ISSN Online: 2756-3898, ISSN Print: 2714-500X https://doi.org/10.47514/phyaccess.2023.3.2.003

Assessment of Heavy Metals in Fish Tissues of Tilapia and Catfish from River Hadejia, Northern Nigeria

Lawan M Yalwa[1], Sani G Durumin Iya[1] and Haruna Ahmad[1]

[1] Department of Physics, Faculty of Natural and Applied Sciences, Sule Lamido University, 048 Kafin Hausa, Jigawa State, Nigeria

Corresponding E-mail: sanig.duruminiya@slu.edu.ng

Received 02-072023
Accepted for publication 04-08-2023
Published 04-08-2023

Abstract

Kidney failure has become a growing problem at Hadejia Emirates over the last decade. This can be attributed to water pollution, possibly due to heavy metal contamination of River Hadejia that affects organisms living in it, such as fish. This study is aimed to determine the concentration of heavy metals (As, Cd, Cr, Pb) in two fish muscles. The research was conducted on tilapia and catfish where two samples of both fishes were used. The fish tissues were cut and oven-dried at 110 °C, and then a motor and pestle were used to powder the dried fish sample. A wet digestion method was used based on the analytical methods for Atomic Absorption Spectrometry (AAS). The result obtained shows that the concentrations of heavy metals (Cr, Cd, As and Pb) in both fishes were found to be 0.3220 ± 0.0028; 0.1656 ± 0.002 (mg/kg), 0.0319 ± 0.0018; 0.0333 ± 0.0018 (Mg/kg), 0.0697 ± 0.0011; 0.1035 ± 0.0015 (mg/kg) and 1.008 ± 0.0035; 0.600 ± 0.002 (mg/kg) respectively. The mean concentation value of the two samples of both tilapia and catfish were found to be above WHO standard limit except for cadmium in tilapia which is below WHO standard limit.

Keywords: Fish tissues; Tilapia; Catfish; Hadejia River; AAS.

I. INTRODUCTION

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least five times greater than that of water. Their multiple industrial, domestic, agricultural, medical, and technological applications have led to their wide distribution in the environment, raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance [1].

Fish is considered one of the most significant indicators of metal pollution in the aquatic environment [2]. Fish may absorb dissolved elements and heavy metals from surrounding water and food. When fish are exposed to heavy metals in an aquatic ecosystem, they tend to take these metals up which may accumulate in various tissues in significant amounts and are eliciting toxicological effects at critical targets [3]. Some edible species of fish have been widely investigated for the hazardous effects of heavy metals on human health [4]. Such as copper, iron, chromium and nickel are essential metals since they play an important role in biological systems, whereas cadmium and lead are non-essential metals, as they are toxic, even in trace amounts [5]. Some metals, including chromium, lead, cadmium, arsenic and mercury are known to be highly toxic to humans and aquatic life, causing liver and kidney problems in addition to genotoxic carcinogens [6].

Heavy metals enter the human body through several pathways such as the food chain, direct ingestion, dermal contact, fume inhalation, and particles through the mouth and nose. Therefore, in surface water environments ingestion and dermal absorption are the main routes of exposure [7]. Measurement of heavy metals in rivers is important because it is the route through which metals are flushed from large areas of land into oceans. It is also important because, inside the water, these heavy metals get into other organisms such as fish which are consumed by humans [8].

The toxic effects of these elements include health issues such as abdominal pain, high blood pressure, kidney damage and eventually failure, irritability, skeletal harm and degradation, cancer, nerve damage, headaches, and its consequences on the intellectual system. These specific effects, however, depend on the type of contaminant, its concentration and the cause and span of contact [9]. Although most of these elements are carcinogenic, they adopt diverse pathways and only affect certain organs and systems. Arsenic is believed by the World Health Organization (WHO) to be amongst the worst cancer-causing components present extensively in the environment and food and has many other adverse health effects including skin lesions, neurological problems, circulatory malfunction, diabetes, hepatic and renal syndromes, respiratory complications, several types of cancer including leukaemia, problems with male and female fertility, and mortality as a consequence of chronic diseases [10].

II. MATERIALS AND METHOD

A. *Description of the Study Area*

Hadejia is a Hausa town in eastern Jigawa State, northern Nigeria. Hadejia lies between latitude 12.4506 N and longitude 10.0404 E. It shares a boundary with Kirikasamma Local Government from the East, Mallam Madori Local Government from the North, and Auyo Local Government from the West. The town lies to the north of the Hadejia River and is upstream from the Hadejia-Nguru wetlands [11].

The Hadejia River is a river in northern Nigeria and is a tributary of the Yobe River (Komadugu Yobe). Among the cities and towns that lie on or near its banks are Hadejia and Nguru. Damming of the river for irrigation has led to a decrease in the amount of water in the Hadejia-Nguru wetlands, which the river forms along with Nguru Lake. The Hadejia River is now 80% controlled by the Tiga and Challawa Gorge dams in Kano State [12].

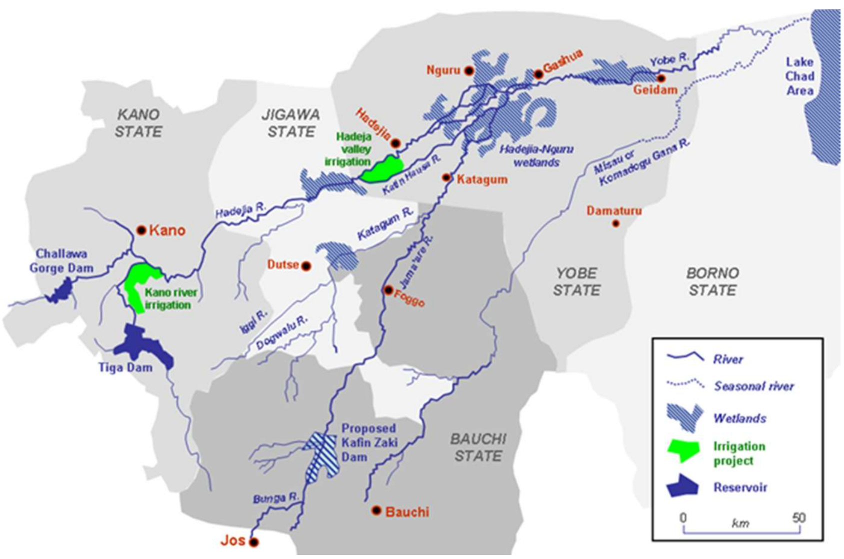

Fig. 1 Map of the Study Area [13]

B. *Fish Sample Collection*

The fish samples were collected (bought) at the river bank after a fisherman had caught them using a fishing net. The fish were caught alive and placed in a transparent container after fetching some water from the River. This is required to keep the fish alive before taking it to the laboratory for digestion.

C. *Fish Sample Digestion*

The muscle tissue of the fish (dorsal muscle) was used in this study because it is the major target tissue for metal storage and is the most edible part of the fish. The scales, fins and head were removed. The fish tissues were cut and oven-dried at $110\ °C$ to a constant weight, thereafter the motor and pestle were used to powder the dried sample of fish.

A wet digestion method was used based on the analytical methods for Atomic Absorption Spectrometry (AAS). 5 g dry weight sample was put into a 50 mL beaker with 5 mL of HNO_3 and 5 mL H_2SO_4. When the fish tissues stopped reacting with HNO_3 and H_2SO_4, the beaker was then placed on a hot plate and heated at 60 °C for 30 minutes. After allowing the beaker to cool, 10 mL of HNO_3 was then added and replaced to the hot plate and heated slowly to 100 °C until the sample turned black. After the sample turned black (for tilapia), then the beaker was removed from the hot plate and allowed to cool before adding some water until the sample was clear. The content of the beaker was then transferred into a 50 mL volumetric flask and diluted with ultra-pure water (deionized water). A fume hood was used for the safety of the sample digestion.

III. RESULT AND DISCUSSION

The average mean concentrations of heavy metals present in the Tilapia Fish Sample are presented in Table I, and also the result for the World Health Organization (WHO) Standard Limit in mg/kg. The concentration of heavy metals in the Tilapia fish samples is above the standard limit of the World Health Organization. Table I revealed the average mean concentration of arsenic (As) as 0.0697 ± 0.0011 (mg/kg) which is above the standard limit of the World Health Organization of 0.0015. Similarly, Cadmium (Cd), Chromium (Cr) and lead (Pb) were 0.0319 ± 0.0018, 0.3220 ± 0.0028 and 1.0080 ± 0.0035 (mg/kg) respectively. This vividly indicates that Tilapia fish obtained from the study area are contaminated with these heavy metals. It was reported by [14] that, exposure to a very high level of lead (Pb) over a short period resulted in tiredness, constipation, irritability, loss of appetite, headache and memory loss. Furthermore, research by [15] revealed that Arsenic (As) contamination in organic form (seafood) is less harmful than in inorganic form. Though long term exposure resulted in skin, lung and bladder cancer and kidney failure.

Table I. Mean Concentration of the Heavy Metals in Tilapia Fish Sample with WHO Standard Limit in mg/kg.

Heavy metals (mg/kg)	Sample A (mg)	Sample B (mg)	Mean value (mg/kg)	WHO standard limit (mg/kg)
Arsenic (As)	0.0714 ± 0.0014	0.0679 ± 0.0007	0.0697 ± 0.0011	0.0015
Cadmium (Cd)	0.0301 ± 0.0021	0.0336 ± 0.0014	0.0319 ± 0.0018	0.0100
Chromium (Cr)	0.3255 ± 0.0035	0.3185 ± 0.0021	0.3220 ± 0.0028	0.0030
Lead (Pb)	1.0045 ± 0.0035	1.0115 ± 0.0035	1.0080 ± 0.0035	0.0100

Fig. 2 presents the mean concentration of the Heavy Metals in Tilapia Fish Samples compared with the World Health Organization (WHO) Standard Limit in mg/kg.

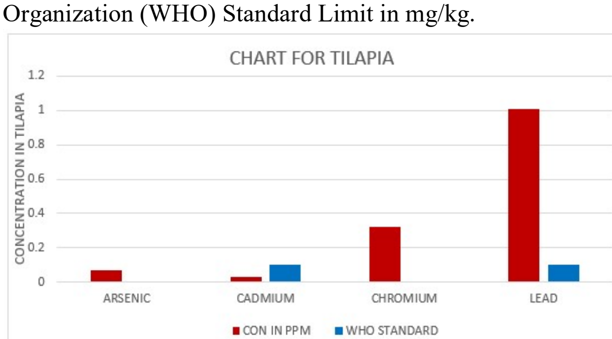

Fig. 2 Mean concentration of the Heavy Metals in Tilapia Fish Samples compared with the World Health Organization (WHO) Standard Limit in mg/kg.

Similarly, Table II shows the average mean concentrations of heavy metals present in the Catfish Sample, the result revealed that the concentration of heavy metals is 0.1035 ± 0.0015, 0.0333 ± 0.0015, 0.1656 ± 0.0023 and 0.600 ± 0.002 for Arsenic (As), Cadmium (Cd), Chromium (Cr) and Lead (Pb) respectively. The standard limit for the World Health Organization (WHO) was set as 0.0015, 0.0100, 0.0030 and 0.0100 for Arsenic (As), Cadmium (Cd), Chromium (Cr) and Lead (Pb) respectively. Cadmium (Cd) which is a by-product of zinc production is one of the most toxic elements: when exposed to it sufficiently retained in the human body and it is very toxic to the kidney, particularly the proximal tubular cells. Furthermore, Cd cause bone damage through bone demineralization and renal dysfunction [16].

Table II. Mean Concentration of Heavy Metals in Catfish Sample with WHO Standard limit.

Heavy Metals (mg/kg)	Sample A (mg/kg)	Sample B (mg/kg)	Mean value (mg/kg)	WHO Standard limit (mg/kg)
Arsenic (As)	0.1110 ± 0.0010	0.096 ± 0.002	0.1035 ± 0.0015	0.0015
Cadmium (Cd)	0.0265 ± 0.0015	0.040 ± 0.002	0.0333 ± 0.0018	0.0100
Chromium (Cr)	0.1515 ± 0.0025	0.180 ± 0.002	0.1656 ± 0.0023	0.0030
Lead (Pb)	0.6140 ± 0.0020	0.586 ± 0.002	0.6000 ± 0.0020	0.0100

IV. CONCLUSION

This research was aimed at assessing heavy metal levels in fish tissues along the Hadejia River. The results obtained revealed the concentration of the selected heavy metals, Arsenic (As), Cadmium (Cd), Chromium (Cr) and Lead (Pb) in tilapia and catfish in River Hadejia to be above the World Health Organization (WHO) standard limit except for the concentration of cadmium in tilapia. These can cause serious health risks to the people consuming these fish within the location. The concentration in these fish was found to be in the order, Pb>Cr>As>Cd. Therefore, there is a need for continual assessment of the level of heavy metal pollution in fish from the Hadejia River to reduce the level of pollution via sensitization and education.

Reference

[1] R. G. Ackman, C. McLeod, S. Rakshit and K. K. Misra, "Lipids and Fatty Acids of Five Fresh Water Food Fishes of India. J. Food Lipids, vol. 9, pp. 127-145, 2012.

[2] M. N. Rashed, "Monitoring of environmental heavy metals in fish from Nasser Lake". Env. Int., vol. 27, pp. 27-33, 2001.

[3] T. Seymore, H. H. Du-Preez, J. H. J. Van-Vuren, A. Deacon and G. Strydom, "Variations in selected water quality variables and metal concentrations in the sediment of the lower Olifants and Selati rivers, South Africa". Koedoe, vol. 37, no. 2, pp. 1-18, 1994.

[4] A. K. Isiyaku and S. B. Ghoshal. "Photoluminescence spectral features of silicon nanowires". J. Teknol., vol. 2, no. 78, pp. 153-158, 2016.

[5] S. Abdulkadir, S. Ishaq, K. I. Auta, B. Ibrahim, and A. K. Isiyaku, “Household Plastic Waste Generation and Composition in Selected Locations within Kaduna Metropolis”. Int. J. of Emerging Multidisciplinaries: Biomedical and Clinical Res., vol. 1, 2023.

[6] I. M. Adesiyan, M. Bisi-Johnson, O. T. Aladesanmi, A. I. Okoh and A. O. Ogunfowokan, “Concentrations and human health risk of heavy metals in rivers in Southwest Nigeria”. J. of Health and Pollution, vol. 8, no. 19, pp. 180907, 2018.

[7] X. Tang, N. Hashmi, M. Z., Zhang, H. Qian, M. Yu and Y. Chen, “A preliminary study on the occurrence and dissipation of estrogen in livestock wastewater”. Bull. of Env. Contamination & Toxicology, vol. 90, pp. 391-396, 2013.

[8] A. A. Olajire and F. E Imeokparia, “A study of the water quality of the Osun River: Metal monitoring and geochemistry”. Bull. of the Chem. Soc. of Eth., vol. 14, no. 1, 2000.

[9] O. O. Babalola, R. E. Okonji J. O. Atoyebi, F. Sennuga, M. M. Raimi, E. E. Ejim-Eze, O. A. Adeniran, O. T. Akinsiku, J. O. Areola, O. O. John and S. O. Odebunmi, “Distribution of lead in selected organs and tissues of albino rats exposed to acute lead toxicity”. Scientific Research and Essay, vol. 5, no. 9, pp. 845-848, 2010.

[10] J. O. Olusola and A. A. Festus, “Assessment of Heavy Metals in Some Marine Fish Species Relevant to their Concentration in Water and Sediment from Coastal Waters of Ondo State”. Nig. J. of Marine Sci., vol. 5, no. 2, 2015, DOI: 10.4172/2155-9910.1000163.

[11] J. Gambo, H. Z. B. M. Shafri, A. Abubakar, Y. A. Yusuf and M. B. Adam, “Comparative Analysis of Malaria Cases Using Geospatial-statistical Approach in Hadejia Metropolis, Jigawa State, Nigeria”. IOP Conf. Series: Earth & Env. Sci., vol. 540, no. 1, pp. 012035, July 2020.

[12] B. J. M. Goes, “Effects of river regulation on aquatic macrophyte growth and floods in the Hadejia-Nguru Wetlands and flow in the Yobe River, Northern Nigeria; implications for future water management”. River Res. & App., vol. 18, no. 1, pp. 81-95, 2022.

[13] A. Shuaibu, J. Hounkpè, Y. A. Bossa and R. M. Kalin, “Flood risk assessment and mapping in the Hadejia River Basin, Nigeria, using hydro-geomorphic approach and multi-criterion decision-making method”. Water, vol. 14, no. 22, pp. 3709, 2022.

[14] I. A. Isangedighi and G. S. l David, “Heavy Metals Contamination in Fish: Effects on Human Health”. J. of Aquatic Sci. & Marine Bio, vol. 2, no. 4, pp. 7-12, 2019.

[15] I. A. R. C. International Agency for Research on Cancer A review of human carcinogens: Metals, arsenic, dust and fibres. The Lancet Oncology, vol. 10, pp. 453-454. 2009.

[16] A. T. SDR, “Toxicological profile for cadmium. Georgia: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services; 2012.