Research Article

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Heavy Metal Residues in Edible Parts of Common Carp (*Cyprinus Carpio* L.) in Northern Iraq Water Bodies

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Abstract

This study aimed to assess the contamination of heavy metals in *Cyprinus carpio*, a commonly consumed fish species, and evaluate the potential health risks for humans. The research analysed metal concentrations in different parts of the fish over several months across various locations: Sirwan station, Darbandikhan dam, and Tanjaro River. The focus was on the fish's dorsal part (below the dorsal fin) and the caudal region (caudal peduncle) from August 2021 to January 2022. Six heavy metals: Co, Cr, Cd, Cu, Hg, and Pb, were investigated using an ICP-OES (Spectro across) multi-element system. The results revealed that metal concentrations were generally low in the dorsal flesh, with Hg often below the detection limit, especially in August, September, and October. Elevated Hg levels were detected only in November and January, likely due to minimal regional contamination, seasonal variations, and low bioaccumulation in carp. Cd levels were significantly higher in the dorsal part during August, September, and October. In August, Cd was elevated only in the caudal part. Pb was detected in August, September, and October, while Cu levels were significantly elevated in November across both flesh sections, with the highest concentrations observed in the Sirwan River. Co levels were elevated in October in both portions. Cr was undetectable across all months and locations. The study indicates varying heavy metal concentrations in *Cyprinus carpio* across different locations and months, with Cu being the highest in Sirwan River and Hg mostly undetectable.

Keywords: Accumulation heavy metals, Common carp, Darbandikhan dam, Sirwan, Tanjaro river.

Introduction

Water is essential to any country's areas of politics and economy, including farming, fisheries, management of forestry, agriculture, livestock production, and other creative industries that greatly impact the region's development (1). A lake constitutes a substantial expanse of water bordered by terrestrial formations that host numerous aquatic species, including fish. The lake's water quality has significantly deteriorated due to numerous factors, such as wastewater discharge, salting, and municipal sewage (2). In Kurdistan, surface water like rivers, artificial lakes (dams), ponds, springs, along with springs, and wells' groundwater are vital for life activities. The availability and quality of these water sources depend on environmental conditions, including the chemical composition of parent rocks, precipitation levels, soil formation processes, and the duration water remains underground (3).

Darbandikhan Lake, located approximately 60 kilometers to the southeast of the urban center of Sulaymaniyah, is fed by the Tanjaro and Sirwan Rivers. This dam is crucial for the local population, providing drinking and irrigation water. The Darbandikhan dam is rich in aquatic species and supports fishing activities (4). Heavy metal contamination impacts freshwater environments, primarily due to wastewater discharge from commercial, industrial, and agricultural activities. This polluted water contains hazardous levels of heavy metals, which harm aquatic life and human health (5). *Hydrilla verticillata* plant effectively removes cadmium and lead from contaminated water. Studies indicate that as metal concentration increases, the plant's uptake of both metals also rises, with a higher lead absorption rate than cadmium. This suggests that *H. verticillata* is more efficient at accumulating lead than cadmium under these conditions. In addition, other studies have explored chemical treatments for heavy metal removal by creating biological surfaces that adsorb natural and synthetic substances (6 and 7).

The river under examination flows through several minor and major industrial zones, polluting Darbandikhan Lake. Furthermore, solid garbage generated in Sulaymaniyah is deposited indiscriminately beside the river, while the city's sewage effluent empties into the Tanjaro River, located south of the metropolitan area. As a result, the primary goal of this study is to quantify the concentrations of heavy metals (Cd, Co, Cr, Cu, Pb, and Hg) within the dorsal and caudal peduncle regions of the common carp sampled from Darbandikhan Lake, Sirwan, and the Tanjaro River.

Methods and Materials

The study examined common carp (*Cyprinus carpio*) from Sirwan station, Darbandikhan dam, and Tanjaro River (Figure 1). Heavy metal concentrations in the dorsal and caudal region of the fish were analyzed over six months, from August 2021 to January 2022. Darbandikhan Lake, located 60 kilometers southeast of Sulaymaniyah City in the Kurdistan Region, is a significant public health concern due to water contamination. Its hydrological contribution comes from the Tanjaro and Sirwan Rivers, atmospheric precipitation, and groundwater from nearby springs. The issue of water contamination represents a considerable public health concern (8).

Fish specimens measuring an average length 25 cm were selectively chosen to mitigate variations in heavy metal accumulation. To isolate heavy metals from the fish, local fishermen procured specimens on-site utilizing a fishing net and transported to the laboratory in an ice box.

The Food and Agriculture Organization of the United Nations (1983) dissected fish specimens to extract meat from the dorsal region and caudal peduncle, then frozen, dried, and incinerated. Ash samples were weighed, digested, and filtered. The solution was filtered and stored. Heavy metal content was quantified using an ICP-OES system with Argon gas and a nebulizer gas flow rate. Analysis was performed at 14-16°C using three independent sample replicates.

Statistical analysis

The dataset derived from this research was subjected to statistical analysis employing fundamental statistical techniques and was organized into tables via the XLSTAT software application version (2016). The means were evaluated through ANOVA (Duncan LSD) at a significance threshold of 95% ($p < 0.05$).

Figure 1: Sampling locations for heavy metal analysis in *Cyprinus carpio* across the Kurdistan Region.

Results

A recent study involved collecting flesh samples from the dorsal and caudal sections of fish to evaluate the levels of heavy metals Cd, Hg, Pb, Co, Cu, and Cr. Table 1 shows the concentrations of these heavy metals in the dorsal flesh from August 2021 to January 2022. The peak concentration of Hg in the dorsal flesh was observed in January 2022, measuring 4.29 ppb, whereas it was below the detection limit from August 2021 to October 2021. The highest concentration of Cd in dorsal flesh was observed in August 2021 at 78.13 ppb, and its concentration varied significantly ($p < 0.05$) over the study period. Pb reached its highest concentration in dorsal flesh in August 2021 at 227.35 ppb, while it was below the detection limit from November 2021 to January 2022. The peak concentration of Cu in dorsal flesh occurred in November 2021 at 32737.11 ppb, with a significant difference ($p < 0.05$) noted throughout the study period. Co showed its highest concentration in dorsal meat in October 2021 at 1213.93 ppb, varying significantly over the study period, whereas Cr remained below the detection limit from August 2021 to January 2022.

Table 1. The concentrations of heavy metals (Hg, Cd, Pb, Cu, Co, and Cr) in the dorsal muscle tissue of common carp were investigated over the study period spanning from August 2021 to January 2022.

Months	Hg	Cd	Pb	Cu	Co	Cr
August 2021	BDL	78.13 a	227.35 a	14031.99 b	77.64 c	BDL
September 2021	BDL	24.84 ab	168.17 ab	10654.59 b	936.45 b	BDL
October 2021	BDL	49.34 ab	118.99 ab	14224.29 b	1213.93 a	BDL
November 2021	1.14b	6.17 b	BDL	32737.11 a	286.83 c	BDL
December 2021	1.17b	4.08 b	BDL	7845.13 b	219.65 c	BDL
January 2022	4.29a	3.57 b	BDL	9578.68 b	63.38 c	BDL

BDL = Values reported as 'Below Detection Limit'. Parameters sharing the same letter(s) are not significantly different at a p-value of 0.05 or greater.

Table 2 displays the concentrations of the heavy metals analyzed in caudal flesh from August 2021 to January 2022. The highest concentration of Hg was observed in January 2022. Cd showed its highest concentration in August 2021 at 151.86 ppb, with significantly different concentrations observed throughout the study period ($p < 0.05$). Pb peaked in September 2021 and was below the detection limit from November 2021 to January 2022. Cu reached its highest concentration in November 2021 at 37126.65 ppb, with significantly different concentrations noted during the study period ($p < 0.05$). Co recorded its highest concentration in October 2021 at 1604.13 ppb, showing significant variability across the study period. Cr remained below the detection limit throughout the study period.

Table 2. The concentrations of heavy metals (Hg, Cd, Pb, Cu, Co, and Cr) in the caudal flesh of common carp were monitored from August 2021 to January 2022.

Months	Hg	Cd	Pb	Cu	Co	Cr
August 2021	BDL	151.86 a	93.28 a	17653.12 b	142.61 c	BDL
September 2021	BDL	31.07 b	219.79 a	6391.08 d	902.89 b	BDL
October 2021	BDL	24.49 b	104.44 a	16705.81 bc	1604.13 a	BDL
November 2021	1.24 a	6.26 b	BDL	37126.65 a	326.47 c	BDL
December 2021	BDL	4.21 b	BDL	5691.93 d	194.73 c	BDL
January 2022	3.45 a	3.22 b	BDL	9528.98 cd	74.38 c	BDL

BDL = Below Detection Limit; Means with the same letter(s) of the same parameter are not significantly different at p ³ 0.05

The heavy metal levels in carp flesh, in general, are shown in Table (3) with ($p < 0.05$) significance level, where the maximum levels of Hg in fish were recorded in January 2022. The Hg concentration from August 2021 till October 2021 was below the detection limit; the highest concentration of Cd was recorded in August with (115 ppb) with a significant difference in concentration throughout the study, while the highest levels of Pb were recorded in September 2021 with (193,98 ppb). Between November 2021 and January 2022, the concentration of Pb was below the detection limit. The concentration of Cu was recorded every month of the study period, but the highest levels were found in November 2021 (34931.88 ppb), when the concentration changed significantly. The highest concentration of Co was found in October 2021 (1409.03 ppb), when the concentration changed significantly. During the study period, the concentration of Cr was below the detection limit.

Table 3. The levels of heavy metals (Hg, Cd, Pb, Cu, Co, and Cr in ppb) in fish flesh from August 2021 to January 2022

Months	Hg	Cd	Pb	Cu	Co	Cr
August 2021	BDL	115.00 a	160.31 a	15842.56 b	110.12 c	BDL
September 2021	BDL	27.96 b	193.98 a	8522.84 c	919.67 b	BDL
October 2021	BDL	36.92 b	111.71 ab	15465.05 b	1409.03 a	BDL
November2021	1.19b	6.21 b	BDL	34931.88 a	306.65 c	BDL
December 2021	1.09b	4.15 b	BDL	6768.53 c	207.19 c	BDL
January 2022	3.78a	3.40 b	BDL	9553.83 c	68.88 c	BDL

BDL = Values below the detection limit are considered undetectable. Groups sharing identical letters for the same parameter do not exhibit statistically significant differences at a confidence level of $p \geq 0.05$.

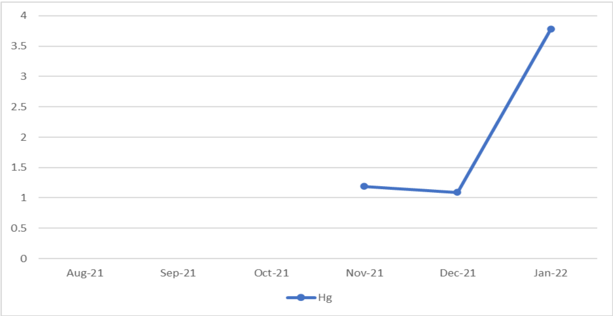


Chart 1: Concentration of Hg in ppb in fish flesh

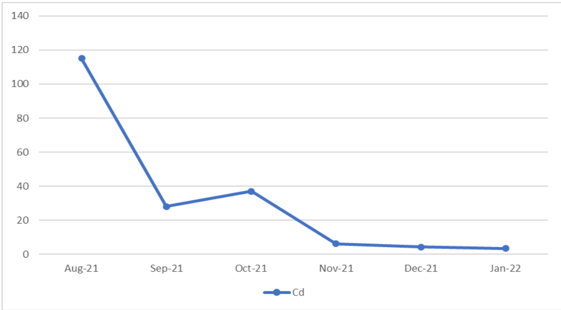


Chart 2: Concentration of Cd in ppb in fish flesh

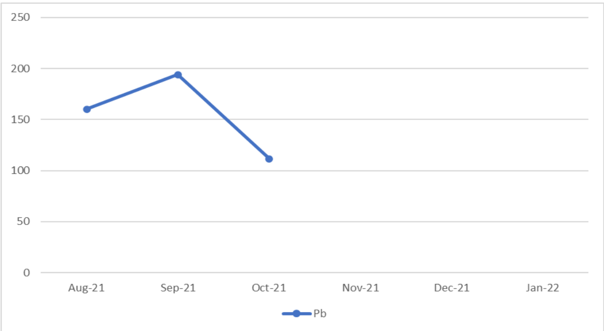


Chart 3: Concentration of Pb in ppb in fish flesh

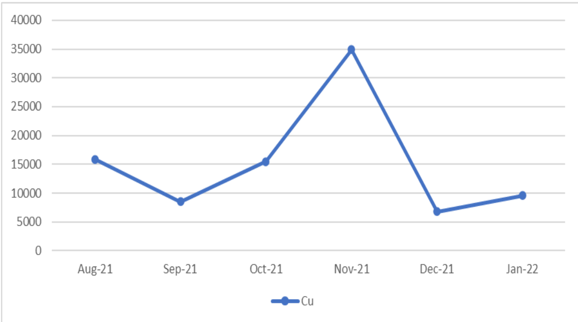


Chart 4: Concentration of Cu in ppb in fish flesh

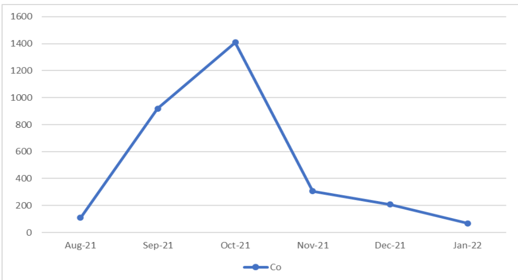


Chart 5: Concentration of Co in ppb in fish flesh

The concentration of studied heavy metal in dorsal flesh in the study locations is shown in Table 4 with ($p < 0.05$). Significantly, Cr was not detected in any area, and no statistically significant differences were found for Cd and Pb. Hg and Cu were significantly higher in Sirwan, and Co in Tanjaro.

Table 4. The concentration of studied heavy metal in the dorsal flesh of fish at the research stations

Study Locations	Hg	Cd	Pb	Cu	Co	Cr
Darbandikhan	BDL	19.34 a	72.64 a	11363.39 b	494.60 ab	BDL
Tanjaro	1.09 b	39.59 a	102.97 a	14425.58 b	576.15 a	BDL
Sirwan	2.71 a	24.15 a	83.14 a	18746.92 a	328.20 b	BDL

BDL= When values are below the detection limit or means share the same letter(s) for a given parameter, they are not considered significantly different at a p-value of 0.05.

In Table 5, Cr was undetected across all locations, and no significant differences were observed for Cd, Pb, and Co. Cu levels were notably higher in the Sirwan location. In Table 6, Cr was not detected in any locations. No significant differences were observed for Cd and Pb. Co levels were higher in both Darbandikhan and Tanjaro. Cu was significantly elevated in the Sirwan River. Chart 10 displays the concentration of Co in parts per billion (ppb) in fish meat.

Table 5. Concentration of studied heavy metal in caudal flesh of fish at the studied stations

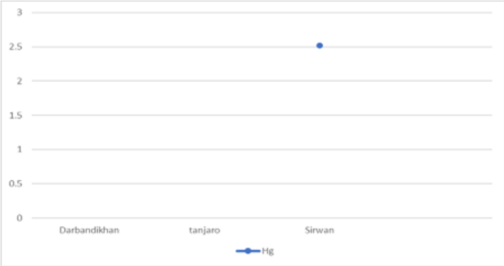
Study Locations	Hg	Cd	Pb	Cu	Co	Cr
Darbandikhan	BDL	12.32 a	68.58 a	13125.22 b	603.13 a	BDL
Tanjaro	BDL	68.64 a	24.65 a	13123.40 b	676.37 a	BDL
Sirwan	2.32 a	29.60 a	117.02 a	20300.17 a	343.11 a	BDL

BDL= Below Detection Limit means with the same letter(s) of the same parameter are not significantly different at p ³ 0.05.

Table 6. The concentration of Studied Heavy Metals (ppb) in Fish Meat at Darbandikhan, Tanjaro, and Sirwan Stations

Study Locations	Hg	Cd	Pb	Cu	Co	Cr
Darbandikhan	BDL	15.83 a	70.61 a	12244.30 b	548.86 a	BDL
Tanjaro	BDL	54.11 a	63.81 a	13774.49 b	626.26 a	BDL
Sirwan	2.52 a	26.87 a	100.08 a	19523.55 a	335.65 b	BDL

BDL= Detection Limit: Non-significant Differences ($p \geq 0.05$) Among Means Sharing the Same Letter(s) for Each Parameter.



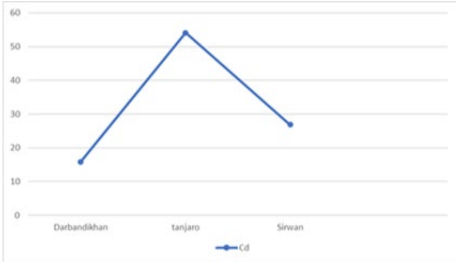
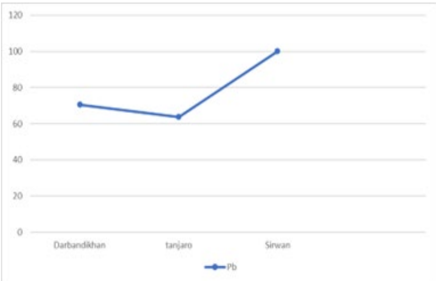


Chart 6: Concentration of Hg in ppb in fish flesh

Chart 7: Concentration of Cd in ppb in fish flesh



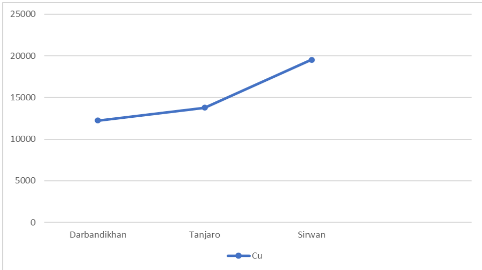


Chart 8: Concentration of Pb in ppb in fish flesh

Chart 9: Concentration of Cu in ppb in fish meat

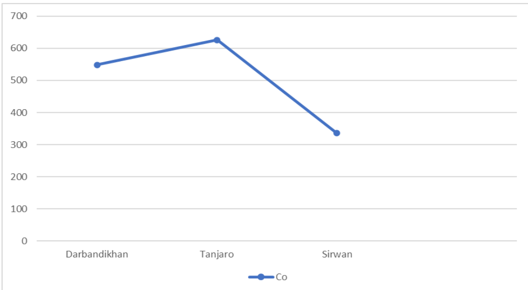


Chart 10: Concentration of Co in ppb in fish flesh

Charts 6 to 10 collectively illustrate the various heavy metal concentrations studied in fish flesh across the research station.Regarding the correlation between the stations and the study period, Table 7 shows the concentration of these heavy metals in the dorsal flesh. Similar correlations are evident in Table 8 for specific heavy metal concentrations and Table 9 for overall concentrations in fish meat ($p < 0.05$).

Cr was not detected in any position during the study period. Hg was found only in Sirwan and Darbandikhan in November 2021, Darbandikhan in December 2021, and in Sirwan in January 2022. Cd levels were notably higher in August 2021 in Tanjaro. Pb was not detected at any study locations from November 2021 to January 2022. Cu levels were significantly elevated in Sirwan in November 2021. Co levels were notably higher in Tanjaro in October 2021, as detailed in Table 7.

Table 7. The concentrations of studied heavy metals in the dorsal flesh of fish across the study locations during the research period measured in parts per billion (ppb).

Month/Location	Hg	Cd	Pb	Cu	Co	Cr
August-2021/ Sirwan	BDL	60.72 ab	9.48 b	17524.40 bc	194.78 e	BDL
August-2021/ Tanjaro	BDL	168.26 a	606.80 a	12825.95 bcdef	BDL	BDL
August-2021/ Darbandikhan	BDL	5.42 b	65.75 b	11745.63 bcdef	37.15 e	BDL
September-2021/ Sirwan	BDL	5.60 b	466.31 a	9897.40 cdef	395.31 de	BDL
September-2021/ Tanjaro	BDL	51.88 b	4.32 b	17035.71 bcd	1367.27 ab	BDL
September-2021/ Darbandikhan	BDL	17.06 b	33.89 b	5030.66 def	1046.77 bc	BDL
October-2021/ Sirwan	BDL	62.44 ab	20.02 b	11470.17 bcdef	754.13 cd	BDL
October-2021/ Tanjaro	BDL	1.91 b	3.73 b	14478.02 bcde	1561.28 a	BDL
October-2021/ Darbandikhan	BDL	83.67 ab	333.21 ab	16724.69 bcd	1326.38 ab	BDL
November-2021/ Sirwan	1.37 b	7.19 b	BDL	59843.18 a	275.11 de	BDL
November-2021/ Tanjaro		6.71 b	BDL	15361.64 bcd	227.08 e	BDL
November-2021/ Darbandikhan	1.07 b	4.61 b	BDL	23006.51 b	358.31 de	BDL
December-2021/ Sirwan	BDL	3.03 b	BDL	2219.53 f	220.42 e	BDL
December-2021/ Tanjaro	BDL	6.09 b	BDL	18313.58 bc	282.97 de	BDL
December-2021/ Darbandikhan	1.52 b	3.13 b	BDL	3002.26 ef	155.55 e	BDL
January-2022/ Sirwan	10.87 a	5.92 b	BDL	11526.86 bcdef	129.46 e	BDL
January-2022/ Tanjaro	BDL	2.67 b	BDL	8538.57 cdef	17.27 e	BDL
January-2022/ Darbandikhan	BDL	2.12 b	BDL	8670.60 cdef	43.42 e	BDL

BDL= Below Detection Limit means with the same letter(s) of the same parameter are not significantly different at p ³ 0.05.

Cr was undetectable. Hg was detected in Sirwan and Darbandikhan only in November 2021 and again in Sirwan in January 2022. Cd was found in Tanjaro in August 2021. Pb was present in Sirwan in September 2021 but was not detected in any location from November 2021 to January 2022. Cu levels were elevated in Sirwan in November 2021. Co was notably higher in Tanjaro in October 2021, as indicated in Table 8.

Table 8. The concentrations of studied heavy metals in the caudal (tail) flesh of fish across the study locations during the research period, measured in parts per billion (ppb).

Month/Location	Hg	Cd	Pb	Cu	Co	Cr
August-2021/ Sirwan	BDL	114.06 b	17.97 b	21567.79 bc	388.55 cde	BDL
August-2021/ Tanjaro	BDL	335.52 a	130.84 b	16778.28 bcd	BDL	BDL
August-2021/ Darbandikhan	BDL	6.00 b	131.03 b	14613.30 bcd	38.26 e	BDL
September-2021/ Sirwan	BDL	BDL	642.12 a	2290.25 d	164.91 de	BDL
September-2021/ Tanjaro	BDL	58.95 b	7.63 b	14006.83 bcd	1321.15 abc	BDL
September-2021/ Darbandikhan	BDL	33.27 b	9.61 b	2876.17 d	1222.60 bcd	BDL
October-2021/ Sirwan	BDL	48.24 b	39.04 b	10038.10 bcd	814.92 blade	BDL
October-2021/ Tanjaro	BDL	2.82 b	6.45 b	15970.66 bcd	2292.23 a	BDL
October-2021/ Darbandikhan	BDL	22.41 b	267.83 ab	24108.66 bc	1705.25 ab	BDL
November-2021/ Sirwan	1.59 b	8.13 b	BDL	74473.14 a	308.52 cde	BDL
November-2021/ Tanjaro	BDL	4.75 b	BDL	12538.73 bcd	231.58 de	BDL
November-2021/ Darbandikhan	1.14 b	5.90 b	BDL	24368.06 b	439.30 cde	BDL
December-2021/ Sirwan	BDL	2.73 b	BDL	2679.98 d	243.17 de	BDL
December-2021/ Tanjaro	BDL	6.18 b	BDL	11072.62 bcd	193.03 de	BDL
December-2021/ Darbandikhan	BDL	3.74 b	BDL	3323.19 d	147.99 de	BDL
January-2022/ Sirwan	8.35 a	3.44 b	BDL	10751.76 bcd	138.57 de	BDL
January-2022/ Tanjaro	BDL	3.63 b	BDL	8373.26 cd	19.22 e	BDL
January-2022/ Darbandikhan	BDL	2.59 b	BDL	9461.92 bcd	65.37 e	BDL

BDL= Below Detection Limit" indicates that the parameter concentration is not detectable within the measurement limits. Parameters designated with the same letter(s) are not significantly different at a significance level of $p \geq 0.05$.

Table 9 displays the levels of Mercury across all months and locations studied, with exceptions for certain months and locations. Cd was notably higher in Tanjaro in August 2021, Pb in Sirwan in September 2021, Cu in Sirwan in November 2021, and Co in Tanjaro in October 2021. Cr was below detectable levels in all months and locations.

Discussion

Fish species like *C. carpio* and *Tinca tinca* from Lake Beysehir, Turkey, and Oreochromis mossambicus and Clarias gariepinus from South Africa show high metal accumulation in their gills and intestines (9 and 10).

A study in Al-Masab Alamm River, Al-Nassiriya, Iraq, found that heavy metal levels in water, sediment, algae, and fish samples surpassed acceptable limits established by the World Health Organization and the Food and Agriculture Organization (11). n the same way, research into the ecosystem of the Euphrates River near Al-Nassiriya City Center in South Iraq found high levels of heavy metals in many parts of the ecosystem. Lead and copper mostly gathered in the liver (12). C. carpio showed different concentrations of heavy metals, indicating a gill > liver > kidney > muscle pattern. This highlights the distinct accumulation patterns present in various fish organs (12).

Research on carp fingerlings revealed distinct metal concentration patterns in fish muscles, which can accumulate in tissues like the liver, muscles, and intestines, potentially posing health risks and affecting fish consumption safety (13, 14,15, 16).

Heavy metals accumulated in fish impact fish health andimpact fish health and pose risks to human beings' health through the food chain, particularly in heavy metal-contaminated environments (17). Monitoring heavy metal concentrations in fish is essential for evaluating freshwater pollution and possible risks linked to human consumption (17). Also, the testing of metal levels in muscle tissues follows safety rules set by different countries and the WHO. This ensures that fish don't have too many metals like Zn, Cu, Pb, and Cd (18 and 19), lowering the risk to public health.

The cadmium (Cd) levels in the muscles of *Carassius carassius* exceeded the permissible limits established by Turkish regulations. In contrast, *Oreochromis niloticus* exhibited acceptable concentrations of Zn and Cu in its muscle tissues compared to other studies. Overall, the non-essential metals, such as Cd and Pb, were found in *O. niloticus* at lower levels than reported in the existing literature (20). Fish are important indicators of heavy metal pollution in water bodies, with pollution levels varying regionally due to local sources and environmental awareness (21).

Heavy metals tend to accumulate in various tissues, such as the liver, muscles, and bones, posing health risks to fish and humans (22). They are among the most concerning pollutants globally, defined by their high density (>5 mg/ml) (23).

Conclusions

The levels of heavy metals in both dorsal and caudal muscles showed distinct patterns: Cr was undetected throughout all months studied; Cd levels peaked in August 2021; Cu levels were highest in November 2021; and Co concentrations were highest in October 2021. Across all locations, Cr remained below detectable levels. No significant differences were noted in Pb and Cd concentrations. Cu levels were notably higher in Sirwan for both muscle types. Co levels were higher in Tanjaro in the dorsal muscle but did not show significant differences in the caudal muscle.

Notably, muscle tissue beneath the dorsal fin had lower concentrations of heavy metals than the caudal peduncle portion, suggesting it may be safer for human consumption.

Conflicts of interest

The authors declare that there is no conflict of interest.

Ethical Clearance

This work is approved by The Research Ethical Committee.

Table 9. The levels of investigated heavy metals at the specified sites over the observation period in parts per billion (ppb).

Month/Location	Hg	Cd	Pb	Cu	Co	Cr
August-2021/ Sirwan	BDL	87.39 b	13.72 c	19546.09 bc	291.66 de	BDL
August-2021/ Tanjaro	BDL	251.89 a	368.82 a	14802.12 bcd	BDL	BDL
August-2021/ Darbandikhan	BDL	5.71 b	98.39 bc	13179.47 cde	37.71 e	BDL
September-2021/ Sirwan	BDL	3.30 b	554.22 a	6093.83 def	280.11 de	BDL
September-2021/ Tanjaro	BDL	55.41 b	5.97 c	15521.27 bcd	1344.21 b	BDL
September-2021/ Darbandikhan	BDL	25.16 b	21.75 c	3953.42 ef	1134.68 bc	BDL
October-2021/ Sirwan	BDL	55.34 b	29.53 c	10754.13 cdef	784.53 cd	BDL
October-2021/ Tanjaro	BDL	2.36 b	5.09 c	15224.34 bcd	1926.75 a	BDL
October-2021/ Darbandikhan	BDL	53.04 b	300.52 ab	20416.67 bc	1515.82 ab	BDL
November-2021/ Sirwan	1.48b	7.66 b	BDL	67158.16 a	291.81 de	BDL
November-2021/ Tanjaro	BDL	5.73 b	BDL	13950.18 cd	229.33 de	BDL
November-2021/ Darbandikhan	1.51a	5.25 b	BDL	23687.28 b	398.81 de	BDL
December-2021/ Sirwan	BDL	2.88 b	BDL	2449.76 f	231.80 de	BDL
December-2021/ Tanjaro	1.26b	6.14 b	BDL	14693.10 bcd	238.00 de	BDL
December-2021/ Darbandikhan	BDL	3.44 b	BDL	3162.73 f	151.77 e	BDL
January-2022/ Sirwan	9.61a	4.68 b	BDL	11139.31 cdef	134.01 e	BDL
January-2022/ Tanjaro	BDL	3.15 b	BDL	8455.92 def	18.24 e	BDL
January-2022/ Darbandikhan	BDL	2.36 b	BDL	9066.26 def	54.39 e	BDL

BDL= Below Detection Limit," groups sharing the same letter(s) for a given parameter do not show significant differences at a significance level of $p \geq 0.05$.

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البقايا التراكمية لبعض المعادن الثقيلة في الأجزاء الصالحة للأكل من سمك الكارب الاعتيادي في المسطحات المائية شمال العراق

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الخلاصة

هدفت هذه الدراسة إلى تقييم تلوث المعادن الثقيلة في *Cyprinus carpio*، وهو نوع من الأسماك المستهلكة بشكل شائع، وتقييم المخاطر الصحية المحتملة على البشر. قام البحث بتحليل تركيزات المعادن في أجزاء مختلفة من الأسماك على مدى عدة أشهر، عبر مواقع مختلفة: محطة سيروان، وسد دربنديخان، ونهر تانجارو. كان التركيز على الجزء الظهري (تحت الزعنفة الظهرية) و الجزء الذيلي (منطقة السويقة الذيلية) من الأسماك من شهر آب 2021 إلى شهر كانون الثاني 2022. تم التحقيق في ستة معادن ثقيلة: Co و Cr و Cd و Cu و Hg و Pb، باستخدام نظام ICP-OES (Spectro acros) متعدد العناصر. كشفت النتائج أن تركيزات المعادن كانت منخفضة بشكل عام في لحم الظهر، مع وجود الزئبق غالبًا أقل من حد الكشف، خاصة في آب و أيلول وتشرين الأول. تم الكشف عن مستويات مرتفعة من الزئبق فقط في تشرين الثاني و كانون الثاني، ويرجع ذلك على الأرجح إلى التلوث الإقليمي الضئيل والتغيرات الموسمية وانخفاض التراكم البيولوجي في أسماك لكارب الاعتيادي. كانت مستويات الكادميوم أعلى بشكل ملحوظ في الجزء الظهري خلال آب و أيلول و تشرين الأول. وفي آب، ارتفع الكادميوم فقط في الجزء الذيلي. وتم الكشف عن الرصاص في آب وأيلول و تشرين الأول، بينما ارتفعت مستويات النحاس بشكل ملحوظ في تشرين الثاني عبر قسمي اللحم، مع ملاحظة أعلى التركيزات في نهر سيروان. وارتفعت مستويات الكوبالت في تشرين الأول في كلا القسمين. وكان الكروم غير قابل للكشف في جميع الأشهر والمواقع. وتشير الدراسة إلى اختلاف تركيزات المعادن الثقيلة في سمكة *Cyprinus carpio* عبر مواقع وأشهر مختلفة، حيث كان النحاس هو الأعلى في نهر سيروان وكان الزئبق غير قابل للكشف في الغالب.

الكلمات المفتاحية: تراكم المعادن الثقيلة، الكارب الاعتيادي ، سد دربنديخان، سيروان، نهر تانجارو.