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TRACE METAL LEVELS AND THEIR SEASONAL VARIATIONS IN THE TISSUES OF FISH (*CYPRINUS CARPIO* L., 1758) FROM YENIÇAĞA LAKE, TURKEY

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ABSTRACT

The concentrations of some metals (Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Mo, Cd, Sn, Ba, and Pb) were determined by ICP-MS in the muscles, gills, and liver of the carp *Cyprinus carpio* to study heavy metal load in the tissues, bioaccumulation factor (BAF), and seasonal variations. Heavy metals were accumulated at varying levels and clearly distinguishable in different tissues of *Cyprinus carpio* from Yeniçağa Lake. The distribution pattern of Al, Cr, Ni, Cu, As, Cd, Sn, and Pb followed the order liver>gill>muscle but that for Mn, Fe, Zn, and Ba the order gill>liver>muscle. Concentrations of Zn, Al, Fe, Ba, Mn and Cu, in particular, were very high in the tissues studied. The BAF values of Al, Fe, Cu, Zn and Mo were remarkably high in all of the carp tissues investigated. In particular, Pb and As results from the muscle tissue of the carp were not within the safe limits for human consumption. In the present study, the effects of season on the accumulation of heavy metals in the muscle, liver, and gills of the carp were also determined, and differences were found for the majority of heavy metals ($p < 0.05$). In general, the concentrations of the tested heavy metals were observed to be higher in spring and summer but lower in autumn and winter.

KEYWORDS: Yeniçağa Lake, heavy metal, bioaccumulation factor (BAF), seasonal variation, *Cyprinus carpio*

1. INTRODUCTION

The contamination of aquatic ecosystems with heavy metals has gained more concentrated worldwide attention in recent years, and many studies have been published on heavy metals in the aquatic environment [1]. Heavy metals from natural and anthropogenic sources are continuously released into aquatic ecosystems; therefore, they pose a serious threat to most life forms due to their toxicity,

long persistence, bioaccumulation, and biomagnifications in the food-chain [2]. The long-term monitoring of anthropogenic pollution in the aquatic ecosystem is an issue of concern in terms of both the environment and human health. In studies, aquatic organisms are often widely used for biological monitoring. Among these indicator organisms, a significant role is assigned to fish due to their significant capacity to accumulate heavy metals, and their essential role in the enrichment of anthropogenic compounds in the food-chain [3-6].

Many fish species can be considered as top consumers in aquatic ecosystems [7]. Consequently, pollutants discharged into the aquatic environment are likely to accumulate in fish and represent a potential risk to not only the fish themselves but also piscivorous birds and mammals, including humans. Concentrations of heavy metals in the organs of fish are determined primarily by the pollution level of water and food, and, thus, are an indicator of the environmental pollution level [3-5, 8].

Concentrations of heavy metals in the tissues of animals are a result of uptake and release processes that possess the characteristic kinetics for the elements and their biological half-life, and are influenced by the age and size of individuals, the feeding habits of the species, their life cycle and life history, and the seasons [3-9]. Heavy metals may enter fish bodies through the body surface, the gills, and the digestive tract. The gills are regarded as the important site due to their direct uptake from the water, whereas the body surface is generally assumed to play a minor role [7-10]. Foods can also constitute an important route for heavy metal accumulation and biomagnifications in the food-chain [7].

Yeniçağa Lake is located in the Western Black Sea region, and is one of the important wetland areas in Turkey because its habitats support many bird species and plant taxa. It has been chosen as a pilot area with the aim of developing a model component for the sustainable management of peat lands' carbon storage within the framework of climate change mitigation. However, the quality of the surface water of Yeniçağa Lake has diminished over the last decades as a result of increased anthropogenic factors.

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The lake continuously receives significant amounts of nutrient-rich water from two main creeks (Kuzuviran and Deliler) due to the direct discharge of untreated domestic wastewater into the creeks (Fig. 1). Furthermore, untreated municipal wastewater, nutrient-rich water from a slaughterhouse located on the eastern coast of the lake, and water rich with heavy metals from artesian wells are the major factors for increasing the pollution level in the lake. Such simultaneous activities have reduced water quality and disrupted biodiversity in the lake [11-13]. The trace metal level of the water, sediment, and plankton of the lake have been studied alongside its potential sources (water and sediment of creeks, artesian and sewage waters and soil), and these results are reported by Saygı and Atasagun Yiğit [13]. According to the results of the present studies, Ba, Mn, Fe, Al, and Zn were measured at high levels in the water and sediment of the lake, and these metals had accumulated in plankton in high concentrations.

In this study, the gills, liver, and muscles of *Cyprinus carpio* were chosen as target organs for assessing metal accumulation. The concentration of metals in gills is an important means of verifying the metal content of the waters. Metal concentrations in the muscles of the fish were analyzed to determine their safety for human consumption. *Cyprinus carpio* from Yeniçağa Lake has been an important protein source for the people living in the region over recent decades. Taking into account the metal content already found in the lake, creeks, artesian water, and plankton, an accumulation of metals in fish tissue was anticipated. Therefore, in the present study, we characterized heavy metal levels in the gill, muscle, and liver tissues of carps from Yeniçağa Lake on a seasonal basis and assessed the level of concentrations in terms of safety for human consumption in muscle tissue.

2. MATERIALS AND METHODS

2.1. Site description

Yeniçağa Lake (40° 47' N, 32° 02' E) is located in the western Black Sea region of Turkey. The lake basin occurs in a depression of 7x2.5 km size formed after tectonic activities during the early Quaternary, and the lake is located on the North Anatolian Fault Zone [14]. It appears that the lake surface area has been reduced about 3-fold to its present size since its formation. Today, Yeniçağa Lake is a shallow, endorheic, eutrophic lake with a maximum depth of 5.2 m and a surface area of 1800 ha. The lake is mainly fed by two creeks (the Kuzuviran and the Deliler). However, an artificial channel was constructed on the Aşağıdere and operated between 1965 and 1990 in order to control overflow from the lake (Fig. 1). This artificial channel has since been closed completely due to an excessive decrease in the volume of lake water since 1990. The quality of water of Yeniçağa Lake has diminished over the last decades as a result of increased anthropogenic factors.

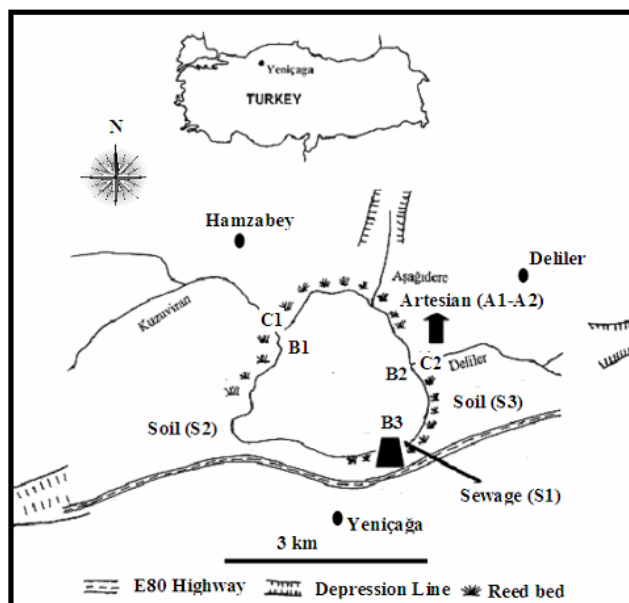


FIGURE 1 - Map of Yeniçağa Lake, Turkey.

2.2. Sampling and sample preparation

A total of 34 samples of *Cyprinus carpio* were collected from Yeniçağa Lake during four consecutive seasons from April 2008 to February 2009 with fishnets by professional fishermen. Sampling of fish was performed in April, July, November 2008 and February 2009. The samples were brought to the laboratory on the same day. The mean length and weight of the carps were 355 ± 23.5 mm and 960.2 ± 65.3 g, respectively. The length and weight of the fish did not vary significantly from season to season ($p > 0.05$).

Approximately 5 g of the epaxial muscles on the dorsal surface of the fish, the entire liver and 2-3 gill rakers from each sample were dissected and washed with distilled water. The samples were digested with 2 ml HNO_3 and 1 ml HClO_4 on a hot plate at 80 °C. The digests were left to cool at room temperature and diluted with 5 ml distilled water [15, 16]. All used mineral acids were of the highest quality grade (Suprapure, Merck, Germany). All the plastics and glassware were cleaned by soaking overnight in a 10% nitric acid solution, and then rinsed with deionized water.

The trace metal analyses of fish samples (Al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Mo, Cd, Sn, Ba, Pb) were carried out using Inductively Coupled Plasma-Mass Atomic Emission Spectrophotometry (ICP-MS Thermo Elemental X7). The accuracy of chemical analyses was checked using a standard blank solution. The detection limits were 2 ppt for Cd, 10 ppt for Pb, 20 ppt for Cu, 50 ppt for Zn and Fe, 100 ppt for Al, 25 ppt for As, 3 ppt for Co, 30 ppt for Mn and Ni, 1 ppt for Sn, 3 ppt for Cr, 10 ppt for Ba, and 1 ppt for Mo.

The BAF was calculated according to the equation of $\text{BAF} = \text{CB}/\text{CWT}$ (CB: mg/kg wet weight concentration of heavy metals in the fish, CWT: the mg/L concentration of heavy metals in the water) [17].

One-way ANOVA and/or Post-Hoc LSD test were performed to compare the metal concentrations of different tissues and to determine seasonal differences at the level of 0.05.

3. RESULTS AND DISCUSSION

All metal concentrations were determined on a wet weight basis (mg/kg). The mean trace metal concentrations in the muscles, liver, and gills of *Cyprinus carpio* are summarized in Table 1. In this study, the order in which the heavy metals were found was Zn>Al>Fe>Mn>Cu>Ba>Ni>Pb>As>Mo>Cr>Co>Cd>Sn in the liver; Zn>Al>Fe>Mn>Ba>Cu>Ni>As>Pb>Cr>Co>Mo>Sn = Cd in the gills; and Zn>Al>Fe>Cu>Mn>Ba>Pb>As>Mo>Ni>Cr>Co>Cd in muscle. The distribution pattern of Al, Cr, Ni, Cu, As, Cd, Sn, and Pb followed the order liver>gill>muscle while this pattern was determined to be gill>liver>muscle for Mn, Fe, Zn, and Ba. All the metals, except for Sn, were detected in the analyzed samples, but Sn was below the limits of detection (1 ppt) in the muscle of *Cyprinus carpio*. Zn, Al, Fe, Ba, Mn and Cu concentrations, in particular, were very high in all studied tissues (Table 1).

Heavy metals were accumulated at varying levels and clearly distinguishable in the different tissues of *Cyprinus carpio* from Yeniçağa Lake. The highest concentrations were found in the liver and gills while the lowest concentration was detected in the muscles. Relatively high concentrations of heavy metals in the liver and gill have been reported for a number of fish species (*Cyprinus carpio* from 10 uncontaminated fishponds in Czech Republic [18], *Cyprinus carpio* from the Indus River (Pakistan) [19], *Leuciscus cephalus* and *Lepomis gibbosus* from Sarıçay [20], *Silurus triostegus* and *Mastacembelus simack* from Tigris

River [21], *Cyprinus carpio* from Beyşehir and Kovada Lake [22, 23]).

In this study, among the heavy metals, the elements which accumulated most in the muscles of the fish were Zn (37.14 mg kg⁻¹), Al (34.52 mg kg⁻¹), Fe (7.99 mg kg⁻¹), Mn (1.51 mg kg⁻¹), Cu (1.52 mg kg⁻¹), and Ba (0.94 mg kg⁻¹). These heavy metals also demonstrated significant accumulation in the liver and gills. The concentration values of Zn, Al, Fe, Mn, Ba and Cu in the liver and gills were recorded to be 362-674 mg kg⁻¹, 172-88 mg kg⁻¹, 59-81 mg kg⁻¹, 13.9-38.9 mg kg⁻¹, 6.50-33.9 mg kg⁻¹ and 8-6.63 mg kg⁻¹, respectively (Table 1). Heavy metals, such as Fe, Cu, Zn, and Mn, are essential and found at considerably higher concentrations in metabolic organs, such as the liver, than in muscle tissues, presumably due to their function as a cofactor for the activation of a number of enzymes [24]. The liver and gill are target organs of accumulation for many heavy metals. The accumulation of metals in the liver may be based on its extremely high concentration levels of metallothionein proteins [25]. The concentration of metals detected in the gill is an important indicator reflecting the status of the water in which the fish live [7, 26, 27]. In contrast, it has been reported that muscle is not an active tissue in accumulating heavy metals [28, 29]. Our results, therefore, seem to be consistent with information available in the literature. In fact, the gill results found were very noteworthy due to the high accumulation of Zn, Al, Fe, Mn and Ba we observed. The gills are in direct contact with water and pollutants that may be present in water. When considering the concentration of heavy metals determined in water samples taken from Yeniçağa Lake, they can be listed in terms of higher to lower levels in the following order: Fe>Al>Mn>Zn>Ba>Ni>Cr>As>Cu>Pb>Co [13]. Zn, Al, Fe, Mn, and Ba, were also present at high concentration in the water of the

TABLE 1 - Statistical analyses results, heavy metal contents (mg kg⁻¹ wet weight) and BAFs of different tissues of *Cyprinus carpio* collected from Yeniçağa Lake (same letter in the row shows no statistical difference, p=0.05).

	Water (mg/l)	Liver	BAF (liver)	Gill	BAF (gill)	Muscle	BAF (muscle)
Al	0,0287	172.9 ^a	6024	87.6 ^b	3052	34.52 ^c	1203
Cr	0,0022	0.63 ^a	289	0.38 ^b	174	0.13 ^c	60
Mn	0,0782	13.90 ^a	178	38.98 ^b	498	1.51 ^c	19
Fe	0,0458	59.45 ^a	1298	81.18 ^b	1772	7.99 ^c	174
Co	0,0004	0.23 ^a	561	0.29 ^a	707	0.03 ^b	73
Ni	0,0034	2.67 ^a	788	2.15 ^b	634	0.14 ^c	41
Cu	0,0010	8.60 ^a	8600	6.63 ^{ab}	6630	1.52 ^c	1520
Zn	0,0271	362.08 ^a	13361	674.1 ^b	24871	37.14 ^c	1370
As	0,0141	1.08 ^a	77	0.88 ^a	62	0.23 ^b	16
Mo	0,0008	0.85 ^a	1118	0.18 ^b	237	0.20 ^b	263
Cd	0,00487	0.04 ^a	8	0.015 ^b	3	0.005 ^b	1
Sn	0,0003	0.01 ^a	40	0.015 ^b	60	ND	0
Ba	0,0855	6.50 ^a	76	33.96 ^b	397	0.94 ^c	11
Pb	0,0044	1.68 ^a	384	0.75 ^b	171	0.30 ^b	68

lake, and the high accumulation of these metals observed in the gills was a result of the high volumes of water being filtered through the gills.

BAF is a number that shows bioaccumulation as a ratio of the concentration of a chemical inside an organism to the concentration in the surrounding environment [17]. The BAFs of the carp tissues are presented in Table 1. While the BAFs for Al, Fe, Cu, Zn and Mo were remarkably high in all of the carp tissues investigated, those of other heavy metals were comparatively lower. The BAF values of some heavy metals, found at their highest level in carp liver, were 13361 for Zn, 8600 for Cu, 6024 for Al, 1298 for Fe, and 1118 for Mo. On the other hand, the BAFs of the carps' gill tissues were calculated as 24781 for Zn, 6630 for Cu, 3052 for Al, 1772 for Fe, and 237 for Mo. Relatively high bioaccumulation of Fe, Cu and Zn in the liver and gill have been reported for a number of fish species (*Cyprinus carpio* from Kızılırmak [30], *Carassius auratus*, *Capoeta trutta* and *Cyprinus carpio* from Atatürk Dam Lake [31], *Carassius carassius* and *Chondrostoma nasus* from Enne Dam Lake [32]). Bioaccumulation rates in the muscle tissue of carp were calculated as 1520 for Cu, 1370 for Zn, 1203 for Al, 263 for Mo, and 174 for Fe. The latter demonstrated a relatively higher accumulation in the muscle tissue of the carp, but the BAF value for Fe was lower than that for Mo. Although Mn and Ba were among the most abundant elements observed in all of the carp tissues, their BAFs were quite low, ranging from 19 to 11. Iron, copper and zinc are essential, with considerably higher concentrations in metabolic organs, such as liver. Iron is essential for the synthesis of hemoglobin and involved in numerous enzymatic reactions whereas copper is involved in electron transport. In addition, the activity of numerous enzymes depends on the presence of copper. The main role of Zn is that as a cofactor in many enzymatic systems, involved in the utilization of almost all nutrients [24]. Therefore, higher bioaccumulation of Cu, Zn and Fe in the tissue of carp can be attributed to stated essential activity of these elements.

Heavy metal accumulation in fish can pose a health risk to the humans who consume them. Since the muscle of fish is the tissue consumed, research into the heavy metal accumulation of muscle tissue has paid particular attention to this area. Although many standards or guides are available on metal residues in fish tissue, we were unable to find a uniform reference for acceptable levels of most metals in fresh water fishes. The following information has been compiled by Codex Alimentarius Commission [33], Turkish Food Codex [34] and International Standards (FAO) [35]: The permissible limits proposed by these standards and the following maximum levels for the metals studied, above which consumption is not permitted, are 0.2 mg kg⁻¹ for Pb; 0.05 mg kg⁻¹ for Cd, 10-20 mg kg⁻¹ for Cu, 0.1 mg kg⁻¹ for As, 50 mg kg⁻¹ for Fe, 40 mg kg⁻¹ for Zn, 2 mg kg⁻¹ for Cr, and 10 mg kg⁻¹ for Ni. A comparison between the results we obtained and the recommended safe levels that have been previously pub-

lished showed that Pb and As values analyzed in muscle tissues herein were higher than the maximum permitted concentrations proposed by the guidelines. Moreover, our Zn values detected in the muscle were very close to the maximal permitted limit of these guidelines. Zinc is an essential element and carefully regulated by physiological mechanisms in most organisms. However, it is also regarded as potentially hazardous substance that can endanger human health [20]. Lead is a neurotoxin that causes behavioral deficits in vertebrates, a decrease in survival and growth rates, and learning disabilities [36]. Therefore, we can conclude that these metals pose a threat to health after the consumption of Yeniçağa Lake carps, particularly in the case of As, Zn and Pb. It should be emphasized that Cd accumulates in human tissue and is, hence, harmful to human health. The limit for Cd was not exceeded in the tissue of carps analyzed in this study. Although Mn is one of the most abundant heavy metals in the water of Yeniçağa Lake [13], no important Mn accumulation was found in carp muscles of the lake (result below the permissible limit). Giving similar results, Mn had not accumulated in the fish muscle, a finding that has been reported for a number of fish species [37, 38]. A comparison between our results and the recommended safe levels of standards showed that Cr, Fe, Ni and Cu were lower than the guidelines for the edible parts of the examined fish.

In the present study, the effects of season on the accumulation of heavy metals in the muscle, liver, and gills of the carp were also determined, and the results are summarized in Table 2. Statistically, significance analyses (ANOVA) were performed to assess seasonal variation, and differences were found for the majority of heavy metals ($p < 0.05$). In general, the concentration of the tested heavy metals was observed to be higher in spring and summer but lower in autumn and winter. However, exceptional results were also found for some of the metals, and Sn, Cd, Mo, and Ni, were not detected in any of the carp tissues in autumn and winter samples. The highest Al, Fe, Cu, Pb and Zn concentrations in the muscle were recorded in winter samples, and we can infer that this phenomenon could be related to an increase of fatty tissues in the muscle of carps during this season. On the other hand, heavy metal accumulation in the muscle tissue of the carp was lower in the summer period, and the majority of heavy metals (Cr, Mn, As, Ni, Mo, and Ba) accumulated in the muscle during spring. Maximum heavy metal accumulation in the liver and gills of the carp was determined in the summer months, but an exceptional result was obtained for Al (maximum level in autumn). Our seasonal results are consistent with other studies regarding differences in metal accumulation in fish tissues being related to seasons. The relatively high concentrations of heavy metals in spring and summer were also found in *Capoeta capoeta umbla* from Keban Dam Lake [39], *Cyprinus carpio*, *Sander lucioperca* and *Carassius carassius* from Kovada Lake [23-40], *Cyprinus carpio* from Beyşehir Lake [22], and *Leuciscus cephalus* from Sava River [41].

TABLE 2 - Statistical analyses results, mean concentrations (mg kg⁻¹ wet weight), and standard deviations of heavy metals found in the muscle, liver, and gill tissue of *Cyprinus carpio* during four seasons in Yeniçağa Lake (same letter in the column shows no statistical difference, p=0.05).

		Al	Cr	Mn	Fe	Co	Ni	Cu
Muscle	Spring	15.24±1.50 ^a	0.22±0.03 ^a	1.78 ±0.30 ^a	8.42 ±1.25 ^a	0.04 ± 0.01 ^a	0.31 ±0.12 ^a	0.28±0.07 ^a
	Summer	5.40±0.61 ^b	0.09±0.02 ^a	0.98±0.18 ^a	3.21±0.37 ^b	0.02±0.00 ^a	0.22±0.08 ^a	0.80±0.05 ^b
	Autumn	42.14±1.78 ^c	0.08±0.03 ^a	1.75±0.27 ^a	9.58±1.22 ^a	0.03±0.01 ^a	ND	0.71±0.08 ^b
	Winter	75.32±2.97 ^d	0.15±0.03 ^a	1.58±0.10 ^a	10.77±2.02 ^a	0.04±0.01 ^a	ND	1.47±0.17 ^c
Liver	Spring	148.21±10.74 ^a	0.45±0.08 ^a	9.75±1.83 ^a	120.2±7.19 ^a	0.27±0.08 ^a	1.74±0.23 ^a	1.56±0.23 ^a
	Summer	155.25±11.33 ^a	1.80±0.37 ^b	38.40±5.25 ^b	80.35±10.25 ^b	0.55±0.07 ^b	7.80±1.05 ^b	3.50±0.46 ^b
	Autumn	280.20±53.2 ^b	0.20±0.05 ^c	5.25±2.50 ^{bc}	19.65±4.18 ^c	0.07±0.02 ^c	ND	2.25±0.15 ^c
	Winter	108.04±22.40 ^c	0.06±0.03 ^d	2.15±1.01 ^c	17.61±8.23 ^c	0.04±0.01 ^c	ND	1.20±0.09 ^{cd}
Gill	Spring	30.01±6.15 ^a	0.24±0.05 ^a	29.08±3.69 ^a	38.88±7.30 ^a	0.25±0.03 ^a	1.90±0.28 ^a	1.44±0.25 ^a
	Summer	17.04±12.12 ^{ab}	0.59±0.53 ^a	55.47±38.59 ^b	161.29±73.15 ^b	0.50±0.23 ^b	4.33±2.24 ^a	2.95±0.47 ^{ab}
	Autumn	203.3±187.7 ^c	0.49±0.21 ^a	40.42±12.09 ^b	66.01±10.90 ^c	0.27±0.06 ^a	ND	1.20±0.09 ^{ab}
	Winter	100.0±45.1 ^d	0.21±0.16 ^a	30.95±5.92 ^a	58.56±14.09 ^c	0.23±0.02 ^a	ND	12.91±5.87 ^c
		Zn	As	Mo	Cd	Sn	Ba	Pb
Muscle	Spring	38.72±2.14 ^a	0.47±0.11 ^a	0.64±0.02	0.01±0.01	0.01±0.01 ^a	1.81±0.10 ^a	0.16±0.03 ^a
	Summer	10.05±0.65 ^b	0.09±0.01 ^b	ND	ND	0.01±0.00 ^a	0.68±0.14 ^a	0.21±0.05 ^b
	Autumn	41.26±3.45 ^c	0.15±0.02 ^b	ND	ND	ND	0.56±0.12 ^b	0.32±0.07 ^c
	Winter	58.54±12.43 ^{cd}	0.22±0.03 ^b	ND	ND	ND	0.70±0.23 ^b	0.47±0.13 ^d
Liver	Spring	487.5±32.80 ^a	0.71±0.11 ^a	1.62±0.28 ^a	0.03±0.00 ^a	0.06±0.01 ^a	6.90±1.68 ^a	1.49±0.33 ^a
	Summer	571.09±107.3 ^{ab}	2.48±0.53 ^b	1.95±0.16 ^a	0.17±0.03 ^a	0.61±0.08 ^b	17.77±6.74 ^b	3.35±0.51 ^b
	Autumn	244.48±133.3 ^c	0.67±0.11 ^a	ND	ND	ND	0.95±0.52 ^c	1.04±0.42 ^a
	Winter	145.23±54.97 ^{cd}	0.48±0.11 ^a	ND	ND	ND	0.99±0.68 ^c	0.95±0.42 ^a
Gill	Spring	958.9±275.0 ^b	0.68±0.25 ^a	0.47±0.02 ^a	ND	ND	27.50±10.36 ^a	1.00±0.65 ^b
	Summer	1110.0±289.0 ^b	1.13±0.90 ^{ab}	0.08±0.02 ^b	0.03±0.25	0.06±0.05	48.79±31.50 ^b	1.26±0.75 ^b
	Autumn	341.8±162.4 ^a	1.07±0.64 ^{ab}	ND	ND	ND	34.63±9.29 ^a	0.61±0.38 ^b
	Winter	285.3±55.71 ^a	0.65±0.16 ^a	ND	ND	ND	32.92±7.13 ^a	0.16±0.03 ^a

The seasonal variation of metal accumulation can depend on biotic and abiotic factors, including seasonal conditions, the kind of metal, the internal biological cycles of the organism, and changes in the availability of a metal in the environment. The increase of heavy metal accumulation in spring and summer could also be due to an increase in the physiological activity of fish because of increasing water temperature and higher food supply during spring [6-41].

4. CONCLUSION

This study was carried out to provide information on heavy metal concentrations in *Cyprinus carpio* from Yeniçağa Lake. High levels of heavy metals were found in the liver/or gill, while the lowest levels were observed in the muscle of *Cyprinus carpio*. The Pb and As values analyzed in the edible part of fish were all over the limit for fish proposed by FAO, TFC, and Codex Alimentarius Commission. In particular, the Pb and As results from the

muscle tissues of the carps were not within the safe limits for human consumption. The detected Zn level in the muscle of the fish was very close to the maximum limit permitted in the above guidelines. In conclusion, although the level of Zn observed was not high, a potential danger may emerge in the future.

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