Animal Health Prod and Hyg (2023) 12 (1) : 45 - 51

Animal Health, Production and Hygiene

www.dergipark.or.tr/tr/pub/aduveterinary

Research Article

Investigation of Some Heavy Metal Levels of Carp Fish (*Cyprinus carpio*) Which is Hunted in Büyük Menderes River

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ABSTRACT

In this study, the heavy metal accumulation lithium, beryllium, boron, chromium, manganese, iron, cobalt, nickel, copper, zinc, rubidium, lead, strontium, cadmium, arsenic, vanadium, and uranium (Li, Be, B, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Pb, Sr, Cd. As, V, and U) in the muscle and liver tissues of *Cyprinus carpio* fish caught from three different regions of Büyük Menderes River were investigated. A total of 30 *Cyprinus carpio* were caught from three different regions of the Büyük Menderes River. Muscle and liver tissues of the fish samples were dissected and were solubilized in a microwave oven. The heavy metal levels were performed by ICP-MS. Average concentrations of heavy metals in fish muscle tissue samples collected from each region investigated were found as Li: 0.25±0.01, Be: 1.56±0.05, B: 1.70±0.08, Cr: 1.33±0.09, Mn: 0.32±0.02, Fe: 23.42±1.55, Co: 0.09±0.028, Ni: 0.66±0.06, Cu: 1.43±0.25, Zn: 12.51±1.16, Rb: 1.47±0.22, Pb: 0.45±0.02, Sr: 1.18±0.58, Cd: 0.09±0.01, As: 0.03±0.01, V: 26.04±1.05, U: 0.22±0.07 µg/g. The levels of Li, Be, B, Cr, Co, Rb, Cd, V, and U were higher than the limit levels. Li, Cr, Mn, Fe, Ni, Zn, Pb, Cd, V, and U heavy metals in liver; Be, B, Co, Rb, Sr and As heavy metals were found to be higher in muscle tissue. Results demonstrate that the third region has the highest levels of heavy metal pollution among the three regions investigated. In addition to that, the source of the heavy metal toxicity determined in the second region was found as the third region. According to obtained results, human consumption of fish caught in all three regions may be risky to health.
Keywords: *Bioaccumulation, Cyprinus carpio, heavy metal, pollution.*

Büyük Menderes Nehri'nde Avlanan Sazan Balıklarının (*Cyprinus carpio*) Bazı Ağır Metal Düzeylerinin Araştırılması

ÖZET

Bu çalışmada, Büyük Menderes Nehri'nin üç farklı bölgesinden avlanan *Cyprinus carpio* türüne ait balıkların kas ve karaciğer dokularındaki lityum, berilyum, bor, krom, manganez, demir, kobalt, nikel, bakır, çinko, rubidyum, kurşun, stronsiyum, kadmiyum, arsenik, vanadyum ve uranyum (Li, Be, B, Cr, Mn, Fe, Co, Ni, Cu, Zn, Rb, Pb, Sr, Cd. As, V ve U) ağır metal birikimleri incelenmiştir. Büyük Menderes Nehri'nin üç farklı bölgesinden toplam 30 adet *Cyprinus carpio* yakalanmıştır. Balık örneklerinin kas ve karaciğer dokuları disekte edilerek mikrodalga fırında çözündürülmüştür. Ağır metal seviyelerinin ölçümü ICP-MS ile yapılmıştır. Analiz edilen üç farklı bölgeye ait balıklarda ortalama ağır metal düzeyleri kas dokuda Li: 0,25±0,01, Be: 1,56±0,05, B: 1,70±0,08, Cr: 1,33±0,09, Mn: 0,32±0.02, Fe: 23,42±1,55, Co: 0,09±0,028, Ni: 0,66±0,06, Cu: 1,43±0,25, Zn: 12,51±1,16, Rb: 1,47±0,22, Pb: 0,45±0,02, Sr: 1,18±0,58, Cd: 0,09±0,01, As: 0,03±0,01, V: 26,04±1,05, U: 0,22±0,07 µg/g olarak bulunmuştur. Li, Be, B, Cr, Co, Rb, Cd, V ve U düzeylerinin sınır değerlerin üstünde olduğu görülmüştür. Li, Cr, Mn, Fe, Ni, Zn, Pb, Cd, V ve U ağır metalleri karaciğerde; Be, B, Co, Rb, Sr ve As ağır metalleri kas dokusunda daha yüksek düzeyde bulunmuştur. İncelenen üç bölge arasında, ağır metal kirliliğinin en çok ikinci bölgede olduğu, üçüncü bölgenin kirliliğinin temel nedeninin, ikinci bölge olduğu görülmüştür. Her üç bölgeden avlanan balıkların insanlar tarafından tüketilmesinin sağlık açısından riskli olabileceği düşünülmektedir.
Anahtar kelimeler: *Ağır metal, biyoakümülasyon, Cyprinus carpio, kirlilik.*

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Received Date: 26.04.2023 – Accepted Date: 22.05.2023

DOI: 10.53913/aduveterinary.1288137

Introduction

The Büyük Menderes River is the most extended river in Western Anatolia, and it covers a vast area of cities such as Aydın, Denizli, Afyon, and Uşak. For centuries, the population living in this region has thrived because of the river basin, which provides the main source of water for agricultural lands. However, due to migration, the increased population led to urbanization and industrialization, which are the primary causes of environmental pollution and ecological problems.

Metals, which are capable of forming cations by losing electrons and exhibit high electrical conductivity, are naturally occurring substances in the ecosystem. These substances can be found in different amounts in various locations in nature, such as the atmosphere, the earth's crust, and water bodies. Additionally, they can accumulate within living organisms (Järup, 2003). Out of the 35 naturally occurring metals, 23 have a specific density greater than 5 g/cm^3 (Davis, 1984). Typically the specific density of these metals is approximately 6 g/cm^3, and their atomic weight exceeds 40.04 (the atomic weight of Ca) (Duffus, 2002). These metals are generally referred to as heavy metals (Ming-Ho, 2005). Heavy metals are defined in Health Sciences Literature as metals with potentially toxic properties, regardless of their atomic weight (Ozbolat and Tuli, 2016). The US EPA (United States Environmental Protection Agency) (1986) and IARC (International Agency for Research on Cancer) (2019) classify heavy metals as human carcinogens. Although heavy metals are naturally present in all ecosystems, their concentrations can vary greatly due to both natural and human-induced factors. This can lead to differing levels of heavy metals across various environments.

There are many factors that can impact how heavy metals accumulate and spread in the environment. These include natural processes like the erosion of the earth's crust, as well as human activities such as mining, soil degradation, and the inappropriate disposal of industrial and urban waste. The use of harmful insecticides and pesticides, as well as air, water, and soil pollution, is also among the various factors that can affect the accumulation and distribution of heavy metals in the environment (Ming-Ho, 2005). Therefore, heavy metals have been classified as environmental pollutants (Tiller, 1989). These pollutants persist and can be found in various industrial wastes, and they cannot be decomposed or neutralized through natural processes. Heavy metals enter the ecosystem and subsequently move up the food chain, impacting various living organisms. This pollution process typically begins with industrial activities and affects the atmosphere, soil, water, plants, animals, and ultimately, humans (Dittmar, 2011).

Several factors can affect the extent of harm caused by heavy metals, including the amount and method of exposure, the specific type of metal, as well as individual characteristics like age, gender, genetic makeup, and nutritional status. Certain heavy metals, such as arsenic, cadmium, chromium, lead, and mercury, are particularly toxic and can damage various organs even at low levels of exposure. Additionally, the accumulation of heavy metals in the environment can increase their toxicity and have negative effects on living organisms (Piskorova et al., 2003).

Animals can suffer from severe illnesses when exposed to heavy metals in a contaminated environment, as the levels of heavy metals in their tissues and milk can quickly rise (Kottferova and Korenekova, 1998). This can result in various health issues, including reduced vitality, reproductive problems, weakened immunity, and the development of cancer and teratogenic diseases (Houpert et al., 1997). Numerous local studies have demonstrated that soil and vegetables may contain toxic levels of heavy metals such as cadmium, lead, copper, zinc, iron, chromium, and manganese (Bires et al., 1995). Animal feed grown on polluted soils can also contain heavy metals, which may accumulate in the tissues of the animals that consume them (Qadir et al., 2000). Furthermore, fish with high nutritional value living in aquatic ecosystems can also be impacted by heavy metal pollution. Animal-based food products, such as meat and milk, can contain heavy metals, which can significantly affect human health if consumed (Licata et al., 2004).

Heavy metal pollution is a major environmental issue in aquatic ecosystems, and the amount of heavy metals present depends on the soil and rock structure of the area (Tunca, 2012). The concentration of heavy metals present in these ecosystems is influenced by the soil and rock composition of the region, and human activities like mining, agriculture, and industrial processes further exacerbate this issue.

In this study, heavy metals as bioaccumulative pollutants which are the major environmental pollution source in the aquatic environment are aimed to be studied. Carps fish (*Cyprinus carpio*) tissue samples in three different sampling sites in Büyük Menderes River were used to determine heavy metal pollution levels.

Materials and Methods

Cyprinus carpio fishes, were hunted in three regions determined in Büyük Menderes River. The first region includes parts of the river basin in the provinces of Afyon, Uşak and Denizli. The second region includes the areas of the river basin in districts of Aydın province (except for Söke district). Third Region included part of the river basin in Söke district. Between February 2018 and March 2018, when fishing was not prohibited. Samples were collected from local fishermen. Study materials consisted of the muscle and liver tissues of 30 *Cyprinus carpio* fish that were dissected from three distinct regions of the Büyük Menderes River. Liver and muscle tissue samples taken from *Cyprinus carpio* were dissolved in microwave oven (Cem Mars 5). Teflon tubes were used to hold approximately 0.5 g of each sample.

To facilitate their dissolution, the tubes were subjected to microwave heating for a duration of 20 minutes, following the addition of 5 ml of 65% HNO_3 and 2 ml of 37% HCl. The heating process was done at 210ºC, with 80% power and approximately 1 atm of pressure. After heating, the tubes were allowed to cool for 90 minutes. Once cooled, the samples were transferred to 25 ml volumetric flasks and made ready for ICP-MS analysis by adding deionized water to reach the 25 ml final volume (Aktaş, 2013).

A multi-standard stock solution (10 ppm) containing 16 elements was used in ICP-MS to perform elemental analysis. For each element, an intermediate stock solution with a concentration of 1 ppm and six standard solutions with densities of 10, 20, 50, 100, 200, and 400 ppb were prepared to be used in ICP-MS. The device was calibrated before detecting the heavy metal content of the dissolved samples. The Bruker 820-MS device was utilized to determine the heavy metal content in muscle and liver tissue samples from *Cyprinus carpio* species. muscle and liver samples. In the research, the normality of variables was examined through the implementation of Shapiro-Wilk and Kolmogorov-Smirnov tests. Anova analysis was utilized to assess variables that followed a normal distribution, while the Kruskal-Wallis analysis was employed for variables that did not exhibit a normal distribution. The posthoc test Duncan was used during the Anova analysis to detect any differences, while the Mann-Whitney U test was employed for the Kruskal-Wallis analysis. Results were deemed significant if their statistical significance level was below 0.05.

Results

The heavy metal concentrations in the muscle and liver tissue of *Cyprinus carpio* specimens that were captured are illustrated in Table 1 and Table 2. The results indicate that the third region had the highest levels of heavy metals. Additionally, it was inferred that the second region was the cause of heavy metal pollution in the third region.

Table 1. Muscle tissue heavy metal levels (µg/g).

Metals	Region 1 $\bar{X}\pm S_{\bar{x}}$ (n=10)	Region 2 $\bar{X}\pm S_{\bar{x}}$ (n=10)	Region 3 $\bar{X}\pm S_{\bar{x}}$ (n=10)	P*
Li	0.25 ± 0.01^a	0.28 ± 0.02^a	0.23 ± 0.01^a	0.084
Be	1.62 ± 0.09^a	1.62 ± 0.08^a	1.46 ± 0.07^a	0.450
B	1.56 ± 0.08^b	2.07 ± 0.17^a	1.48 ± 0.07^c	0.028
Cr	1.44 ± 0.24^a	1.30 ± 0.10^a	1.24 ± 0.10^a	0.650
Mn	0.24 ± 0.07^c	0.36 ± 0.04^a	0.36 ± 0.04^b	0.012
Fe	17.46 ± 1.81^b	26.96 ± 2.46^a	25.84 ± 2.81^a	0.018
Co	0.06 ± 0.01^a	0.16 ± 0.08^a	0.07 ± 0.01^a	0.061
Ni	0.40 ± 0.071^b	0.66 ± 0.09^{ab}	0.93 ± 0.12^a	0.004
Cu	0.83 ± 0.02^a	1.89 ± 0.61^a	1.57 ± 0.36^a	0.118
Zn	9.74 ± 1.16^a	13.35 ± 1.88^a	14.43 ± 2.62^a	0.229
Rb	3.10 ± 0.19^a	0.61 ± 0.04^c	0.71 ± 0.08^b	0.000
Pb	0.43 ± 0.03^a	0.49 ± 0.05^a	0.42 ± 0.04^a	0.338
Sr	0.78 ± 0.27^a	0.95 ± 0.14^a	1.82 ± 0.74^a	0.256
Cd	0.08 ± 0.01^a	0.09 ± 0.01^a	0.11 ± 0.04^a	0.588
As	0^{**}	0.06 ± 0.03^a	0.02 ± 0.02^b	0.039
V	25.39 ± 1.78^a	27.98 ± 2.12^a	24.73 ± 1.52^a	0.424
U	0.24 ± 0.01^a	0.23 ± 0.01^a	0.20 ± 0.01^a	0.123

a,b,c The difference between groups with different letters in each parameter line is significant.
* P<0.05 was accepted as statistically significant.
** :Below the limit of analysis.

The samples were analyzed for the presence of arsenic, beryllium, boron, cadmium, chromium, cobalt, copper, lithium, lead, manganese, nickel, rubidium, strontium, uranium, vanadium and zinc.

The statistical analysis of the results was carried out with the IBM SPSS Statistics 22 package program (IBM SPSS Statistics®, Chicago, IL, USA). The statistical values such as mean and standard error were determined from the

Discussion

Heavy metals, which constitute a considerable part of water pollution, are among inseparable causes of environmental pollution. Heavy metals in fish tissues, though in small amounts, may accumulate and gradually reach levels causing toxic effect. According to previous studies, the amount of heavy metal accumulation in fish is influenced by the specific type of metal, as well as the

Table 2. Liver tissue heavy metal levels (µg/g).

Metals	Region 1 X̄±S$_{\bar{x}}$ (n=10)	Region 2 X̄±S$_{\bar{x}}$ (n=10)	Region 3 X̄±S$_{\bar{x}}$ (n=10)	P*
Li	0.21±0.02[a]	0,17±0.01[a]	0.16±0.01[a]	0.118
Be	1.25±0.04[a]	1.19±0.07[a]	1.27±0.05[a]	0.557
B	1.66±0.023[a]	1.01±0.08[b]	1.06±0.15[c]	0.002
Cr	1.94±0.10[a]	1.71±0.14[a]	1.73±0.06[a]	0.272
Mn	0.51±0.08[c]	0.77±0.18[b]	1.03±0.21[a]	0.030
Fe	275.00±55.26[a]	407.00±92.21[a]	340.00±71.05[a]	0.123
Co	0.03±0.01[b]	0.05±0.01[a]	0.02±0.05[c]	0.037
Ni	6.60±1.12[a]	9.34±2.01[a]	7.82±1.47[a]	0.338
Cu	1.50±0.10[a]	2.83±0.62[a]	4.34±1.40[a]	0.065
Zn	40.47±3.79[c]	128.00±13.72[b]	167.00±65.03[a]	0.000
Rb	2.42±0.16[a]	0.50±0.03[b]	0.52±0.06[b]	0.000
Pb	0.70±0.13[a]	0.49±0.04[a]	0.69±0.10[a]	0.229
Sr	0.50±0.09[a]	0.59±0.06[a]	0.63±0.12[a]	0.442
Cd	0.11±0.04[b]	0.11±0.01[b]	0.30±0.09[a]	0.002
As	0**	0**	0.01±0.01[a]	0.368
V	38.78±1.37[a]	37.12±2.85[a]	39.96±1.58[a]	0.618
U	0.20±0.01[a]	0.19±0.01[a]	0.20±0.01[a]	0.751

[a,b,c] The difference between groups with different letters in each parameter line is significant.
* P<0.05 was accepted as statistically significant.
** Below the limit of analysis.

type of fish and tissue involved (Korkmaz et al., 2012; Petrovic et al., 2013). Uysal et al. (1986) conducted a study on the coasts of the Aegean Sea and discovered that fish species capable of adjusting to pollution displayed significant levels of heavy metal buildup. The degree of adaptation, however, varied among different species. Linde et al. (1998), reported that heavy metal accumulations in fish may vary depending on the age, size and length of the fish. Melgar et al. (1997) examined weekly cadmium toxicity and accumulation in tissues. In the first weeks, it was observed that heavy metal accumulation in other tissues was prevented as a result of detoxification in the liver, gills and kidneys. However, it has been reported that heavy metals accumulate significantly in the muscle, brain, bone, ovary and testicles by increasing the accumulation with long-term exposure, making the detoxification insufficient.

According to Cicik et al. (2004), there exists a correlation between the accumulation of heavy metals and various tissues and organs. The order of accumulation, from highest to lowest, was found to be kidney, spleen, gill, liver, and muscle. Furthermore, the study reported that the accumulation of heavy metals increased as the exposure time increased. De Conto et al. (1997) observed a simulated cadmium deposition exposure process in fish of the *Cyprinus carpio* species, heavy metal deposition in muscle and other tissues and organs. Accordingly, cadmium concentrations increased rapidly in the kidney and liver, while the level of pollutants in muscle increased significantly after 106 days. In the kidney and liver, they observed that as the concentration of pollutants in the water increased, their toxic concentrations increased and there was immediate loss of cadmium in the muscle during the initial 43 depuration days.

The study determined that the muscle tissue tends to accumulate higher levels of heavy metals such as Be, B, Co, Rb, Sr, and As than the liver tissue. Although this situation contradicts with other studies in the literature, it is thought that long-term exposure of fish to these heavy metals is caused. The concentration of metals such as Li, Cr, Mn, Fe, Ni, Cu, Zn, Pb, Cd, V, and U is higher in the liver tissue compared to the muscle tissue. Specifically, the accumulation of Fe, Ni, Cu, Cd, and V metals in the liver tissue is significantly greater than in the muscle tissue.

Akbulut and Akbulut (2010) investigated the levels of heavy metals, namely Br, Hg, Co, Cr, Cu, Pb, and Zn, in the muscle and gill tissues of three fish species, namely *Capoeta tinca*, *Capoeta capoeta*, and *Leuciscus cephalus*, caught in Kızılırmak River. Based on the study findings, the levels of heavy metals in the muscle tissue exhibit a relationship in the following order: Zn> Cu> Pb> Br> Cr> Hg> Co. Similarly, the heavy metal levels in the muscle tissue show the following relationship: V> Fe> Zn> B> Be> Rb> Cu> Cr> Sr> Ni> Pb> Mn> Li> U> Co> Cd> As. In terms of heavy metal levels in the liver tissue, the relationship is as follows: Fe> Zn> V> Ni> Cu> Cr> B> Be> Rb> Mn> Pb> Sr> U> Li> Cd> Co> As.

Table 3. Comparison of average heavy metal levels in muscle tissue with national studies, national limit and certified reference values DORM-4 (µg/g).

Metals	Measured Values	Türkmen et al. (2009)	Topçuoğlu et al. (2002)	National Standard Limit Values (TKB, 2002)	DORM-4 (NRC, 2014)
Li	0.25	-	-	-	0.10
Be	1.57	-	-	-	-
B	1.70	-	-	1.00	0.03-1.00
Cr	1.33	0.05-1.87	0.06-0.84	-	1.00
Mn	0.32	0.14-1.33	0.69-3.56	-	3.17
Fe	23.42	9.99-43.30	30.00-60.00	-	343.00
Co	0.09	0.01-0.53	0.05-0.40	-	0.25
Ni	0.67	0.06-4.70	0.01-2.04	-	1.34
Cu	1.43	0.21-5.89	1.01-4.54	20.00	15.70
Zn	12.51	3.85-15.90	25.70-44.20	50.00	51.60
Rb	1.47	-	-	-	0.05
Pb	0.45	0.09-0.81	0.05-0.06	0.20	0.40
Sr	1.18	-	-	-	10.10
Cd	0.09	0.01-0.38	0.02-0.24	0.10	0.10
As	0.03	-	-	1.00	0.10
V	26.04	-	-	-	1.57
U	0.22	-	-	-	0.05

The information presented in Table 3 compares the average levels of heavy metals detected in the muscle tissue of fish in present study to those found in other national studies and various national and international standards. In a research conducted by Turkmen et al. (2009) involving 20 fish species from the Aegean Sea and the Mediterranean, it was observed that the average levels of Cu, Zn, and Cd were similar to the findings of this study. However, the average level of Pb was significantly elevated in their research. Topcuoğlu et al. (2002) conducted an independent study examining a variety of marine organisms discovered along the Turkish Black Sea coastline. The findings of present study indicated that the mean levels of Fe, Ni, Cu, and Cd observed in this research were in agreement with the concentrations documented in previous studies concerning the muscle tissues of acorn, whiting, horse mackerel, and red mullet. However, the average levels of Mn, Co, and Zn were low in this research, while the average levels of Cr and Pb were high. Upon evaluation of this study based on national standards (Kalafatoglu et al., 1997; TKB 2002), it was discovered that the mean levels of Cu, Zn, and As were below the limit values, whereas the mean level of Cd was very close to the limit values. As for B and Pb, their mean levels were high based on national standards. On the other hand, when this study was evaluated using DORM-4: Fish protein certified reference material for trace metals (NRC, 2015), it was observed that the mean levels of Mn, Fe, Co, Ni, Cu, Zn, and Sr were below the references values. However, Li, B, Cr, Rb, Pb, V, and U had high average levels. Even though the average level of Cd was low compared to international standards, it was discovered that the interregional assessment exceeded the limit value in Region 3 (also see Table 2).

The mean levels of heavy metals in liver tissue obtained from various regions were compared with national and international studies in Table 4. Turkmen et al. (2008) conducted a study on *Engraulis encrasicolus* and *Spicara* sp. in the Aegean Sea, the Sea of Marmara, and the Black Sea coast of Turkey. The comparison of the minimum and maximum liver tissue levels measured in their study with those in this study showed that the average levels of Mn, Cu, Zn, Rb, Sr, As, Cd, Pb, Fe, and Ni were low. The liver tissue levels obtained in this study were also compared with the liver heavy metal levels measured in Usero et al. (2003) study, revealing that the mean levels of Mn and Cu were low, while the mean levels of Cr, Ni, Zn, and Pb were high. Additionally, the liver tissue levels in this study were compared with the DOLT-4: Dogfish liver certified reference material for trace metals values generated from shark liver measurements (NRC, 2014). The mean levels of Fe, Cu, Zn, Cd, and As were low, while the mean levels of Ni and Pb were high.

Table 4. Comparison of mean heavy metal levels in liver tissue with national studies, international studies and certificate reference values (DOLT-4) (µg/g)

Metals	Measured Values	Türkmen et al. (2008)	Usero et al. (2003)	DOLT-4 (NRC, 2014)
Cr	1.79	0.28–2.97	0,01-0.06	-
Mn	0.77	0.72–9.67	1.23-4.61	-
Fe	340.97	55.20–316.00	185.00-560.00	1833.00
Ni	7.92	0.47–11.60	0,08-0,39	0.97
Cu	2.89	0.99–30.70	13.70-164.0	31.20
Zn	111.69	12.50–145.00	15.00-81.80	116.00
Pb	0.63	0.26–3.38	0.20-0.60	0.16
Cd	0.17	0.06–0.69	0.08-0.51	24.30
As	0.01	-	-	9.66

The results obtained in present study align with the findings from previous studies conducted by Çolak Esetlili (2010) and Arslan (2010) in the Alangüllü region, as well as the study conducted by Beyhan and Algül (2018) in the Bafa Lake region. It should be noted that Alangüllü and Bafa Lake form a part of the Büyük Menderes Basin.

Conclusion

The main objective of this study was to evaluate the concentrations of toxic metals in the muscle and liver tissues of *Cyprinus carpio* fish that were collected from three different regions of the Büyük Menderes River. The purpose was to compare the measured levels with the acceptable limits established by both national and international standards, as well as other research studies previously conducted on this topic. Results indicated that levels of Li, Be, B, Cr, Co, Rb, Cd, Pb, V, and U metals in the muscle tissue were above acceptable limits. Additionally, Ni and Pb levels in the liver tissue exceeded those reported in previous national and international studies. These findings confirm that the Büyük Menderes River is contaminated with chemical wastes, industrial and domestic wastes, and agricultural practices including fertilization and pesticides used in mining activities. The build-up of Ni and B in the tissues of fish is believed to be the result of the waste produced by geothermal power plants. Other metals such as Be, Co, Rb, Sr, and As) were found to accumulate primarily in the muscle tissue of the fish, as opposed to the liver tissue. This suggests that exposure to heavy metals over an extended period of time has led to the continuous presence of pollutants. Without prompt intervention, this pollution is likely to worsen and have more severe consequences. Therefore, it is imperative that official institutions and organizations increase their audits of the Büyük Menderes River and Basin to eliminate environmental risk factors. The discharge of geothermal plant waste to rivers should be halted, or facilities that do not comply should face closure sanctions. Treatment plants to manage domestic and industrial wastes should be established immediately, and organic agricultural practices should be improved. Consumption of *Cyprinus carpio* fish caught from the Büyük Menderes River poses a risk to public health due to toxic metals such as Co, Cd, B, Pb, Li, Be, B, Cr, Rb, V, and U, which are especially high in muscle tissue and can cause various diseases in the long term. As such, consumption of these fish should be banned if necessary. It should be noted that pollution in the Büyük Menderes River is a threat to the entire ecosystem, and measures should be taken to reduce the release of ions into the environment.

Acknowledgements

This article summarizes Ömer Ali EMEK's master thesis. This research was supported by the Aydın Adnan Menderes University BAP [VTF-17067].

This study was presented as an oral presentation at 2nd International Conference on Veterinary Biochemistry and Clinical Biochemistry, October 24-26, 2019, Ankara-TÜRKİYE

Conflict of Interest

The authors declare that they have no conflict of interest in this study.

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