University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.v13ii 20.*

Age-Dependent Bioaccumulation of Heavy Metals in the Liver of Common Carp (Cyprinus carpio)

Manar Hussein Naema
Esraa Abdul Khaliq Zegyer
manar7usein@gmail.com
azegher@uowasit.edu.iq
Department of Biology, College of Science, Wasit University, Wasit, Iraq.

I. Abstract

Heavy metal pollution in the Tigris River presents considerable ecological and health hazards. This study measured the levels of Lead (Pb) and Cadmium (Cd) that built up in the livers of *Cyprinus carpio* of different ages (3 months vs. 6 months). Twenty samples were obtained from the Tigris River in Wasit Province. Liver samples underwent wet digestion and were subsequently analyzed using ICP-OES. The results showed that there were big differences based on age ($P < 0.05$). Adult fish (6 months) had the most Pb (0.218 ppm) and Cd (0.184 ppm), while juvenile fish (3 months) had much lower levels (Pb: 0.035 ppm; Cd: 0.008 ppm). In a number of adult specimens, metal concentrations exceeded international safety thresholds (0.3 mg/kg for Pb and 0.05 mg/kg for Cd). The study shows that the liver of C. carpio is a good way to tell if metals are building up in the environment, and that age is a key factor in bioaccumulation. This shows that eating fish from contaminated areas could be bad for public health.

Keywords : *Bioaccumulation, Common carp, Cadmium, Lead, Liver.*

II. Introduction

The aquatic environment serves as a ultimate sink for diverse pollutants, with heavy metals like Lead (Pb), Cadmium (Cd), and Copper (Cu) being of paramount concern due to their toxicity and non-biodegradable nature [1]. In Iraq, the Tigris River face severe environmental pressures from rapid urbanization and industrial growth. Anthropogenic activities, such as untreated sewage and agricultural runoff, have significantly elevated trace element concentrations in both water and sediments [2, 3].

Fish are recognized as reliable bio-indicators that reflect the cumulative effect of pollutants over time [4]. They accumulate metals through multiple pathways, including direct uptake from water or ingestion of contaminated food [5]. The common carp (Cyprinus carpio) is an ideal model for toxicological studies due to its bottom-feeding behavior, which increases its contact with contaminated sedentary layers [6].

The liver is the principal target organ for investigating metal toxicity, acting as the metabolic hub for detoxification [7]. Due to its high content of metal-binding proteins like metallothioneins, it has a high affinity for accumulating trace elements. However, excessive metal uptake can lead to oxidative stress and cellular damage [8]. Despite extensive research, the critical role of biological factors, particularly fish age, is often overlooked [9].

Age is a decisive factor in bioaccumulation, as metabolic rates and exposure duration change significantly during growth [9]. The transition from fingerling stages (3 months) to advanced juveniles (6 months) involves physiological shifts that alter how the liver stores trace elements [10]. These quantitative indicators are essential for assessing the safety of fish for human consumption [11].

In the Wasit province sectors of the Tigris River, there is a lack of comparative data on age-dependent accumulation in C. carpio [13]. This study aims to provide a quantitative analysis of metal burden by comparing two distinct age groups (3 vs. 6 months). Such research is crucial for developing precise environmental risk assessments and ensuring public health safety in the region [14, 15].

III. Materials and Methods

Twenty specimens of common carp (*Cyprinus carpio*) were acquired from a local aquaculture facility (fish ponds) in Wasit Province, utilizing water directly from the Tigris River. The sampling took place in September and October, which is late summer and early fall. There were two age groups for the specimens: Group A (Juveniles, about 3 months old) and Group B (Adults, about 6 months old). After being caught, the fish were put in tanks with air to keep their bodies stable until they could be cut open and their liver tissue could be studied.

Liver samples (1–2 g) were taken by ventral incision were put in sterile polyethylene tubes and stored at -20°C to maintain chemical stability until the digestion process [16].

2.1. Sample Digestion

The liver tissues were subjected to a vigorous wet digestion technique to extract the trapped metals from the organic matrix. To prepare the sample, one gram (1 g) of liver tissue was weighed into a 100 mL conical flask, followed by the addition of 5 mL of pure nitric acid (HNO_3 70%) and 1 mL of perchloric acid ($HClO_4$). The mixture was allowed to stand at room temperature for one hour before being placed on a hot plate at 100°C until violet vapors became apparent. Subsequently, the temperature was increased to 150-200°C until white vapors developed, signifying the progression of the reaction. Digestion was considered complete once the remaining solution turned pale yellow. Finally, the digested samples were filtered using Whatman filter paper (0.45 µm), and the total volume was adjusted to 25 mL using distilled water containing 1% HNO_3.

2.2. Determination of Lead (Pb) and Cadmium (Cd) Accumulation

Lead (Pb) and cadmium (Cd) contents were measured in the hepatic tissues of 10 C. carpio specimens from two different age groups (3 and 6 months). The analysis was carried out utilizing Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). This innovative technique uses high-temperature argon plasma to excite elemental atoms, resulting in the emission of distinct electromagnetic radiation. The intensity of this radiation is proportional to the element's concentration, making it a very sensitive and reliable approach for detecting trace elements [17].

2.3 Statistical Analysis

To ensure computational efficiency, a high-performance computer machine with an Intel Core i7 CPU was used for statistical processing and data analysis. IBM SPSS Statistics (Version 26) was used for formal statistical comparisons, whereas Microsoft Excel was used to arrange quantitative data and preliminary computations. The mean values ± standard deviation (Mean ± SD) are used to display the findings. An independent samples t-test was used to assess the significance of variations in heavy metal contents (Pb and Cd) between the two age groups (Juveniles vs. Adults). At a confidence level of $P < 0.05$, statistical significance was determined

IV. Results

3.1. Lead (Pb) Concentrations

Lead (Pb) contents in *Cyprinus carpio* hepatic tissues were analysed using ICP-OES, and substantial changes were found in relation to fish age. The findings show a steady buildup of lead related to age, with the mature group having significantly larger metal loads than the juvenile group, which had the lowest measurable values. An independent samples t-test indicated substantial age differences ($P \leq 0.05$), as shown in Table 2 and Chart 1.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 20.

Crucially, the examination revealed that lead levels in numerous adult specimens exceeded the maximum allowable range set by international safety guidelines for aquatic creatures. This increase in the elder generation indicates a bioaccumulative tendency that might offer toxicological hazards.

Table 1: Concentrations (ppm) of lead (Pb) in the livers of adult and juvenile fish.

Adult Cyprinus carpio	Juvenile Cyprinus carpio
0.123	0.078
0.218	0.072
0.089	0.074
0.088	0.041
0.093	0.041
0.076	0.035
0.081	0.039
0.086	0.063
0.079	0.051
0.091	0.035

Table 2: Mean values and standard deviation of lead (Pb) concentrations in the livers of adult and juvenile fish.

Group	Mean ± SD
Adult *Cyprinus carpio*	0.1024 ± 0.0426
Juvenile *Cyprinus carpio*	0.0529 ± 0.0172
P-value	0.006

University of Thi-Qar Journal of agricultural research
Thi-Qar Journal of agricultural research
ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 20.

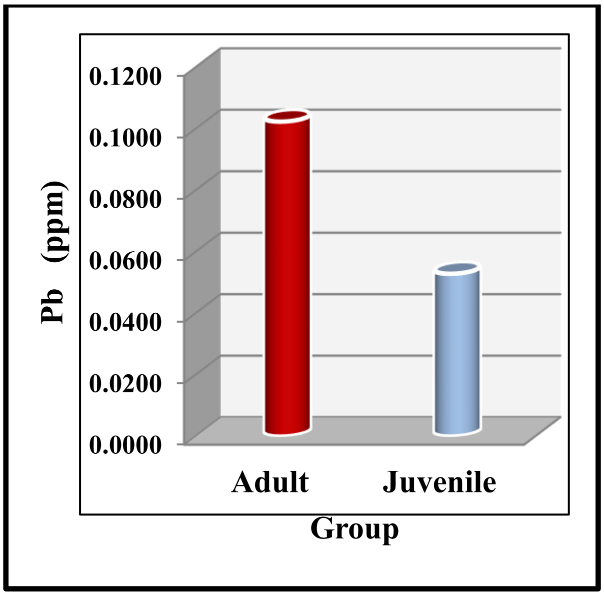

Chart 1: Average lead concentration in fish liver at both ages.

3.2. Cadmium (Cd) Concentrations

Cadmium (Cd) bioaccumulation in *Cyprinus carpio's* hepatic tissues followed a pattern similar to that of lead (Table 3). The data show that age is a determining factor in metal sequestration, with the adult cohort exhibiting the greatest concentration levels and juvenile specimens maintaining much lower loads. An independent samples t-test confirmed a significant difference ($P \leq 0.05$) between the two age groups (see Table 4 and Chart 2).

Analytical results indicate that cadmium levels in most adult fish specimens either met or exceeded international safety limits, suggesting long-term accumulation and raising concerns about aquatic environmental quality.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 20.

Table 3: Concentrations (ppm) of cadmium (Cd) in the livers of adult and juvenile fish.

Adult Cyprinus carpio	Juvenile Cyprinus carpio
0.184	0.012
0.047	0.013
0.021	0.011
0.038	0.012
0.021	0.008
0.043	0.013
0.027	0.014
0.025	0.009
0.031	0.011
0.042	0.015

Table 4: Mean values and standard deviation of Cadmium (Cd) concentrations in the livers of adult and juvenile fish.

Group	Mean ± SD
Adult Cyprinus carpio	0.0479 ± 0.0487
Juvenile Cyprinus carpio	0.0118 ± 0.0022
P-value	0.044

University of Thi-Qar Journal of agricultural research

Thi-Qar Journal of agricultural research

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)

https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 20.

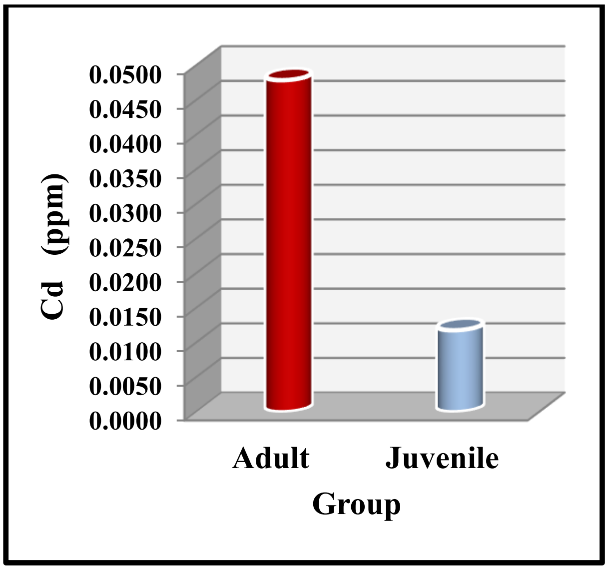

Chart 2: Average cadmium concentration in fish liver at both ages.

V. Discussion

4.1: Age-Related Bioaccumulation and Physiological Mechanisms

The elevated concentrations of Pb and Cd in the liver of adult C. carpio underscore the organ's pivotal role as a primary reservoir for heavy metal sequestration. This accumulation is largely attributed to the liver's high affinity for metal-binding proteins, particularly metallothioneins, which facilitate the detoxification and long-term storage of divalent cations [11, 8].

The pronounced disparity in metal burdens between the age cohorts can be elucidated through various biological and ecological determinants. Older fish undergo a more prolonged duration of exposure to contaminated water and sediments, resulting in a steady, incremental buildup of these non-biodegradable elements [9].

Furthermore, as benthic feeders, adult carp exhibit increased ingestion rates of nutrient-rich but potentially contaminated organic matter, which significantly enhances the biomagnification process within their tissues [18]. From a physiological perspective, the more advanced hepatic architecture and superior lipid reserves in mature fish provide a heightened capacity for retaining toxic metals compared to their juvenile counterparts [14]. While juveniles possess higher metabolic rates, their limited residency in the aquatic environment results in a comparatively lower toxicological profile [10].

4.2: Environmental and Seasonal Influence

The detection of heavy metals exceeding international safety thresholds is primarily driven by anthropogenic pressures, such as industrial effluents and agricultural runoff, which deteriorate the sedentary strata of the Tigris River [1, 12].

A critical factor influencing the observed concentrations is the temporal context of the study, which was conducted during the late summer season. During this period, the Tigris River is characterized by diminished water levels and elevated ambient temperatures. Such thermal conditions are known to accelerate the metabolic

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 https://doi.org/10.54174/utjagr.v13ii 20.

activity of freshwater fish, leading to intensified filtration and consumption rates, which consequently facilitates a more rapid uptake of Pb and Cd [2, 14].

Additionally, the reduced river discharge during the dry summer months induces a "concentration effect," whereby dissolved pollutants and heavy metals precipitate and settle more rapidly into the bottom sediments. This environmental condition increases the bioavailability of toxins for benthic species like C. carpio, justifying the peak bioaccumulation levels recorded in this investigation [2, 18].

VI. Conclusion

The study conclusively demonstrates that the bioaccumulation of Lead (Pb) and Cadmium (Cd) in the liver of *Cyprinus carpio* is significantly affected by biological and environmental factors. Quantitative analysis reveals a strong positive correlation between fish age and metal accumulation, with adult fish (6 months old) showing markedly higher metal concentrations than juveniles. This difference is linked to longer exposure, benthic feeding habits, and the greater physiological capacity of adult liver tissues to sequester metals.

Additionally, elevated metal levels correspond with the summer season, when higher temperatures and reduced water flow enhance metal uptake. Since Pb and Cd concentrations in adult fish exceed international safety limits, these results highlight a notable ecological imbalance in the Tigris River (Wasit sectors) and pose potential health risks to local consumers. Therefore, ongoing environmental monitoring and stricter controls on industrial discharges are urgently needed to reduce heavy metal contamination in Iraqi freshwater environments.

VII. References

Duruibe, J. O., Ogwuegbu, M. O., and Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences, 2(5), 112–118.

Al-Obaidy, A. M. J., Al-Janabi, Z. Z., and Al-Mashhady, A. A. (2015). Heavy metals in the river Tigris within Baghdad City, Iraq. Journal of Al-Nahrain University, 18(1), 75–82.

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., and Sutton, D. J. (2012). Heavy metal toxicity and the environment. Molecular, Clinical and Environmental Toxicology, 101, 133–164.

Authman, M. M., Zaki, M. S., Khallaf, E. A., and Abbas, H. H. (2015). Use of fish as bio-indicator of the effects of heavy metals pollution. Journal of Aquaculture Research and Development, 6(4), 1–13.

Barone, G., Storelli, A., Garofalo, R., and Storelli, M. M. (2015). Assessment of mercury, cadmium, and lead in fish from the South Adriatic Sea (Italy). Journal of Food Composition and Analysis, 40, 149–154.

Yousafzai, A. M., Siraj, M., Ahmad, H., and Chivers, D. P. (2012). Bioaccumulation of heavy metals in common carp: Implications for human health. Pakistan Journal of Zoology, 44(2).

Vutukuru, S. S. (2005). Acute effects of hexavalent chromium on survival, oxidative stress, and cell death in the liver of fish. International Journal of Environmental Research and Public Health, 2(3), 456–462.

Amiard, J. C., Amiard-Triquet, C., Barka, S., Pellerin, J., and Rainbow, P. S. (2006). Metallothioneins in aquatic invertebrates: Their role in metal detoxification and as biomarkers. Aquatic Toxicology, 76(2), 160–202.

ISSN Onlin:2708 -9347, ISSN Print: 2708 -9339 Volume 15, Issue 1 (2026)
https://iasj.rdd.edu.iq/journals/journal/issue/20226 *https://doi.org/10.54174/utjagr.v13ii 20.*

Ali, H., and Khan, E. (2021). Bioaccumulation of non-essential hazardous heavy metals in freshwater fish. Environmental Science and Pollution Research, 28(1), 401–417.

Catarino, A. I., Tan, Q. G., Pan, K., and Wang, W. X. (2012). Metabolic rate and metal accumulation in aquatic organisms. Environmental Pollution, 164, 127–133.

Ahmed, Q., Bat, L., Yousuf, F., and Ali, Q. M. (2022). Lead and Cadmium bioaccumulation in the liver of freshwater fish. Journal of Applied Sciences, 22(3), 145–152.

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., and Krishnamurthy, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals. Interdisciplinary Toxicology, 7(2), 60–72.

Jihad, S. M., and Al-Haidarey, M. J. S. (2020). Assessment of heavy metals in water, sediment and fish of Tigris River in Wasit Province, Iraq. Journal of Physics: Conference Series, 1660(1), 012015.

Rahman, M. S., Molla, A. H., Saha, N., and Rahman, A. (2023). Seasonal variation of heavy metals in the Tigris River and its impact on fish health. Marine Pollution Bulletin, 188, 114620.

Al-Hejuje, M. M. (2014). Application of water quality index for Tigris River within Wasit Province, Iraq. Basrah Journal of Science, 32(1).

Boss, C. B., and Fredeen, K. J. (2004). Concepts, instrumentation, and techniques in inductively coupled plasma optical emission spectrometry (3rd ed.). PerkinElmer, Inc.

Skoog, D. A., Holler, F. J., and Crouch, S. R. (2023). Principles of instrumental analysis (7th ed.). Cengage Learning.

Ali, H., Khan, E., and Ilahi, I. (2019). Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. Journal of Chemistry, 2019, 1–14.