengths were 239,19 nm, Zn absorption wavelengths were 224,7 nm, Cd absorption wavelengths were 231,3 nm, and Ni absorption wavelengths were 241 nm.

Statistical Methods

Minitab statistical package programs were used to conduct statistical analysis of the data. We used a one-way ANOVA test with a significance level of 0,05 to compare data between seasons, and we also used principal component analysis on the mean of metal concentrations in carp's organs for every season.

Findings

The length and weight ranges, as well as their relationships, are shown in Table 1. Table 2 shows the levels of Zn, Cu, Fe, and Cd measured in Cyprinus carpio tissues (gonads, gills, and muscle) over four seasons.

Table.1: Cyprinus carpio fish species in relation to Size

Weight ranges	Length ranges	Formula	R value
80.1-1179 419,1 ± 299,3	24-78,7 34,2 ± 9,1	Y = 0,31 X + 22,02	0,93
221-1203 374,4 ± 260,7	27,1 – 60,4 32,8 ± 6,9	Y = 0,029 X + 21,85	0,95

299-389 297,76 ± 59,71	36,7 – 34 29,987 ± 2,12	Y = 0,028 X + 20,97	0,92
124-415 237,8 ± 155,3	24-41 – 38 26,9 ± 4,7	Y = 0,026 X + 19,59	0,96

Table 2: Cyprinus carpio fish species in relation to Age, Gender, Seasons

Organs	Metals	Gender	Age	Zn	Pb	Cu	Fe	Cd	Ni
Gonads	Spring	Male	3-4	59,87 ± 32,71	8,55 ± 2,19	4,99 ± 0,05	10,92± 4,98	2,91 ± 3,11	6,71± 0,49
		Female	3-4	60,01 ± 32,92	8,75 ± 2,23	5,01 ± 0,05	10,89±5,02	2,98 ± 3,15	6,75± 0,51
	Summer	Male	3-4	59,85 ± 27,01	8,17 ± 2,13	5,11 ± 0,06	11,87 ± 7,68	3,01 ± 2,91	5,87 ± 0,89
		Female	3-4	60,09 ± 28,32	8,23 ± 2,19	5,11 ± 0,06	11,91 ± 7,89	2,99 ± 2,87	6,03 ± 0,92
	Autumn	Male	3-4	81,97 ± 44,52	7,91 ± 2,29	4,91 ± 0,07	11,78 ± 4,79	1,56 ± 1,87	7,31± 1,44
		Female	3-4	82,01± 43,99	8,11 ± 2,91	5,12 ± 0,08	12,13 ± 5,01	1,61 ± 1,92	7,49± 1,51
	Winter	Male	3-4	42.01 ± 33,29	9,71± 0,68	4,91± 0,02	18,97 ± 19,36	2,18 ± 1,71	5,71 ± 0,69
		Female	3-4	42.93± 34,31	9,87± 0,72	4,91± 0,03	18,97 ± 20,12	2,29 ± 1,83	5,71 ± 0,72
Gills	Spring	Male	3-4	106,72 ± 24,77	3,11 ± 1,91	5,19 ± 0,06	17,92 ± 5,67	3,77 ± 3,29	6,71± 0,48
		Female	3-4	106,72 ± 24,91	3,21 ± 1,97	5,25 ± 0,07	18,11 ± 5,98	3,89 ± 3,34	6,75± 0,51
	Summer	Male	3-4	98,78 ± 22,19	4,09± 2,31	5,21 ± 0,04	14,93 ± 7,81	5,11 ± 2,33	5,39 ± 0,39
		Female	3-4	97,81 ± 21,25	4,11± 2,42	5,39 ± 0,05	14,93 ± 8,12	5,11 ± 2,45	5,61 ± 0,42
	Autumn	Male	3-4	91,27 ± 19,28	9,89 ± 2,76	5,19 ± 0,05	21,11 ± 4,87	1,01 ± 1,12	4,32 ± 0,61
		Female	3-4	92,11 ± 19,98	10,03 ± 3,01	5,68 ± 0,05	21,68 ± 4,94	1,22 ± 1,31	4,49 ± 0,75
	Winter	Male	3-4	88,32 ± 24,39	10,03 ± 1,27	4,91 ± 0,04	40,89 ± 21,23	1,42 ± 2,02	4,29± 0,29
		Female	3-4	88,32 ± 23,41	10,21 ± 1,33	5,01 ± 0,05	41,03± 21,43	1,45 ± 2,11	4,31± 0,31
	Spring	Male	3-4	68,74 ± 39,21	12,01± 2,17	5,11 ± 0,07	8,92 ± 2,31	2,68 ± 2,99	6,82± 2,39
		Female	3-4	68,56± 40,01	12,23± 2,49	5,11 ± 0,06	9,06± 2,42	2,78 ± 3,04	6,91± 2,64

Muscle	Summer	Male	3-4	22,89 ± 23,43	8,91± 2,11	4,91± 0,07	5,75 ± 1,81	4,33 ± 3,71	8,39 ± 1,67
		Female	3-4	23,03 ± 23,56	9,04± 2,23	4,91± 0,08	5,88 ± 1,93	4,95 ± 3,77	8,48 ± 1,88
	Autumn	Male	3-4	18,32 ± 5,29	8,49 ± 2,32	5,11 ± 0,21	5,01 ± 1,22	3,99 ± 2,87	43,29 ± 0,74
		Female	3-4	18,67 ± 5,56	8,71 ± 2,79	5,43 ± 0,34	5,54 ± 1,23	4,12 ± 2,98	44,21 ± 0,89
	Winter	Male	3-4	12,84 ± 4,85	8,72 ± 6,11	5,27± 0,04	5,58 ± 0,87	0,71 ± 0,92	4,96 ± 0,71
		Female	3-4	12,98± 5,12	8,72 ± 7,01	5,39± 0,05	6,02± 0,72	0,81 ± 0,58	4,76 ± 0,69

As seen in table (2), various tissues in male fish ranging in age from 3 to 4 years old showed different capacities for heavy metal accumulation. Heavy metal concentrations were highest in the gills and gonads and lowest in the muscles. Zinc concentrations in Cyprinus carpio gonads, gills, and muscle were 42.01 to 81.97 mg.kg, 90.87 to 106.72 mg.kg, and 12,84 to 68.74 mg.kg, respectively (Table 2), In the spring, the highest zinc concentrations were found in the gills. Lead levels in carp gonads, gills, and muscle ranged from 8,55 to 9,71 mg/kg, 2,99 to 11,76 mg/kg, and 8,72 to 12,01 mg/kg (Table 2). Lead concentrations in muscle were found to be highest during the spring season. Copper levels in Cyprinuscarpio gonads, gills, and muscle ranged from 4,99-4,91 mg/kg, 5,23-5,11 mg/kg, and 5,11-5,27 mg/kg, respectively (Table 2). Copper concentrations in muscles were found to be highest during the winter season. Carp gonads, gills, and muscle iron concentrations ranged from 10,92 to 18,97 mg.kg, 14,93 to 40,89 mg.kg, and 5,58 to 8,92 mg.kg, respectively (Table 2).

Winter had the highest iron concentrations in the gills. Cadmium levels in Cyprinus carpio gonads, gills, and muscle ranged from 0,16 to 0,29 mg/kg and 0,06 to 0,5 mg/kg and 0,04 to 0,29 mg/kg, respectively (Table 2).

In the summer, the highest cadmium concentrations were found in the gills. Nickel levels in gonads, gills, and muscle ranged from 5,71 to 7,31 mg/kg, 4,29 to 6,71 mg/kg, and 5,82 to 6,82 mg/kg (Table 2), with muscle having the highest level. Lead and cadmium concentrations in organs of all carp samples varied significantly (P 0,005) from season to season, as did zinc, lead, iron, and nickel concentrations. The sequence of Zn > Pb > Fe > Ni > Cu > Cd in common carp gonads, gills, and muscle was Zn > Pb > Fe > Ni > Cu > Cd.

The concentrations of heavy metals in fish are important for both human consumption and environmental management. In this study, we looked at heavy metal concentrations in carp tissues in the Taqtaq Region of the Little Zab River in Northern Iraq. It was also hoped to see if metal concentrations in the study varied seasonally (Mahboob, et al., 2020). Many species of fish in various areas have shown that target organs, such as gills, have a tendency to accumulate high levels of heavy metals (Rashid, & Saler, 2018). The highest levels of Zn were found in the gills of Cyprinus carpio, followed by the gonads and muscle. Metal concentrations in gills are similar to metal concentrations in the waters where the fish species live (Ahmed, et al., 2017). Their accumulation in the gills could be due to the element's interaction with mucus, which is difficult to completely remove from the lamellae before tissues are prepared for analysis. Metal adsorption on the gills' surface, which is the first target for pollutants in water, may have an impact on the gill's total metal levels (Paul, et al., 2020).

In comparison to the gonads and gills, muscle had lower heavy metal concentrations. A number of fish species have shown that the muscle is not an active tissue in the accumulation of heavy metals (Shekha, et al., 2013). The highest levels of lead, copper, and iron were found in the winter, while the lowest levels were found in the spring. The highest levels of zinc and nickel were found in the spring, while the lowest levels were found in the winter. Summer had the highest concentration of cadmium, while winter had the lowest. Heavy metal concentrations were found in cyprinus carpio in Karakaya dam lake (Aytekin, et al., 2019), stizostedion luciperca and Tinca tinca in Kovada kake (Das, et al., 2017), and stizostedion luciperca and Tinca tinca in Kovada kake (Rashid, 2017). The increase in heavy metal levels in the summer and winter could be linked to increased physiological activity of fish in the summer, which is primarily caused by rising water temperatures and a decrease in waste water from agricultural activities in the winter. Zinc, lead, cadmium, and nickel concentrations were higher in all seasons than the IAEA-407 values (Jaiswal, et al., 2018), with the exception of Fe and copper (Zn: 67,1 mg.kg, Pb: 0,12 mg.kg, Cu: 3,28 mg.kg, Fe: 146 mg.kg, Cd: 0,189 mg.kg, Ni: 0,6 mg.kg).

PCA was used to verify possible bioaccumulation patterns in organs and detect possible differences in contamination levels between seasons in the study area by using the mean of metal concentrations in organs of carp caught seasonally as variables. According to PCA, both organs and seasons explained 72,72 percent of the total variance in metal concentration (39,97 percent for factor 1 and 32,76 percent for factor 2).

Furthermore, various tissues from female fish ranging in age from 3 to 4 years old showed different capacities for heavy metal accumulation. Heavy metal concentrations were highest in the gills and gonads and lowest in the muscles. Zinc concentrations in Cyprinus carpio gonads, gills, and muscle ranged from 42.93 to 82.01 mg/kg, 90.87 to 106.72 mg/kg, and 12,98 to 68.56 mg/kg, respectively (Table 2), In the spring, the highest zinc concentrations were found in the gills. Lead levels in carp gonads, gills, and muscle ranged from 8,75 to 9,87 mg/kg, 3,04 to 11,76 mg/kg, and 8,72 to 12,23 mg/kg (Table 2). Lead concentrations in muscle were found to be highest during the spring season. Copper levels in Cyprinuscarpio gonads, gills, and muscle ranged from 5,01-4,91 mg/kg, 5,23-5,11 mg/kg, and 5,11-5,39 mg/kg, respectively (Table 2). Copper concentrations in muscles were found to be highest during the winter season. The iron concentrations in the carp's gonads, gills, and muscle ranged from 10,89 to 18,97 mg.kg, 14,93 to 41,03 mg.kg, and 6,02 to 9,06 mg.kg, respectively (Table 2).

Winter had the highest iron concentrations in the gills. Cadmium levels in Cyprinus carpio gonads, gills, and muscle ranged from 0,16 to 0,29 mg/kg and 0,06 to 0,5 mg/kg and 0,04 to 0,29 mg/kg, respectively (Table 2).

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In comparison to the gonads and gills, muscle had lower heavy metal concentrations. A number of fish species have shown that the muscle is not an active tissue in the accumulation of heavy metals (Izuchukwu Ujah, et al., 2017). The highest levels of lead, copper, and iron were found in the winter, while the lowest levels were found in the spring. The highest levels of zinc and nickel were found in the spring, while the lowest levels were found in the winter. Summer had the highest concentration of cadmium, while winter had the lowest. Heavy metal concentrations were found in cyprinus carpio in Karakaya dam lake (Liu, et al., 2020), stizostedion luciperca and Tinca tinca in Kovada kake (Baki, et al., 2018), and stizostedion luciperca and Tinca tinca in Kovada kake (Mehmood, et al., 2019). The increase in heavy metal levels in the summer and winter could be linked to increased physiological activity of fish in the summer, which is primarily caused by rising water temperatures and a decrease in waste water from agricultural activities in the winter. Zinc, lead, cadmium, and nickel concentrations were higher in all seasons than the IAEA-407 values (Bulut, et al., 2021), with the exception of Fe and copper (Zn: 67,1 mg.kg, Pb: 0,12 mg.kg, Cu: 3,28 mg.kg, Fe: 146 mg.kg, Cd: 0,189 mg.kg, Ni: 0,6 mg.kg). PCA was used to verify possible bioaccumulation patterns in organs and detect possible differences in contamination levels between seasons in the study area by using the mean of metal concentrations in organs of carp caught seasonally as variables. According to PCA, both organs and seasons explained 72,72 percent of the total variance in metal concentration (39,97 percent for factor 1 and 32,76 percent for factor 2).

III. CONCLUSION

Since of anthropogenic activities, the river's water, which was potable before 2020, has been observed to rapidly deteriorate in quality. Agricultural wastes are also dumped into the dam. These could be the sources of the high metal levels, particularly dam sediment and biotic components.

Heavy metal concentrations differed between tissues. The effects of the seasons on heavy metal accumulation in the organs of Cyprinus carpio were investigated in this study. Zinc concentrations were found to be higher in general during all seasons. Zinc, lead, cadmium, and nickel concentrations were higher than the IAEA-407 values in all seasons (Abarshi, et al., 2017). In the spring, all metal concentrations reached their highest levels. Metal concentrations in gills were generally higher than gonads and muscle, according to the current data. It is clear from the above results that the concentration of heavy metals in the Taqtaq Region of the Little Zab River in Northern Iraq is high. To summarize, efforts should be made to protect rivers from pollution in order to reduce environmental risks. They are alarmingly high in the fish samples examined, indicating that a potential threat may arise in the future, depending on the region's agricultural and industrial development.

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