Network for Research and Development in Africa
International Journal of Pure and Applied Science Research
ISSN: 2384-5918, Volume 12, Issue 1
PP 107-118 (February, 2025)
OTL: 45727711-11210-1
arcnjournals@gmail.com
https://arcnjournals.org

Health Risk Assessment of some Heavy Metals (Cd, Pb, Cr, As and Zn) in Some Species of Fish obtained from Karage town, Jakusko, Yobe State, Nigeria

Akinsola, R. O. PhD[1]; Karage, M.A[2]; Tijjani, A. M[3]; and Jovial, S. A[4].
[1]Department of Science Laboratory Technology, Federal Polytechnic Damaturu, Yobe State, Nigeria
[2,3&4]Department of Chemistry, Faculty of Science, Yobe State University Damaturu, Yobe State

Abstract: *This study was carried out to determine for five heavy metals (Viz; Cd, Pb, As, Cr^{2+}, and Zn) in fruit, vegetable, (gills, liver and muscles) of catfish (Chrysichthys nigrodigitatus) and Tilapia fish (Tilapia), water and sediment from two (2) different study locations (Gada and Tsamiya farmlands) Karage Village of Jakusko Local Government Area of Yobe State were analyzed with Buck Scientific 210 VGB Atomic Absorption Spectrophotometer (AAS) AVG. The results show that the levels concentrations (mg/kg) of Zn and Pb were significantly higher in all the organs of fish analyzed from Gada and Tsamiya River with the exception of Pb concentrations in the gills and liver which showed no significant difference at the Tsamiya River site. The characteristic similarity in metal accumulation in liver, gills and flesh in both locations were in the order of Zn > Pb > Cr. There was slight variation in the pattern of bioaccumulation of the other metals (Cr, Cd and Pb) in the organs. The order of accumulation of metals in the organs were as follows; Gada: liver/gills: Zn > Pb > Cr > Cd > As; liver: Zn> Pb > Cd> Cr. Tsamiya: gills/liver: Zn> Pb > Cr; and Liver: Zn > Pb> Cr. In general, these findings showed that the levels of Zn, Pb, Cr and Cd in the fish caught at Gada and Tsamiya river were above recommended levels with the exception of Arsenic (As) which were significantly lower than standards set by WHO/FAO/UNEP.*

Key words: *Bioaccumulation, Toxicity, Contamination, Pollution, Spectrophotometry, Metals, Sediment, Health.*

INTRODUCTION

Several reports indicated and increasing incidences of kidney disease in the communities surrounding in Karage town Jakusko LGA of Yobe state, Nigeria present a cause of concern. This could attribute to possible contamination of soil due to the large scale use of agrochemicals to improve agricultural production (Salamatu A. Amshi *et al*., 2019). This research is expected to reveal some promising possibilities for establishing target and intervention program recommended to identify cause and effect links and sustainable information in tackling the problem.

Heavy metals occur naturally in the earth and become concentrated due to human activities such as industrial production, mining, agriculture, and transportation (Abulude *et al*., 2007; Adeleken & Abegunde, 2011). These metals play both beneficial and harmful roles in human life (Abulude *et al.,* 2007; Adeleken & Abegunde, 2011; Agbaire & Oyibo, 2009), but at higher concentrations, they can cause poisoning. The toxicity of heavy metals arises from their lack of metabolic function and their ability to disrupt normal cellular processes, leading to adverse effects in various organs. Additionally, certain heavy metals, such as mercury and lead, tend to accumulate in biological tissues through bioaccumulation, posing significant health risks. Therefore, it is crucial to monitor and regulate the levels of toxic metals in foodstuffs to safeguard human health (Authority of Ireland – Food Safety, 2009).

Heavy metal can be incorporated into food chains and concentrated in aquatic organisms to a level that affects their physiological state of the effective pollutants are the heavy metals which have drastic environmental impact on all organisms. Trace metals such as Zn, Cu and Fe play a biochemical role in the life processes of all aquatic plants and animals; therefore, they are essential in the aquatic environment in trace amounts (Manson, 2002).

Heavy metals enter the human body mainly through two routes which are inhalation (Breathing) and ingestion. Ingestion is the main route of exposure to these elements in human population (Türkdogan*et et al*., 2003; Damek-Poprawa and Sawicka-Kapusta, 2003; Ejazul*et al*., 2007). Absorption through the skin is another route of exposure when the metals come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial, or residential settings. Industrial exposure accounts for a common route of exposure foradults (Ngan *et al*., 2006).

Ingestion is the most common route of exposure in children. Children may acquire toxic levels from the normal hand-to-mouth activity with contaminated soil or by actually eating objects that are not food (Dupler, 2001). Less common routes of exposure are during a radiological procedure, from inappropriate dosing or monitoring during intravenous nutrition and from broken thermometers (Smith *et al*., 1997).

Fish is a basic and important food for human nutrition (Abdel-Baki *et al.*, 2011), such as fatty acid in fish that can reduce the risk of heart diseases and stroke due to their contribution in lowering the cholesterol levels in blood and also provides minerals and vitamins (Azaman *et al.,* 2015). The high demand for fish has resulted in the increase in the number of fish ponds in Nigeria. ...

Its quality therefore depends on factors such as geological morphology, vegetation and land use (Mishsra *et al.,* 2013). Water is the natural habitat of fishes and other aquatic animals, it is therefore of great importance to study water quality while studying fish production especially when done in an artificial setting (Agbaire *et al*., 2015). The aim of this research work is to determine the levels of some heavy metals in fish samples obtainable in Karage Community, with the following specific objectives:

1. To determine the levels of Arsenic, Cadmium, Chromium, Lead and Zinc in fish from Karage Community.

2. To compare the levels of some heavy metals with that of threshold concentration given recommended by WHO and FAO
3. To make a comparative survey to ascertain the levels of toxicity and relate to kidney failure.

2.1 STUDY LOCATIONS

Two (2) different study locations (Gada and Tsamiya farmlands) were chosen in the Northern Geopolitical Region of the Federal Republic of Nigeria, Karage Community of Jakusko Local Government Area of Yobe State.

2.2 Study area

Karage is a community in Yobe State in North-Eastern Nigeria, on the Yobe River a few miles below the convergence of the Hadejia River and Jama'are River. Average elevation is about 299m, with geocoordinate 12`50`13.2" N and 10`54`38.6" E. The hottest months are March and April with temperature ranges between 38 - 40°C, with rainfall of 500 to 1000mm.

Karage is one among the largest village under Bade Emirate council in Yobe State. Since 1976 it has been the Headquarter of bade local government area. The Bade language is spoken in karage and in an area fanning out east and south of Gashua. Bade is one of seven languages of Chadic family indigenous to Yobe state. The town lies near the Nguru – Gashua wetlands, an economically and important ecological system.

Fig. I: Map of Karage community

3.0 Materials and Method

3.1 Sample collection

The species of fish used for this study were tilapia fish (*Tilapia zilli*) and cat fish (*Chrysichthysnigrodigatatus).* Each fish species was caught at karage river using drag net which are usually used by local fishermen. The netted fish was carried in a picnic box with some quantity of lagoon water to the laboratory. Each fish was properly cleaned by rinsing with distilled water. It then drained under folds of filter, weighed, wrapped in aluminum foil and then frozen prior to analysis. For analysis the fish samples were defrosted for two hours. The scales will be removed and each separated into Gills, Livers and the Muscles. The fish parts from the two lagoons was dried at 80 ^{0}C for 2 hours in Gallenkamp hot air oven and then grounded to fine powder using pestle and mortar.

The equipment used in this study were all calibrated to check their status before and in the middle of the experiments. Apparatus such as volumetric flasks, measuring cylinder and digestion flasks were thoroughly washed with detergents and tap water and then rinsed with deionized water. All Glass wares were cleaned with 10% concentrated Nitric acid (HNO3) in order to clear out any heavy metal on their surfaces and then rinsed with distilled-deionised water. The digestion tubes were soaked with 1% (w/v) potassium dichromate in 98% (v/v) H2SO4 and the volumetric flasks in 10% (v/v) HNO3 for 24 hours followed by rinsing with deionized water and then dried in oven and kept in dust free place until analysis began. Prior to each use, the apparatus was soaked and rinsed in deionized water.

3.1.1 Sample Pre-Treatment/Digestion

The samples were allowed to dry using hot oven (Model 30GC lab oven) and then ground into fine powder by using a porcelain mortar and pestle. As much as 100mg of each sample was weighed in to thoroughly clean plastic container (microwave tube) and 6ml of 65% HNO3 and 2 ml of hydrogen peroxide 3:1 was added and allowed and to stand for a while. The plastic container (microwave tube) was then covered and placed in to microwave digester (Master 40 serial No: 40G106M) and digested. The digestion was carried out at a temperature of (120 ^{0}0) for 30 min and then ramped at 20 per min to 180 and hold for 10 mins. The digestion was followed by a cooling to room temperature in the microwave. Potential presence of heavy metal in chemical which used in digestion was determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality. The digested samples were diluted with deionized water to a total volume of 25 ml.

2.1.2 Preparation of 1000 mg/Litre stock AAS standard solution for selected heavy metals (such as Pb, Cr and Cd and other metals),

The determination of a given metal concentration in the experimental solution was based on its respective calibration curve. In plotting the calibration curves for lead, cadmium, zinc and other metals, a stock solution of each metal ion of (1000 ppm) was prepared by dissolving; 1.5980 g of Pb $(NO_3)2$, 2.1032 g of Cd $(NO_3)2$ (and other metals so as to get exactly 1.0 g of the desired metal in 100 ml of solution) in deionized water and then diluting to 1 liter in a volumetric flask.

2.2 Determination of metal content by AAS

Calibration curves were prepared to determine the concentration of the metals in the sample solution. The instrument was calibrated using series of working standards. The working standard solutions of each metal were prepared from standard solutions of their respective metals and their absorbance's were taken using the AAS. Calibration curve for each metal ion to be analyzed was prepared by plotting the absorbance as a function of metal ion standard concentration.

Concentration of the metal ions present in the sample was determined by reading their absorbance using AAS (Buck scientific model 210GP) and comparing it on the respective standard calibration curve. Three replicate determinations were carried out on each sample. The metals were determined by absorption /concentration mode and the instrument readout was recorded for each solution manually. The same analytical procedure was employed for the determination of elements in digested blank solutions and for the spiked samples.

2.3 Data Analysis

Data was analyzed using Microsoft Office Excel. The data were expressed in term of descriptive statistics while the figures were presented with Mean values as (Mean±SD).

Table 2.1: E**lements with their wavelength**

S/No.	ELEMENTS	WAVELENGTH (nm)	Slit (nm)
1	Lead	283.2	0.7
2	Zinc	213.9	0.7
3	Chromium	357.9	0.7
4	Cadmium	228.8	0.7
5	Arsenic	193.7	0.7

4.0 Results and Discussion

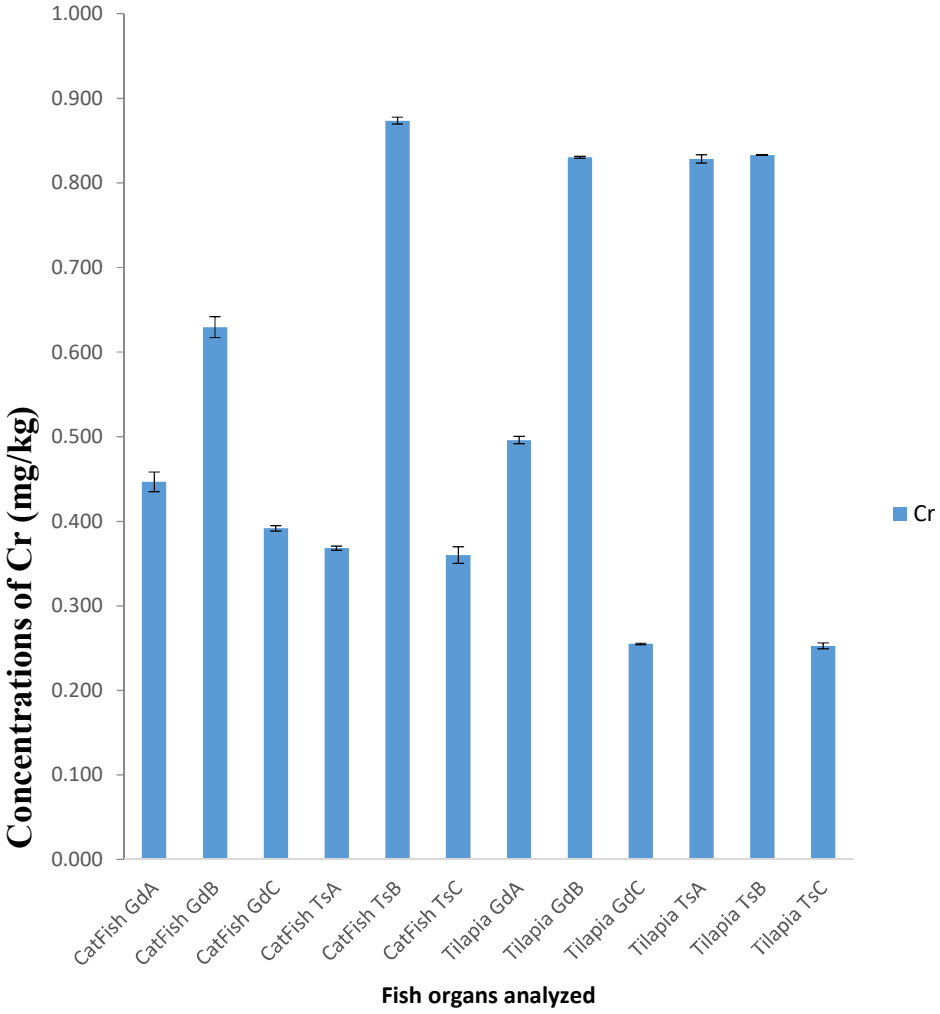

Figure: 1a Concentration of Chromium in Fish organs analyzed

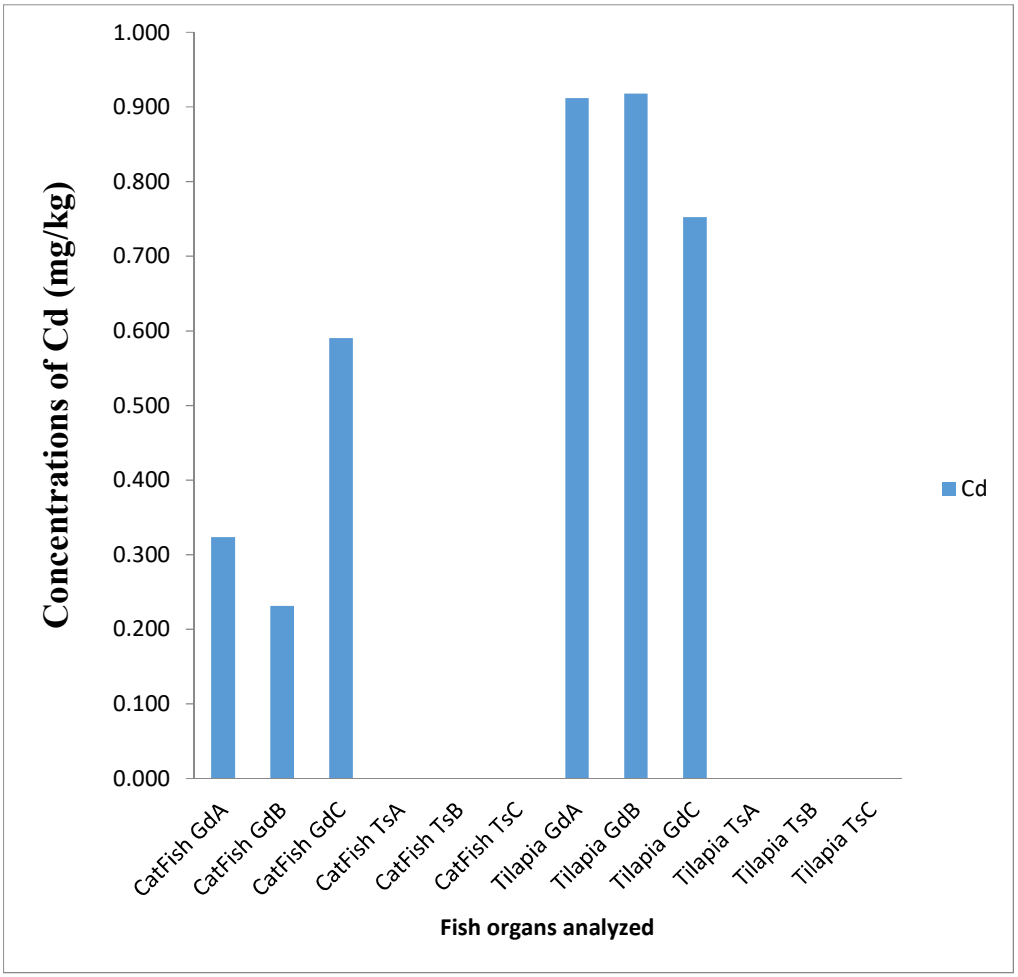

Figure 1b Concentration of Cadmium in Fish organs analyzed

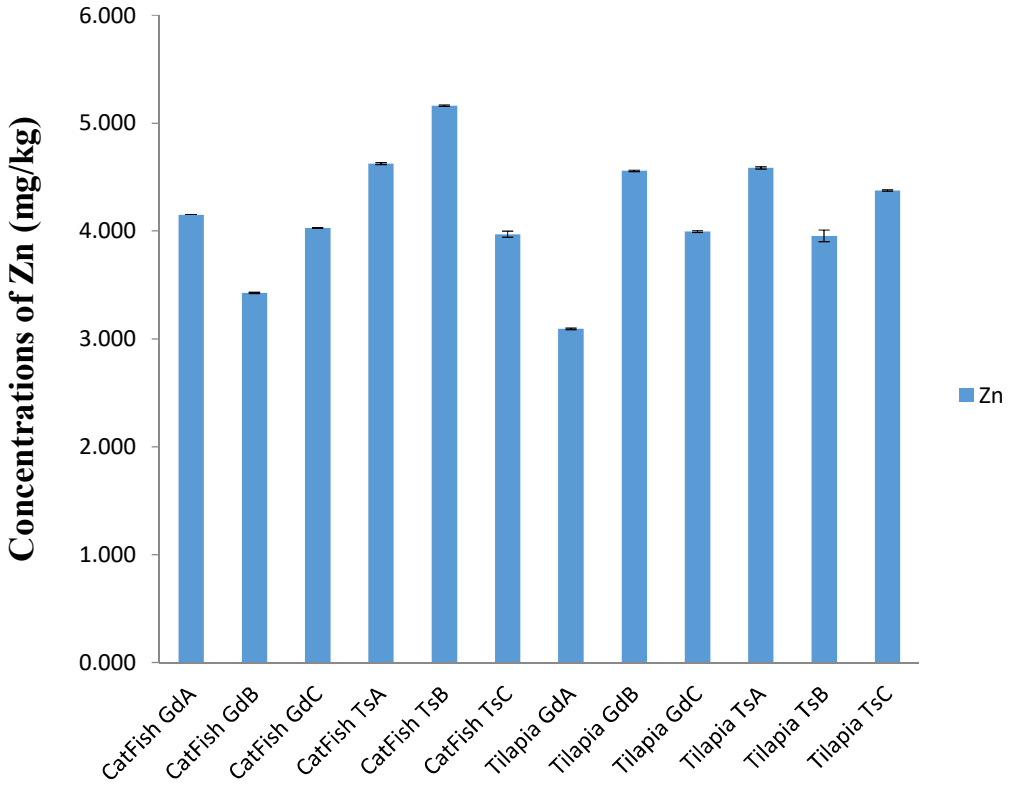

Figure 1c Concentration of Zinc in Fish organs analyzed

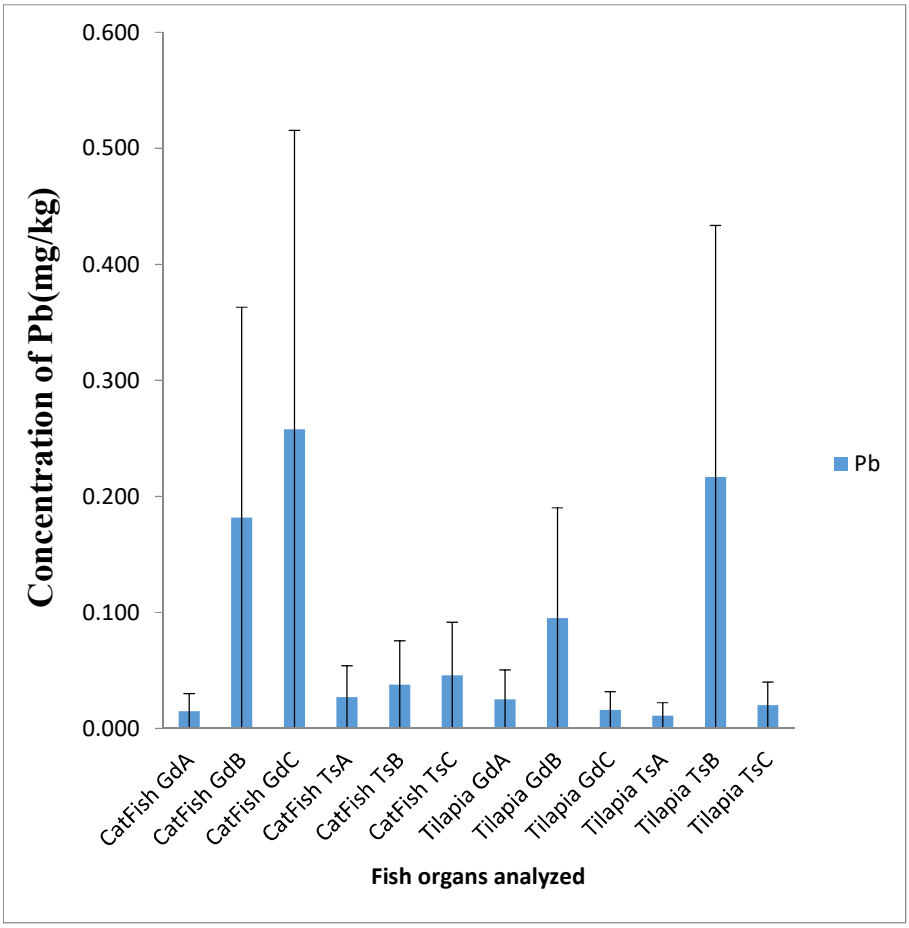

Figure 1d Concentration of Lead in Fish organs analyzed

The mean concentrations of heavy metals determined in the fish samples are presented in Tables 4.1 above. The mean concentrations of chromium ranged from 0.368-0.447 ppm, 0.630-0.874 ppm and 0.360-0.392 ppm in flesh, gill and liver respectively in catfish, while the concentrations ranged from 0.496-0.828 ppm, 0.830-0.833 ppm and 0.253-0.255 ppm in flesh, gill and liver in tilapia. Chromium (Cr) is an essential metal in humans, it reduces body fat and also improve lean body mass (Fazureen et al., 2015). Lack of Cr can affect the growth and disturbances in glucose, lipid and protein metabolism (Akoto *et al.,* 2018). However, elevated of level of chromium could have an undesirable fatal effect in excess amount. The highest concentration of chromium (0.833 ppm) was recorded in the gills of tilapia Ts B and the lowest (0.253 ppm) in liver of Tilapia Ts B. The gill has been reported as an important site for the entry of heavy metals which provokes lesions and gill damage (Lock and Overbeeke, 1981; Bols *et al.,* 2001; Akintujoye *et al*., 2013). However, the values of chromium obtained in this study were lower than the values reported in a similar by Yeasmin et al. 2019, in fish samples collected from a heavy industrial area, Chittagong, Bangladesh.

The mean concentrations of arsenic were found to be below detectable limit in all the studied samples. The mean concentrations of lead ranged from 1.316-2.810 ppm in flesh, 1.233-2.772 ppm in gill and 1.500-2.675 ppm in liver of catfish, and in talapia the concentration were 2.807-2.966, 2.612-3.409 and 2.717-2.910 ppm in flesh, gill and liver respectively. The

concentrations of lead have maximum value of (3.409 ppm) Tilapia Ts B in gill and the least lead concentrations of (1.500 ppm) was found in Cat Fish Ts C liver. The concentrations lead in this study was higher than the permissible limit of 1.5 ppm, recommended standard FAO/WHO (1984). Moreover, result of lead in this study were lower than values reported by Obasohan (2007) in which high levels of heavy metals were detected in mudfish from Ogba River, Benin city, Nigeria, Akintujoye et al. 2013 in fish tissue of 29.92-47.80 mg/g from Ubeji, Warri, Delta State, Nigeria and Gashua et al., 2018 also reported lead in similar study higher than the values obtained in this study.

The concentrations of cadmium ranged from 0.00-0.324 ppm, 0.00-0.231 ppm and 0.00-0.590 ppm in flesh, gill and liver respectively in catfish, while the concentrations ranged from 0.00-0.912 ppm, 0.00-0.918 ppm and 0.00-0.752 ppm in flesh, gill and liver in tilapia. Cadmium was below detectable in CatFish Ts A (Flesh), CatFish Ts B (gill), CatFish Ts C (liver), Tilapia Ts A (Flesh) samples, and with the highest concentration (0.918 ppm) in Tilapia Gd B (gill). High consumption of cadmium has been implicated in cases of prostate cancer and cancer in kidney, liver and stomach distortion (Waalkes, 2000; Sulaiman *et al.,* 2019a). The results of this finding were below permissible of 2.0 ppm in all the studied samples.

The concentrations of zinc in gill of CatFish Ts B were higher than levels in flesh and liver of the studies samples. The mean zinc values were ranged from 4.151-4.626 ppm in flesh, 3.426-5.162 ppm in gill and 3.970-4.029 ppm in liver in catfish, while talapia values were ranged from 3.09-4.586 ppm in flesh, 3.955-4.558 ppm in gill and 3.996-4.375 ppm in liver of catfish. The lowest zinc concentration was found to be (3.426 ppm) in CatFish Gd B in gill, while the highest was found to be (5.162 ppm) in CatFish Ts B. The variation in the level of heavy metal accumulation in the flesh gills and liver of the different fish species may support the view that there is a variation in ability of different fish organs to accumulate heavy metals. The general trend was found in the following order; Zn > Pb > Cr > Cd.

Conclusion

The findings of this study indicated that the levels of Zn, Pb, Cr, and Cd in fish samples obtained from Karage town, Jakusko, Yobe State, Nigeria, exceeded the permissible limits set by WHO/FAO, raising concerns about potential health risks associated with their consumption. The observed bioaccumulation patterns suggest that these heavy metals accumulated differently in fish organs, with higher concentrations found in the liver and gills. The presence of toxic metals such as Pb and Cd, which are known to have adverse health effects, highlights the need for regular monitoring of heavy metal contamination in aquatic environments to ensure food safety. Although arsenic levels were below detectable limits, the overall contamination profile suggests potential environmental pollution from anthropogenic sources, such as agricultural and industrial activities. These findings emphasize the importance of implementing regulatory measures to mitigate heavy metal pollution and safeguard public health.

References

Abulude, F., Obidiran, G., & Orungbemi, F. (2007). Determination of physicochemical parameters and trace metal content of drinking water samples in Akure, Nigeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry, 6*(4), 2297–2303.

Adeleken, B., & Abegunde, K. (2011). Heavy metal contamination of soil and groundwater at automobile mechanic village in Ibadan, Nigeria. *International Journal of the Physical Sciences, 6*(5), 1045–1058.

Agbaire, P., & Oyibo, P. (2009). Seasonal variation of some physicochemical properties of borehole water in Abraka, Nigeria. *African Journal of Pure and Applied Chemistry, 3*(6), 116–118.

Akintujoye, J. F., Anumudu, C. I., & Awobode, H. O. (2013). Assessment of heavy metal residues in water, fish tissue, and human blood from Ubeji, Warri, Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management, 17*(2), 291–297.

Akoto, O., Eshun, F. B., Darko, G., & Adei, E. (2014). Concentrations and health risk assessments of heavy metals in fish from the Fosu Lagoon. *International Journal of Environmental Research, 8*(2), 403–410.

Bols, N. C., Brubacher, J. L., Ganassin, R. C., & Lee, L. E. (2001). Ecotoxicology and innate immunity in fish. *Developmental & Comparative Immunology, 25*(8), 853–873.

Food and Agriculture Organization/World Health Organization (FAO/WHO). (1984). List of maximum levels recommended for contaminants by the Joint FAO/WHO Codex Alimentarius Commission. *Second Series CAC/FAL, Rome*, 3, 1–8.

Fazureen, A., Hafizan, J., Kamaruzzaman, Y., Azman, A., Mohd Khairul Amri, K., Mohd Ekhwan, T., Ahmad Dasuki, M., Mohammad Azizi, A., Che Noraini, C. H., & Ahmad Shakir, M. S. (2015). Heavy metal in fish: Analysis and human health—a review. *Jurnal Teknologi (Sciences & Engineering), 77*(1), 61–69.

Gashua, M. M., Kabir, J., Suleiman, M. M., Abdulrahman, H. I., Talba, A. M., Ahmed, N. O., & Jajere, S. M. (2018). Assessment of some heavy metals in the liver of freshwater catfish (*Clarias gariepinus*) in northeastern Nigeria. *Research Journal of Animal, Veterinary and Fishery Sciences, 6*(3), 1–6.

Manson, C. F. (2002). Water pollution biology. In R. M. Harrison (Ed.), *Causes, effects, and control* (pp. 82–112).

Salamatu, A. A., Aliyu, A., Hassan, Y., & Hananiya, M. (2019). Health risk assessment of some heavy metals (Cd, Pb, Cr) in soil samples from Gashua, Yobe, Nigeria.

Smith, S. R., Jaffe, D. M., & Skinner, M. A. (1997). Case report of metallic mercury injury. *Pediatric Emergency Care, 13*(2), 114–116.

Sulaiman, M. B., Asegbeloyin, J. N., Ihedioha, J. N., Oyeka, E. E., & Oji, E. O. (2019). Trace metals content of soil around a municipal solid waste dumpsite in Gombe, Nigeria: Assessing the ecological and human health impact. *Journal of Chemical Risk, 9*(3), 173–190.

Thompson, B. C., & Kelly, R. (2000). Buffering agents for acidic substances produced in the digestion of Chinese cabbage, winter green, and tomato. *Bulletin on Agriculture, 3*, 16–22.

Turkdogan, O. S., Perkins, D. L., & Tyler, H. E. (2003). Vegetable uptake of heavy metals and absorption in contaminated soil. *Asia Pollution Bulletin, 4*(2), 146–155.

Waalkes, M. P. (2000). Cadmium carcinogenesis in review. *Journal of Inorganic Biochemistry, 79*, 240–244.