

Assessment of Heavy Metals Concentrations in Five Fish Species Collected from Argungu River, Lungu and Laka Lakes in Argungu, Kebbi State.

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ABSTRACT

Heavy metal pollution of water bodies is a threat to public water supplies and also to consumers of fishery resources. This study aimed at assessing the concentration of heavy metals distribution in five (5) fish species of Matan Fada Area in Argungu river, Lungu and Laka Lakes. Five (5) fish species; *Alestes baremose*, *Hyperopisus bebe occidentalis*, *Hydrocynus brevis*, *Clarias gariepinus* and *Tilapia zilli* were sampled from February to April, 2023 at three different locations. Heavy metals (Cadmium, Iron, Copper, Lead and Chromium) were detected in the muscles of the five fish species using Atomic Absorption Spectrophotometry (AAS). The heavy metal levels detected were in the range: Cd: 1.00 ± 0.00 to 3.00 ± 0.00 mg/kg; Fe: 7.67 ± 0.11 to 41.98 ± 0.79 mg/kg; Cu: 1.00 ± 0.00 to 4.25 ± 0.00 mg/kg; Pb: 1.00 ± 0.00 to 13.83 ± 0.00 mg/kg; and Cr: 0.42 ± 0.00 to 1.75 ± 0.00 mg/kg. The heavy metal with the highest mean concentration in all fish species is Fe, followed by Cu, Pb, Cd and Cr. This gave a ranking of: Fe > Cu > Pb > Cd > Cr. All the values exceeded the recommended value set by WHO (2017). The findings indicated that the five fish species have high concentrations of Cd, Fe, Cu, Pb and Cr, which can be dangerous for people who consume these fish species from the Matan Fada Area of the Argungu river and the two neighboring lakes.

Keywords: Argungu, Heavy Metals, Lakes and Fish Species.

INTRODUCTION

Fish, as human food, are regarded as a good source of protein, polyunsaturated fatty acids especially omega-3 fatty acids, calcium, zinc (Zn), and iron (Izuchukwu *et al.*, 2017). Due to its lesser cost and greater nutritive value, fish is one of the most significant sources of the listed items among the food products of animal origin. In future, seafood will be an energetic source of food protein and the protection for human consumption of products from aquaculture is of public health concern. Heavy metals are the essential source of food pollution and health hazard. The main threats to human health are associated with contact to arsenic, cadmium, lead and mercury and copper (Jakia *et al.*, 2018). The possibility for heavy metal contamination to negatively affect human health has resulted in many studies of heavy metal contamination in fish and shellfish species, mainly in regions heavily impacted by anthropogenic inputs (Izuchukwu *et al.*, 2017; Taiwo *et al.*, 2019).

Levels of contaminants in fish are of concern not only for the potential effects on the fish themselves, but also of the effects on organisms that consume

them including humans (Taiwo *et al.*, 2019). Strategies on the maximum allowable levels of metals in seafood have been introduced in many parts of the world for the safe consumption of fish species (Izuchukwu *et al.*, 2017). Studies and monitoring programs investigating heavy metal levels in fish are becoming more attractive and significant, particularly in less industrialized parts of the world where fish serve as the major source of protein (Taiwo *et al.*, 2019). Even among the rich, fish is being consumed as an essentially healthy food (Ejike and Liman, 2017; Elbeshti *et al.*, 2018; Elinge *et al.*, 2019). Fish is considered as a healthy and nutritious constituent of a balanced diet and a vital source of proteins and lipids, including long chain polyunsaturated fatty acids, and lipo-soluble vitamins. Studies showed that people who include fish in their diets have lower risk of coronary heart disease, hypertension, and cancer (Ejike and Liman, 2017; Nwude *et al.*, 2020; Mustapha *et al.*, 2021).

Though, in contrast fish can be a source of contamination and in some conditions can contain amounts of heavy metals which are highly toxic

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(Ejike and Liman, 2017). It has been demonstrated that consuming food contaminated with heavy metals can lead to major health risks, including renal disease, neurological damage, reduced cognitive function, heart disease, gastrointestinal disorders, bone fractures, cancer, and even death (Elbeshti *et al.*, 2018). Heavy metals are poisonous to human health and are pollutants in the aquatic environment. Biological differences (e.g., species, size, age, gender, sexual maturity, nutrition) and environmental variables (e.g., water chemistry, salinity, temperature, and levels of contamination) are the main factors that influence the concentration of heavy metals in fish (Bawa *et al.*, 2017; Taiwo *et al.*, 2017; Kelle *et al.*, 2018). According to Takla *et al.* (2022), heavy metal accumulation in fish is strongly predisposed by environmental concentrations such as the levels in the water and sediments. However, metal accumulation has been found to vary markedly between species in the same area, as a result of differences in feeding habits (Elbeshti *et al.*, 2018; Taiwo *et al.*, 2019; Elinge *et al.*, 2019) and position in the food chain (Taiwo *et al.*, 2019). Sediment contaminated with heavy metals may have long-term effects on ecosystem health and human health by influencing aquatic organisms' ability to bioaccumulate metals and water quality. Most of the time, mining and industrial growth along large rivers and estuaries are the primary terrestrial sources of the majority of the anthropogenic metal load in marine and seabed sediments. (Takla *et al.*, 2022). The contamination of the aquatic environment with heavy metals has become a worldwide problem because they have everlasting, potential toxic effects on organisms (Malik *et al.*, 2012). These heavy metals in the aquatic environments are generally examined by determining their concentrations in water, sediments and fish (Osesua *et al.*, 2019). Heavy metals are usually effective poisons and their bioaccumulation in organisms lead to intoxication, reduced fertility, tissue damage and dysfunction of a variety of organs (Mukesh *et al.*, 2008; Shahbaa *et al.*, 2020). Fish showed significant role in shortening the toxicity of heavy metals which have a great ecological significance due to their accumulative behavior and toxicity. The most anthropogenic sources of metals are intensive farming, blocks industry and sewage disposal (Jakia *et al.*, 2018). Since fish is an important constituent of human diet in Nigeria, therefore evidence on levels of metal concentrations in the fish species of Argungu River and two neighboring lakes could assist to monitor the environmental impact and health of general public

that are dependent on the water body. This study was carried out to assess the levels of five heavy metals (Cadmium, Iron, Copper, Lead, and Chromium) in the muscles of five different fish species collected from Argungu River, Lungu and Laka lakes.

MATERIALS AND METHODS

Study Area

This study was conducted in Argungu local government area, Kebbi State located in the extreme north-western region of Nigeria, between latitude 12.45° N and longitude 4.31° E. The area is locally bordered by Arewa, Augie, Birnin Kebbi, and Yabo Local Government Areas to the west, north, south, and east respectively. The average annual rainfall of Argungu is approximately 800 mm, and the average annual temperature is 26 °C during the rainy season. The weather is tropical with an extended dry season and wet season that alternate. The predominant vegetation is grass, shrubs, and sparse trees (Savannah Vegetation).

Argungu is located on latitude 12.45°N longitude 4.31°E. As shown in Figure 1, the river source is near Funtua in the south of Katsina State, some 275 km in straight line from Sokoto, it flows North-West through Gusau in Zamfara State. Further downstream the river enters Sokoto State where it passes by Sokoto town and is joined by River Rima, then turning south and flowing through Argungu to Birnin Kebbi, Kebbi State, Nigeria. About 120 km south of Birnin Kebbi, it reaches its confluence with the river Niger (Obaroh *et al.*, 2015). Argungu River is the main source of drinking water and is used for recreational activities, fishing, irrigation, and tourism for international fishing festivals. Wastes are disposed into this river, and there is intense farming around it, which is reported to degrade water quality (Bawa *et al.*, 2018).

This research was conducted in the Matan Fada Area of The Sokoto-Rima River System in Argungu and two Surrounding Lakes, in Kebbi State, Nigeria. Argungu is situated in the extreme north-western part of Nigeria with an area of about 428 km² and a height of 241 m above sea level. The sampling points were located at Matan Fada site of the Argungu River, and two (2) neighboring lakes (Lungu Lake and Laka Lake). The positions of these points were accurately located using a Germin 010-02256-00 ETREX 22x and were presented in Table 1.

Table 1: The Coordinates of the Sampling Locations

Sample Locations	Coordinates
Matan Fada Site	12° 45'17.32"N 4° 31'35.93"E
Lungu Lake Site	12° 45'6.05"N 4° 31'14.06"E
Laka Lake Site	12° 45'1.87"N 4° 31'9.51"E

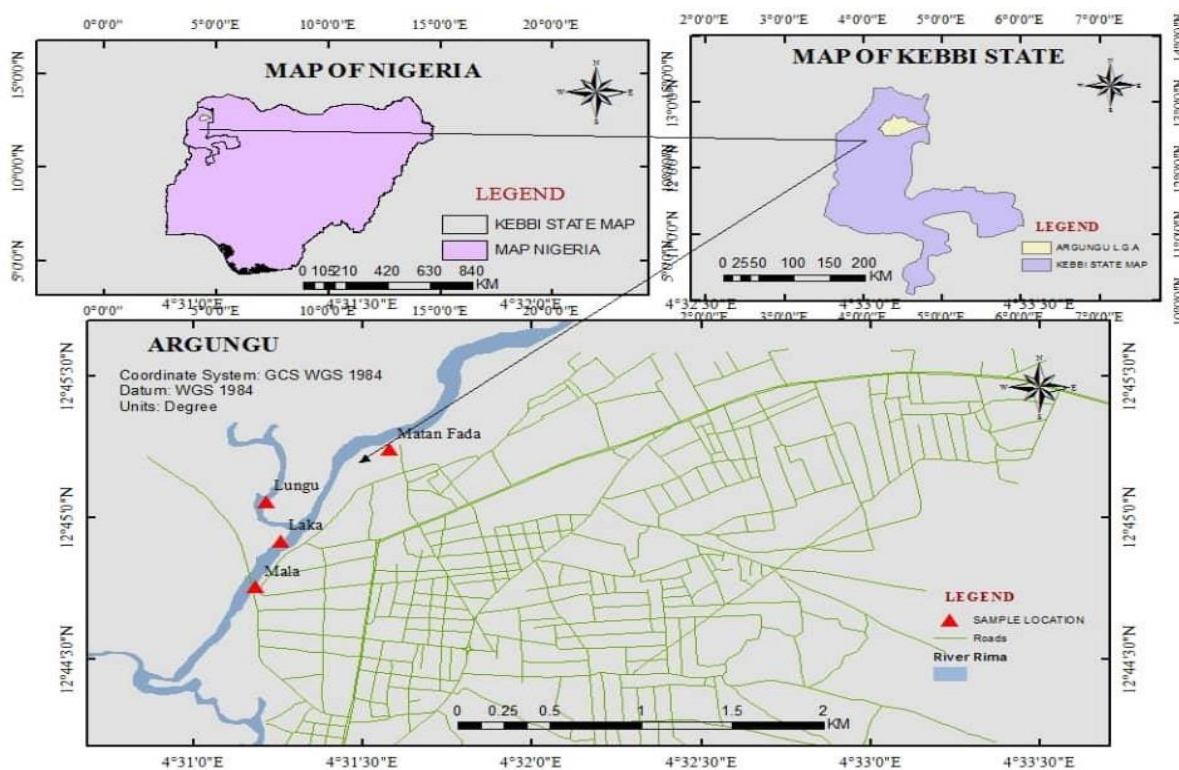


Figure 1: Map of the study area showing River Argungu

Collection of Fish Samples

The sampling was conducted according to the method reported by Osesua *et al.* (2019). A total of 36 fish samples with uniform size was collected from Argungu at landing site after the fishermen had caught them using fishing net. The fish samples considered are; *Alestes baremose*, *Hyperopisus bebe*, *Hydrocynus brevis*, *Clarias gariepinus* (Catfish) and *Oreochromis niloticus* (Tilapia fish). The five samples of each fish were bought once in a month for three months (5 x 3 = 15 fishes) at the landing site after the fisher men had caught them using fishing net. After collection, the fish samples were washed with the distilled water and dissected at the site to separate the muscles of each fish species. Each separate muscles part was put into a separate pre-cleaned polyethene bag and transported to the Usmanu Danfodiyo University Sokoto Old Chemistry laboratory for drying in readiness for digestion process.

Preparation of Aqua Regia Solution

Aqua Regia solution, HCl-HNO₃ (3:1) was prepared by adding 25 cm³ of Concentrated HCl to 75cm³ of Concentrated HNO₃.

Preparation/digestion of Fish Sample

The fish samples were prepared using the method used by Ejike and Liman (2017), the muscles part of fish sample needed for the analysis was separated and oven-dried at 80 °C for 48 hrs. These samples were ground to powder using clean mortar and pestle. One (1) gram of each homogenized fish part (muscles) was weighed into different beakers and into each beaker was added 20 cm³ of the mixture of aqua regia solution and digested to a clear colorless solution using hot plate at 80 °C. The digests were allowed to cool, filtered through Whatman No. 1 filter paper. The filtrate was transferred into 100 cm³ volumetric flask and made up to mark with distilled water. The prepared sample solution was transferred into the pre-cleaned labeled sample bottles in readiness for Atomic Adsorption Spectrophotometer (AAS) analysis. All the digested samples were taken to Sokoto Energy Research

Centre, Usmanu Danfodiyo University, Sokoto for AAS analysis.

Statistical Analysis

The data obtained was subjected to descriptive and inferential statistics. Descriptive statistics, mainly mean and standard deviation, was used to describe the concentrations of heavy metals in the five different fish samples. Analysis of Variance (ANOVA) was used to test for significant differences in heavy metal content of the five different fish species. One-way analysis of variance (ANOVA) using a Minitab Software was also used in all cases for mean metal level comparisons at 95% level of significance.

RESULTS AND DISCUSSION

The concentrations of Cd, Fe, Cu, Pb and Cr in the muscles of the five fish species analysed from three locations collected from Argungu landing site are shown in Table 2. The concentration of Iron (Fe) was the highest. The lowest metal concentration was for Cadmium (Cd) with the exception of *Clarias gariepinus* for river site (3.00 ± 0.00 mg/kg) and Lungu Lake (2.50 ± 0.00 mg/kg) in the muscles of the five fish species sampled. There were slight differences among the heavy metal concentrations of the fish sampled. None of the fish species sampled had a consistently high or low level for all the five metals analysed. *Clarias gariepinus* had the highest levels of Cadmium and Iron with mean values of (3.00 ± 0.00 mg/kg) and (41.98 mg/kg) at river site respectively; *Alestes baremose* and *Clarias gariepinus* had the highest levels of copper of (4.25 ± 0.00 mg/kg) at Laka Lake and *Clarias gariepinus* at Lungu Lake respectively, similarly *Clarias gariepinus* had the highest levels of Lead and Chromium with mean values of (4.25 ± 0.00 mg/kg) and (1.50 ± 0.00 mg/kg) at Laka Lake and river site. Generally, *Clarias gariepinus* fish species accumulated more heavy metals than the other fish species from the study area. The overall average concentrations of Cd, Fe, Cu, Pb, and Cr in the muscles of the five fish species was 41.98 ; 4.25 ± 0.00 ; 4.25 ± 0.00 ; 3.00 ± 0.00 and 1.50 ± 0.00 mg/kg respectively. This gave a ranking of: Fe > Cu > Pb > Cd > Cr.

The metal levels in the muscles of each organism gave a similar ranking. *Clarias gariepinus* had a significantly higher ($P < 0.05$) mean concentration of Cd (3.00 ± 0.00 mg/kg) than in all other species, followed by *Tilapia zilli* with an average concentration of 2.00 ± 0.00 . The average concentration of Cd in the fish muscles was in the order *Clarias gariepinus* > *Tilapia zilli* > *Hydrocynus brevis* > *Hyperopisus bebe* > *Alestes baremose* with mean values of 3.00 ± 0.00 , 2.00 ± 0.00 , 1.50 ± 0.00 , 1.00 ± 0.00 , 0.50 ± 0.00 mg/kg respectively (Figure 1). The analysis of variance (ANOVA) result showed that there was no

significant difference ($p > 0.05$) in Cd level observed between the fish species during the study period ($P = 0.234$).

Iron was detected in all five fish species and are higher than the WHO maximum limit of 0.300 mg/kg. The concentration of Fe was significantly ($P < 0.05$) higher in *Clarias gariepinus* with an average value of 41.98 ± 0.79 mg/kg than the other fish species. The average concentration of Fe was in the following order *Clarias gariepinus* > *Alestes baremose* > *Tilapia zilli* > *Hydrocynus brevis* > *Hyperopisus bebe* with values of 41.98 ± 0.79 , 38.98 ± 0.22 , 37.39 ± 0.36 , 24.21 ± 0.21 , 20.62 ± 0.14 mg/kg respectively (Fig. 2).

The analysis of variance (ANOVA) result showed that there was no significant difference ($p > 0.05$) in Fe level observed between the fish species during the study period ($P = 0.134$).

Cu concentration was significantly ($P < 0.05$) higher in *Clarias gariepinus* than the other fish species with an average value of 4.25 ± 0.00 mg/kg followed by *Tilapia zilli* with an average value of 4.00 ± 0.00 mg/kg. The average concentration of Cu in the muscles of the remaining fish species was *Alestes baremose* > *Hyperopisus beb* > *Hydrocynus brevis* with values of 4.25 ± 0.00 , 3.17 ± 0.00 , 3.00 ± 0.00 mg/kg respectively (Fig. 3). The analysis of variance (ANOVA) result showed that there was significant difference ($p < 0.05$) in Cu level observed between the fish species during the study period ($P = 0.000$).

Lead was detected in all five fish species and higher than the WHO (2019) maximum limit of 0.010 mg/g but *Hyperopisus bebe* has mean value of 13.83 ± 0.00 mg/kg which is also higher than the allowable limits stipulated by WHO (2017) as stated earlier. The concentration of Pb was significantly ($P < 0.05$) higher in *Hyperopisus bebe* with an average value of 13.83 ± 0.00 than the other fish species. The average concentration of Pb was in the following order *Clarias gariepinus* > *Hydrocynus brevis* > *Tilapia zilli* > *Alestes baremose* with values of 4.25 ± 0.00 , 4.08 ± 0.00 , 3.58 ± 0.00 , 3.25 ± 0.00 mg/kg respectively (Fig. 4). The analysis of variance (ANOVA) result showed that there was no significant difference ($p > 0.05$) in Pb level observed between the fish species during the study period ($P = 0.339$).

Average concentration of Cr was in the following order: *Clarias gariepinus* > *Alestes baremose* > *Tilapia zilli* > *Hydrocynus brevis* and *Hyperopisus bebe* with the following values: 1.50 ± 0.00 , 1.25 ± 0.00 , 1.00 ± 0.00 , 1.00 ± 0.00 mg/kg respectively. There were significant ($P < 0.05$) differences in Cr concentrations among fish species (Fig. 5). The analysis of variance (ANOVA) result showed that there was significant difference ($p < 0.05$) in Cr level observed between the fish species during the study period ($P = 0.003$).

Table 2: Triplicate Measurement of Heavy Metals in the Fish Samples (mg/kg) from three different locations

Fish species	Location	Cd			Fe			Cu			Pb			Cr		
		February	March	April	February	March	April	February	March	April	February	March	April	February	March	April
<i>Alestes baremose</i>	River site	0.50±0.00	0.50±0.00	0.25±0.00	21.51±0.07	19.36±0.06	10.75±0.03	3.50±0.00	3.00±0.00	1.75±0.00	2.00±0.00	1.75±0.00	1.00±0.00	1.00±0.00	1.00±0.00	0.50±0.00
	Laka L	0.25±0.00	0.25±0.00	0.25±0.00	30.26±0.17	24.21±0.13	15.13±0.08	4.25±0.00	3.25±0.00	2.00±0.00	3.25±0.00	2.50±0.00	1.50±0.00	1.25±0.00	1.00±0.00	0.58±0.14
<i>Hyperopisus bebe</i>	Lungu L River site	0.25±0.00	0.25±0.00	0.25±0.00	38.98±0.22	31.18±0.17	23.39±0.13	3.25±0.00	2.50±0.00	2.00±0.00	3.08±0.14	2.50±0.00	1.83±0.14	1.00±0.00	0.75±0.00	0.58±0.14
	Laka L	0.67±0.38	0.75±0.00	0.75±0.00	11.76±0.08	10.59±0.08	16.53±0.04	2.25±0.00	2.00±0.00	1.25±0.00	1.75±0.00	1.67±0.00	1.00±0.00	0.75±0.00	0.75±0.00	0.50±0.00
<i>Hydrocynus brevis</i>	Lungu L River site	0.75±0.00	0.75±0.00	1.00±0.00	20.62±0.14	10.59±0.08	10.31±0.07	3.17±0.00	2.25±0.00	1.50±0.00	13.83±0.00	9.75±0.00	7.00±0.00	1.00±0.00	0.75±0.00	0.50±0.00
	Laka L	1.50±0.00	1.50±0.00	1.50±0.00	23.83±0.24	21.48±0.21	11.92±0.12	3.00±0.00	2.75±0.00	1.50±0.00	4.08±0.14	3.75±0.00	2.00±0.00	0.25±0.00	1.00±0.00	0.50±0.00
<i>Clarias gariepinus</i>	Lungu L River site	0.25±0.00	0.25±0.00	0.25±0.00	24.21±0.04	16.94±0.18	14.52±0.03	2.75±0.00	2.00±0.00	1.75±0.00	2.50±0.00	1.75±0.00	1.50±0.00	0.75±0.00	0.50±0.00	0.50±0.00
	Laka L	1.50±0.00	2.00±0.00	0.25±0.00	23.91±0.07	16.74±0.05	11.95±0.04	1.75±0.00	1.25±0.00	1.00±0.00	2.00±0.00	1.42±0.14	1.00±0.00	0.75±0.00	0.50±0.00	0.42±0.14
<i>Tilapia zilli</i>	Lungu L River site	3.00±0.00	3.00±0.00	3.00±0.00	41.98±0.79	33.58±0.64	20.99±0.40	3.50±0.00	2.75±0.00	1.75±0.00	3.25±0.00	2.75±0.00	1.75±0.00	1.50±0.00	1.17±0.14	0.75±0.00
	Laka L	0.50±0.00	0.50±0.00	0.50±0.00	20.23±0.05	16.18±0.04	12.14±0.03	3.50±0.00	2.75±0.00	2.00±0.00	4.25±0.00	3.25±0.00	2.17±0.58	0.75±0.00	0.67±0.00	0.50±0.00
<i>Tilapia zilli</i>	Lungu L River site	2.50±0.00	2.50±0.00	2.50±0.00	17.29±0.25	13.83±0.20	8.64±0.12	4.25±0.00	3.25±0.00	2.00±0.00	2.83±0.14	2.25±0.00	1.50±0.00	0.75±0.00	0.75±0.00	0.50±0.00
	Laka L	2.00±0.00	2.00±0.00	2.00±0.00	15.33±0.23	12.27±0.18	7.67±0.11	2.25±0.00	1.75±0.00	1.00±0.00	1.75±0.00	1.50±0.00	1.00±0.00	1.00±0.00	1.00±0.00	0.58±0.14
	Lungu L	1.00±0.00	1.00±0.00	1.00±0.00	15.33±0.23	23.92±0.43	15.95±0.29	2.50±0.00	2.17±0.14	1.50±0.00	3.25±0.00	3.00±0.00	2.00±0.00	0.75±0.00	0.75±0.00	0.50±0.00
	Lungu L	0.75±0.00	0.75±0.00	0.75±0.00	37.39±0.36	33.65±0.32	18.70±0.18	4.00±0.00	3.75±0.00	2.00±0.00	3.58±0.14	2.58±0.58	1.75±0.00	1.25±0.00	1.00±0.00	0.50±0.00
SATANDARD WHO (mg/kg)		0.010			0.300			2.250			0.010			0.5		

Note: Results = Mean ± SD of Triplicate.

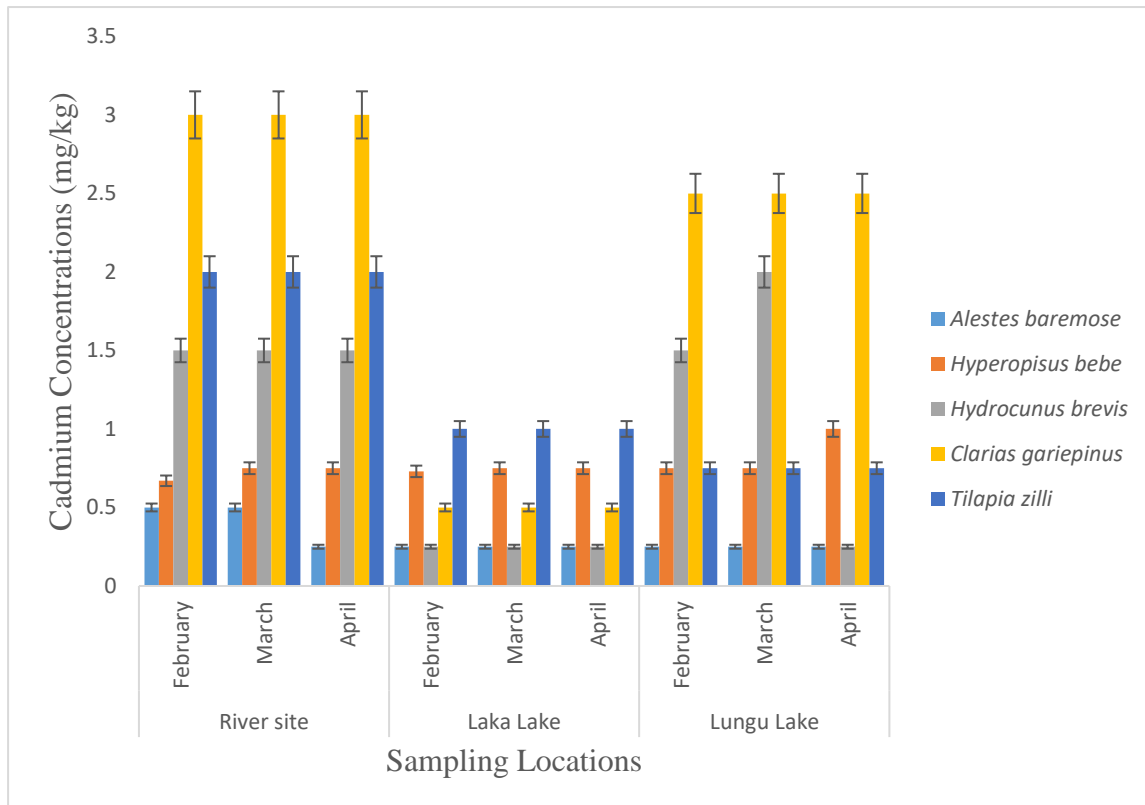


Figure 1: Concentration of Cd in the muscles of fish species.

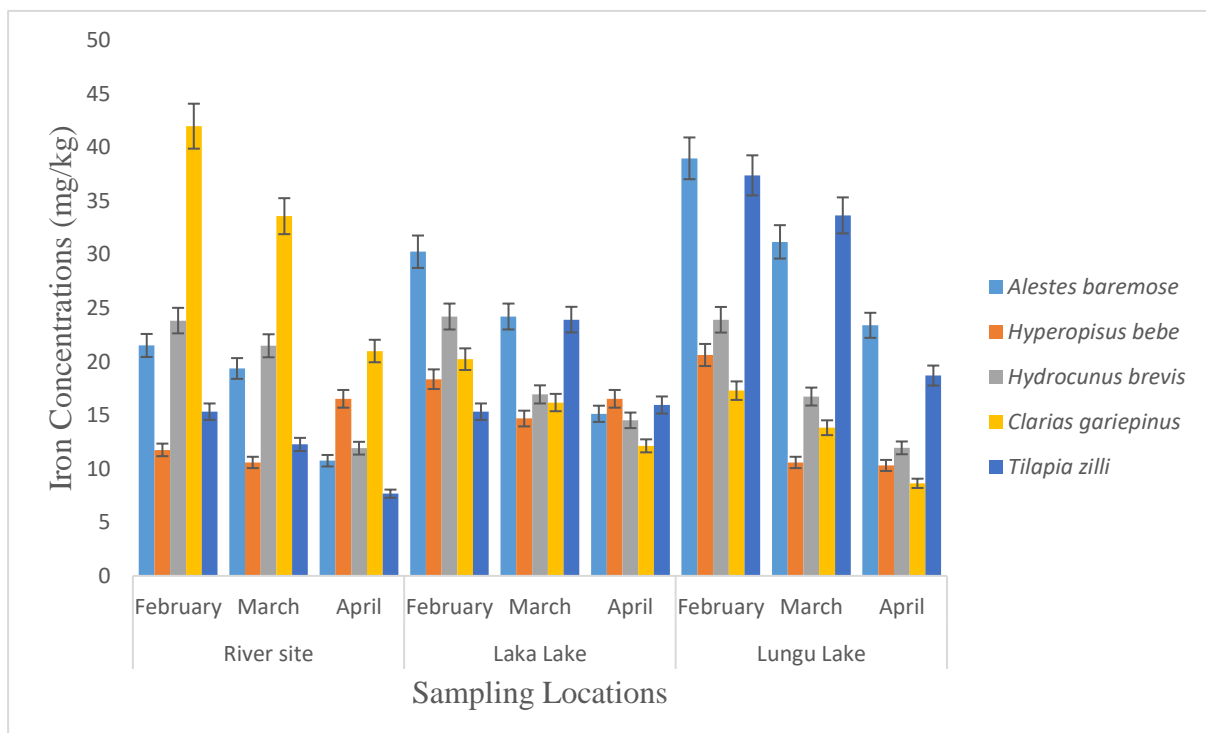


Figure 2: Concentration of Fe in the muscles of fish species.

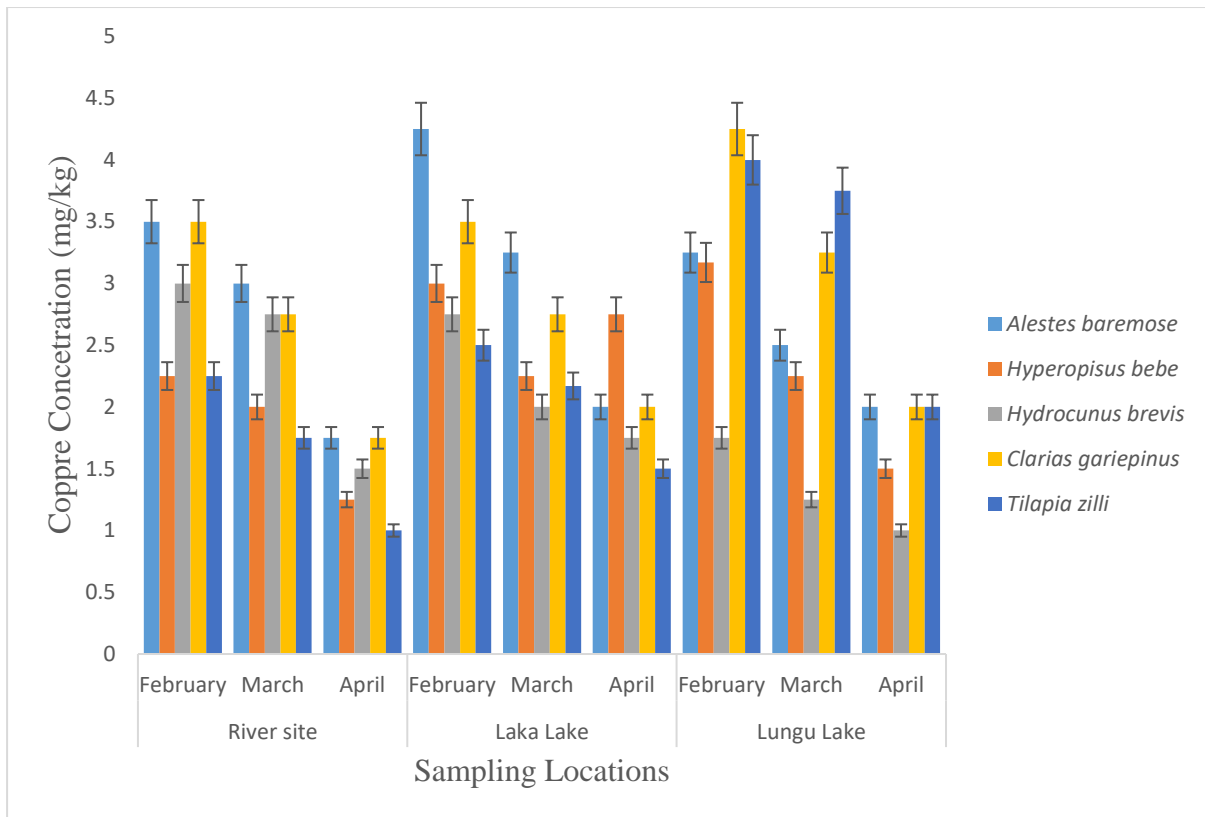


Figure 3: Concentration of Cu in the muscles of fish species

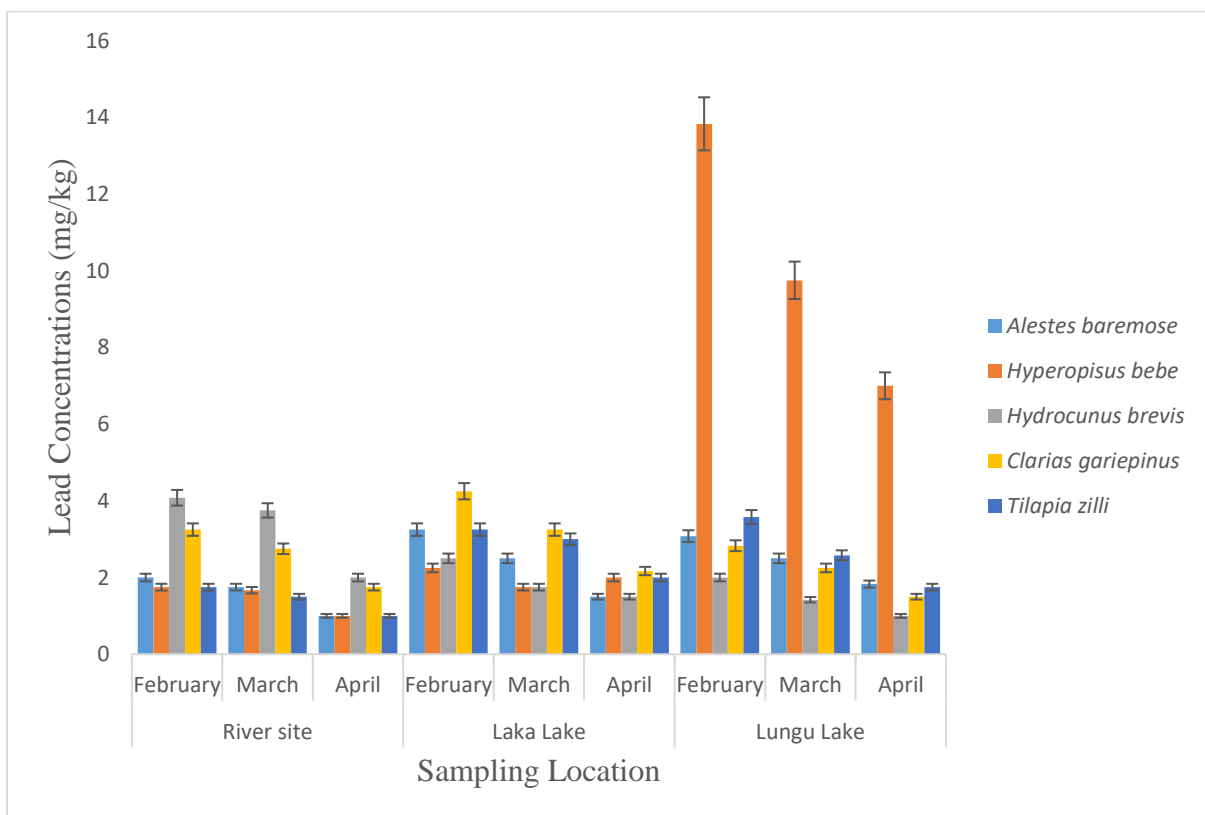


Figure 4: Concentration of Pb in the muscles of fish species

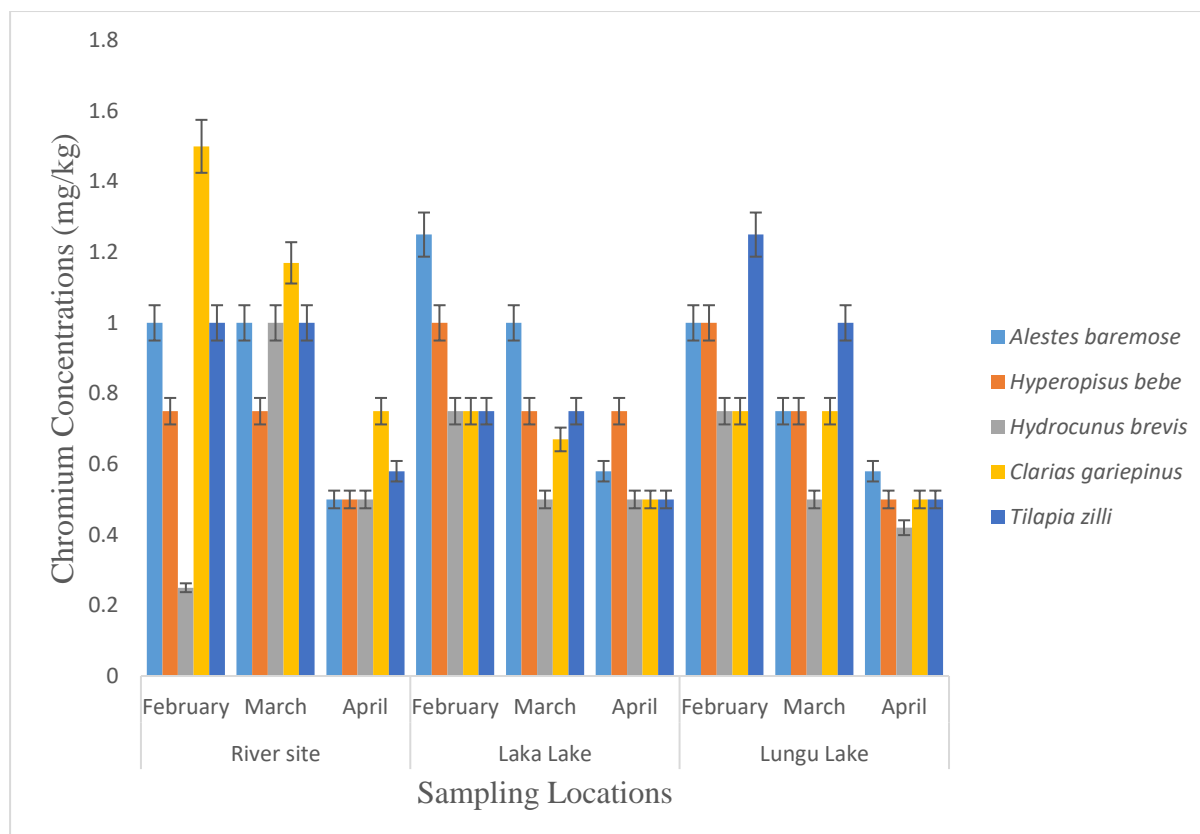


Figure 5: Concentration of Cr in the muscles of fish species

DISCUSSION

The Cd concentrations are generally low in all the fish samples. The Muscle parts of *Clarias gariepinus* led the rank with 3.00 ± 0.00 mg/kg of Cd content while the Muscle parts of the *Alestes baremose* fish sample had the lowest Cd content with 0.25 ± 0.00 mg/kg. The *Hyperopisus bebe*, *Hydrocynus brevis* and *Tilapia zilli* had concentrations of $0.67 \pm 0.38 - 1.00 \pm 0.00$ mg/kg, $0.25 \pm 0.00 - 2.00 \pm 0.00$ mg/kg, and $0.75 \pm 0.00 - 2.00 \pm 0.00$ mg/kg respectively. Comparison with the work of Taiwo *et al.* (2019) showed that the muscle parts of the fish samples of *Alestes baremose* had concentrations lower than 11.35 mg/kg obtained by Taiwo *et al.* (2019) in their study of the heavy metals concentration in eight fish species from Epe Lagoon (Nigeria). The muscle part of both *Clarias gariepinus* and *Oreochromis niloticus* gave the concentration of Cd higher than 1.00 mg/kg and 1.30 mg/kg values obtained (Ejike and Liman, 2017). Similarly, the muscle part of *Hyperopisus bebe* and that of *Hydrocynus brevis* gave Cd concentrations lower than 0.13 mg/kg and 0.26 mg/kg reported by Sylvester and Tariwari (2016). The concentration of Cd in all the fish samples collected from the study areas exceed the maximum level set by the WHO (0.010 mg/kg). The analysis of variance (ANOVA) result showed that there was no significant difference ($p > 0.05$) between stations and months in Cd level observed in

all the fish species during the study period ($P = 0.931$).

Fe had its lowest concentration in *Tilapia zilli* 7.67 mg/kg while *Clarias gariepinus* recorded the highest concentration of Fe with 41.98 mg/kg. The Fe concentration in *Alestes baremose*, *Hyperopisus bebe*, and *Hydrocynus brevis* were 10.75- 38.98 mg/kg, 10.59-20.62 mg/kg, and 11.92-24.21 mg/kg respectively. The concentration of muscles part of *Alestes baremose* were higher than the value 7.27 mg/kg gotten where Taiwo *et al.* (2019) studied the heavy metals concentration in Eight Fish Species from Epe Lagoon (Nigeria). However, muscles part of both *Clarias gariepinus* and *Oreochromis niloticus* had concentrations higher than the values of 1.127 mg/kg and 1.000 mg/kg stipulated by Mustapha *et al.* (2021). The level of concentration of Fe were comparable to those reported for the muscles of these fish species by Taiwo *et al.* (2017) for *Tilapia zilli* and *Clarias gariepinus* respectively who studied three species of fish (*Tilapia zilli*, *Synodontis nigrita* and *Clarias gariepinus*) from Lagos lagoon, Nigeria. However, similar results were reported by Ejike and Liman (2017) showed that the muscle part of *Clarias gariepinus* and *Oreochromis niloticus* were comparable with the current studies. Similarly, the muscle part of *Hyperopisus bebe* and that of *Hydrocynus brevis* gave Fe concentrations lower than 102.20 mg/kg and 102.20 mg/kg reported by Sylvester and Tariwari

(2016). And also, higher than 0.30 mg/kg recommended by WHO (2003). The analysis of variance (ANOVA) result showed that there was significant difference ($p < 0.05$) between stations and months in Fe level observed in all the fish species during the study period ($P = 0.004$).

The muscle part of *Tilapia zilli* and *Hydrocynus brevis* showed the lowest Cu concentration with 1.00 ± 0.00 mg/kg while the muscle part of *Alestes baremose* and *Clarias gariepinus* had the highest Cu concentration 4.25 ± 0.00 mg/kg respectively. The *Hyperopisus bebe*, had the Cu concentration of $1.25 \pm 0.00 - 3.17 \pm 0.00$ mg/kg. Comparison with the work of Taiwo *et al.* (2019) showed that the muscle parts of the fish samples of *Alestes baremose* had Cu concentrations higher than 2.57 mg/kg obtained by Taiwo *et al.* (2019) studied the heavy metals concentration in Eight Fish Species from Epe Lagoon (Nigeria). The muscle part of *Clarias gariepinus* and *Oreochromis niloticus* gave the concentration of Cu higher than 0.29 mg/kg and 2.19 mg/kg values stipulated by Sylvester and Tariwari (2016). Similarly, the muscle part of *Hyperopisus bebe* and that of *Hydrocynus brevis* gave Cd concentrations lower than; 6.36 mg/kg reported by Sylvester and Tariwari (2016). The concentration of Cu in all the fish samples collected from the study area exceeded the allowable limits stipulated by WHO, 2017 as recommended with a value of 2.250 mg/kg. The analysis of variance (ANOVA) result showed that there was significant difference ($p < 0.05$) between stations and months in Cu level observed in all the fish species during the study period ($P = 0.000$).

The muscle part of *Hyperopisus bebe* recorded the highest Pb concentration (13.83 ± 0.00 mg/kg) of all the samples analyzed. The values $1.00 \pm 0.00 - 3.25$ mg/kg, $1.00 \pm 0.00 - 4.08 \pm 0.00$ mg/kg, $1.50 \pm 0.00 - 3.25 \pm 0.00$ mg/kg and $1.00 \pm 0.00 - 3.58 \pm 0.00$ mg/kg were the concentrations gotten from fish samples of *Alestes baremose*, *Hydrocynus brevis*, *Clarias gariepinus* and *Tilapia zilli* respectively. The muscle parts of the fish sample *Alestes baremose* gave Pb concentrations that were lower than the value of 4.19 mg/kg obtained by Taiwo *et al.* (2019). The muscle part of both *Clarias gariepinus* and *Oreochromis niloticus* gave the concentration of Pb higher than 0.45-4.18 mg/kg and lower 0.13-2.18 mg/kg values obtained by Nwude *et al.* (2020). Similar to that, the muscle part of *Hyperopisus bebe* and that of *Hydrocynus brevis* gave Pb concentrations higher than 0.03 mg/kg and 0.05 mg/kg reported by Sylvester and Tariwari (2016) which were higher than the acceptable limit of 0.010 mg/kg according to WHO 2003. The analysis of variance (ANOVA) result showed that there was no significant difference ($p > 0.05$) between stations

and months in Pb level observed in all the fish species during the study period ($P = 0.224$).

The Cr concentrations are generally low in all the fish samples. The Muscle parts of *Clarias gariepinus* and *Tilapia zilli* led the rank with 1.17 ± 0.00 mg/kg and 1.25 ± 0.00 mg/kg of Cr content. The *Hyperopisus bebe*, *Hydrocynus brevis* and *Alestes baremose* had concentrations of Cr which ranges from $0.42 \pm 0.14 - 1.00 \pm 0.00$ mg/kg. The analysis of variance (ANOVA) result showed that there was significant difference ($p < 0.05$) between stations and months in Cr level observed in all the fish species during the study period ($P = 0.000$). However, among all the heavy metals determined across all the fish species, Chromium had the lowest concentration from the study area. Comparison with the work of Taiwo *et al.* (2019) showed that the muscle parts of the fish samples of *Alestes baremose* had concentrations lower than 2.00 mg/kg obtained by Wilberforce *et al.* (2016) in their study of Comparative Assay of Heavy Metals in Gills and Muscles of Common Fishes in Afikpo, Ebonyi State, Nigeria. The muscle part of both *Clarias gariepinus* and *Oreochromis niloticus* gave the concentration of Cr higher than 0.660 mg/kg and 0.042- 0.123 mg/kg values obtained by Faye-ofori *et al.* (2015); Ibrahim and Kassim (2012) respectively. Similarly, the muscle part of *Hyperopisus bebe* and that of *Hydrocynus brevis* gave Cr concentrations lower than 1.30 mg/kg and 1.36 mg/kg reported by Sylvester and Tariwari (2016). The concentration of Cr in all the fish samples collected from the study area exceed the maximum limit 0.13 recommended by WHO.

Conclusion

Heavy metals are poisonous to both humans and fish, thus, should be scrutinized regularly from the Argungu river and Lungu and Laka lakes. The overall average concentrations of Cd, Fe, Cu, Pb, and Cr in the muscles of the five fish species studied gave a ranking of: Fe > Cu > Pb > Cd > Cr. These metals are essential in human diets in minute quantities; their consumption should not exceed the limits set by WHO. The high concentration of these metals in the fish species studied calls for attention in their consumption. However, if eaten in moderation, the fish are safe for consumption. The concentration of heavy metals in the fish species is an indication of the level of pollution in Argungu river and two neighboring (Lungu and Laka) Lakes. This level of pollution could be due to intensive agricultural farming by the use of Agro-chemicals and inadequate monitoring of dumping of waste disposal near the river. It is necessary to monitor the use of Agro-chemicals by farmers, dumping of domestic sewage and released of sewage water into the water bodies of the Argungu.

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