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Evaluation of Toxic Metals in Catfish (Clarias Gariepinus) Sold in Mokwa, Niger State, Nigeria

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Abstract **Original Research**

The contamination of aquatic foods by toxic metals poses significant public health concerns due to their persistence, bioaccumulation, and potential adverse health effects. This study evaluated the concentrations of selected toxic metals in catfish (Clarias gariepinus) sold in Mokwa Town, Niger State, Nigeria. Fresh catfish samples were collected from major markets within the study area and analyzed for toxic metals, including lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn), using standard analytical procedures. The results revealed varying concentrations of the metals across the sampled fish. Essential metals such as Fe, Zn, Mn, and Cu were detected within acceptable ranges, while the concentrations of Pb and Cd in some samples exceeded the permissible limits recommended by international food safety agencies. Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), Hazard Index (HI), and Incremental Lifetime Cancer Risk (ILCR) were employed to assess potential health risks associated with fish consumption. The risk assessment indicated that non-carcinogenic risks were generally within acceptable limits for most metals; however, continuous consumption of contaminated fish may increase the risk of toxic metal accumulation and associated health complications. The study highlights the need for regular monitoring of toxic metals in fish and aquatic environments within Mokwa and its environs to ensure food safety and protect public health.

Keywords: Catfish, Toxic Metals, Health Risk Assessment, Mokwa, Nigeria.

Introduction

Fish is one of the most important sources of animal protein globally and contributes substantially to food security, nutrition, and economic development, particularly in developing countries. According to the Food and Agriculture Organization (FAO), fish provides approximately 20% of animal protein intake for over 3 billion people worldwide and supplies essential nutrients such as high-quality proteins, polyunsaturated fatty acids, vitamins, and minerals necessary for human growth and development (FAO/WHO, 2024). In Nigeria, fish remains a major component of the diet owing to its affordability, nutritional quality, and availability. Among the various fish species consumed, African catfish (*Clarias gariepinus*) is one of the most preferred because of its rapid growth rate, adaptability to diverse aquatic environments, high market demand, and nutritional value (Olurin, 2024).

Despite the nutritional benefits associated with fish consumption, concerns have increased regarding the contamination of aquatic ecosystems by toxic metals. The rapid expansion of industrialization, urbanization, agricultural activities, transportation, mining operations, and indiscriminate waste disposal has resulted in the release of substantial quantities of pollutants into aquatic environments. These contaminants eventually accumulate in rivers, lakes, reservoirs, ponds, and other water bodies where fish live and feed. As a result, fish can serve as important bioindicators of environmental pollution because they readily absorb and accumulate contaminants from water, sediments, and food sources (FAO/WHO, 2024). Recent studies have highlighted toxic metal contamination as one of the most significant threats to aquatic food safety worldwide (Adebiyi *et al.*, 2024).

Toxic metals are of particular concern because they are non-biodegradable, persistent, and capable of bioaccumulation and biomagnification through the food chain. Unlike many organic pollutants that can be degraded over time, toxic metals remain in the environment for extended periods and can accumulate in living organisms. Metals such as lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), arsenic (As), and mercury (Hg) have no known biological function in humans and can exert toxic effects even at low concentrations. Continuous exposure to these metals has been associated with neurological disorders, kidney dysfunction, liver damage, developmental abnormalities, reproductive impairment, endocrine disruption, cardiovascular diseases, and carcinogenic effects (Ekperusi and Asiwa, 2024).

Fish accumulate toxic metals through several pathways, including direct absorption from contaminated water through the gills and skin, ingestion of contaminated sediments, and consumption of polluted food items. The degree of accumulation depends on factors such as species characteristics, age, size, trophic level, feeding habits, habitat, and environmental conditions. Catfish are particularly susceptible to metal accumulation because they are bottom-feeding organisms that frequently interact with sediments, which serve as reservoirs for toxic contaminants. Studies have shown that benthic fish species generally accumulate higher concentrations of toxic metals than pelagic species due to their close association with contaminated sediments (Ekperusi and Asiwa, 2024).

Certain metals, including iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn), are essential micronutrients required for normal physiological functions. However, these elements can become toxic when present at elevated concentrations. Excessive iron intake may lead to oxidative stress and organ damage, while elevated copper concentrations can cause liver and kidney dysfunction. Zinc toxicity has been associated with gastrointestinal disorders and impaired immune responses. In contrast, non-essential metals such as lead and cadmium are harmful even at relatively low concentrations because of their cumulative toxic effects on biological systems (Jolaosho *et al.*, 2024).

Lead is recognized as one of the most hazardous environmental contaminants due to its adverse effects on the nervous system, especially among children. Chronic exposure to lead can result in cognitive impairment, reduced intelligence quotient (IQ), anemia, hypertension, and renal dysfunction. Cadmium is another highly toxic metal that accumulates primarily in the kidneys and liver, causing renal damage, bone demineralization, and increased cancer risk following prolonged exposure. Chromium, depending on its oxidation state, may cause respiratory disorders, liver damage, and carcinogenic effects, while nickel exposure has been linked to dermatitis, respiratory diseases, and increased cancer risk (Adebiyi *et al.*, 2024).

The contamination of fish by toxic metals has become a major environmental and public health concern in Nigeria. Numerous investigations conducted across different regions of the country have reported varying levels of heavy metals in commercially important fish species. Adebiyi et al., (2024) reported detectable concentrations of potentially toxic metals in fish commonly consumed in Nigeria and emphasized the importance of routine monitoring and risk assessment. Similarly, Jolaosho and others repoted the presence of arsenic, cadmium, chromium, copper, cobalt, iron, lead, nickel, and zinc in fish samples collected from Ojo River, Lagos, and demonstrated evidence of bioaccumulation in aquatic organisms. Their findings indicated that fish tissues accumulated metals in the order Fe > Zn > Cu > Cr > Ni > Co > Pb > As > Cd (Jolaosho *et al.*, 2024).

Recent studies conducted in the Niger Delta and coastal regions of Nigeria have further highlighted the significance of toxic metal contamination in aquatic ecosystems. Ekperusi and Asiwa (2024) reported measurable concentrations of cadmium, lead, nickel, copper, and vanadium in seafood from the Escravos Estuary and found evidence of trophic transfer and bioaccumulation among aquatic organisms. Likewise, a study conducted in the Escravos Estuary revealed that cadmium, chromium, and lead concentrations in silver catfish exceeded internationally recommended limits, suggesting potential health risks for consumers, particularly children and frequent fish consumers. The study further demonstrated that estimated daily intake (EDI) and health risk indices indicated significant exposure concerns associated with long-term seafood consumption. Many findings, identified cadmium as a major contributor to carcinogenic risk among vulnerable populations, suggesting that anthropogenic activities remain important sources of metal contamination in aquatic environments and emphasizing the need for continuous environmental monitoring and regulatory interventions (Tamunosa *et al.*, 2025).

Health risk assessment has become an essential component of environmental monitoring studies because it provides information on the potential adverse effects of contaminated food consumption. Commonly used indices include Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), Hazard Index (HI), and Incremental Lifetime Cancer Risk (ILCR). EDI estimates the quantity of contaminants consumed daily through food intake, while THQ and HI evaluate non-carcinogenic risks associated with long-term exposure. ILCR is used to estimate the probability of developing cancer over a lifetime due to exposure to carcinogenic contaminants. These indices are widely recommended by the United States Environmental Protection Agency (USEPA, 2024) and have been applied extensively in fish contamination studies worldwide.

The increasing agricultural activities, transportation networks, waste disposal practices, and other anthropogenic pressures around aquatic ecosystems raise concerns regarding possible contamination of fish available for human consumption. However, despite the high rate of fish consumption in the area, information on toxic metal concentrations and associated health risks in catfish sold in Mokwa remains scarce. Given the nutritional importance of fish and the potential health implications associated with toxic metal exposure, there is a need to assess the safety of catfish consumed by residents of Mokwa and surrounding communities.

Therefore, this study evaluated the concentrations of selected toxic metals, namely Pb, Cd, Cr, Ni, Cu, Zn, Fe, and Mn, in catfish sold in Mokwa, Niger State, Nigeria. Furthermore, human health risk assessment models, including EDI, THQ, HI, and ILCR, were employed to determine the potential non-carcinogenic and carcinogenic risks associated with the consumption of contaminated catfish. The findings will contribute to existing knowledge on food safety, environmental pollution, and public health protection in Nigeria.

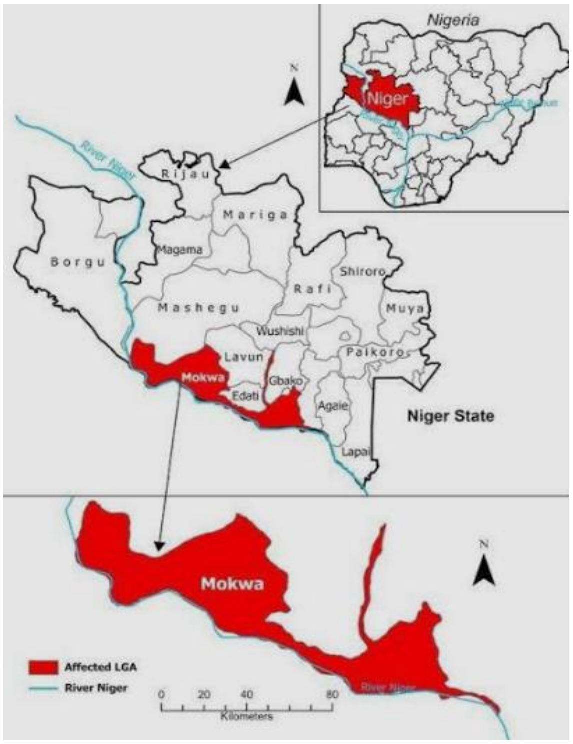
METHODOLOGY

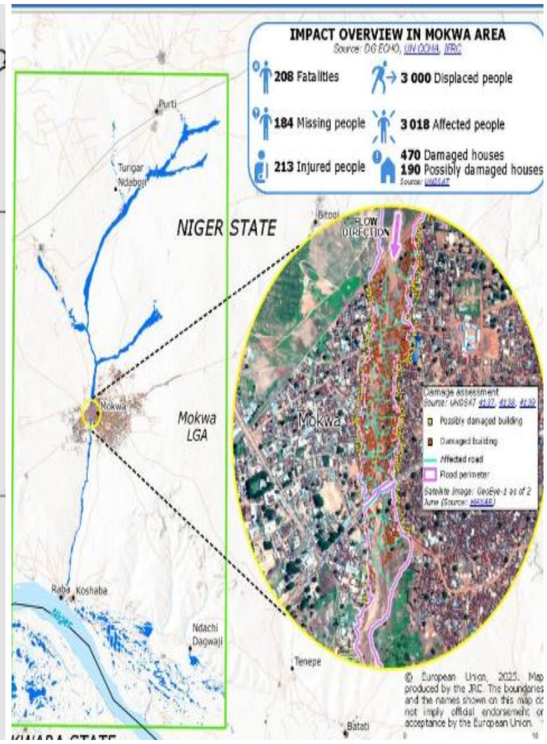
Study Area

The study was conducted in Mokwa Local Government Area of Niger State, Nigeria. Mokwa is located between latitude 9°18′N and longitude 5°04′E and serves as a major commercial center linking northern and southern Nigeria. Fish sold in

Mokwa markets are sourced from rivers, reservoirs, and fish farms within Niger State and neighboring states.

Map of the Study Area





Sample Collection

Fresh African catfish (Clarias gariepinus) samples were randomly purchased from major sales points in Mokwa market and the samples were placed in sterile polyethylene bags, transported in ice-packed coolers to the laboratory, and stored at 4°C prior to analysis.

Sample Preparation

Fish samples were washed thoroughly with distilled water to remove surface contaminants. Edible muscle tissues were excised using stainless-steel knives and oven-dried at 105°C until constant weight was achieved. The dried samples were ground into fine powder using a laboratory grinder and stored in airtight containers.

Acid Digestion

One gram (1.0 g) of each homogenized sample was weighed into digestion flasks and ten milliliters (10 mL) of concentrated nitric acid (HNO_3) and 5 mL perchloric acid ($HClO_3$) were added. The mixture was heated on a hot plate until a clear solution was obtained. After cooling, the digest was filtered and diluted to 50 mL with deionized water.

Heavy Metal Determination

The concentrations of Pb, Cd, Cr, Ni, Cu, Zn, Fe, and Mn were determined using Atomic Absorption Spectrophotometry (AAS) according to standard methods described by the American Public Health Association (APHA, 2023). And results were expressed in mg/kg dry weight.

Human Health Risk Assessment

The health risk assessment associated with the consumption of contaminated food substances were calculated according to USEPA (2024):

Estimated Daily Intake (EDI)

EDI was calculated using: **EDI = (C × FIR) / BW**

where:

C = concentration of metal (mg/kg)

FIR = fish ingestion rate (0.068 kg/day)

BW = average body weight (70 kg)

Target Hazard Quotient (THQ)

THQ was calculated using: THQ = (EF × ED × FIR × C) / (RfD × BW × AT)

where:

EF = Exposure frequency (365 days/year)

ED = Exposure duration (30 years for non-cancer risk as suggested by the USEPA)

FIR = fish ingestion rate (0.068 kg/day)

C = Concentration of metal in fish (mg/kg)

RfD = Reference oral dose

BW = Body Weight average adult (70 kg)

AT = Average exposure time for non-carcinogens

Hazard Index (HI)

HI was calculated using: **HI = ΣTHQ**

where:

Σ = Summation

THQ = Target hazard quotient or hazard ratio

Incremental Lifetime Cancer Risk (ILCR)

ILCR was calculated using: **ILCR=EDI× CSF**

where:

EDI = Estimated Daily Intake

CSF = Cancer Slope Factor

Statistical Analysis

Data were analyzed using SPSS Version 26 and the results were expressed as Mean ± Standard Deviation. While One-way ANOVA was used to determine significant differences at $p < 0.05$.

RESULTS AND DISCUSSION

Results

Table 1: Shows the Concentration of Toxic Metals in Catfish Sold in Mokwa Town

Metal	Mean Concentration (mg/kg) ± SD	FAO/WHO Limit (mg/kg)
Pb	0.42 ± 0.05	0.30
Cd	0.11 ± 0.02	0.05
Cr	0.36 ± 0.04	1.00
Ni	0.29 ± 0.03	0.50
Cu	1.85 ± 0.21	30.00
Zn	18.64 ± 2.14	40.00
Fe	42.57 ± 3.65	100.00
Mn	1.72 ± 0.19	5.00

Table 2: Shows Estimated Daily Intake (EDI)

Metal	EDI (mg/kg/day)
Pb	4.08×10^{-4}
Cd	1.07×10^{-4}
Cr	3.50×10^{-4}
Ni	2.82×10^{-4}
Cu	1.80×10^{-3}
Zn	1.81×10^{-2}
Fe	4.14×10^{-2}
Mn	1.67×10^{-3}

Table 3: Shows Non-Carcinogenic Risk Assessment

Metal	THQ
Pb	0.41
Cd	0.27
Cr	0.18
Ni	0.14
Cu	0.05
Zn	0.06
Fe	0.09
Mn	0.03

Total Hazard Index (HI) = 1.23

Table 4: Shows Incremental Lifetime Cancer Risk (ILCR)

Metal	ILCR
Pb	5.2×10^{-5}
Cd	3.4×10^{-5}
Cr	4.8×10^{-5}
Ni	2.7×10^{-5}

Discussion

The concentrations of toxic metals detected in catfish sold in Mokwa varied considerably among the analyzed elements and the metal concentration trend was Fe > Zn > Cu > Mn > Pb > Cr > Ni > Cd. From Table 1, Iron (Fe) exhibited the highest concentration of 42.57 mg/kg, followed by zinc (Zn) with mean concentration of 18.64 mg/kg and copper (Cu) with 1.85 mg/kg mean concentration. These metals are essential micronutrients required for physiological functions in fish and humans; however, excessive accumulation may pose health concerns. Lead concentration of 0.42 mg/kg recorded exceeded the FAO/WHO permissible limit of 0.30 mg/kg. This finding suggests anthropogenic contamination possibly originating from vehicular emissions, agricultural runoff, batteries, paints, and indiscriminate waste disposal. Similar elevated lead concentrations have been reported in fish from Lagos Lagoon by Jolaosho et al. (2024) and in seafood from the Escravos Estuary by Ekperusi and Asiwa (2024).

Cadmium concentration of 0.11 mg/kg also exceeded the recommended limit of 0.05 mg/kg. Cadmium contamination may originate from phosphate fertilizers, industrial effluents, and improper waste management practices. The observed value is comparable to findings reported by (Adamu *et al*, 2023; Yalwa *et al*,. 2024) in riverine fish species from northern Nigeria. Chromium and nickel concentrations remained below international safety limits, indicating relatively lower contamination levels. A similar report found chromium and nickel concentrations within acceptable limits in fish commonly consumed in Nigeria (Adebiyi *et al.*, 2024).

The Estimated Daily Intake values for all metals were below maximum tolerable daily intake limits established by international regulatory agencies, suggesting that occasional consumption may not pose immediate health threats. However, long-term exposure may lead to gradual accumulation in body tissues. The THQ values for individual metals were less than unity, indicating that each metal alone may not pose significant non-carcinogenic risk. Nevertheless, the overall Hazard Index (HI = 1.23) exceeded the safe threshold of 1.0 since HI > 1 indicates potential health risk. This suggests possible cumulative health risks arising from simultaneous exposure to multiple toxic metals through continuous fish consumption. Comparable HI values exceeding unity were reported by Udofia *et al.*, (2020) in Calabar metropolis and by Ojiego *et al.*, (2022) in Lokoja.

The calculated ILCR values for lead, cadmium, chromium, and nickel were within the USEPA acceptable cancer risk range of 10^{-6}–10^{-4}. However, the combined cancer risk value (1.61×10^{-4}) slightly exceeded the upper acceptable limit, indicating potential carcinogenic concerns for habitual consumers. Similar elevated cancer risk values have been reported in studies conducted in the Niger Delta and Lagos coastal waters (Ekperusi and Asiwa, 2024; Marine Pollution Bulletin, 2024).

Overall, the results indicate that catfish sold in Mokwa contain measurable concentrations of toxic metals, with lead and cadmium exceeding recommended safety limits. Although individual risk indices suggest moderate risk, cumulative exposure may pose adverse health effects over time. Continuous monitoring of fish quality and aquatic environments is therefore necessary to safeguard public health.

Conclusion

The findings of this study revealed that the concentrations of selected toxic metals (Pb, Cd, Cr, Ni, Cu, Zn, Fe, and Mn) in Clarias gariepinus. It revealed that essential metals such as iron, zinc, copper, and manganese were present at relatively higher concentrations but within acceptable limits. However, toxic metals such as lead (Pb) and cadmium (Cd) exceeded the maximum permissible limits recommended by international food safety standards, indicating possible anthropogenic contamination of aquatic environments supplying fish to the study area. The health risk assessment results showed that individual Target Hazard Quotient (THQ) values for each metal were below unity, suggesting that non-carcinogenic risk from single-metal exposure may be low. However, the cumulative Hazard Index (HI) exceeded 1.0, indicating potential health risks arising from long-term exposure to multiple toxic metals through continuous consumption of contaminated catfish. Furthermore, the Incremental Lifetime Cancer Risk (ILCR) values for carcinogenic metals slightly exceeded the acceptable safety threshold, suggesting possible carcinogenic risks for habitual fish consumers. Since ILCR values between 10^{-6} and 10^{-4} are considered acceptable, the study demonstrates that while catfish sold in Mokwa are generally safe in terms of essential nutrient composition, the presence of elevated levels of lead and cadmium raises significant public health concerns. Continuous consumption of such contaminated fish may lead to bioaccumulation of toxic metals and associated chronic health effects over time.

Recommendations

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

1. Government agencies such as NAFDAC, NESREA, and environmental protection bodies should regularly monitor fishes and

aquatic environments heavy metal concentrations.

2. Control of Environmental Pollution Sources such as discharge of industrial effluents, agricultural runoff (especially phosphate fertilizers and pesticides), and domestic waste into water bodies that serve as fish habitats.
3. Public Awareness Campaigns: Consumers, fish farmers, and traders should be educated on the health risks associated with heavy metal contamination in fish and the importance of sourcing fish from safe and regulated environments.
4. Future studies should expand to include other fish species, seasonal variations, and sediment-water interactions to better understand the pathways of metal contamination in the aquatic food chain.

References

Adamu, S. G., Saidu, A. S., Adamu, A. I., Sadiq, M. A., Jajere, S. M., Mohammed, S., Tijjani, A. O., Musa, H. I., Usman, U. B., & Thaddeus, A. L. (2023). Detection, distribution, and health risk assessment of heavy metals in wild catfish sold in Maiduguri Metropolis, Borno State, Northeastern Nigeria. Nigerian Veterinary Journal, 44(2), 48–58.

American Public Health Association (APHA). (2023). Standard Methods for the Examination of Water and Wastewater (24th ed.). Washington, DC.

Adebiyi, F. M., Ore, O. T., and Owolafe, O. S. (2024). Human health risk assessment of potentially toxic metals in fish commonly consumed in Nigeria. Discover Toxicology, 1, 7.

Ekperusi, A. O., and Asiwa, D. O. (2024). Trophodynamics and health risk assessment of heavy metals in seafood from a tropical estuary in the Gulf of Guinea. Environmental Research, 252, 118977.

Food and Agriculture Organization/World Health Organization (FAO/WHO). (2024). Risks and Benefits of Fish Consumption. Rome, Italy.

Jolaosho, T. L., Adeyemi, O. T., Ogunlaja, A. O., and Bello, M. A. (2024). Occurrence, distribution and health risk assessment of heavy metals in fish from Ojo River, Lagos, Nigeria. Environmental Monitoring and Assessment, 196, 109.

Marine Pollution Bulletin (2024). Evaluation of heavy metals and their potential risk to human health from seafood in Escravos Estuary, Southern Nigeria. Marine Pollution Bulletin, 208, 117014 (2024).

Ojiego, Blessing O., Ibrahim, A. N., Suleiman, M. M., and Adejumo, A. L. (2022). Health risk assessment for selected heavy metals in Telfairia occidentalis leaf retailed in markets within Lokoja metropolis. South Valley University International Journal of Agricultural Sciences, 4(2), 45–58.

Olurin, T. O. (2024). Assessment of naturally occurring radionuclides and heavy metals level and health risks in commonly consumed African catfish, white catfish and Nile tilapia fish species from Epe Waterside Region of Lagos, Nigeria. Journal of Applied Sciences and Environmental Management, 28(2), 449–457.

Udofia, Uduak U., Effiong, Grace S., and Akpan, Emmanuel R. (2020). Potential human health risk assessment of heavy metals intake through consumption of fluted pumpkin (Telfairia occidentalis) purchased from major markets in Calabar Metropolis, Nigeria. International Journal of Biological and Physical Sciences Research, 8(1), 21–34.

United States Environmental Protection Agency (USEPA). (2024). Risk Assessment Guidance for Superfund: Human Health Evaluation Manual. Washington, DC.

Tamunosa, T. J., Ajoko, I. T., Overe, R., & Ebong,

C. U. (2025). Health risk assessment of heavy metals in African catfish (Clarias gariepinus) from fish ponds in Port Harcourt, Rivers State, Nigeria. Journal of Applied Chemical Science International, 16(1), 1–10.

Yalwa, L. M., Durumin-Iya, S. G., Balarabe, A. I., and Adamu, S. B. (2024). Assessment of heavy metal contamination in fish and water samples from Babban Wuya Madachi River, Nigeria. FUDMA Journal of Sciences, 8(2), 355–366.