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ETHMALOSA FIMBRIATA AND *CHRYSICHTHYS MACROPOGON* AS BIO-INDICATORS OF HEAVY METAL IN FOUR COASTAL TOWNS OF ILAJE LGA, ONDO STATE, NIGERIA

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ABSTRACT
This study aimed to assess the accumulation level of Cadmium (Cd), Zinc (Zn), Lead (Pb), Copper (Cu), Iron (Fe), and Manganese (Mn) in two organs (gills and muscle) of two fish species (*Ethmalosa fimbriata* and *Chrysichthys macropogon*) from four coastal towns (Ayetoro, Bijimi, Idiogba and Asumogha) of Ilaje Local Government Area, Ondo State, Nigeria. Fish samples used were collected monthly for a period of four months in the four stations using the gillnet with mesh sizes of 0.6cm, 1.0cm, 2.0cm, 3.0cm and 4.0cm throughout the period of study. The samples were digested and heavy metal concentration was analyze using Atomic Absorption Spectrophotometer (Model AA240FS). Concentrations of heavy metal in both species occurred in the order: Fe>Mn>Zn>Cu>Pb>Cd. Heavy metal concentration was higher in the gills compared to muscles where metabolic activity is relatively lower. Lead concentration in the samples across the four stations varied from 0.328 to 0.923 mg/kg. Concentrations of Zn in samples of the two fishes ranged from 1.644±0.53 to 2.095±0.26 while cadmium concentrations in muscle and gill of *E. fimbriata* varied from 0.003±0.00 to 0.355±0.41. Bio-accumulation of metal in *E. fimbriata* and *C. macropogon* from the study area shows aquatic pollution.

Keywords: Heavy metal, Fish, Environmental pollution, Coastal water, Concentration, Bio-accumulation

INTRODUCTION
Most toxic chemicals such as heavy metal, are mostly taken in by fish both from the water and from their feed, in the case of aquaculture this often leads to public health risks (Javed & Usmani, 2019). Heavy metal as used in context refers to a class of metals whereby its concentration in marine environment also includes water bodies mainly due to pollution caused by industries marred by disposal of raw effluents into the rivers. It includes any metal or metalloid that is of environmental concern.
The term 'Heavy metal' was derived from negative impact of Lead, Copper, Iron, Cadmium, Zinc and Manganese in aquatic bodies inhabited by organisms where all these metals are denser than iron. In general terms, it has also been used for other toxic metals or even metalloids such as arsenic, as regards to the density of such metals. Heavy metals present in water mainly include Lead (Pb), Zinc (Zn), Copper (Cu), Iron (Fe), Cadmium (Cd), Manganese (Mn) (Obasi & Akudinobi, 2020).
Fish are like living batteries that soak up metal pollutants and are therefore used as bio-accumulators but have disadvantage of comparison of metal concentrations between different sites, where atomic absorption method has impaired the water quality oh the samples were collected near or below concentrations of the metals (Idris *et al.* 2022).
An indirect assessment of pollution in the marine environment is the bioaccumulation of heavy metal in tissues or muscles of some marine organisms (Saidon *et al.* 2024).
For this reason, it is very important to monitor the compliance of fish muscle contamination with established standards as it serves as an early warning indicator to assess heavy metal contamination or other related water quality problems and enable prompt actions to be taken to ensure safety of human health and the ecosystem (Jiang *et al.*, 2018). Singh *et al.* (2017) have also demonstrated that concentration of metal varied according to their species as accumulation was higher in some species than others.
Fish have enjoyed being used as subjects for testing as they are the most familiar organisms in the water and also due to their utility to man as a source of food (Derby & Sorensen, 2008). Therefore, this study provides the level of concentration of heavy metals in two fish species where *E. fimbriata* and *C. macropogon* are of commercial value within Ilaje Local Government Are of Ondo state. Yet, metal also occurs in trace amounts from the environment and is introduced through the ores, the dust resulting from the wind, the plant that may have fire and the earth as well (Tadesse *et al.* 2018).
This study was aimed at assessing the levels of heavy metals; Pb, Cu, Fe, Cd, Zn, and Mn in gills and muscles of *Ethmalosa fimbriata* and *Chrysichthys macropogon* found in the coastal waters of Ilaje Local Government Area of Ondo State, Nigeria, towards ecological protection. Heavy metals are considered a natural trace ingredient of aquatic ecosystems (Rahman *et al.*, 2013) and in suspended marine waters they are less concentrated as compared to the major cation and anion toxicity and bioaccumulation of lead and cadmium in marine, protozoa communities.
Apart from the natural sources of heavy metal pollution other sources include anthropogenic or human mediated such as industrial effluents from production, extraction, agricultural and metal plating industries. Other anthropogenic source are domestic waste waters, non-point and atmospheric precipitation (Pandey & Kumari, 2023).
Nevertheless, enhancement has been observed as a result of increased content of pollutants in the water bodies as well as in the tissues of water inhabiting individuals particularly fish (Kolarova & Napiórkowski, 2021). Despite some heavy

metals being appreciated as essential macro and trace elements especially at non adverse effect levels (Moghaddam *et al.*, 2020), such metals are capable of causing certain toxic effects at levels which is common in a polluted setting.
Also, metals unlike many organic pollutants are capable of being biopersistent in nature (Akram *et al*., 2023) and have a tendency to bioconcentrate up the food chain (Saidon *et al.* 2024), with levels in the topmost links of the food chain being higher than in the entire water column above them. In recent years, there is increasing willingness to use these fishes in the assessment of aquatic environmental systems integrity (Souza & Vianna, 2020).
Pollution of the environment has come up as one of the most important issues of science and society for more than fifty years now (Alumona & Onwuanabile, 2019). Some of these anthropogenic poisonous substances are also non-biodegradable, non-oxidizable and non-metabolizable, posing a significant environmental pollutant challenge to these compounds (Yusuf, 2021). Sustained exposure is likely to cause constitutional disturbances to man and animals including acute toxicity, cell (genetic) alterations, cancer and birth defects of man and animals (Yarkwan *et al.,* 2024).

MATERIALS AND METHODS

Study Area

The research was conducted in four coastal towns of Ilaje Local Government Area, Ondo State (Ayetoro, Bijimi, Idiogba, Asumogha). Ilaje Local Government Area is at the extreme southern part of Ondo State. Ilaje Local Government Area shares boundaries with Okitipupa Local Government Area in the North; the Atlantic Ocean in the South; Ijebu Waterside Local Government Area (Ogun State) in the West and Delta state in the East. It comprises of several fishing communities located within the river tributaries discharging into the Atlantic and those along the coastline (Bayode *et al.* 2015). The coastal areas of Ondo State consist of over five hundred settlements spreading over 3,000 km2. ILGA has the longest coastline in Nigeria (about 78 km) with long history in fishing dating back to the pre-colonial days (Bayode *et al.* 2015). The study area falls within Latitudes 6.00° and 6° 30'North and Longitudes 4° 45' and 5° 45' east of the Greenwich Meridian. The area is positioned within the equatorial evergreen swamp forest. There are over 80 fishing communities along the coastline and are the major fish producers in Ondo State (Bayode *et al.* 2015). A few of them (Ayetoro (06°06'N 04°46'E), Idiogba (06°05'N 04°47'E), Bijimi (06°04'N 04°49'E) and Asumogha (06°03'N 04°39'E) were purposely selected for this study based on extensive fishing activities in the towns and accessibility.
The coastal environment on the other hand has some population density because a number of areas all over the region have highest settlements that are more than 500 with the total area of 3000 km^2 as described by Bayode *et al.* (2015). The coastline coverage for Ilaje Local Government Area is around 78 km and it has recorded activities of people engaged in fishing much earlier than the colonial period. Practically, this area consists of` 80 fishing villages mostly dominant for fish farming activities and are the leading fish farmers in Ondo State (Saher *et al.,* 2023).
This region is in the Niger-delta where there is oil search activity in Nigeria. It includes rivers and streams which run through the various towns and empty out into the coastal ocean (Bight of Benin, Atlantic Ocean). The adjacent waters at the deeper mouth of the tributaries extend in a great area of salinity and this makes a main fishing zone for those who depend entirely on water for their living.

Collection of Fish Sample

Every month for four months period, sample collection was done in Ayetoro, Bijimi, Idiogba, and Asumogha using the fixed gillnet throughout the study with mesh sizes 0.6cm, 1.0cm, 2.0cm, 3.0cm and 4.0cm. The fish samples taken from each station, were kept in an insulated chest filled with ice and taken to the laboratory for identification by means of field guides including FAO (2014). The fishes were then killed, tagged and frozen at cooling temperature of 4^oC until they were needed for analysis.

Determination of Heavy Metal

The fishes were grouped in the laboratory according to their weight. Fair weight grouping was conducted, based on a review that was carried out to assess the actual distribution of fishes in the research sites as Group A: 0-50g; Group B: 51 – 100g; Group C: 101-151g; and Group D: 151-200g. All the fishes in each group were euthanized and the gills and muscles were removed with clean stainless-steel surgical in place of the vertebral column. The muscles and gills were oven dried at 105^0C to constant weight. The fish samples were thoroughly homogenized using a grinding mill to obtain powder form.
For drying, a rapid routine was performed in agreement with Crompton (2016) while taking the digest of the samples, the dried tissues of the muscles (0.1g) were carefully weighed and placed directly into pyrex volumetric glass of 100cm. $5cm^3$ of concentrated nitric acid was added, and the contents of beaker were covered and placed on hot plate at a temperature of 40^0C. After heating for fifteen minutes, another $5cm^3$ of concentrated nitric acid and $10cm^3$ of concentrated tetraoxosulphate (vi) acid was added and the plate was then open with the temperature gradually raised to 1000^0C.
The solution was allowed to cool after it had been boiled for twenty minutes and then heating the digested samples diluted with $10cm^3$ of distilled water. The resulting solutions were boiled until the food samples were dissolved and then allowed to cool.
The samples were transferred in $100cm^3$ volumetric flask to ions and filled in with distilled water to the cutting line. The digests were stored in plastic containers for fourteen days and heavy metal content was analyzed with the Varian AA.240FS Atomic Absorption Spectrophotometer (analyst 200/400 atomic absorption spectrophotometers).

Data Analysis

The data generated were analyzed using the Statistical Package for Social Sciences version 16.0 and One-way Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Table 1 presents the mean concentrations of heavy metals Pb, Cu, Fe, Cd, Zn, and Mn in gills of *E. fimbriata* in all the four study areas. In Table 2, concentrations of heavy metal in *E. fimbriata* muscle are presented. Likewise, concentrations of heavy metals in gills of *C. macropogon* are presented in Table 3. Table 4 presents concentrations of heavy metal in muscles of *C. macropogon* in all the four study areas. The gills of the fishes from Ayetoro give the highest mean values of concentration for Pb. The study found that *E. fimbriata* in Asumogha had the lowest Fe concentration while the fish samples from Bijimi had the highest concentrations. The findings further analyzed that Cd concentrations in *E. fimbriata* gill in Idiogba had the least levels, while the Bjimi concentration was the highest. The study reports that *E. fimbriata* gills contained the least amount of zinc in Ayetoro and the fish from Idiogba possessed the highest level of zinc concentration (2.095 ± 0.26mg/kg). The results showed that Mn was least concentrated in the *E. fimbriata* gills from fish obtained from Idiogba. The most concentration of Mn was found in *E. fimbriata* in Ayetoro. The maximum value of heavy metal concentration in the muscle of *E. fimbriata* in Asumogha which is the least (0.003±0.00mg/kg) and Ayetoro fishes have the maximum value (0.008±0.02mg/kg). *E. fimbriata* in Ayetoro has been shown to have the lowest concentration of Cu in its muscle. The lowest level was recorded in Asumogha and the highest level in Idiogba. Concentration level of Cd in muscle of *E. fimbriata* in Asumogha was the least while Idiogba showed the highest concentration. Lowest concentration of Zn was observed in Ayetoro while Idiogba had the highest concentration.

In the study, it appeared that the muscle of C. macropogon exhibited the least concentration of Pb with 0.002 ± 0.00mg/kg in Bijimi while the peak concentration was observed in Asumogha. Asumogha had the lowest concentration of Cu while the highest was encountered in Ayetoro.

The least concentration of Fe was reported in Asumogha, whereas the greatest was reported in fishes in Bijimi. The least concentration of Cd was located in Ayetoro. The least value of ZN concentration in muscle samples of *C. macropogon* was seen in group A in Ayetoro (1.644±0.53 mg/kg), the details of which are in table 4. The fish inhabiting Bijimi was noted to have a mean concentration of Zn of 2.040+/- 0.65 mg/kg.

The least value of Mn concentration in muscle of *C. macropogon* was recorded from Bijim (0.521±0.14mg/kg) i.e figure 25 while the mean concentration of Mn in the muscle of fishes from Asumogha was the highest (0.613±0.31mg/kg).

Table 1: Heavy metal Concentration in the gill of *Ethmalosa fimbriata*

Metal (mg/kg)	Asumogha	Ayetoro	Bijimi	Idiogba
Pb	1.093±0.60^{b}	1.328±1.02^{b}	1.319±0.42^{b}	0.923±0.52^{b}
Cu	0.708±0.18^{a}	0.665±0.26^{a}	0.782±0.24^{a}	0.742±0.15^{a}
Fe	2.644±0.45^{a}	2.737±0.63^{a}	2.748±0.36^{a}	2.699±0.66^{a}
Cd	0.163±0.17^{a}	0.127±0.24^{a}	0.352±0.34^{b}	0.106±0.20^{a}
Zn	1.919±0.38^{ab}	1.655±0.62^{a}	1.942±0.41^{ab}	2.095±0.26^{b}
Mn	0.790±0.41^{abc}	0.973±0.72^{c}	0.915±0.60^{bc}	0.588±0.33^{ab}

Means in the same row and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD.

Table 2: Heavy metal concentration in the Muscle of *Ethmalosa fimbriata*

Metal (mg/kg)	Asumogha	Ayetoro	Bijimi	Idiogba
Pb	0.003±0.00^{a}	0.008±0.02^{a}	0.004±0.00^{a}	0.004±0.01^{a}
Cu	0.708±0.18^{a}	0.665±0.26^{a}	0.780±0.24^{a}	0.721±0.20^{a}
Fe	2.644±0.45^{a}	2.737±0.63^{a}	2.754±0.36^{a}	2.810±0.48^{a}
Cd	0.009±0.02^{a}	0.007±0.01^{a}	0.003±0.00^{a}	0.018±0.05^{a}
Zn	1.919±0.38^{ab}	1.651±0.62^{a}	1.938±0.41^{ab}	2.077±0.24^{b}
Mn	0.563±0.19^{ab}	0.459±0.19^{a}	0.506±0.12^{a}	0.457±0.13^{a}

Means in the same row and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD.

Table 3: Heavy metal Concentration in the gill of *C. macropogon*

Metal (mg/kg)	Asumogha	Ayetoro	Bijimi	Idiogba
Pb	1.643±0.95^{b}	1.527±0.96^{b}	1.597±0.80^{b}	1.823±1.22^{b}
Cu	0.647±0.25^{a}	0.834±0.43^{a}	0.698±0.47^{a}	0.685±0.30^{a}
Fe	2.876±0.86^{a}	2.485±0.63^{a}	2.802±0.78^{a}	2.876±0.63^{a}
Cd	0.200±0.27^{abc}	0.060±0.13^{ab}	0.355±0.41^{c}	0.237±0.20^{bc}
Zn	1.873±0.49^{a}	1.644±0.53^{a}	1.979±0.72^{a}	1.910±0.72^{a}
Mn	1.157±0.58^{b}	0.868±0.67^{ab}	0.797±0.44^{a}	0.626±0.25^{a}

Means in the same row and with homogenous superscript are not significantly different (p>0.05); All values are expressed as Mean±SD.

Table 4: Heavy metal Concentration in the Muscle of *C. macropogon*

Metal (mg/kg)	Asumogha	Ayetoro	Bijimi	Idiogba
Pb	0.012±0.03^{a}	0.003±0.00^{a}	0.002±0.00^{a}	0.006±0.01^{a}
Cu	0.634±0.25^{a}	0.834±0.43^{a}	0.725±0.46^{a}	0.685±0.30^{a}
Fe	2.849±0.85^{a}	2.494±0.63^{a}	2.893±0.62^{a}	2.876±0.63^{a}
Cd	0.019±0.04^{a}	0.003±0.01^{a}	0.047±0.13^{ab}	0.008±0.02^{a}
Zn	1.860±0.49^{a}	1.644±0.53^{a}	2.040±0.65^{a}	1.910±0.72^{a}
Mn	0.613±0.31^{a}	0.546±0.18^{a}	0.521±0.14^{a}	0.537±0.11^{a}

Means in the same row and with homogenous superscript are not significantly different (p>0.05);
All values are expressed as Mean±SD.

Concentration of heavy metal across the four stations

The gills of the fishes from Ayetoro give the highest mean values of concentration for Pb. The Pb in the fishes sampled from all the sampling stations were found not to be significantly different. The concentration of heavy metal in *E fimbriata* from Bijimi was 0.782±0.24 mg/kg. The Cu concentrations in the gill of fishes from all the sampling stations tested were found to be not significantly different. The study found that *E. fimbriata* in Asumogha had the lowest Fe concentration while the fish samples from Bijimi had the highest concentrations. The study further analyzed the concentrations of Cd in the gill and established that *E. fimbriata* in Idiogba had the least levels, while that of Bijimi was the highest with no significant differences reported. The study reports that *E. fimbriata* gills contained the least amount of zinc in Ayetoro and the fish from Idiogba possessed the highest level of zinc concentration of 2.095 ± 0.26 mg/kg but the differences were not significant. The results showed that Mn was least concentrated in *E. fimbriata* gills obtained from Idiogba. The most concentration of Mn was found in Ayetoro fish in *E. fimbriata*. No significant differences were observed. The maximum value of heavy metal concentration in the muscle of *E. fimbriata* in Asumogha is the least (0.003±0.00 mg/kg) and Ayetoro fishes have the maximum value (0.008±0.02 mg/kg). Still, no significant change in fishes' muscle tissue concentration has been established. *E. fimbriata* in Ayetoro has been shown to have the lowest concentration of Cu in its muscle. Most studies showed that the highest concentration of Cu was in the muscle of *E. fimbriata* in Bijimi. On the other hand, the lowest level was recorded in Asumogha and the highest level in Idiogba. These findings were not statistically significant. As depicted in the table, concentration level of Cd in muscle of *E. fimbriata* in Asumogha was the least while Idiogba showed the highest concentration. Lowest concentration of Zn was observed in Ayetoro but Idiogba had the highest concentration. There was no significant variation in the least concentration levels of Mn observed in Idiogba and the most concentration in Asumogha. There was no significant difference in these concentrations across all the sampling stations. Results on the heavy metal concentrations in the gills of *C. macropogon* are summarized in Table 3. The lowest Pb concentration was observed in Ayetoro, while the highest in Idiogba. The lowest amount of Cu was recorded in Asumogha whereas the maximum came from Ayetoro. The least prevalence of Fe was obtained in Ayetoro and the peak in Asumogha. These concentrations were not statistically different at all the sampling stations. The table shows that there is significant variation in the concentration of Cd, Zn, and Mn in the gills of *C. macropogon* among the different sampling sites. In this case, the weakest concentration of this element has been detected in Ayetoro region while its highest was recorded in Bijimi region. In contrast, this least concentration was the same as that observed in Idiogba whereas that of Asumogha was the highest.

In the study, it appeared that the muscle of *C. macropogon* exhibited the least concentration of Pb with 0.002 ± 0.00 mg/kg in Bijimi while the peak concentration was observed in Asumogha. In the trace metal concentrations in fish muscle samples, as usual, Asumogha had the lowest concentration of Cu while the highest was encountered in Ayetoro.

The least concentration of Fe was reported in Asumogha, whereas the highest was reported in fishes in Bijimi. The least concentration of Cd was found in Ayetoro. The least value of Zn concentration in muscle samples of *C. macropogon* was seen in group A in Ayetoro (1.644±0.53 mg/kg), the details of which are in table 4. The fish inhahiting Bijimi was noted to have a mean concentration of Zn of 2.040+/- 0.65 mg/kg. The concentration of Zn in the muscle of the fishes in all the sampling stations was statistically at the same level ($p > 0.05$). The least value of Mn concentration in muscle of *C. macropogon* was recorded from Bijimi (0.521±0.14 mg/kg) while the mean concentration of Mn in the muscle of fishes from Asumogha was the highest (0.613±0.31mg/kg). Manganese was also comparable in the muscle of fishes sampled from all the sites with a p value of more than 0.05. Undie *et al.* (2019) and Olusola and Festus (2015) studies confirmed that heavy metal was also present in the organ of fish in Ilaje Local Government Area, that reveals a story of prosperity of heavy metals within the cellular tissues of biota dwelling in the coastal waters of Ondo State. On the other hand, samples for this study were taken from four major towns where fishing activities is predominant in Ilaje Local Government Area.

It is clear that, in the coastal waters, although heavy metal pollution of fish caused by oil exploitation is less than pollution by man-made and other geo-chemical processes, pollution indices showed that the levels of Cd in all the fish samples also did not exceed the NCBP and the FEPA level of 2.1 per gram of fish or 0.5 mg/kg for predatory birds (Akan *et al.,* 2012). In the present study the concentration of Manganese and Iron in both species was above FAO/WHO Permissible limits across the research area and therefore this is a treat to the fishes over a period causing bio accumulation. Earlier studies conducted by Abdus-Salam *et al.* (2010) at Ugbonla and other axis of Ilaje indicate high levels of heavy metals concentrations than this present study.

Heavy Metal Concentration in Fish

Concentrations of Lead (Pb) in the gill and muscle tissues of two studied ichthyological species *E. fimbriata* and *C. macropogon* showed significant differences ($P<0.05$) across the four sites. the acceptable limit of Lead (Pb) in the gill tissue of *E. fimbriata* and *C. macropogon* was still within the allowable limit of 2 mg/kg of FAO (FAO, 1990). The inclusive findings were in accordance with the Author's report on Odofia *et al*. (2015) which fished out marine fishes from Ondo State, Nigeria concomitantly.

Gills are generally exposed to the atmosphere and are assisted organs including water loss (Sonone *et al.,* 2020). Hence why it does not even exist in low concentrations would still have adverse effects on living systems (Zhang & Reynolds, 2019). The magnitude of Cd associated in the study areas were characteristic descript of considerable health risk to most of the fishing consumers at the survey area and many more according to Abdul-Baki *et al.* (2024).

The mean concentrations of Cadmium in both fish species were also at the equivalent of the WHO/FAO maximum tolerance limit of 0.2 mg/kg. The concentration of Mn were above the biological permissible limit of 0.5mg/kg set by the FAO/WHO throughout the study area in both species and this could be because of human interference such as washing or swimming or bathing or transportation or waste disposal activities that perpetually raise the heavy metals levels in the water resources as opined by Adesiyan (2018).

Similarly, population increase, urbanization, industrial activities and agricultural practices further compounded the situation (Popoola et *al.,* 2019). The observed concentration levels of Mn and Fe in this study were also comparable to the values reported for Akinmoladun *et al.* (2022) in Epe Lagoon. However, inappropriately low rates of egestion of consumed particles can also cause toxicants to build up in the tissues of fish species (Garai *et al.* 2021). Essential minerals for growth and healthy maintenance of all the faunal species include Zinc

(Zn), Copper (Cu) and Manganese (Mn). However, they exert harmful actions when administered or present in concentrations than what is acceptably normal (Du Plessis *et al.*, 2015).

The concentration levels of all the heavy metal in the two fish species (*E. fimbriata* and *C. macropogon*) from the studied area are however within the upper allowable limit warranted by the report of WHO (2011), which agreed with the report of Olayinka-Olagunju, 2021 in the water except Pb and Mn that were due to the higher internal burden of bio-concentrating ability of the two metal and so have to be controlled or extended disposal into the oceanic waters as Iron (Fe) is a serious health risk.

CONCLUSION

Some studies have been conducted in Ilaje LGA of Nigeria to determine the heavy metal content in different fish species. Yet, there have been no cases reported where nutrition or water from this region and its fisheries led to metal poisoning. The present results showed that the metal concentrations were lowest in muscle and highest in the gill due to physiological roles in fish metabolism as the gills are metabolically active. For that reason, the total concentration of heavy metal in the gills is more than that in the muscle due to lower metabolic activity on a daily basis in muscles. On the basis of result of the investigation at the same time, it was revealed that the levels of heavy metal like cadmium, zinc, copper and lead in *E. fimbriata* and *C. macropogon* exceeded the levels prescribed by FAO and WHO in gills but not in muscles while Mn and Fe in gills and muscles of both fish species from the study areas overstepped FAO/WHO limits and this has been associated with human-induced activities. *Chrysichthys macropogon* is the most abundant economic species of the fishery and its muscle in Ondo State coastal waters were found to be saddled with bio-heavy metal since the levels recorded were beyond the approved limits of various standards. Therefore, it is known that the fishes in the areas of study are in slightly polluted environment, and can pose a threat to the fishes over time. There is also concern for the movement and management of human activities in the coastline with the need for coordination by proper authorities for the run off waters to have minimal impact on the fish. Thus, the present study suggests continuous pollution assessment study of aquatic organisms in coastal waters of Ilaje LGA, Ondo State, Nigeria.

REFERENCES

Abdul-Baki, Z., Diab, A., & Yusuf, A. (2024). Strategic responses of the clients of multinational audit firms to corporate governance audit regulation. *Journal of Accounting Literature*. ISSN: 0737-4607

Abdus-Salam, N., Adekola, F. A., & Apata, A. O. (2010). A physicochemical assessment of water quality of oil producing areas of Ilaje, Nigeria. *Advances in Natural and Applied Sciences*, *4*(3), 333-345. http://www.aensi.org/anas.html

Adesiyan, I. M., Bisi-Johnson, M., Aladesanmi, O. T., Okoh, A. I., & Ogunfowokan, A. O. (2018). Concentrations and human health risk of heavy metals in rivers in Southwest Nigeria. *Journal of Health and pollution*, *8*(19), 180907.

Akan, J. C., Mohmoud, S., Yikala, B. S., & Ogugbuaja, V. O. (2012). Bioaccumulation of some heavy metals in fish samples from River Benue in Vinikilang, Adamawa State, Nigeria.

Akinmoladun, A., Aganwonyi, I., Nwankwo, E., Ayadi , P., & Omonmhenle , S. (2022). Heavy metals investigation in Sarotherodon melanotheron obtained from Ayetoro River, Ilaje, OndoState. *Journal of Scientific Research and Development*, *21*(2), 1-11. Retrieved from http://jsrd.unilag.edu.ng/article/view/1760

Akram, S., Muzaffar, A., & Farooq, Q. (2023). Persistent organic pollutant fragile effects, their sources, transportation and state of the art technologies. *International Journal of Agriculture and Environment*, *2*(2), 26-45. https://doi.org/10.62881/ijae.v2i2.33

Ali, H., & Khan, E. (2018). Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. *Environmental chemistry letters*, *16*(3), 903-917.

Alumona, I. M., & Onwuanabile, K. M. (2019). Environmental insecurity in Nigeria. *Internal Security Management in Nigeria: Perspectives, Challenges and Lessons*, 181-213.

Badejo, A. A., Ndambuki, J. M., Kupolati, W. K., Adekunle, A. A., Taiwo, S. A., & Omole, D. O. (2015). Appraisal of access to safe drinking water in southwest Nigeria. *African Journal of Science, Technology, Innovation and Development*, *7*(6), 441-445.

Bayode, P. O., Olabode, T. A., & Taiwo, T. A. (2018). Consumer’s preference and perception of smoke-dried white shrimp (Nematopalaemon hastatus) in coastal areas of Ondo State, Nigeria. *International Journal of Fisheries and Aquaculture*, *10*(3), 22 33. https://doi.org/10.5897/ijfa2017.0661

Chen, H. G., & Zhang, Y. H. P. (2015). New biorefineries and sustainable agriculture: Increased food, biofuels, and ecosystem security. *Renewable and Sustainable Energy Reviews*, *47*, 117 132. https://doi.org/10.1016/j.rser.2015.02.048

Derby, C. D., & Sorensen, P. W. (2008). Neural processing, perception, and behavioral responses to natural chemical stimuli by fish and crustaceans. *Journal of chemical ecology*, *34*, 898-914. DOI:10.4236/ajac.2012.311097

Du Plessis, E., Korsten, L., Buys, E., Pillay, B., & Taylor, M. (2015). Investigation into the link between water quality and microbiological safety of selected fruit and vegetables from farming to processing stages (Volume 1). *WRC Report*.

FAO (2020): Tracking progress on food and agriculture-related SDG indicators 2020 - A report on the indicators under FAO custodianship.

Garai, P., Banerjee, P., Mondal, P., & Saha, N. C. (2021). Effect of heavy metals on fishes:Toxicity and bioaccumulation. *J Clin Toxicol. S*, *18*.

Gautam, P. K., Gautam, R. K., Banerjee, S., Chattopadhyaya, M. C., & Pandey, J. D. (2016). Heavy metals in the environment: fate, transport, toxicity and remediation technologies. *Nova Sci Publishers*, *60*, 101-130.

Gikundi, J. (2014). *Planning for sustainable utilization and conservation of urban river corridors in Kenya: A Case Study* *of the Nairobi River* (Doctoral dissertation, University of Nairobi). http://hdl.handle.net/11295/74277

Idris, M. G., Umaru, D., Aliyu, A. N., & Musa, I. H. (2022). Atomic absorption spectroscopy analysis of heavy metals in water at Daura gypsum mining site, Yobe state, Nigeria. *Journal for Foundations and Applications of Physics*, *8*(2), 227-234.

Javed, M., & Usmani, N. (2019). An overview of the adverse effects of heavy metal contamination on fish health. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *89*, 389-403. https://doi.org/10.1007/s40011-017-0875-7

Jiang, Y., Yang, X., Liang, P., Liu, P., & Huang, X. (2018). Microbial fuel cell sensors for water quality early warning systems: Fundamentals, signal resolution, optimization and future challenges. *Renewable and Sustainable Energy Reviews*, *81*, 292-305. https://doi.org/10.1016/j.rser.2017.06.099

Kolarova, N., & Napiórkowski, P. (2021). Trace elements in aquatic environment. Origin, distribution, assessment and toxicity effect for the aquatic biota. *Ecohydrology & Hydrobiology*, *21*(4), 655-668. https://doi.org/10.1016/j.ecohyd.2021.02.002

Lipy, E. P., Hakim, M., Mohanta, L. C., Islam, D., Lyzu, C., Roy, D. C., ... & Abu Sayed, M. (2021). Assessment of heavy metal concentration in water, sediment and common fish species of Dhaleshwari River in Bangladesh and their health implications. *Biological Trace Element Research*, *199*, 4295-4307. ISSN 0974-8431, 1551-1560

Łuczyńska, J., Pietrzak-Fiećko, R., Purkiewicz, A., & Łuczyński, M. J. (2022). Assessment of fish quality based on the content of heavy metals. *International Journal of Environmental Research and Public Health*, *19*(4), 2307. 10.3390/ijerph19042307

Moghaddam, M., Mehdizadeh, L. & Sharifi, Z. Macro- and microelement content and health risk assessment of heavy metals in various herbs of Iran. *Environ Sci Pollut Res* 27, 12320–12331 (2020). https://doi.org/10.1007/s11356-020-07789-2

Obasi, P. N., & Akudinobi, B. B. (2020). Potential health risk and levels of heavy metals in water resources of lead–zinc mining communities of Abakaliki, southeast Nigeria. *Applied Water Science*, *10*(7), 1-23. https://doi.org/10.1007/s13201-020-01233-z

Okereafor, U., Makhatha, M., Mekuto, L., Uche-Okereafor, N., Sebola, T., & Mavumengwana, V. (2020). Toxic metal implications on agricultural soils, plants, animals, aquatic life and human health. *International journal of environmental research and public health*, *17*(7), 2204. 10.3390/ijerph17072204

Olayinka-Olagunju, J. O. (2021). Analysis and potential ecological risk assessment of heavy metals in surface water and sediments of Owena River Ondo State. *FUTA Journal of Research in sciences*, *1*(1), 39-53.

Olusola, J. O., & Festus, A. A. (2015). Assessment of heavy metals in some marine fish species relevant to their concentration in water and sediment from coastal waters of Ondo State, Nigeria. *Journal of Marine Science. Research & Development*, *5*(2), 1.

Olusola, J. O., & Festus, A. A. (2015). Levels of heavy metal in some selected fish species inhabiting Ondo State coastal waters, Nigeria. *Journal of Environmental & Analytical Toxicology*, *5*(5), 303. https://doi.org/10.4172/2161-0525.1000303

Pandey, S., & Kumari, N. (2023). Impact assessment of heavy metal pollution in surface water bodies. *Metals in Water*, 129-154. https://doi.org/10.1016/B978-0-323-95919-3.00004

Popoola, O. O., Olajuyigbe, A. E., & Rowland, O. E. (2019). Assessment of the implications of biodiversity change in the coastal area of Ondo State, Nigeria. *Journal of Sustainable Technology*, *10*(1).

Rahman, M. S., Saha, N., Molla, A. H., & Al-Reza, S. M. (2013). Assessment of Anthropogenic Influence on Heavy Metals Contamination in the Aquatic Ecosystem Components: Water, Sediment, and Fish. *Soil and Sediment Contamination: An International Journal*, *23*(4), 353-373. https://doi.org/10.1080/15320383.2014.829025

Saher, N., Maljavac, S., Tomurad, A., Tikel, S., Gavran, P., Germuth, J., Lovricevic, F., Saher,N. U., Taha, Z., Ajibare, A., Olawusi-Peters, O., Akinola, J., Van, G., Dinh, Q., Van Tran, G., Lombardía, M., García-Florez, L., Rodríguez, E., Juan, Y., & Pichs, B. (2023). Pertinent and traditional approaches towards fishery. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.94733

Saidon, N. B., Szabó, R., Budai, P., & Lehel, J. (2024). Trophic transfer and biomagnifications potential of environmental contaminants (heavy metals) in aquatic ecosystems. *Environmental pollution*, *340*, 122815. https://doi.org/10.1016/j.envpol.2023.122815

Shahjahan, M., Taslima, K., Rahman, M. S., Al-Emran, M., Alam, S. I., & Faggio, C. (2022). Effects of heavy metals on fish physiology–a review. *Chemosphere*, *300*, 134519. https://doi.org/10.1016/j.chemosphere.2022.134519

Sonone, S., Jadhav, S., Sankhla, M., & Kumar, R. (2020). Water Contamination by Heavy Metal and their Toxic Effect on Aquaculture and Human Health through Food Chain. *Letters in Applied NanoBioScience*, *10*(2), 2148–2166. https://doi.org/10.33263/lianbs102.21482166

Souza, G. B. G., & Vianna, M. (2020). Fish-based indices for assessing ecological quality and biotic integrity in transitional waters: A systematic review. *Ecological Indicators*, *109*, 105665. https://doi.org/10.1016/j.ecolind.2019.105665

Tadesse, M., Tsegaye, D., & Girma, G. (2018). Assessment of the level of some physic chemical parameters and heavy metals of Rebu river in oromia region, Ethiopia. *MOJ Biology and Medicine*, *3*(3), 99-118.

Undie, U. U., Eneji, I. S., & Khan, M. E. (2019). Assessment of Heavy Metals in Water and Fishes of Oyo Field and Ilaje Coastal Waters, Ondo State, Nigeria. *Environmental & Earth Sciences Research Journal*, *6*(3).

WHO (World Health Organization) (2011). *Guidelines for drinking-water quality* (4th ed., http://www.whqlibdoc.who.int/publications/2011/9789241548151_eng.pdf). Geneva.

Yarkwan, B., Isaac, T. O., Okopi, A., & Izah, S. C. (2024). Evidence of the Toxic Potentials of Agrochemicals on Human Health and Biodiversity: Carcinogens and Mutagens. In *Food Safety and Quality in the Global South* (pp. 331-359). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-2428-4_11

YUSUF, Abdulwasiu Adewale. "IMPACT OF ANTHROPOGENIC ACTIVITIES ON WATER QUALITY AND ITS HEALTH IMPLICATIONS IN PARTS OF MINNA METROPOLIS, NIGER STATE, NIGERIA." PhD diss., 2021.

Zafarzadeh, A., Bay, A., Fakhri, Y., Keramati, H., & Hosseini Pouya, R. (2018). Heavy metal (Pb, Cu, Zn, and Cd) concentrations in the water and muscle of common carp (Cyprinus carpio) fish and associated non-carcinogenic risk assessment: Alagol wetland in the Golestan, Iran. *Toxin reviews*, *37*(2), 154-160.

Zhang, H., & Reynolds, M. (2019). Cadmium exposure in living organisms: A short review. *Science of the Total Environment*, *678*, 761-767. https://doi.org/10.1016/j.scitotenv.2019.04.395