Sahel Journal of Life Sciences FUDMA (SAJOLS)
June 2024 Vol. 2(2):162-166
ISSN: 3027-0456 (Print)
ISSN: 1595-5915(Online)
DOI: https://doi.org/10.33003/sajols-2024-0202-22

Research Article

Health Risk Assessment Associated with Consumption of *Oreochromis niloticus* from Ajiwa Reservoir, Katsina State, Nigeria

***Yusuf Ibrahim, Timothy Auta and James Bemshima Orpin**

Department of Biological Sciences, Faculty of Life Sciences, Federal University Dutsin-Ma, Katsina State, Nigeria

***Corresponding Author's email*: yusufibyusuf@gmail.com; +2348035501059**

ABSTRACT

Ajiwa Reservoir, essential for local fish and vegetable markets, is under threat from agricultural waste and effluents containing heavy metals. This study evaluates the health risks of consuming *Oreochromis niloticus* from the reservoir by analyzing water and fish samples for cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni), and lead (Pb) using an Atomic Absorption Spectrophotometer (AAS). Samples were collected biweekly from September to December 2023. The mean concentrations of heavy metals in water were Co (0.45±0.23 mg/L), Cu (0.05±0.04 mg/L), Mn (0.06±0.09 mg/L), Ni (0.10±0.07 mg/L), and Pb (0.40±0.18 mg/L), with Co, Mn, Ni, and Pb exceeding WHO standards. Fish tissues showed Co (1.03±0.16 mg/L), Cu (0.13±0.05 mg/L), Mn (0.10±0.19 mg/L), Ni (0.18±0.22 mg/L), and Pb (0.21±0.66 mg/L), with Co, Ni, and Pb above the acceptable limits. Health risk assessments revealed Non-Cancer Risk (HQ>1) and Cancer Risk (>1), indicating significant health hazards from consuming fish from the reservoir. The Bioconcentration Factor (BAF) ranked Cu > Co > Ni > Mn > Pb. The contamination of water and fish with heavy metals in Ajiwa Reservoir poses severe health risks, exceeding WHO standards.

Keywords: *Oreochromis niloticus*; Non-Cancer Risk; Cancer Risk; Bioaccumulation Factor

Citation: Ibrahim, Y., Auta, T. and Orpin, J. B. (2024). Health Risk Assessment Associated with Consumption of *Oreochromis niloticus* from Ajiwa Reservoir, Katsina State, Nigeria. *Sahel Journal of Life Sciences FUDMA*, 2(2): 162-166. DOI: https://doi.org/10.33003/sajols-2024-0202-22

INTRODUCTION

Water is essential for life on Earth, supporting all activities of living organisms (Aziz *et al.*, 2022). Clean water is a fundamental need, yet in 2017, over two billion people lacked access to it (World Health Organization, 2019). By 2020, 74% of the global population had access to clean drinking water (Ritchie & Roser, 2021). For those without nearby water sources, securing safe drinking water can be time-consuming (Sorenson *et al.*, 2011), with some traveling long distances (Islam & Azad, 2018). The human body can survive about three days without water (Rylander *et al.*, 2013), which is essential for vital functions such as temperature regulation and cell viability (Weinthal *et al.*, 2015). Access to clean, affordable water significantly impacts life expectancy (Clark & Snawder, 2019). Water serves various purposes, including drinking, cleaning, irrigation, manufacturing, cooling, hydroelectric power, and environmental preservation (Shadabi & Ward, 2022).

Freshwater ecosystems, including lakes, ponds, rivers, reservoirs, and creeks, face threats from physical and chemical factors. Variables like pressure, temperature, dissolved oxygen, and pH significantly affect aquatic life (Ibrahim *et al.*, 2023). Heavy metals, naturally present in the Earth's crust, enter aquatic environments through weathering, metal-bearing rocks, volcanic eruptions, and human activities like industrial, mining, and agricultural operations (Ogbeide & Henry, 2024; Ikponmwen *et al.*, 2023; Babayemi *et al.*, 2017). Improper waste disposal also contributes to heavy metal contamination in rivers (Babayemi *et al.*, 2017; Zhou *et al.*, 2020; Gheorghe *et al.*, 2017).

Fish are crucial aquatic resources, with numerous species significant for 21st-century aquaculture, produced in over 100 countries (Prabu *et al.*, 2019).

Notably, the Nile tilapia (*Oreochromis niloticus*) is abundant in aquaculture, characterized by its deep body, cycloid scales, and olive/grey/black body bars (Gu *et al.*, 2017; Temesgen *et al.*, 2022). This study investigates heavy metal concentrations and bioaccumulation in the Ajiwa Reservoir's *Oreochromis niloticus*, assessing ecological and human health risks related to the local community's reliance on this water body for drinking and fishing.

MATERIALS AND METHOD

Study Area

Ajiwa Reservoir, located in Batagarawa Local Government Area of Katsina State, Nigeria, spans 12°54'69" - 12°57'58" N and 7°42'53" - 7°47'50" E. Situated in the Sudan savannah zone, it experiences distinct wet (May to October) and dry (November to April) seasons. Built in 1973 and commissioned in 1975, the reservoir, fed by the River Tagwai, was restored in 1998 to a height of 14.7 m and a crest length of 1491.8 m, covering a surface area of 607 hectares with a storage capacity of approximately 22,730,000 m³. It provides irrigation and water to local areas and supports local villages economically.

Sample Collection

Water samples were collected fortnightly from four designated stations (A, B, C, and D) along the reservoir's bank between 8-10 am from September to December 2023. Using 1000 ml plastic bottles, water samples were gathered at surface level and transported for heavy metals analysis. Concurrently, 8-12 *O. niloticus* fish, weighing around 350 grams, were obtained from local fishermen for analysis.

Digestion of Water Sample

100 ml of water sample was mixed with 5 ml of hydrochloric acid and heated at 1050°C for two hours, resulting in a 25 ml solution. This was diluted to 100 ml with distilled water, filtered, and prepared for heavy metals analysis.

Collection and Digestion of Fish Samples

Fish samples were cleaned, dissected, and dried at 1050°C for 24 hours. Dried samples were milled and stored until digestion. Digestion involved mixing 2g of samples with 5 ml HNO_3 and 2 ml HCL, heating at 850°C for 30 minutes, cooling, filtering into a 50 ml flask, and diluting with distilled water for heavy metals analysis.

Heavy Metals Analysis

Pre-cleaned equipment was used for collecting and analyzing samples. Water and fish samples were processed using an Atomic Absorption Spectrophotometer to measure concentrations of cobalt, copper, manganese, nickel, and lead.

Health Risk Assessment

The Average Daily Dose (ADD), Non-Cancer Hazard Index (HQ), and Cancer Risk (CR) of heavy metals were calculated using established methodologies. The Bioaccumulation Factor (BAF) was determined as the ratio of heavy metal concentrations in fish to those in water.

Data Analysis

Data was analyzed using SPSS version 20.0 and summarized with descriptive statistics. One-way ANOVA was applied to assess the concentration of heavy metals in water and fish, with statistical significance set at $P < 0.05$.

RESULTS AND DISCUSSION

The mean concentration of cobalt found in this study was 0.45±0.23 mg/L, which is below the WHO/NESREA standard. This indicates that the water samples contain low levels of cobalt, posing no risk to those using the water for domestic or agricultural purposes. These findings are consistent with previous studies, such as the detection of 0.35±0.02 mg/L in the Sharada industrial area and 0.19±0.01 mg/L in the Bompai Industrial Area, as reported by Hassan *et al.* (2022). All these values fall within the maximum permissible limit of 1.0 mg/L for cobalt in dam water as recommended by WHO/NESREA.

The mean concentration of copper in the water samples was 0.05±0.03 mg/L, also below the WHO/NESREA standard. Ahmad *et al.* (2020) reported a copper concentration of 0.03±0.01 mg/L in Ajiwa reservoir water, which is lower than the values found in this study. This discrepancy could be due to variations in sampling sites, increased anthropogenic activities, or differences in sampling periods. Conversely, Mohammed (2023) reported higher copper concentrations in Tsawa-Tsawa, Garhi, and Makera in Zobe Dam, possibly due to agricultural metal pollution in these regions.

The manganese concentration was 0.06±0.09 mg/L, within the WHO/NESREA standard limits. While manganese is essential for life, excessive levels can alter water color and taste, affecting acceptability and potentially harming aquatic organisms. Ahmad *et al.* (2020) reported higher manganese levels of 0.21±0.01 mg/L in Ajiwa Dam and 0.18±0.01 mg/L in Jibia Dam. Yaradua *et al.* (2018) found a concentration of 0.13±0.05 mg/L in Ajiwa Reservoir, suggesting that variations could be attributed to differences in sampling sites or periods. Other studies, such as Uzairu *et al.* (2014) and Sani *et al.* (2016), reported manganese levels ranging from 0.01 to 3.45 mg/L in various Kano State water samples.

Nickel was found at a mean concentration of 0.10±0.07 mg/L, exceeding the WHO/NESREA standard for freshwater. Nickel, while necessary for human health, can cause serious health issues when present above acceptable limits. Unlike Yaradua *et al.* (2018), who did not detect nickel in Ajiwa Reservoir, this study aligns with Ibrahim *et al.* (2018), who found a concentration of 0.11±0.56 mg/L in Jibia water. Higher nickel levels in industrial and irrigation waters have been reported, such as 0.21±0.02 mg/L in Sharada, 0.45±0.03 mg/L in Bompai, and 0.07±0.01 mg/L in Thomas irrigation dam, potentially due to industrial waste discharge. Ogunfowokan *et al.* (2013) observed 0.22 mg/L of nickel in the Asunle River, and Ndede and Manohar (2014) found 1.11 mg/L in Kenya, both exceeding the standard limit.

The mean lead concentration was 0.40±0.18 mg/L, significantly higher than the WHO/NESREA standard of 0.01 mg/L. Elevated lead levels in the Ajiwa reservoir may result from household effluent, agricultural fertilizers, natural metal dissolution, or industrial effluents. Musa *et al.* (2020) reported lower lead concentrations in Ajiwa (0.01±0.01 mg/L) and Jibia (0.02±0.01 mg/L) reservoirs. Higher lead concentrations have also been observed by Ibrahim *et al.* (2018) and Malami *et al.* (2014) in various Kano State water sources, suggesting contamination from nearby agricultural and industrial activities.

The study determined that the Non-Cancer Risk (HQ) values for all metals analyzed (Co, Cu, Mn, Ni, Pb) exceeded 1, indicating an unacceptable level of non-carcinogenic health risks from consuming *O. niloticus* from Ajiwa Reservoir. Additionally, all calculated Cancer Risk values were greater than 10^-3, signalling significant health concerns. Prolonged exposure to these metals can lead to respiratory, cardiovascular, gastrointestinal, liver, and neurological disorders, particularly affecting children. These findings contrast with previous studies by Bwala (2023), Ametepey *et al.* (2018), Edward & Muhib (2020), and Wang *et al.* (2021), which reported HQ values below 1.

The bioaccumulation factor (BAF) for heavy metals in fish (Co, Cu, Mn, Ni, Pb) exceeded 1, except for lead. The study demonstrated that heavy metals bioaccumulated in the following order: Cu > Co > Ni > Mn > Pb. This contradicts the findings by Ibrahim *et al.* (2021), Yaradua *et al.* (2018), Bwala (2023), and Edward & Muhib (2020), who reported minimal or no bioaccumulation in fish from Ajiwa Reservoir, Alau Dam, and Escravos River. This discrepancy may be due to differences in sampling periods and prolonged bioaccumulation in fish.

Table 1: Heavy Metals Concentrations in Water of Ajiwa Reservoir, Katsina State. (September – December, 2023)

Parameters	Mean±S.D	Range Values		WHO Limit
		Minimum	Maximum	
Co (mg/L)	0.45±0.23	0.10	0.79	0.3
Cu (mg/L)	0.05±0.03	0.013	0.15	2.0
Mn (mg/L)	0.06±0.09	0.06	0.45	0.5
Ni (mg/L)	0.10±0.07	0.03	0.26	0.02
Pb (mg/L)	0.40±0.18	0.10	0.87	0.01

Table 2: Heavy Metals Concentrations in *Oreochromis niloticus* from Ajiwa Reservoir, Katsina State. (September – December, 2023)

Parameters	Mean±S.D	Range Values		WHO Limit
		Minimum	Maximum	
Co (mg/L)	1.03±0.16	0.70	1.36	0.3
Cu (mg/L)	0.13±0.05	0.02	0.26	10.0
Mn (mg/L)	0.10±0.19	0.02	0.86	15
Ni (mg/L)	0.18±0.22	0.02	0.96	0.1
Pb (mg/L)	0.21±0.66	0.00	0.73	0.1

Table 3. Average Daily Dose (ADD), Non–Cancer Risk (HQ) and Cancer Risk (CR) and Bioaccumulation Factor of *Oreochromis niloticus* Samples from Ajiwa Reservoir

Heavy Metals	ADD	HQ	CR	BAF
Cobalt (Co)	3.16	1.05×10^{2}	3.57	2.28
Copper (Cu)	0.42	1.05×10^{1}	7.96	2.60
Manganese (Mn)	0.32	2.30×10^{0}	4.75	1.66
Nickel (Mn)	0.56	2.82×10^{1}	5.71	1.80

Lead (Pb)	0.65	131.86×10^{2}	5.53	0.52

CONCLUSION

The concentrations of heavy metals in the Ajiwa reservoir are below the WHO permissible limits for Mn and Cu. However, levels of Co, Ni, and Pb exceed the recommended limits. In fish samples, Cu and Mn are within acceptable limits, but Co, Ni, and Pb surpass WHO thresholds. Health risk assessments indicate a significant non-carcinogenic risk for all heavy metals, with high bioaccumulation factors except for lead. The study advocates for strict enforcement of WHO guidelines, continuous monitoring of pollution sources, and remediation efforts to reduce heavy metal levels. Consuming *O. niloticus* from the reservoir poses a substantial health risk, highlighting the need for ongoing surveillance to protect public health.

REFERENCES

Adeboye, I. A. (2017). Determination of Heavy Metals in Water, Fish and Sediment from Ujere Water Reservoir. *Journal of Environmental Analytical Toxicology, 7*(486).

Altayev, H., & Kakajanowa, G. (2023). Evolution of Fish and Importance to Human Life. *Journals of Fisheries, 4*(10-67), 718-720.

Ametepey, S. T., Cobbina, S. J., Akpabey, F. J., Duwiejuah, A. B., & Abuntori, Z. N. (2018). Health Risk Assessment and Heavy Metal Contamination Levels in Vegetables from Tamale Metropolis, Ghana. *International Journal of Food Contamination, 5*(1), 5-12.

Aziz, A., Akram, K., Ulhaq, A. M., Hawaldar, T. T., & Rabbani, R. M. (2022). Examining Role of Drinking Water Plants in Mitigating Drinking Water Induced Morbidity. *Sustainability, 14*(15), 9664.

Babayemi, J. O., Ogundiran M. B., & Osibanjo, O. (2017). Current Levels and Management of Solid Wastes in Nigeria. *Environmental Quality Management, 26*(3), 29-53.

Babayemi, J. O., Ogundiran M. B., & Osibanjo, O. (2016). Overview of Environmental Hazards and Health Effects of Pollution in Developing Countries: A Case Study of Nigeria. *Environmental Quality Management, 26*(1), 51-71.

Bwala, N. M. (2023). Assessment of Heavy Metals in Sediments, Water and Clarias Gariepinus from Alau Dam, Borno State. *Sahel Journal of Life Sciences FUDMA, 1*(1), 155-162.

Clark, R., & Snawder, K. (2019). A cross-national analysis of lifespan inequality, 1950–2015: examining the distribution of mortality within countries. *Social Indicators Research, 148*(3), 705–732.

Edward, M., & Muhib, A. (2020). Heavy Metals Concentrations in Water, Sediment, and Fish around Escravos River, Nigeria. *World Journal of Research and Review, 10*(2), 28-37.

Gheorghe, S., Stoica, C., Vasile, G. G., Nita-Lazar, M., Stanescu, E., & Lucaciu, I. E. (2017). Metals Toxic Effects in Aquatic Ecosystems: Modulators of Water Quality, 10067-65744.

Gu, D., Hu, Y., Wei, H., Zhu, Y., Mu, X., Luo, D., Xu, M., & Yang, Y. (2017). Nile Tilapia *Oreochromis niloticus* (L). *Biological Invasions and its Management in China, 2*, 77-89.

Ibrahim, Y., Auta, T., & Sadauki, M. A. (2023). Physicochemical Condition of Jibia Reservoir Inhabited by a Freshwater Snail *Belamya Crawshayi*. *Sahel Journal of Life Sciences FUDMA, 1*(1), 39–44. https://doi.org/10.33003/sajols-2023-0101-005

Ikponmwen, E. G., & Asuelimen, S. O. (2023). Assessment of water quality parameter and Heavy Metals concentration in *Synodontis courteti* and *Mormyrus macrophthalmus* from lower river Benue, Ibi, Taraba State, Nigeria. *International Journal of Fisheries and Aquatic Studies, 11*(1-2), 11-17.

Islam, M. M., & Azad, K. (2008). Rural-urban migration and child survival in urban Bangladesh: are the urban migrants and poor disadvantaged? *Journal of Biosocial Science, 40*(1), 83–96.

Ogbeide, O., & Henry, B. (2024). Addressing Heavy Metal Pollution in Nigeria: Evaluating Policies, Assessing Impacts, and Enhancing Remediation Strategies. *Journal of Applied Science and Environmental Management, 28*(4), 1007-1010.

Pandiyan, J., Mahboob, S., Jagadheesan, R., Elumalai, K., Krishnappa, K., Al-Misned, F., Kaimkhani, Z. A., & Govindarajan, M. (2020). A Novel Approach to Assess the Heavy Metal Content in the Feathers Offshore Birds: A perspective of environmental research. *Journal of King Saud University of Science, 32*(3065-3307).

Pink, M. R. (2016). Water Rights in Southeast Asia and India. *Palgrave Macmillan*.

Prabu, E., Rajagopalsamy, C. B. T., Ahilan, B., Jeevagan, I. J. M. A., & Renuhadevi, M. J. A. R. (2019). Tilapia, an Excellent Candidate Species for World Aquaculture: A Review. *Annual Research & Review in Biology, 31*(3), 1-14.

Ritchie, H., & Roser, M. (2021). Clean water and sanitation. *Our World in Data*. Retrieved from https://ourworldindata.org/clean-watersanitation

Rylander, C., Odland, J. O., & Sandanger, T. M. (2013). Climate change and the potential effects on maternal and pregnancy outcomes: an assessment of the most vulnerable – the mother, fetus, and newborn child. *Global Health Action, 6*(1). doi:10.3402/gha.v6i0.19538

Shadabi, L., & Ward, F. A. (2022). Predictors of access to safe drinking water: policy implications. *Water Policy, 24*(6), 1-3.

Sorenson, S. B., Morssink, C., & Campos, P. A. (2011). Safe access to safe water in income low-income countries: water fetching in current times. *Social Science & Medicine, 72*(9), 1522–1526.

Temesgen, M., Getahun, A., Lemma, B., & Janssens, G. (2022). Food and Feeding Biology of Nile Tilapia (*Oreochromis niloticus*). In Lake Langeno, Ethiopia. *Sustainability, 14*(2), 974.

Usman, L. U., & Adakole, J. A. (2017). Biodiversity Assessment of some Benthic Macro Invertebrates in Ajiwa Reservoir, Katsina State Nigeria. *UMYU Journal of Microbiology, 2*(2-7).

Wang, Z., Bao, J., Wang, T., Moryani, H. T., Kang, W., Zheng, J., Zhan, C., & Xiao, W. (2021). Hazardous Heavy Metals Accumulation and Health Risk Assessment of Different Vegetables Species in Contaminated Soils from a Typical Mining City, Central Chine. *International Journal of Environmental Research and Public Health*, 18(5), 261-267.

Weinthal, E., Zawahri, N., & Sowers, J. (2015). Securitizing water, climate, and migration in Israel, Jordan, and Syria. *International Environmental Agreements: Politics, Law and Economics, 15*(3), 293–307.

World Health Organization. (2019). Drinking Water. Retrieved from https://www.whO.int/news-room/fact-sheets/detail/drinkingwater

Yaradua, A. I., Alhassan, A. J., Kurfi, A. U., Nasir, A., Idi, A., Muhammad, I. U., & Kanadi, A. M. (2018). Heavy Metals Health Risk Index (HRI) in Human Consumption of Whole Fish and Water from Some Selected Dams in Katsina State Nigeria. *Asian Journal of Fisheries and Aquatic Research, 1*(1), 1-11.

Yi, Y., Tang, C., Yi, T., Yang, Z., & Zhang, S. (2017). Health Risk Assessment of Heavy Metals in Fish and Accumulation Patterns in Food Web in the Upper Yangtez River, China. *Ecotoxicological and Environmental Safety, 145*, 295-308.

Zhou, Y., Li, P., Xue, L., Dong, Z., & Li, D. (2020). Solutes Geochemistry and Groundwater Quality and Irrigation Purposes: A Case Study in Xinle City, North China. *Geochemistry, 80*(4), 12560.