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CHARACTERIZATION OF HEAVY METALS IN WATER AND SILVER CAT FISH *(Crysichthysnigrodigitatus)*AT DADIN KOWA DAM, GOMBE STATE, NIGERIA

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ABSTRACT

The study assessed the concentrations of selected heavy metals in water and Silver catfish (Chrysichthysnigrodigitatus) from Dadin Kowa Dam, Gombe State, Nigeria, with the aim of evaluating potential environmental and public health risks. Water and fish tissue samples were collected from three stations (A, B, and C) and analyzed for arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn) using the Atomic Absorption Spectrophotometry (AAS) Perkin Elmer 400ASS device. The results revealed that arsenic (0.103–0.317 mg/L), cadmium (0.025–0.173 mg/L), and chromium (0.198–0.638 mg/L) in water exceeded the World Health Organization (WHO, 2016) permissible limits of 0.010, 0.003, and 0.050 mg/L, respectively. Lead (Pb) levels (0.003– 0.025 mg/L) were slightly above the limit of 0.010 mg/L, while zinc (0.056– 0.523 mg/L) was found to be below the recommended limit of 5.000 mg/L. In fish tissues, arsenic (0.002–0.032 mg/kg) and chromium (0.066–0.119 mg/kg) exceeded WHO permissible levels, indicating evidence of bioaccumulation. Cadmium (0.000–0.009 mg/kg), lead (0.000–0.008 mg/kg), and zinc (0.015–0.184 mg/kg) remained within acceptable limits. Transfer factor analysis showed generally low levels of bioaccumulation (TF < 1), with zinc exhibiting the highest uptake (0.48 in B), reflecting its biological role, while toxic metals such as arsenic and cadmium showed minimal transfer. The revealed significant contamination of water by arsenic, cadmium, and chromium, posing potential ecological and human health risks. The detection of arsenic and chromium above safe limits in fish tissues further suggests dietary exposure concerns for local communities. The study recommends continuous monitoring of heavy metals in water and aquatic organisms in DadinKowa Dam by relevant environmental and public health agencies to track pollution levels and trends in the interest of protecting public health and environment.

Keywords: Heavy Metals,Silver Catfish,*Crysichthysnigrodigitatus*,Dadinkowa Dam

1.0 INTRODUCTION

Heavy metal contamination is a global issue of concern especially in aquatic environments where it affects both the water and the fish species compositions. Evidence from research within the context of Nigeria suggests a growing concern for protecting different varieties of food from the toxic effects of heavy metals (Haruna, 2022). Heavy metals such as lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and platinum (Pt) occurred naturally as elements and are detected in varying concentrations in all ecosystems and with atomic densities higher than 4g/cm3 (Seydou*et al*., 2022). They are considered significant environmental pollutants due to their toxicity, persistence, and ability to bioaccumulate in living organisms (Tchounwoue*t al.*, 2012). Heavy metals assesses aquatic ecosystems through both natural processes and anthropogenic activities. Natural processes such as weathering of rocks and volcanic eruptions contribute trace amounts of metals to water bodies (Haruna, 2022). However, human activities, including mining, industrial discharge, use of fertilizers and pesticides in agriculture, and urbanization, have significantly elevated the levels of these metals in aquatic systems (Ogoyi*et al.*, 2011). Water bodies such as dams, rivers, and lakes are natural resources that helps support aquatic life, agriculture, domestic use, and industrial activities. However, these ecosystems are increasingly threatened by pollution, particularly from heavy metals such as oil spilage, industrial waste, fertilizers, etc. (FAO, 2022). Heavy metals can adversely affect water quality, disrupt aquatic ecosystems, and pose risks to human health through bioaccumulation and biomagnification in the food chain (WHO, 2023). DadinKowa Dam, located in Gombe State, Nigeria, is an essential water resource for irrigation, domestic water supply, hydropower generation, and fisheries. It is also home to several fish species, including the silver catfish *(Chrysichthysnigrodigitatus)*, which is a source of protein and livelihood for the local population. However, the dam is increasingly exposed to pollution from agricultural runoff (Sadiq*et al*., 2019), domestic waste (Rabiu, 2023), and industrial effluents, which are potential sources of heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), and zinc (Zn) (Abubakar*et al*., 2015). Fish are sensitive to changes in water quality and have the ability to accumulate heavy metals in their tissues through direct contact with contaminated water or consumption of contaminated prey (Javed andUsmani, 2012). The accumulation of heavy metals in fish depends on various factors, including species, age, size, habitat, feeding behavior, and the levels of metals in the surrounding environment (Rashed, 2001). This thereafter, when consumed by humans, contaminated fish with heavy metals can lead to serious health issues, such as neurotoxicity, kidney damage, and even cancer (Clarkson *et al*., 2003). Silver Catfish is a popular freshwater fish in Nigeria, valued for its rich nutritional content, abundance, and appealing taste. However, as a bottom-dwelling omnivore, it is especially susceptible to accumulating toxic substances from polluted water and contaminated sediments (Ekpo *et al*., 2020). Therefore, this study aims to assess the presence and concentrations of heavy metals in water and silver catfish in DadinKowa Dam.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at DadinKowa Dam which is situated at Northeastern part of Nigeria, specifically in Gombe State, approximately 37 km from Gombe town along the Gombe-Biu road, within the Yamaltu/Deba local government area. It is positioned between longitudes 11°30' and 11°32' E and latitudes 10°17' and 10°18' N. The dam was constructed to serve multiple purposes, including irrigation, potable water supply, and hydroelectric power generation. It helps in supporting regional agriculture and providing water to Gombe city and its surrounding areas. Built on the Gongola River, a significant tributary of the Benue River, the dam features a hydroelectric power plant with a capacity of 40 MW, contributing to the national electricity grid and supporting local industries and communities. Additionally, the dam facilitates extensive irrigation projects, enhancing agricultural productivity and food security in the region. It also provides essential clean drinking water to millions of residents in Gombe State, which is particularly important given the arid conditions prevalent in much of northern Nigeria.

2.2 Sample Collection

2.2.1 Water Samples

Water samples were collected randomly from three different points within DadinKowa Dam in triplicates to ensure spatial coverage and capture potential variations in contamination levels. The sampling points included areas near agricultural runoff, domestic waste discharge, and a relatively undisturbed site for comparison tagged as A, B and C as treatments 1, 2 and 3 respectively. 1 liter of water was collected at each point using acid-washed polyethylene bottles. Samples were preserved by adding concentrated nitric acid (HNO_3) to maintain a pH below 2, thereby preventing metal precipitation and microbial activity as described by (APHA, 2017).

2.2.2 Fish Samples

Silver catfish *(Chrysichthysnigrodigitatus)*, ranging from 150–300 g in weight, were randomly collected from fishermen at the dam within the period June, July and August 2025. The fish was selected due to it ecological and economic importance, as well as feeding behavior, which increases its susceptibility to heavy metal accumulation. Fish samples were placed in clean, labeled polythene bags and transported to the laboratory in an icebox to prevent spoilage as described by (Javed andUsmani, 2012).

2.3 Sample Preparation and Analysis

2.3.1 Water Sample Preparation

Water samples collected were filtered using Whatman filter paper to remove debris and suspended particles. A 100 mL aliquot of each sample was digested with 5 mL of concentrated nitric acid (HNO_3) at 80°C until the solution becomes clear. The digested samples were then cooled, diluted to 50 mL with deionized water, and stored in polyethylene bottles for heavy metal analysis.

2.3.2 Fish Sample Preparation

The fish samples were sun-dried for two (2) weeks to remove moisture content until a constant weight is obtained. The samples were dried on a straw mat rather than using iron wire to prevent contamination with iron oxides. This meticulous handling process was essential in maintaining the purity of the samples for accurate analysis of radionuclide concentrations. The dried fish was grounded, sieved into fine powder, and sealed in uncontaminated, geometrically matched plastic containers, identical to the calibration source. The samples were kept in the sealed containers for at least 30 days to attain secular equilibrium. The samples was then digested using a mixture of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) in a 2:1 ratio at 100°C until a clear solution was obtained. The digested samples were cooled, diluted with deionized water, and filtered into clean polyethylene bottles for analysis.

2.4 Heavy Metal Analysis

The concentrations of lead (Pb), cadmium (Cd), chromium (Cr), Arsenic (As) and zinc (Zn) in water and fish samples were determined using Atomic Absorption Spectrophotometry (AAS) Perkin Elmer 400ASS. This technique was selected due to its high sensitivity, precision, and reliability in quantifying trace levels of heavy metals. Calibration standards was prepared using certified reference materials, and the instrument was properly calibrated prior to each analysis to ensure accurate and consistent results.

2.5 Data Analysis

The data obtained from heavy metal analysis were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS). Descriptive statistics such as mean, standard deviation, and range were used to summarize the concentrations of heavy metals in water and fish samples.

3.0 RESULTS AND DISCUSSION

3.1 Concentrations of Heavy Metals in Dadin Kowa Dam

Figure 1 presents the concentrations of heavy metals in water samples collected from Stations A, B, and C. Arsenic (As) concentrations were generally low across the stations, with the highest value observed in Station B (0.3165 mg/L), while the least was station C(0.0785 mg/L). Cadmium (Cd) levels were highest in Station A (0.1724 mg/L) while the least was 0.0254 mg/L in station B. Chromium (Cr) showed relatively higher concentrations across all stations, with Station A having the highest value of 0.6384 mg/L and the least was station C with 0.1976 mg/L. Lead (Pb) concentrations were relatively low compared to other metals, but Stations B (0.0246 mg/L) and C (0.0235 mg/L) recorded higher values than Station A (0.0033 mg/L). Zinc (Zn) was present in all stations, with Station A showing the highest concentration (0.5260 mg/L), followed by Station B (0.3833 mg/L), while Station C recorded the lowest (0.0556 mg/L). Table 1 presents the concentrations of heavy metals in water compared with the World Health Organization (WHO, 2016) permissible limits. The results reveal that arsenic (0.103–0.317 mg/L), cadmium (0.025–0.173 mg/L), and chromium (0.198–0.638 mg/L) exceeded the recommended safe limits of 0.010 mg/L, 0.003 mg/L, and 0.050 mg/L, respectively, indicating potential health risks associated with their presence. Lead concentrations (0.003–0.025 mg/L) ranged around the permissible limit of 0.010 mg/L, with some values slightly higher, suggesting possible contamination concerns. Conversely, zinc (0.056–0.523 mg/L) remained well below the WHO guideline of 5.000 mg/L, indicating that zinc levels in the water are within acceptable standards. The elevated concentrations of arsenic, cadmium, and chromium raise significant environmental and public health concerns.
The arsenic levels recorded in this study are far above the permissible limit which is consistent with Ezekiel*et al.* (2019), who reported widespread arsenic contamination in South Asian groundwater, with concentrations often surpassing safe thresholds and linked to longterm carcinogenic effects. Similarly, Rahman *et al*. (2019) reported arsenic levels in Bangladeshi groundwater ranging from 0.05–0.30 mg/L, values comparable to those observed in this study, thereby reinforcing the global health concern arsenic poses in groundwater systems. Cadmium concentrations detected (0.025–0.173 mg/L) also significantly exceeded the WHO guideline, corroborating the findings of Syarifah*et al*. (2016), who observed cadmium pollution in Thai river basins, attributing high levels to industrial discharges and linking them to renal dysfunction and bone damage. However, in contrast to the findings of Ugonna*et al.*(2020),who reported cadmium levels in rural Nigerian water sources generally within safe limits (<0.005 mg/L), suggesting that the elevated concentrations observed in the present study may be strongly associated with localized anthropogenic pressures, such as mining, agricultural inputs, and waste disposal. Chromium levels (0.198–0.638 mg/L) were also considerably higher than recommended limits. This aligns with the findings of Saha*et al*. (2019), who documented chromium concentrations in Bangladeshi

groundwater exceeding WHO standards, especially near tannery industries. In contrast, studies in less industrialized regions, such as Seydou*et al*. (2022) in Northern Nigeria, revealed chromium concentrations below 0.05 mg/L, highlighting the role of industrial and urban activities in elevating heavy metal levels. From a health-risk perspective, long-term ingestion of arsenic at the measured levels is linked to characteristic skin lesions and increased risks of cardiovascular disease and several cancers; chronic arsenic in groundwater remains a major public-health issue globally (World Health Organization, 2016; ATSDR, 2007).

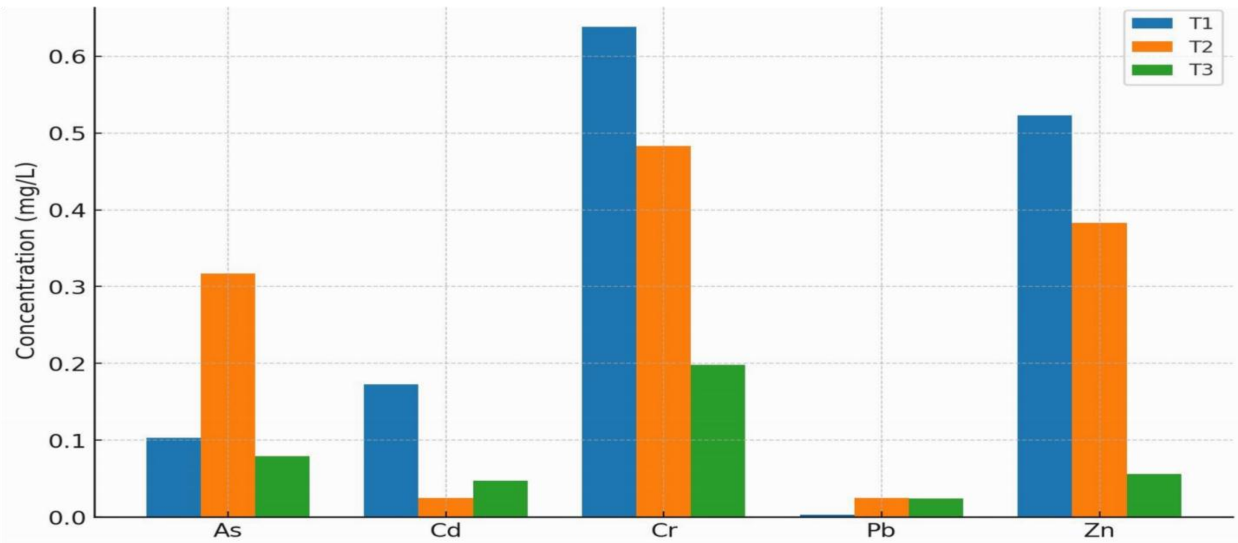

Figure 1: Heavy Metal concentrations in water

Table 2: International Standard Recommended limit of Heavy Metal Concentrations in Water

Heavy Metal	Concentrations (mg/L)	WHO (2016)(mg/L)
Arsenic (As)	0.103 – 0.317	0.010
Cadmium (Cd)	0.025 – 0.173	0.003
Chromium (Cr)	0.198 – 0.638	0.050
Lead (Pb)	0.003 – 0.025	0.010
Zinc (Zn)	0.056 – 0.523	5.000

3.2 Concentrations of Heavy Metals in Silver Catfish from DadinKowa Dam

Figure 2 shows the concentrations of heavy metals in fish tissue samples from the three sampling points (A, B, and C). Arsenic (As) concentrations varied across the stations, with the highest level recorded in station A (0.032 mg/Kg) while the least was in station C(0.002 mg/Kg). Cadmium (Cd) was detected at 0.009 mg/Kg in A and 0.004 mg/Kg in B, but it was below detection level in C. Chromium (Cr) was consistently detected across the stations, with station A recording the highest value (0.119 mg/Kg) while station B recorded the lowest value of 0.066 mg/Kg. Lead (Pb) concentrations showed a progressive increase across the stations, being below detection in A, but rising to 0.004 mg/Kg in B and 0.008 mg/Kg in C. Zinc (Zn) concentrations varied widely, with B showing the highest level (0.184 mg/Kg), followed by A (0.084 mg/Kg), while C had the lowest value (0.015 mg/Kg). The results shows that fish from station A accumulated higher levels of arsenic, cadmium, and chromium, while station B had higher levels of zinc and detectable lead. Station C recorded the lowest arsenic and zinc concentrations but showed a relatively higher accumulation of lead. These variations suggest possible differences in contamination sources or bioaccumulation patterns across the sampling points.

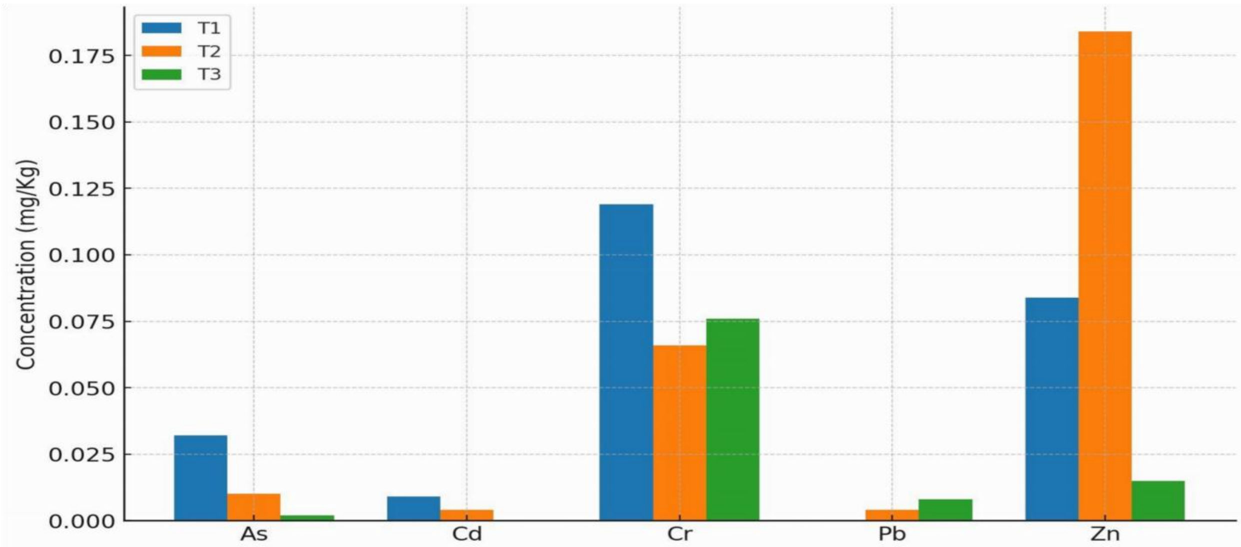

Figure 2: Heavy metal concentration in fish samples

Table 2: Heavy metal concentration in fish samples and International Standard Recommended limit of Heavy Metal Concentrations in Fish

Heavy Metal	Concentrations (mg/L)	WHO (2016)(mg/L)
Arsenic (As)	0.032 – 0.002	0.010
Cadmium (Cd)	0.009 – 0.000	0.100
Chromium (Cr)	0.119 – 0.066	0.050
Lead (Pb)	0.000 – 0.008	0.300
Zinc (Zn)	0.084 – 0.015	5.000

Table 2 compares the concentrations of heavy metals in fish tissues with the WHO (2016) permissible limits. The results indicate that arsenic (0.002–0.032 mg/L) slightly exceeded the recommended limit of 0.010 mg/L, raising potential health concerns. Cadmium levels (0.000–

0.009 mg/L) were found to be below the permissible limit of 0.100 mg/L, indicating no contamination risk. Chromium concentrations (0.066–0.119 mg/L) exceeded the WHO guideline of 0.050 mg/L, suggesting possible pollution and health hazards. Lead levels (0.000–0.008 mg/L) remained far below the limit of 0.300 mg/L, while zinc (0.015– 0.084 mg/L) was also within the acceptable range of 5.000 mg/L. Cadmium, lead, and zinc concentrations were within safe limits, the elevated levels of arsenic and chromium shows the potential bioaccumulation of these heavy metals with concerns that warrant attention. In fish tissues, arsenic (0.002–0.032 mg/kg) and chromium (0.066–0.119 mg/kg) also exceeded WHO (2016) permissible limits, highlighting evidence of bioaccumulation. This is consistent with studies showing that aquatic organisms can concentrate heavy metals from their surrounding environment, posing ecological and dietary risks (Rajeshkumar and Li, 2018). Elevated arsenic in fish tissues is particularly alarming since it can enter the human food chain, leading to chronic exposure risks (FEPA, 2003). Chromium levels above safe thresholds further suggest possible pollution sources near the sampling sites, such as industrial discharges, agricultural runoff, or improper waste disposal. On the other hand, cadmium (0.000–0.009 mg/kg), lead (0.000–0.008 mg/kg), and zinc (0.015–0.184 mg/kg) remained within permissible limits, indicating lower bioavailability or uptake in fish at the studied sites. The implications of these findings are significant for both environmental health and food safety. Elevated arsenic, cadmium, and chromium in water not only threaten aquatic life but also increase risks to human populations relying on these water sources for drinking, irrigation, or fisheries. The detection of arsenic and chromium above safety limits in fish tissues indicates bioaccumulation, suggesting that long-term consumption of contaminated fish may pose chronic health risks to local communities (WHO, 2011). The observed patterns also suggest spatial variation in contamination sources, with station A showing higher arsenic and cadmium, B showing elevated zinc and lead, and station C recording higher lead levels, which may reflect localized anthropogenic inputs.

Table 3: Transfer Factors (TF)

Metal	**A**	**B**	**C**
As	0.31	0.03	0.03
Cd	0.05	0.16	0.00
Cr	0.19	0.14	0.38
Pb	0.00	0.16	0.33
Zn	0.16	0.48	0.27

The transfer factor (TF) values shown in Table 3 shows the different metals indicate generally low levels of bioaccumulation, since none of the metals recorded a TF greater than 1. Arsenic showed the least transfer across all tissues 0.31 in A and 0.03 in both B and C, suggesting minimal uptake by the fish. Cadmium also recorded very low transfer, with only slight accumulation in B (0.16) and no detectable transfer in C. Chromium showed relatively higher TF values, particularly in C (0.38), implying some degree of selective accumulation in the tissue. Lead exhibited no uptake in A but moderate transfer in B (0.16) and C (0.33), which also suggests tissue-specific bioaccumulation. Zinc, an essential trace element, demonstrated the highest transfer among all metals, especially in B (0.48), which reflects its biological importance in fish metabolism. The findings revels that while essential metals such as zinc are more readily transferred into fish tissues, toxic metals such as arsenic, cadmium, and lead are less efficiently accumulated, although their presence, even at low levels, may still pose ecological and public health risks with prolonged exposure.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The findings from this study revealed that arsenic, cadmium, and chromium levels in the water samples consistently exceeded the World Health Organization permissible limits, while lead concentrations was found to be around the threshold limit. Although zinc concentrations were within safe limits, the high level of other heavy metals suggest a clear indication of anthropogenic pollution in the dam. Such contamination may be attributed to agricultural runoff, industrial effluents, mining activities, and improper waste disposal within the dam's catchment area. The bioaccumulation of heavy metals in silver catfish further highlights the ecological and public health implications of the dam's contamination. Fish, being an important protein source for local communities, can act as vectors of toxic elements through the food chain. The elevated cadmium and chromium concentrations in fish tissues raise serious concerns about long-term dietary exposure, as both metals are known to bioaccumulate and cause chronic toxicity.

4.2 Recommendations

Based on the findings from this study, the following recommendations are made:

i. Continuous monitoring of heavy metals in water and aquatic organisms in DadinKowa Dam should be instituted by relevant environmental and public health agencies to track pollution levels and trends.

ii. Industrial, agricultural, and domestic waste discharges into the dam should be strictly regulated to reduce heavy metal contamination at the source. Proper wastewater treatment facilities should be enforced.

iii. Communities relying on the dam for drinking water and fish consumption should be sensitized to the potential risks of heavy metal exposure and encouraged to adopt safer water treatment and fish preparation methods.

iv. Government and stakeholders should provide alternative sources of potable water for communities around DadinKowa Dam to reduce dependence on contaminated water.

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