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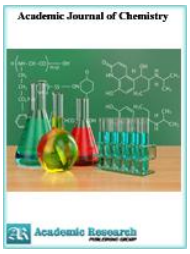


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# Assessment of Heavy Metals in Muscle of Tilapia *zilli* from Some Nun River Estuaries in the Niger Delta Region of Nigeria

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**Abstract:** This study investigated the heavy metal concentration in muscle of Tilapia *zilli* from River Nun in Bayelsa state, Nigeria. The samples were collected from the brackish environment in the Nun river estuary. Tilapia *zilli* were collected from creek lines traversing five communities at Obama, Tebidaba, Clough creek, Ogbainbiri and Samabiri. The samples were preserved in ice chest and transported to the laboratory. The fish samples were prepared by oven-drying, dry-ashing and digested using a mixture of 5 ml of 1 N nitric acid and 10 ml of 1 N hydrochloric acid, afterwards, the acid digest was filtered and made up to 20 ml by diluting to volume with distilled water. The fish sample digests were analyzed using flame atomic absorption spectrometry. Result of the fish ranged from 0.380 – 21.555mg/kg (lead), <0.001 mg/kg (copper), 0.190 – 1.670 mg/kg (chromium), 0.290 – 22.67 mg/kg (manganese), 2.785 – 30.340 mg/kg (zinc), 40.860 – 195.905 mg/kg (iron) and 0.205 – 1.145 mg/kg (nickel). Statistically, there was significance difference ($P<0.05$) in the fish collected from the different locations apart from copper. The heavy metal concentration were above the limits recommended by various agencies including Food and Agricultural Organization/ World Health Organization, Median international standard, European Union, United States Environmental Protection Agency and Water Pollution Control Legislation. The high concentration of heavy metals above permissible level suggests the need for caution during the consumption of Tilapia *zilli* from the Nun estuary due to health implications associated with heavy metals.

**Keywords:** Water pollution; Bioaccumulation; Fisheries; Nun river; Tilapia *zilli*.

## 1. Introduction

Environmental pollution is a major threat to environmental sustainability. The environmental components that are frequently contaminated by anthropogenic activities to a large extent and natural effects to a lesser extent, are water (aquatic ecosystem) [1-5], soil [6] and air (gaseous emissions). The aquatic ecosystem are mainly affected by several factors including runoff after precipitation, wastes of all categories deposited directly into the river and other anthropogenic activities carried out in the water ways including activities of market wastes [5, 7], food processing such as cassava and oil palm processing wastes, abattoir wastes, sewage resulting from pier toilet system, activities of oil and gas in offshore. Run off could emanate from improper discharge of used materials and wastes deposited in the soil including the used and empty cans of pesticides not properly discharged [8-10].

The aquatic ecosystem is a vital resource required for the sustenance of live. For instance, aquatic ecosystem is the home of several diversity of fishes (fin and shelled fish) [11], source of potable water especially in region that groundwater/ borehole is unavailable [12-14], domestic water for washing, cooking, bathing especially in rural areas [15], route of movement through canoeing, boating, source of sand for construction works through dredging [1]. The role of water resources depends on its types which is marine, estuarine and freshwater. The freshwater is mainly used for domestic purpose.

During human activities in surface water, it gets contaminated and alters the physical, chemical and microbiological components of the water. The variation mainly depends on the source of the contaminants. The pollutants also affected the water sediment [16, 17] and bioaccumulate in the fish species in such water bodies [2, 18-22].

One of the frequent contaminants of water resources is the heavy metals which fishes are known to bioaccumulate in their body parts including the liver, kidney, muscle, bones and gills [22]. Typically, heavy metals are metals whose specific gravity is $\geq 5$ g/cm$^3$ [and or 5 times denser than the density of water [2, 12, 22-24]. Some of the heavy metals are essential (chromium, copper, zinc, manganese etc) and as such are required by the body at certain concentrations. But when their concentrations exceed allowable limits they could be deleterious in the body

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just like the non-essential metals such as lead, cadmium, arsenic, mercury etc. Several diseases have been linked to heavy metal toxicity depending on the route of exposure, specific metals and concentration [2, 12, 22].

Fishes from the wild are a major source of livelihood in the coastal region of Niger Delta especially to the indigenous people of Bayelsa state [25]. Fishes are typically a major source of animal protein [26]. As such most of the fishes caught in the wild in Nigerian water ways are consumed as food just as the ones reared in home stead ponds.

In Nigeria several studies have been carried out on the concentration of heavy metals in fish species caught from several water resources [2, 11, 18-22]. Specifically some study have been carried out in the Nun river especially for *Clarias garepinus* [20], *Citharinus citharus* and *Synodontis clarias* at the Amassoma axes in Southern Ijaw local government area [18], *Clarias camerunensis* and *Oreochromis niloticus* in Ekpetiama axes in Yenagoa Local government Area [2]. Therefore, this present study is aimed at assessing heavy metal concentration in *Tilapia zilli* caught from the Obama, Tebidaba, Clough creek, Ogbainbiri and Samabiri communal estuaries of the Nun river system in Bayelsa state, Nigeria. The results were compared with various regulatory standards by Median international standard (MIS), European Union [27], Food and Agricultural Organization/ World Health Organization [28]; United State Environmental Protection Agency [29]; Water Pollution Control Legislation [30] and World Health Organization (WHO) limits.

# 2. Materials and methods

## 2.1. Study Area

Nun river is one of the major rivers in the Niger Delta region of Nigeria. Five communities under study namely: Obama, Tebidaba, Clough creek, Ogboinbiri and Samabiri exist as tributaries of the Nun river in Bayelsa state, Nigeria. The Nun river flows for about 160 km south to the gulf of Guinea, a wide inlet of the Atlantic ocean at Akassa. The main course of the river lies between the coordinates of latitude 5.298847$^{o}$N and longitude 6.414350$^{o}$E [31]. Over the years, the increase in oil and gas exploration activities as well as other anthropogenic input of which illegal oil bunkering, boat transportation and the indiscriminate discharge of municipal waste among others relatively constitute significant environmental aspects of the Nun river and substantially influences the environment. Some of the Nun river tributaries lead to host communities for some of the oil industries in Nigeria. The estuarine is characterized by vast wetlands, mudflats and grassy lakes which are usually covered by oil sheen depending on the water tide. The region lies in the sedimentary basin. The study area depicts climatic conditions similar to the rest of the Niger Delta; it is characterized by two distinct seasons viz: wet and dry season. The temperature and relative humidity of the area is 30 ± 7$^{o}$C and 50 – 95 %, respectively all year round.

## 2.2. Sample Collection, Preparation and Analysis

Replicate samples of *Tilapia zilli* caught by local fisherman in were purchased each of the communities at River nun, Bayelsa state were purchased. The fish samples were transported to the laboratory in an ice chest.

## 2.3. Sample preparation and Analysis

Fish tissues collected from each sampling location were dried in triplicate using a Memmert U27 type drying oven at a temperature of 70$^{o}$C for 24 hours. 2 g of dried samples were each transferred into clean porcelain crucibles and dry-ashed in an Oceanic SX-2 type muffle furnace at a temperature of 450$^{o}$C until the samples were grayish-ash. Samples were left to cool in a dessicator for about 30 minutes. A solution of the ash was prepared by adding 5 ml of 1 N nitric acid ($HNO_3$) and 10 ml of 1 N hydrochloric acid (HCl). A reagent blank containing acid mixtures used was prepared devoid of sample. All samples and reagent were aspirated into the GBC Avanta PM A6600 Flame Atomic Absorption Spectrophotometer (FAAS). Check standard solutions were read as quality assurance at the start, in-between and the end of each analysis sequence; this was also used to assess the repeatability of data on the instrument as percentage recovery was calculated and processed alongside the final metal concentration of test samples. Distilled water blank was run at the start of analysis. Analyte recovery was conducted on spiked tilapia fish sample in triplicates. The spiked samples were subjected to the same sample treatment and analysis method. The results showed good efficiency in analytes digestion and recoveries. The percentage recoveries and coefficient of variation of the spiked replicate samples were Pb, 86.84 – 90.29%, C.V 4.39 – 26.05%; Cr, 84.60 – 89.83%, C.V 6.77 – 21.76%; Mn, 91.88 – 93.12%, C.V 2.68 – 9.75%; Zn, 87.65 – 91.78%, C.V 4.07 – 17.01%; Fe, 94.97 – 98.06%, C.V 0.57 – 3.46%; Ni, 85.86 – 91.45%, C.V 5.17 – 17.25%; apart from Cu which was below the limit of detection (Refer to table 1).

## 2.4. Statistical Analysis

SPSS software version 20 was used to carry out the statistical analysis. Data were expressed as mean ± standard deviation. A one-way analysis of variance was carried out at P = 0.05, and Duncan multiple range test statistics was used to show source of variation among the means.

# 3. Results and Discussion

The level of heavy metals in *Tilapia zilli* caught from the Obama, Tebidaba, Clough creek, Ogbainbiri and Samabiri axes of the river Nun, Bayelsa state is presented in Table 1. Lead concentration ranged from 0.380 –

21.555 mg/kg, being significantly different among the various locations. The concentration in this study was higher than the concentration recommended for food fish by European Union (0.2 µg/g), [27, 32, 33], Median International Standard (2.0 µg/g) [27, 32-34], FAO/WHO (0.5mg/kg) [28, 35], USEPA (0.11mg/kg) [29, 36] WHO (0.11mg/kg) [36, 37] and WPCL (0.05mg/kg) [30, 36]. The findings of this study is also higher than the values previously reported in fishes from other rivers in the Niger Delta region of Nigeria including *Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera* from Warri river [21], *Cithrinus citharus* [18] and *Clarias garepinus* from Amassoma axises of Nun river [20], *Clarias camerunensis* and *Oreochromics niloticus* from Ikoli creek [19]. The variation compared to other studies could be due difference in anthropogenic activities in the area. Lead is one of the toxic elements which have no known use in the body. It could lead to loss of attention, hallucinations and delusions manifesting as poor memory and irritability especially in children [12, 38, 39], reduction in mental ability, learning difficulties, reduced growth, blood anemia, severe stomach ache, muscle weakness, and brain damage [12, 39].

**Table-1.** Concentration of heavy metals (mg/kg) in muscles of Tilapia zilli from Nun River, Bayelsa state, Nigeria.

| Locations | Lead, Pb (mg/kg) | Copper, Cu (mg/kg) | Chromium, Cr (mg/kg) | Manganese, Mn (mg/kg) | Zinc, Zn (mg/kg) | Iron, Fe (mg/kg) | Nickel, Ni (mg/kg) |
|---|---|---|---|---|---|---|---|
| **Obama** | 0.755±0.12a | <0.001±0.00 | 0.190±0.03a | 0.635±0.05a | 20.840±0.95b | 40.860±0.79a | 0.655±0.08b |
| **Tebidaba** | 1.455±0.18a | <0.001±0.00 | 1.670±0.11c | 1.640±0.09b | 2.785±0.47a | 61.015±0.35b | 0.205±0.04a |
| **Clough creek** | 0.380±0.10a | <0.001±0.00 | 0.785±0.15b | 0.290±0.03a | 30.340±1.45d | 47.790±1.66a | 0.975±0.78cd |
| **Ogbainbiri** | 21.555±0.97c | <0.001±0.00 | 0.950±0.109b | 22.670±0.61d | 3.305±0.23a | 179.790±3.03c | 0.820±0.04bc |
| **Samabiri** | 15.480±0.68b | <0.001±0.00 | 0.260±0.06a | 14.640±0.51c | 26.925±1.10c | 195.905±6.41d | 1.145±0.09d |

Data is expressed as mean± standard deviation; Different letters (a, b, c, d ----) along the column indicate significant difference [p= 0.05] according to Duncan Statistics

The chromium level ranged from 0.190 – 1.670 mg/kg. There was significant difference among the various locations. The concentration in this study was higher than the concentration recommended for food fish by Median International Standard (1.0 µg/g) [32-34]. The findings of chromium concentration in this study are also higher than the values previously reported in other locations of Nun river including Ikoli creek at (*Clarias camerunensis* and *Oreochromics niloticus*) [19]. Chromium is known for its strong oxidation properties ranging from -2 to +6 but only +3 and +6 are more stable in the environment [40]. Of these two, $Cr^{3+}$ is needed in human body at certain concentration and above that it could induce toxicity as well. $Cr^{6+}$ is highly toxic probably due to carcinogenic and teratogenic effects [40]. As such, high concentration of chromium could cause several diseases such as gastrointestinal, central nervous system disorder, cancer etc [12].

The concentration of iron ranged from 40.860 – 195.905 mg/kg. Typically, there was significance difference (P<0.05) among the various locations. The concentration in this study was higher than the concentration recommended for food fish by USEPA (0.5 mg/kg) [29, 36] WHO (0.30 mg/kg) [36, 37] and WPCL (0.45 mg/kg) [30, 36]. The findings of this study are also higher than the values previously reported in fishes (*Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera*) from Warri river in the Niger Delta region of Nigeria [21]. Heavy metals are harmful to the human body because they can accumulate inside the body and may have lethal effects even at low concentrations [12]. These effects may be carcinogenic, teratogenic, phytotoxic or synergistic [12]. High iron can cause adverse effects including gastrointestinal irritation, conjunctivitis, choroiditis, and retinitis, and chronic inhalation could lead to benign pneumoconiosis [6, 12, 24, 41]

The manganese concentration ranged from 0.290 – 22.67 mg/kg. Basically there was significance variation (P<0.05) among the various location. The concentration in this study was higher than the concentration recommended for food fish by USEPA (0.02mg/kg) [34, 35] WHO (0.50mg/kg) [36, 37] and WPCL (0.02mg/kg) [30, 36]. Excess manganese level could lead to interference in the absorption of dietary iron which can result in iron deficiency anemia respiratory system and brains disorder [12, 41].

The zinc concentration ranged from 2.785 – 30.340 mg/kg, being significantly different (P<0.05) among the various locations. The concentration in this study was higher than the concentration recommended for food fish by Median International Standard (45.0 µg/g) [32-34], FAO/WHO (40.0 mg/kg) [28, 35], USEPA (5.0 mg/kg) [29, 36], WHO (5.0 mg/kg) [36, 37] and WPCL (4.25 mg/kg) [30, 36]. The findings of this study is also higher than the values previously reported in fishes (*Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera*) from Warri river in the Niger Delta region of Nigeria [21]. High concentration of zinc from the consumption of food could lead to vomiting, muscle cramp and renal damage [12].

The nickel concentration ranged from 0.205 – 1.145 mg/kg, being significantly different (P<0.05) among the various locations. The concentration in this study was higher than the values reported in different *Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera* from Warri River as presented by Aghoghovwia et al. [21]. High concentration of nickel could be carcinogenic and toxic to various organs and part of the body [12, 42].

The level of copper was <0.001 mg/kg in all the locations. The concentration in this study was less than the concentration recommended for food fish by Median International Standard (20.0 µg/g) [32-34], FAO/WHO (30.0 mg/kg) [28, 35], USEPA (2.25 mg/kg) [29, 36] WHO (2.25 mg/kg) [36, 37] and WPCL (2.0 mg/kg) [30, 36]. The findings of this study is also lesser than the values previously reported in fishes (*Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera*) from Warri river in the Niger Delta region of Nigeria [21]. Copper concentration is below the level to cause toxicological distresses including vomiting, cramps, convulsions and worst still death.

The variation indicates different anthropogenic activities, contamination level in the area and fish species. [19, 20], [21] reported that biochemistry of fish affect the bioaccumulation of heavy metals. Furthermore, authors have variously reported that age/size of the fish, lipid content and feeding habits [2, 19, 22, 43], tissue/organ, exposure period, mechanisms of uptake, intrinsic factors could also affect bioaccumulation level in fisheries [2, 19, 22, 44]. [43], [22], [2] reported that the bioavailability, intrinsic fish processes and trophic structure of an aquatic ecosystem as well as differences in threshold values of each metal is a function of homeostasis in fisheries.

## 4. Conclusion

This study assessed the heavy metal concentration in *Tilapia zilli* caught from the Obama, Tebidaba, Clough creek, Ogbainbiri and Samabiri axis of the Nun river estuary in Bayelsa state, Nigeria. The study found that all the heavy metals were above the allowable/permissible level recommended for fish food specified by Food and Agricultural Organization/ World Health Organization, Median international standard and European Union apart from copper which was below measurable detection level. As such, the consumption of *Tilapia zilli* from the study area may induce toxicological effect associated with the bioaccumulation of heavy metals over a prolonged period of time. Therefore, it may be imperative that appropriate regulatory agencies strictly ensure the activities leading to possible water contamination and the relative bioaccumulation of heavy metals in fish tissues of *Tilapia zilli* collected within the study area is reasonably controlled to forestall further deleterious effects via biomagnification across the food chain.

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