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SEASONAL VARIATION OF HEAVY METALS CONCENTRATIONS IN FISH IN OGUTA LAKE, NIGERIA.

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ABSTRACT

Concentrations of heavy metals iron (Fe), copper (Cu), lead (Pb), nickel (Ni), mercury (Hg), chromium (Cr), cadmium (Cd) and arsenic (As), were determined in the head of four fish species, namely, *Trachinotus goreensis*, *Clarias anguillaris*, *Synodontis membranaceous*, and *Tilapia zilli*, in Oguta Lake, Nigeria. Result obtained from analyses using Atomic Absorption Spectrophotometry (AAS) revealed that Fe (13.309 mg/l) was the highest metal accumulated by the fish (*S. membranaceous*) in October, while Hg and As were not detected in all the fish species except in July where 0.003 and 0.005mg/l of As were detected in the fish species (*T. zilli* and *C. anguillaris*), and November where 0.001 mg/l of As was also detected in *S. membranaceous*. The distribution of HMs in the fish species revealed that, overall, Fe was the highest metal accumulated by the fish species, *C.* membranaceous, followed by *T. goreensis*. This high level of Fe accumulated by the fish species may be attributed to the fact that Fe occur at high levels in organic matter at the bottom of the Lake. So being typical bottom dwellers, the fish species were more exposed to the metal. Heavy metals were higher (not significantly) during the dry season than the rainy season. Statistically, however, seasonal variation didn't significantly influence the accumulation of HMs by the fish species. The levels of heavy metals examined in the present study were below maximum permissible limits set by World Health Organization (WHO), indicating that the Oguta Lake is not polluted by heavy metals.

Indexing terms/Keywords

Accumulation, concentration, environment, fish, saturated, solution, species.

Academic Discipline And Sub-Disciplines

Environmental chemistry

SUBJECT CLASSIFICATION

Chemistry

TYPE (METHOD/APPROACH)

Experimental

1.0 INTRODUCTION

Fish is a staple source of food for many families of the world because it has high protein content and low saturated fatty acids (1). Since the ever growing human population keeps increasing, the need for fish and fish products has also increased. It has been estimated that, worldwide, people obtain about 25% of their protein from fish and fish products (2). Fish is important to man in human diet, and it contains two types of omega fatty acids, namely; eicosapentenoic acid (EPA) and docosahexenoic acid (DNA). Omega fatty acids are very important for normal growth of humans where they reduce cholesterol levels and lower the risk associated with sicknesses such as heart diseases, stroke, and premature delivery (3),(4). Fish also contain vitamins and minerals which play essential role in human health (5).

Fish poisoning occurs when heavy metals (HMs) and other environmental contaminants enter the water system through surface runoff, leaching or erosion, and these contaminants are taken up by fish during feeding.Since diet is the main route of exposure to HMs to humans, and fish represent an important part of human diet, polluted fish becomes a very dangerous dietary source of some toxic HMs (6). In the recent past, there has been growing interest in assessing the levels of HMs in food including fish. Such interests have aimed at ensuring the safety of the food supply chain and minimize the potential for hazardous effect on human health. Human activities such as metal-related industries have also contributed to HMs occurrence in aquatic systems. These metals are accumulated by aquatic organisms and may be further transferred up to top trophic levels (7). Fish are often at the top of the aquatic food chain and may bioaccumulate large amounts of these metals from the water (8). Fish have been found to be good indicator of heavy metal (HM) contamination in aquatic system (9),(10).

Numerous studies have focused on HMs pollution in water and the changes it creates by altering the ecological balance of the aquatic environment, creating massive damage to aquatic life and destabilizing activities of aquatic organisms due to their high toxicity and accumulative behavior. Heavy metal (HM) contamination of aquatic environment continues to attract the attention of environmental researchers. In one study, Bashir *et al*. (11) examined the concentrations of HMs (Cd, Cu, Mn, Zn) in the muscle, liver, and gills of two commercial marine fishes (*Arius thalassinus* and *Johnius belangeri*) in east coastal waters Malaysia, Peninsular. Results obtained from analyses using Inductively Coupled-Plasma Mass Spectroscopy revealed that the muscle had the lowest metal concentrations in both fish samples; *A. thalassinus*; Zn (20.54 µg/g), Cu (1.21 µg/g), Mn (0.62 µg/g), Cd (0.058 µg/g), and *J. Belangari*; Zn (18.27 µg/g), Cu (0.66 µg/g), Mn (79.08 µg/g), Cd (0.055 µg/g), respectively. Zinc was the overall highest metal present totaling 498.2 µg/g in *A. thalassinus*. Among the estimated HMs concentrations, Zn and Cd were the overall highest and lowest metals accumulated, respectively, for both species in muscle, liver and gills of the fishes. These results indicated that *A. thalassinus* has a high metal accumulation ability than *J. belangeri* in the Malaysian Peninsular. Heavy metals can enter the food chain through direct consumption of water or aquatic organisms (11). Metals such as Cu, Zn, and Cd have been reported to reach toxic concentration levels potentially dangerous to the aquatic ecological environment (12),(13). Humans are at risk of being contaminated by HMs when they consume fish from HMs infested water environment (14). Since they accumulate HMs in large quantity, fish has been shown to be good indicators of HMs contamination in aquatic systems (15). Heavy metals intake by fish in polluted aquatic environment vary depending on ecological requirements, metabolisms, salinity of water, water pollution level, food and sediments quantity (16).

It has been demonstrated that fish living in polluted water tend to accumulate HMs effectively in their tissue (17). Accumulation of HMs by fish generally depends on certain factors including; time of exposure, way of metal uptake, environmental conditions (water temperature, pH, hardness, salinity), and intrinsic factors such as fish age and feeding habits (17). Results of recent findings revealed that metal accumulation in fish body vary in different concentration (17). The higher the metal concentrations in the aquatic environment, the more HMs that may be taken up and accumulated by the fish (18). Metals in natural waters occur in particulate or soluble form. Soluble species include labile and non-labile fractions. The labile metal compounds are most dangerous to fish. They include various ionic forms, and data have been released indicating that the amounts of metals in the labile fraction and the distribution of HMs in fish body strongly depended on aquatic environmental conditions (19). Related studies by Kock *et al*., (20) demonstrated that Cd and Pb levels in *Salvelinus alpines*' liver and kidneys indicated higher uptake rates of both metals in summer when the water temperature was high. Similar findings have been reported by Douben (21). However, in their contribution, Grieb *et al*., (22) suggested that water acidification directly affects metal accumulation rates by the fish. The authors noted that the concentrations of Cd and Pb were considerably higher in fish samples from acidified lakes, while Cu was also present in appreciable amounts in lakes with relatively higher acidic pH levels (> 4.0). The researchers concluded that water acidification affects bioaccumulation of metals by the fish in an indirect way, by changing solubility of metal compounds. Barron and Albeke (23) reported that water hardness considerably affects uptake of metals across the gill epithelium by reducing Cu accumulation. Nonetheless, in a separate study, Stagg and Shuttleworth (24) revealed that salinity also reduce uptake and accumulation of Cu by the fish, while Pb uptake by the fish was highly favored in saline water environment (25).

The aim of the present study was to investigate seasonal variation of trace metals concentrations in fish head in Oguta Lake, Nigeria.

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2.0 Materials and Method

2.1 Description of study area

The fishes were bought from commercial fishermen at the daily market in Oguta, Nigeria. Oguta is a town on the East bank of Oguta lake in Imo State, Nigeria; and its geographical coordinates are latitude 5°42' O" North and longitude 6°48' O" East, (Fig. 1).

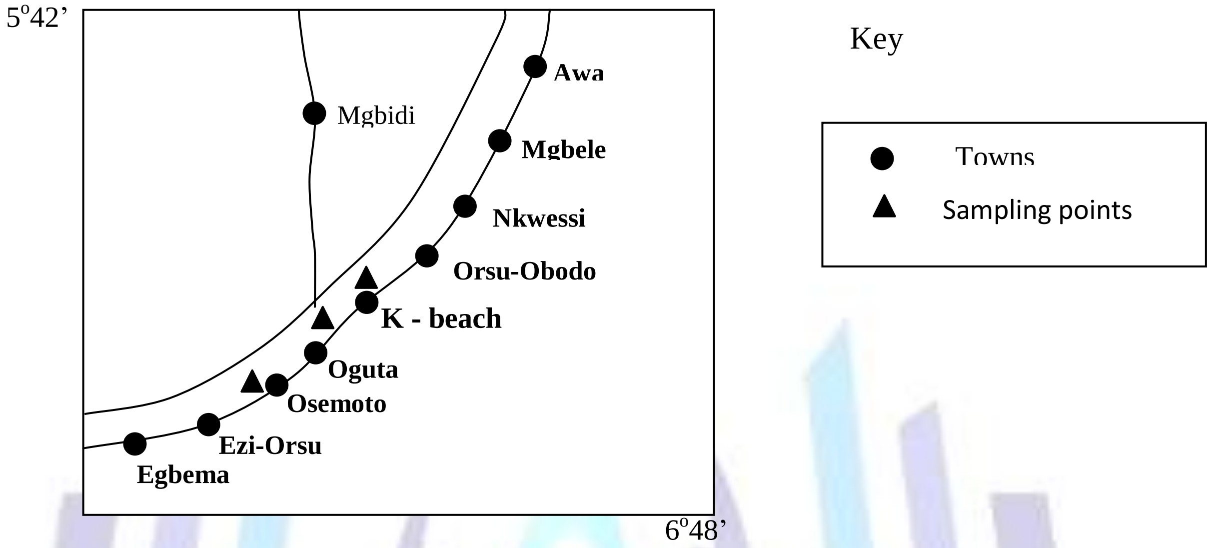

Fig 1: Map of Oguta Lake showing Sampling site

2.2 Fish sample collection, preparation and analyses

Composite sampling was used to obtain fish samples. Twelve adult fish samples, three each for each of the four species of fish (*Trachinotus goreensis*, *Tilapia zilli*, *Clarias anguillaris*, *Synodontis membranacous*) were caught approximately 1km apart in the three sampling points during the rainy season in July. Mean weight of the three fishes in each of the four sets of species ranged between 314 – 520 g weights. These fish sets were place in four separate sterile polythene bags previously washed and rinsed with deionized water, and taken to Fisheries Laboratory of the Department of Fishery and Aquaculture, Federal University of Technology, Owerri, where they were taxonomically identified by an expert.

The fish species were washed thoroughly with deionized water and stored inside a deep freezer (Model Haier thermocol HR-2115x) for 48 h and allowed to thaw. After this period, a sterile surgical knife was used to sever the fish heads which were transferred into sterile sample holding bottles previously washed and rinsed with deionized water. The fish heads were separately dried (each set of three heads) with an electric oven (Model DHG, UK) at 110°C until constant weight. Each set of dried fish head samples was ground to a powder form using an electric blender (Tamashi TBG 296-1) and labeled appropriately in a sample holding bottle.

About 3 g each of the powered fish heads was separately weighed in a 200 ml beaker and digested using a mixture of HCl and HNO_3 in the ratio of 3:1 (aqua regia) using the method described by Ukiwe and Iwu (26). The resultant solution was made up to 100 ml with deionised water in a 100 ml standard flask and 5 ml of this solution was used for analysis of HMs (Fe, Cu, Pb, Ni, Hg, Cr, Cd, As) using an Atomic Absorption Spectrophotometer (AAS) (Model Hitachi FS 240 Varian). Three repetitions were made for each metal analysed and the mean HM concentration (mg/l) was obtained by method described by Ukiwe and Oguzie (27). The above procedure was repeated in August for the rainy season and in October and November respectively for the dry season.

2.3 Data analysis

Data was presented as arithmetic mean and standard deviation. The BMDP Statistical Software was used for data analysis. The one-way Analysis of Variance (ANOVA) was used to determine Statistical difference in HMs concentration in fish species between months. The *F*-test was used to estimate significance in HMs concentration using the above mentioned protocol.

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3.0 Results and Discussion

3.1 Results

Table 1: Mean concentration (mg/l) of heavy metals in fish species head in July

	Fish Species			
Heavy metals	***T. goreensis***	***T. zilli***	***C. anguillaris***	***S. membranaceous***
Fe (Mean ± SD)	6.821 ± 0.2	5.121 ± 0.2	0.431 ± 0.1	7.915 ± 0.2
Cu (Mean ± SD)	0.321 ± 0.4	0.217 ± 0.2	0.015 ± 0.1	0.107 ± 0.1
Pb (Mean ± SD)	ND	ND	0.001 ± 0.0	0.002 ± 0.0
Ni (Mean ± SD)	0.134 ± 0.2	0.112 ± 0.2	0.048 ± 0.2	0.099 ± 0.1
Hg (Mean ± SD)	ND	ND	ND	ND
Cr (Mean ± SD)	0.057 ± 0.1	0.011 ± 0.1	0.091 ± 0.1	0.008 ± 0.0
Cd (Mean ± SD)	0.014 ± 0.2	0.023 ± 0.3	0.094 ± 0.1	0.051 ± 0.1
As (Mean ± SD)	ND	0.005 ± 0.0	0.003 ± 0.0	ND

ND=Not Detected; SD=Standard deviation

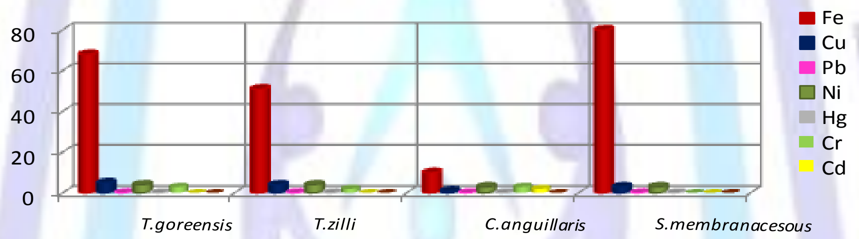

Fig 2 Bar Chart showing the concentration of HMs in fish species head in July

Table 2: Mean concentration (mg/l) of heavy metals in fish species head in August

	Fish Species			
Heavy metals	***T. goreensis***	***T. zilli***	***C. anguillaris***	***S. membranaceous***
Fe (Mean ± SD)	4.934 ± 0.3	4.007 ± 0.2	1.652 ± 0.1	8.935 ± 0.2
Cu (Mean ± SD)	0.176 ± 0.2	0.148 ± 0.2	0.005 ± 0.1	0.048 ± 0.1
Pb (Mean ± SD)	0.002 ± 0.0	0.002 ± 0.0	0.001 ± 0.0	ND
Ni (Mean ± SD)	0.142 ± 0.1	0.063 ± 0.1	0.130 ± 0.1	0.109 ± 0.1
Hg (Mean ± SD)	ND	ND	ND	ND
Cr (Mean ± SD)	0.005 ± 0.0	0.007 ± 0.0	0.109 ± 0.0	0.002 ± 0.0
Cd (Mean ± SD)	0.017 ± 0.0	0.041 ± 0.1	0.051 ± 0.0	0.026 ± 0.1
As (Mean ± SD)	ND	ND	ND	ND

ND=Not Detected; SD=Standard deviation

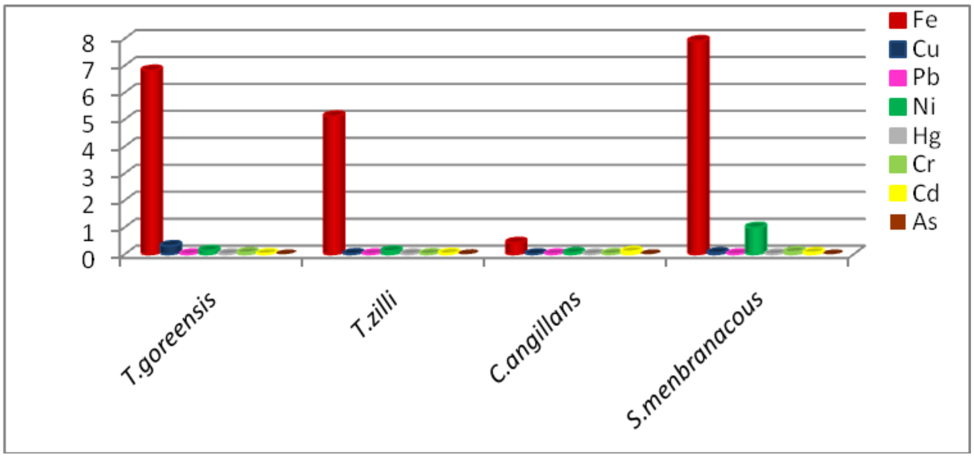

Fig 3 Bar Chart showing the concentration of HMs in fish species head in August

Table 3: Mean concentration (mg/l) of heavy metals in fish species head in October

	Fish Species			
Heavy metals	***T. goreensis***	***T. zilli***	***C. anguillaris***	***S. membranaceous***
Fe (Mean ± SD)	9.785 ± 0.4	8.508 ± 0.2	1.853 ± 0.2	13.309 ± 0.2
Cu (Mean ± SD)	0.365 ± 0.2	0.013 ± 0.0	0.017 ± 0.0	0.068 ± 0.1
Pb (Mean ± SD)	ND	ND	ND	ND
Ni (Mean ± SD)	0.149 ± 0.1	0.125 ± 0.1	0.161 ± 0.1	0.136 ± 0.1
Hg (Mean ± SD)	ND	ND	ND	ND
Cr (Mean ± SD)	0.058 ± 0.2	ND	ND	0.044 ± 0.0
Cd (Mean ± SD)	0.077 ± 0.3	0.091 ± 0.1	0.011 ± 0.1	0.091 ± 0.0
As (Mean ± SD)	ND	ND	ND	ND

ND=Not Detected; SD=Standard deviation

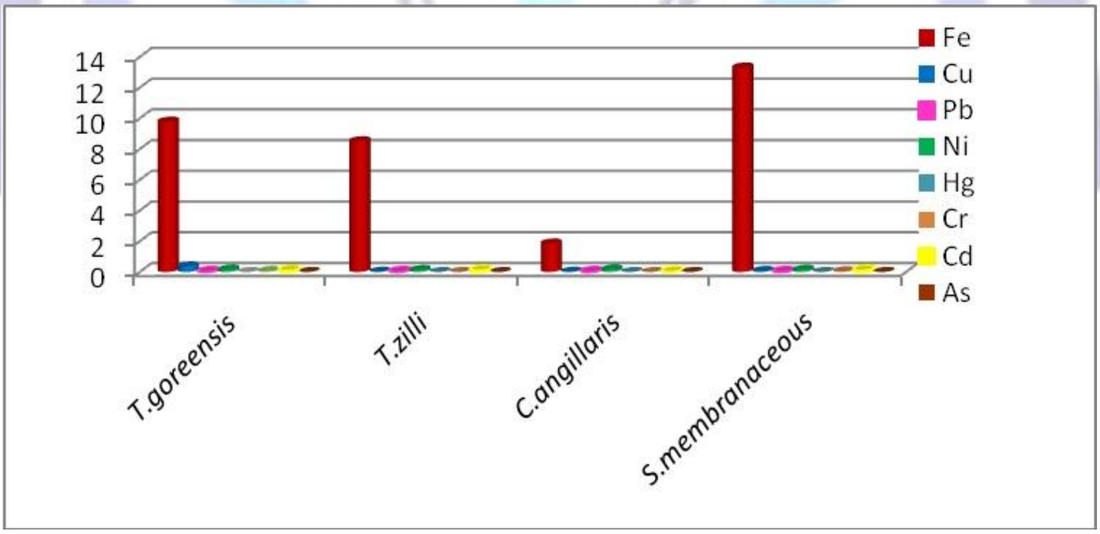

Fig 4 Bar Chart showing the concentration of HMs in fish species head in October

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Table 4: Mean concentration (mg/l) of heavy metals in fish species head in November

	Fish Species			
Heavy metals	***T. goreensis***	***T. zilli***	***C. anguillaris***	***S. membranaceous***
Fe (Mean ± SD)	10.015 ± 0.2	8.146 ± 0.2	2.001 ± 0.1	11.352 ± 0.1
Cu (Mean ± SD)	0.521 ± 0.1	0.361 ± 0.1	0.376 ± 0.1	0.468 ± 0.1
Pb (Mean ± SD)	0.001 ± 0.0	0.001 ± 0.1	0.002 ± 0.0	0.001 ± 0.0
Ni (Mean ± SD)	0.269 ± 0.1	0.247 ± 0.1	0.215 ± 0.1	0.191 ± 0.1
Hg (Mean ± SD)	ND	ND	ND	ND
Cr (Mean ± SD)	0.068 ± 0.1	0.001 ± 0.1	0.013 ± 0.1	0.047 ± 0.1
Cd (Mean ± SD)	0.012 ± 0.1	0.082 ± 0.1	0.002 ± 0.1	0.025 ± 0.0
As (Mean ± SD)	ND	ND	ND	0.001 ± 0.0

ND=Not Detected; SD=Standard deviation

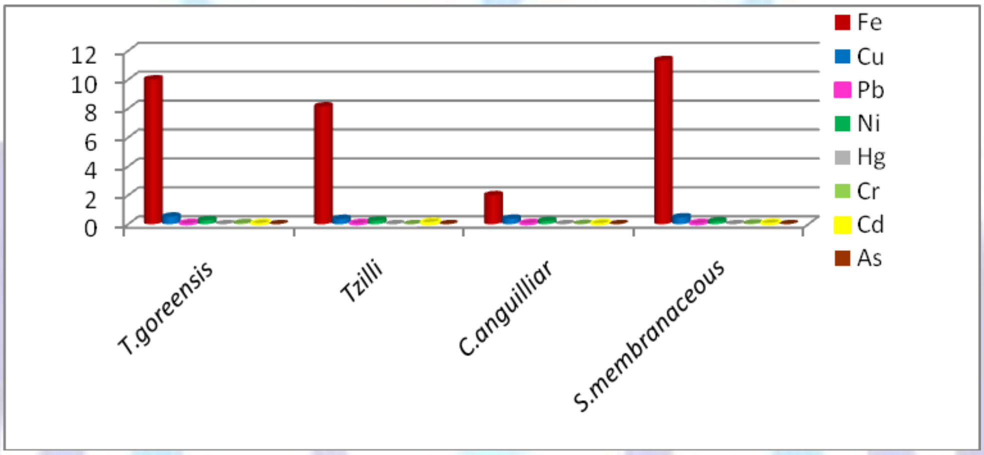

Fig 5 Bar Chart showing the concentration of HMs in fish species head in November

3.2 Discussion

Fig. 2 and **3** shows the Bar Chart of the mean HMs concentrations in different fish species head in July and August. In July, HMs concentrations in the fish species head ranged between ND (Not Detected) to 7.915 mg/l. The highest HM concentration was Fe (7.915 mg/l) obtained for *S. membranaceous*. The lowest HM concentration was Pb (0.001mg/l) obtained for *C. anguillaris*. It was also observed that Fe was the overall highest metal found in the four fish species, while Hg was not detected in any of the fish species. In August, it was observed that *C. membranaceous* accumulated the overall highest HM (Fe=8.935 mg/l), while Pb was the least accumulated HM (Pb = 0.001mg/l). Heavy metal accumulation ranged between 0.001 - 8.935 mg/l, with Fe being the highest accumulated HM in the four fish species (*T. goreensis* - 4.934 mg/l; *T. zilli* - 4.007 mg/l; *C. anguillaris* - 1.652 mg/l, *S. membranaceous* - 8.935 mg/l). Mercury and As were not detected in the four fish species head.

However, **Fig. 4** and **5** represent the total HMs accumulated by the fish species head in October and November. Mercury, As and Pb were not detected in any of the fish species sample in October. But *C. membranaceous* accumulated 13.309 mg/l of Fe followed by *T. goreensis* (9.785 mg/l). Iron was the overall highest HM accumulated by the four fish species while Ni was the second highest metal accumulated by the fish species. Heavy metal concentrations ranged between 0.013 mg/l Cu for *T. zilli* to 13.309 mg/l Fe for *C. membranaceous*. In November, it was also observed that Pb (0.001mg/l) and As (0.001mg/l) were the least metal accumulated by the fish species (*T. goreensis* (Pb); *T. zill* (Pb); and *C. membranaceous* (As). *C. membranaceous* accumulated 11.352 mg/l of Fe as the overall highest metal concentrated. Iron was still the best accumulated HMs in all the four fish samples, while Hg was not detected in any of the four fish species. Arsenic (As) was also not accumulated by *T. goreensis, T. zilli* and *C. anguilliaris* within this period.

Studies abound revealing the ability of different fish species to concentrate HMs (28), (29). However, none of these studies has shown that particular species of fish are able to concentrate HMs better than others. Nonetheless, most researchers are of the opinion that specific metals are more likely to be preferentially accumulated by some fish species (30). This seeming affinity for certain HMs by some fish species has to do with the site (organ) accumulating the HMs and the metabolic activity of the organ (11).

In the present study, it was observed that HMs concentrations were generally higher in the dry season compared to the rainy season. This may be associated with wind distribution of dust and particles which latter found their way into the Oguta Lake raising the metal content of the Lake. This observation of HMs accumulation in fish being higher in dry season than in rainy season was also observed by Olaifa *et al*., (28), working on HMs concentrations of *C. gariepinus* in Ogun River. The authors observed significant difference in HMs accumulated in the dry and rainy season, with the dry season being the highest.

The present investigation also observed that the HMs concentrations in the dry and rainy seasons did not differ significantly between the months. Heavy metals accumulation in *S. membranaceous* was used to test for significant difference in HMs concentration between the months. The *F*-test of HMs accumulation in *S. membranaceous* in July and October was 1.56, while that between August and November was also, 1.56. Testing these values at 7 and 7 degrees of freedom, $P < 0.05$.

For organ specific accumulation of HMs by fish species, studies have however, claimed that the liver (28) adsorbed more HMs than other parts of the fish body. This claim has, however, been disputed by other researchers who believed that the adsorption of HMs by fish is related to other factors which include, as already mentioned, age, size, and species of fish, as well as intrinsic factors of the water environment (31). Eneji *et al.*, (32) demonstrated that bioaccumulation of HM in fish species (*Tilapia zilli* and *Clarias gariepinus*) from River Benue vary within organs but not significantly organ-related, with *T. zilli* gills accumulating the highest concentration (52.2%) of all the detected HMs, followed by the intestine (26.3%), while the muscle tissues accumulated only about 21.5% of the HMs investigated. With regard to HMs accumulation pattern by fish, Oboh and Edema (33) had reported the pattern of metal content in fish as Fe > Mn > Cd, while Eneji *et al*., (32) also reported a slightly different pattern of Fe > Cd > Mn. However, these researchers attributed the variant in pattern to bioavailability, intrinsic fish metabolic processes, as well as trophic structure variation in the fish species. The present study, however, observed HMs accumulation pattern of Fe > Cu > Cd.

4.0 Conclusion

The present research has investigated the concentrations in HMs in fish species (*T. goreensis, T. zilli, C. anguillaris, S. membranaceous*) from Oguta Lake, Nigeria. Mercury and As were not detected in all the fish samples, except insignificant amount (0.005 and 0.003 mg/l) observed for *T. zilli* and *C. anguillaris* in the month of July. The distribution of HMs in fish species revealed that Fe was the highest metal accumulated by the fish species, *C. membranaceous*. *C. membranaceous* also accumulated the highest amount of Fe, followed by *T. goreensis*. This high level of Fe accumulated by the fish species may be attributed to high levels of Fe occurring in organic matter at the bottom of the Lake. So being typical bottom dwellers, the fish species were more exposed to the metal. Other metals accumulated by the fish species were within WHO maximum permissible limits. Heavy metals were higher (not significantly) during the dry season than the rainy season. However, seasonal variation didn't significantly influence the accumulation of HMs by the fish species.

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