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Assessment of Trace Elements Concentration in Tissues of Tilapia Fish (*Tilapia guineensis*) from Badagry Creek, Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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Short Research Article

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ABSTRACT

Aims: To determine trace element (Fe, Cu, Pb, Zn, Cr and Cd) concentrations in *Tilapia guineensis* tissues from Badagry creek, and to test hypotheses of (1) no significant difference in the element concentrations in muscle, liver, gill and kidney of *Tilapia guineensis* and (2) the observed concentrations in fish tissues do not exceed the limits in fish for human consumption.
Study Design: Stratified random sampling.
Place and Duration of Study: Designated fishermen landing points around Badagry creek, Nigeria. Quarterly between November, 2012 and September, 2013.
Methodology: I randomly sampled *Tilapia guineensis* from the fishermen catches in the selected landing points of Badagry creek. In the laboratory, extraction and digestion of tissues (muscle, liver, gills and kidney) of specimen fishes were done using standard methods. The concentrations of Fe, Cu, Pb, Zn, Cr and Cd in the digested fish tissues specimens (filtrate) for each set of samples were measured using Atomic Absorption Spectrophotometer (Spectra AA-240, Agilent Technologies) with air-acetylene flame.
Results: Mean concentrations in muscle, liver, gill and kidney respectively, expressed in mg/kg dry weight were 30.18, 122.29, 168.89 and 41.30 for Fe, 0.32, 5.27, 2.51 and 1.54 for Cu, 13.87, 15.10, 17.86 and 20.11 for Pb, 17.15, 15.32, 30.73 and 11.58 for Zn, 94.60, 98.93, 134.67 and 150.51 for

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Cr and Below Detection Limit (BDL), BDL, 0.06 and BDL for Cd. The concentration of iron in gills was significantly higher than liver, kidney and muscles (*P* =.02). Zinc concentration was also significantly higher in gills than in muscle, liver and kidney (*P* =.00). Average metal concentrations in muscle, liver, gill and kidney decrease in the following magnitude orders respectively: Cr>Fe>Zn>Pb>Cu>Cd; Fe>Cr>Zn>Pb>Cu>Cd; Fe>Cr>Zn>Pb>Cu>Cd; Cr>Fe>Pb>Zn>Cu>Cd. Element concentrations in fish edible tissues were below the FAO/WHO limits except for Pb and Cr.

Conclusion: The concentrations of Pb and Cr in examined edible fish were posing a public health hazard and calls for continuous monitoring by relevant authorities/agencies.

Keywords: Heavy metals; Tilapia guineensis; Badagry creek; concentrations; atomic absorption spectrophotometer.

1. INTRODUCTION

Nigeria is endowed with abundant water-bodies which form excellent environment for numerous fish species and other aquatic fauna and flora. However, these water bodies are subjected to multipurpose usage and therefore prone to various degrees of environmental pollution and degradation that are hazardous to fisheries resources and humans. Anthropogenic sources are usually responsible for a variety of different toxic substances in the environment. The fate for most environmentally persistent chemicals is the water column and sediment of aquatic ecosystems [1]. These chemicals go into the food chain through the processes of bioaccumulation and bio-magnification. Heavy metals pollution in aquatic environments and their uptake in the food chain by aquatic organisms put public health at risk [2].

The craving for fish is on the increase in Nigeria because of the touted health benefits of eating fish. Fish contains Omega III fatty acids that are known to reduce cardiovascular diseases, hypertension and arteriosclerosis, thus becoming a preferred source of animal protein for those nearing 50 years of age and above [3]. Fish is widely recognized as an excellent source of protein of very high quality. In spite of the significant role of fish in the diet of Nigerians, one of the challenges facing Nigeria today is that of ensuring sustainable fisheries development and subsequently ensuring seafood safety especially fish. Over last three decades, there has been increasing concern in the problem of accumulation of toxic metals to hazardous levels in aquatic biota [4,5,6]. Metals are naturally occurring elements but become contaminants if concentrations in the environment are altered from natural distributions through human activities. According to [7], excessive pollution of surface waters could lead to health hazards in man, either through drinking water or consumption of fish. [8] also stated that fish could accumulate trace metals and act as indicators of pollution.

Tilapia guineensis (Bleeker, 1862) is among the notable and highly demanded fish species for consumption in Badagry creek, Nigeria [2]. The creek is one of the coastal waters in the Barrier Lagoon Complex (an ecologically important lagoon system), Nigeria. *Tilapia guineensis* is frequently caught and largely eaten in Badagry and its environs, so their toxic metal content should be of concern to human health. In view of the paucity of information on heavy metals in the edible fish species from this water-body, the present study was undertaken to determine the concentration levels of selected elements Fe, Cu, Pb, Zn, Cr and Cd in the muscle, liver, gill and kidney tissues of Tilapia fish (*Tilapia guineensis*).

2. MATERIALS AND METHODS

2.1 Study Area

Badagry creek (Fig. 1) is located in Lagos state, Nigeria between longitude $2^{\circ}42^{1}$ and $3^{\circ}23^{1}$E and latitude $6^{\circ}23^{1}$ and $6^{\circ}28^{1}$N. The creek is situated in the westernmost region of the Barrier Lagoon Complex in Nigeria (Fig. 1). It is estimated to be more than 51 km from Lagos. The creek is fed mainly by River Ajara in the Republic of Benin and the Yewa River in Nigeria while it also links Ologe lagoon. Badagry creek empties into the Lagos harbour like other creeks and lagoons in the state. According to [9], the creek is influenced by tides and floods from the Lagos Lagoon and Cotonou harbour through Lake Nokue and Lake Porto-Novo. The climate is dominated by heavy rainy season which lasts from May to October and dry season from November to April. The rain is marked by two peaks in May to July and September to October [2].

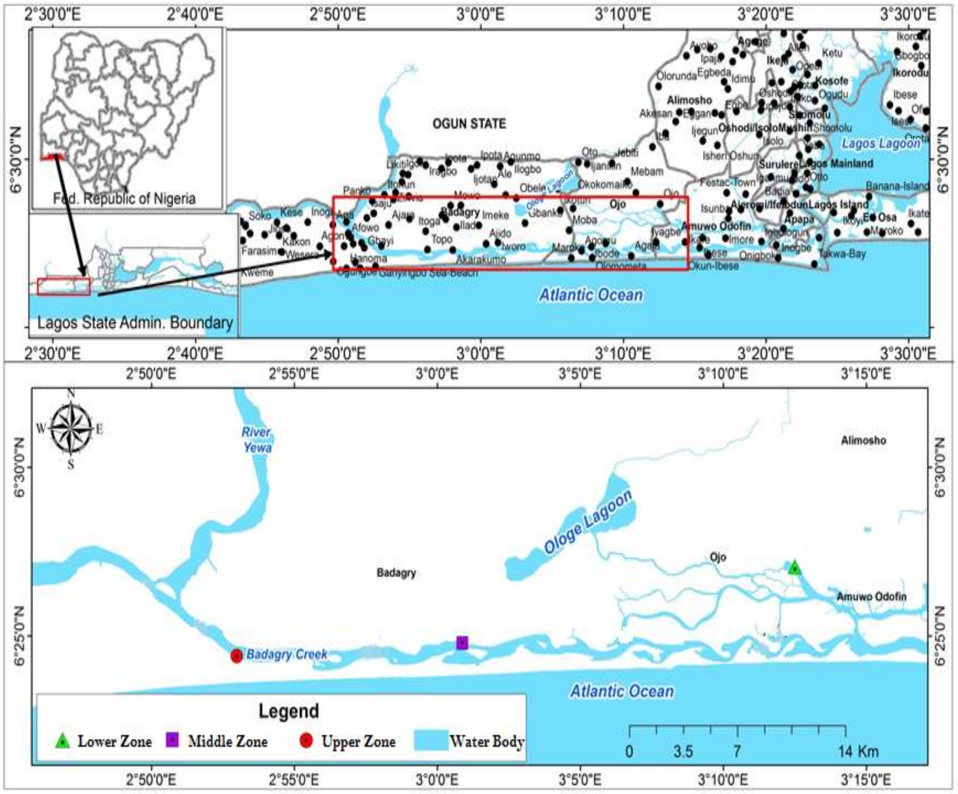

Fig. 1. Map of Badagry creek and its environs showing fishermen landing points represented by zones

2.2 Fish Sampling

The sampling and collection of investigated Tilapia fish (*Tilapia guineensis*) in the fishermen catches in the selected landing points were conducted between November 2012 and September 2013 on quarterly basis. Artisanal fishermen in this creek use plank canoes and deploy surface and bottom-set gillnets, cast-nets, ring-nets, drift-nets, and beach-seines for their fishing operations. Basically, the fish species (six to eight average–sized *Tilapia guineensis*) were randomly sampled from the fishermen landings and transported in a cooler containing ice to Nigerian Institute for Oceanography and Marine Research, Department of Biological Oceanography laboratory and refrigerated until dissection for various tissues.

2.3 Preparation of Fish Samples for Digestion

The preserved fish (*Tilapia guineensis*) specimens were thawed and wiped dry before laboratory analysis. All laboratory equipment and glassware for usage were cleaned (decontaminated) with HNO_3 10% (v/v) for 24 hours, then rinsed with distilled water and oven dried at 105℃ prior to sample preparation [10]. Some biometric data (total length in cm and weight in gram) of the fish species were taken. With the aid of a dissecting set, each of the fin-fishes was dissected between the pectoral fin and vent. The tissues (muscle, liver, gills and kidney) of the fin-fishes were extracted.

2.4 Digestion of Fish Samples for Determination of Trace Elements

Tilapia fish (*Tilapia guineensis)* separated tissues extracted were put in petri-dishes and dry at 120℃ until they reached a constant weight. Thereafter, 2 g of separated tissues were placed into digestion flasks and ultrapure Conc. HNO_3 and H_2O_2 (2:1 v/v) was added. The different tissues samples were digested in triplicates according to AOAC method [10]. The samples were left overnight at room temperature. The digestion flasks containing the mixture were then heated to 130℃ on a hot plate in a fume cupboard until dissolution and evaporated to 5ml. After total digestion and subsequent cooling, the digested solution was filtered through Whatman filter paper no. 1 into 25 ml volumetric flask [10]. The reaction vessels and watch glasses were rinsed with de-ionized water to recover any residual metals inside 25 ml volumetric flask and made up to the mark with de-ionized water. The sample solutions were stored in polyethylene bottles at 4℃ until analysis.

2.5 Determination of Trace Elements (Atomic Absorption Spectrophotometer)

2.5.1 Stock and working standard solutions

The stock solutions of Fe, Cu, Pb, Zn, Cr and Cd (1000 mg.L-1) were obtained by dissolving the appropriate metal salts (Analytical Grade) using nitric acid. Working standard solutions for system calibration and control of analytical accuracy were prepared from the stock solutions by serial dilutions in distilled water.

2.5.2 Calibration of instrument

The instrument calibration was done using working standard solutions of known and increasing concentrations for each analyte element of interest in order to determine the instrument signal response to changes in concentration. In measuring the signals of the working standards, the AAS constructs a suitable calibration curve of absorbance verses concentration. The AAS uses this suitable graph to determine concentrations of unkown analyte.

2.5.3 Sample analysis

The levels of Trace element (Fe, Cu, Pb, Zn, Cr and Cd) in the digested fish tissues specimens (filtrate) for each set of samples were measured using Atomic Absorption Spectrophotometer (Spectra AA-240, Agilent Technologies) with air-acetylene flame by comparing their absorbance's with those of standards (solutions of known metal concentration). All the instrumental adjustments had been as recommended in the manual by the manufacturer. For Quality Assurance/Quality Control (QA/QC) purposes, AAS standard solutions (factory prepared) were run as samples for accuracy check after every five samples measurements [10]. The results were expressed in milligrams of metal per dry weight kilogram of fish tissues (mg/kg).

2.6 Statistical Analysis

Data generated from this study were subjected to descriptive statistics and inferential statistics using SPSS 15 software for windows evaluation version. All data were tested using normality and equal variance tests. Data were then subjected to one way analysis of variance (ANOVA) and significant differences accepted at $P \leq 0.05$ [11]. Mean values were separated with Tukey's HSD multiple range tests where significant differences were found. Additionally, to determine public health hazard associated with fish consumption, element concentrations in edible tissues (mg/kg) were compared to the Maximum Acceptable Levels (MAL) as set by the FAO/WHO [12,13].

3. RESULTS AND DISCUSSION

Heavy metal concentrations in the muscles, livers, gills and kidneys of *Tilapia guineensis* from Badagry creek, Nigeria are presented in Table 1. The total length and weight of *Tilapia guineensis* sampled ranged from 16.5 cm to 24.5 cm and from 62.5 g to 222.5 g, respectively. The standard deviation values obtained (Table 1) were as a result of wide variations in the concentrations. Heavy metals occur naturally in the ecosystem with large variations in concentrations [2].

The results of this study showed that the concentration of trace elements in fish (*Tilapia guineensis*) varies with the different tissues of the fish. This could be as a result of different affinity of metals to fish tissues, different uptake, deposition and excretion rates [14]. According to [15], heavy metal concentrations in the tissues of fish vary due to differences in metal concentrations and chemical characteristics of water from which fish are sampled, their ecological needs; metabolism and feeding habits.

The concentration of Iron in the fish (*Tilapia guineensis*) ranged from 18.93 to 44.32 mg/kg (muscle), 25.78 to 256.85 mg/kg (liver), 75.52 to 209.01 mg/kg (gill) and 32.95 to 51.84 mg/kg (kidney). Iron concentration (Table 1) in gills (168.89 ± 62.68mg/kg) was significantly higher than liver, kidney and muscles (P = .02). Muscles had the minimum iron concentration (30.18 ± 11.14 mg/kg) among the tissues. The Fe concentrations in fish tissues in this study compared well with the values reported in catfish (*Chrysichthys nigrodigitatus)* from Badagry creek

[16]. However, they were higher than values recorded for the same fish species from Lagos Lagoon [17], and those reported in some tissues of *Leuciscus Cephalus* from Karasu River, Erzurum-Turkey [18], but lower than levels recorded in various organs of *Tilapia mossambicus* from Industrially Polluted Patalganga River, India [19]. The levels of Fe in the tissues of fish studied were in the order: Gill > Liver > Kidney > Muscle. Similar trend was reported for cat fish (*Chrysichthys nigrodigitatus*) in Badagry creek [16]. The high value of Fe observed in this study may be due to increase in total dissolved iron in the creek. Iron is one of the most abundant metals in the Earth's crust. However, Fe is not considered as toxic to aquatic organisms. It is essential to all organisms, except for a few bacteria. Its distribution is heavily regulated in mammals and excess of it in the body causes liver and kidney damage (haemochromatosis).

The levels of total detectable Copper (Table 1) in the fish (*Tilapia guineensis*) varied from 0.18 to 0.52 mg/kg (muscle), 0.05 mg/kg to 11.99 mg/kg (liver), BDL to 4.98 mg/kg (gill) and 0.79 to 3.09 mg/kg (kidney). Among the four tissues investigated, liver showed higher ability to accumulate copper than gill, kidney and muscle. The difference was, however, non- significant (*P* = .19). The Cu concentrations in tissues of fish examined compared well with concentrations reported in *Chrysichthys nigrodigitatus* tissues from same water body [16]. However, they were higher than Cu values recorded in tissues of tilapia fish from Tono irrigation reservoir in Ghana [20], but were lower than Cu concentrations reported in different tissues of mudfish (*Parachanna obscura)* from Ogba River, Benin city, Nigeria [21], and those recorded in Tilapia (*Oreochromis niloticus*) of Northern delta lakes, Egypt [22]. Copper is acutely toxic to most forms of aquatic life at relatively low concentrations. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys and acute chronic damage to the nervous system. Copper concentrations in the fish tissues studied were in the order: Liver > Gill > Kidney > Muscle. The low level of copper in fish muscles could be due to low levels of binding proteins in the muscles [23]. However, the mean concentrations of copper in the fish tissues (Table 2) were below the Maximum Acceptable Levels (MAL) prescribed by [12,13].

Lead concentration in the fish (*Tilapia guineensis*) was from 9.58 to 23.77 mg/kg (muscle), 8.81 to 25.49 mg/kg (liver), 13.52 to 27.36 mg/kg (gill) and 15.39 to 24.68 mg/kg (kidney) throughout this study (Table 1). The Lead values in the various fish tissues investigated were high and exceeded the Maximum Acceptable Levels (MAL) of 0.5 mg/kg dry weight prescribed by [12,13] (Table 2). The possible increase in automobile traffic emissions from lead tetraethyl in petroleum and emissions from heavy duty generators around the Badagry creek catchment could have contributed

Table 1. Trace element concentrations in *Tilapia guineensis* species tissues from Badagry creek (November, 2012 – September, 2013)

Metals (mg/kg)	Muscle (Range) Mean ± SD	Liver (Range) Mean ± SD	Gill (Range) Mean ± SD	Kidney (Range) Mean ± SD	*P* Value
Fe	(18.93 – 44.32) 30.18 ± 11.14^{B}	(25.78 - 256.85) 122.29 ± 107.33$^{A\ B}$	(75.52 - 209.01) 168.89 ± 62.68^{A}	(32.95 - 51.84) 41.30 ± 7.85$^{A\ B}$	*P* = .02
Cu	(0.18 – 0.52) 0.32 ± 0.16^{A}	(0.05 - 11.99) 5.27 ± 5.68^{A}	(BDL - 4.98) 2.51 ± 2.18^{A}	(0.79 - 3.09) 1.54 ± 1.07^{A}	*P* = .19
Pb	(9.58 - 23.77) 13.87 ± 6.70^{A}	(8.81 - 25.49) 15.10 ± 7.25^{A}	(13.52 - 27.36) 17.86 ± 6.48^{A}	(15.39 - 24.68) 20.11 ± 4.39^{A}	*P* = .52
Zn	(13.24 - 22.12) 17.15 ± 3.68^{B}	(7.60 - 23.40) 15.32 ± 7.21^{B}	(27.00 - 34.22) 30.73 ± 2.99^{A}	(8.78 - 15.91) 11.58 ± 3.32^{B}	*P* = .00
Cr	(22.36 - 176.42) 94.60 ± 78.11^{A}	(16.79 - 193.51) 98.93 ± 86.97^{A}	(49.82 - 217.64) 134.67 ± 94.24^{A}	(48.61 - 210.59) 150.51 ± 70.68^{A}	*P* = .73
Cd	BDL BDL	BDL BDL	(BDL – 0.06) 0.06 ± 0.03	BDL BDL	

Fe: iron; Cu: copper; Pb: lead; Zn: zinc; Cr: chromium; Cd: cadmium. Values expressed in Mean ± SD are of 4 replicates. BDL: Below detectable limit.

Means that do not share a letter are significantly different. (P value less than or equal to .05 signifies significant difference, while values greater than .05 signifies no significant difference) to the elevated Lead concentration. Lead concentrations in tissues of fish examined in this study compared well with concentrations reported in Cat fish *Chrysichthys nigrodigitatus* tissues from same water body [16], and in the same fish species from Lagos Lagoon [17], but higher than values reported in mudfish (*Parachanna obscura*) tissues from Ogba River, Benin city, Nigeria [21], and in *Tilapia guineensis* organs of the Nokoué Lake, Southern Benin [14]. Among the various fish tissues examined, kidney accumulated highest lead mean concentration while the lowest was in muscle. The difference was however non-significant (*P* = .52). Lead is a great threat to life if present in substantial quantity. According to [24], it is toxic even at low concentrations and has no known function in biochemical processes. In humans, exposure to lead can result in a wide range of biological effects depending on the level of duration of exposure [25]. The mean Lead levels in the fish tissues examined were in the order: Kidney > Gill > Liver > Muscle.

The concentration of Zinc in the fish (*Tilapia guineensis*) studied (Table 1) ranged from 13.24 to 22.12 mg/kg (muscle), 7.60 to 23.40 mg/kg (liver), 27.00 to 34.22 mg/kg (gill) and 8.78 to 15.91 mg/kg (kidney). Zinc concentrations (Table 1) in various fish tissues was significantly higher in gills (30.73 ± 2.99 mg/kg) than in muscle, liver and kidney (*P* = .00). Zinc mean levels in the various fish tissues investigated were below the Maximum Acceptable Levels (MAL) prescribed by [12,13] (Table 2). The Zn concentrations in fish tissues in this study compared favourably with values reported in catfish (*Chrysichthys nigrodigitatus)* tissues from Badagry creek [16], slightly higher than levels recorded for *Tilapia guineensis* from Lagos Lagoon [17], and mudfish (*Parachanna obscura)* tissues from Ogba River, Benin city, Nigeria [21], but lower than the concentrations recorded in various organs of *Tilapia mossambicus* from Industrially Polluted Patalganga River, India [19]. The Zinc mean concentrations in the fish tissues studied were in the order: Gill > Muscle > Liver > Kidney. The higher zinc levels in the gills as compared with other tissues could be related to the uptake pathway. Zinc is an essential element for plants and animals as it is necessary for the functioning of certain enzymes. However, it is acutely and chronically toxic to aquatic organisms, particularly fishes. Excessive intake of Zn in humans may lead to vomiting, dehydration, abdominal pains, nausea, lethargy and dehydration [26].

Chromium content in Tilapia fish (*Tilapia guineensis*) varied from 22.36 to 176.42 mg/kg (muscle), 16.79 to 193.51 mg/kg (liver), 49.82 to 217.64 mg/kg (gill) and 48.61 to 210.59 mg/kg (kidney). Kidney accumulated higher chromium than that of gill, liver and muscle, the difference was however, non-significant (*P* = .73). Muscle had the minimum chromium concentration (94.60 ± 78.11mg/kg). Chromium may accumulate differentially in different types of tissues. In fish; gill, kidney and liver have been found to contain the highest Cr concentrations while muscle has been found to have very little capacity for Cr accumulation [27]. Muscle tissue has been found inactive for accumulation of Chromium [28]. Chromium levels in the various fish tissues of *Tilapia guineensis* investigated exceeded the Maximum Acceptable Levels (MAL) prescribed by [12,13] (Table 2). The probable cause of the elevated Chromium could be human activities around Badagry creek and adjoining water bodies arising from discharges of effluents from electropainting and metal finishing industries. The Cr concentrations recorded in fish tissues in this study were similar to the levels found in catfish (*Chrysichthys nigrodigitatus)* tissues from Badagry creek [16], higher than levels reported in mudfish (*Parachanna obscura)* tissues from Ogba River, Benin city, Nigeria [21], in tissues of *Leuciscus Cephalus* from Karasu River, Erzurum-Turkey [18], and in Tilapia *Oreochromis niloticus* sampled from Hashenge Lake, Ethiopia [29]. Chromium often accumulates in aquatic life, adding to the danger of consuming fishes that may have been exposed to high levels of chromium. It has been reported that under certain environmental conditions and certain metabolic transformations, chromium (III) may readily be oxidized to chromium (VI) compounds that are toxic to human health [30].

Cadmium was below detectable limit in the tissues of the *Tilapia guineensis* fish investigated, with an exception of gill throughout this study. Cadmium levels in gill were from below detectable limit (BDL) to 0.06 mg/kg (Table 1). Cadmium level in the gill of *Tilapia guineensis* was lower than the Maximum Acceptable Levels (MAL) prescribed by [12,13] (Table 2). Cadmium is generally found in trace concentrations and at high pH. The Cd concentration in the fish gills was slightly lower than those reported in Cat fish *Chrysichthys nigrodigitatus* gill tissues from same water body [16], and for mudfish *Parachanna obscura* gills from Ogba River, Benin city, Nigeria [21]. The Cd concentrations detected in the gills showed that

Table 2. Trace elements concentration in the Muscle, liver and kidney of Tilapia fish (*Tilapia guineensis*) from Badagry creek and standards in mg/kg

Elements	Muscle	Liver	Kidney	FAO/WHO tolerance level in fish
Fe	30.18	122.29	41.30	-
Cu	0.32	5.27	1.54	30
Pb*	13.87	15.10	20.11	0.5
Zn	17.15	15.32	11.58	30
Cr*	94.60	98.93	150.51	1.0
Cd	-	-	-	0.5

**: element with values above FAO, (1983) / WHO, (1989) Standards.*
- : no values presented

the main uptake route was through gills. Cd is non-essential element known to have a toxic potential. Cadmium even in low concentration is quite toxic to human health [31]. It has cumulative and highly toxic effects in all chemical forms and accumulates in plant cells.

The tissues of *Tilapia guineensis* samples showed different capacities for accumulating elements. Average element concentrations in muscle, liver, gills and kidney decrease in the following orders of magnitude respectively: Cr > Fe > Zn > Pb > Cu > Cd; Fe > Cr > Zn > Pb > Cu > Cd; Fe > Cr > Zn > Pb > Cu > Cd; Cr > Fe > Pb > Zn > Cu > Cd. These patterns of trace elements accumulation in muscle, gills and kidney of *Tilapia guineensis* fish in Badagry creek in this study were almost similar to the previously reported result of [16] on cat fish (*Chrysichthys nigrodigitatus*). This observation may be attributed to the fact that both fishes investigated were collected in the same water body. According to [32], multiple factors including abiotic properties of water and season can play a significant role in accumulation of metal in different fish tissues. Furthermore, as far as the accumulation of metals in different tissues of the Tilapia fish (*Tilapia guineensis*) was concerned, the minimum mean concentration of elements (except Zinc, having least mean concentration in kidney) were obtained in the muscles (Table 1). Basically, muscle contained a smaller amount of metals than skin, gill and viscera [33]. The concentration of any pollutant in any given tissue depends on its rate of absorption and the dynamic processes associated with its elimination by the fish. The concentration of metals was highest in gills for iron, zinc and cadmium. Copper was greatest in liver while lead and chromium were highest in kidney. The levels of heavy metals in the gills reflect the concentrations of metals in the waters, where the fish live, while the concentrations of metals in liver represent storage of metals in the fish body [34]. [35] had demonstrated that higher metal content in viscera is related to their important role in trace metal storage in fish.

High element levels can harm the organism without killing it directly. It produces adverse biological effects on an organism's survival, activity, growth, metabolism, or reproduction. Adverse effects on an organism's activity, growth, metabolism, and reproduction are examples of sublethal effects [36]. Elevated levels of elements in the fish can pose a public health hazard. Humans are exposed to metals via analogous pathways: diffusion into the bloodstream via the lungs and skin, drinking contaminated water, and eating contaminated food [36]. Lead and Chromium are among the elements that are especially toxic to aquatic organisms and humans. In view of the higher levels of Lead and Chromium in the fish investigated as compared to FAO/WHO limits, it could be inferred that excessive consumption of the *Tilapia guineensis* fish from Badagry creek could lead to health hazards in man.

4. CONCLUSION

This study has established the concentrations of some elements in different tissues of Tilapia fish (*Tilapia guineensis*) from Badagry creek ecosystem. *Tilapia guineensis* tend to accumulate elements in their tissues, an indication of good bio-indicator of trace element contamination. Element concentrations in muscles were lower than those measured in the kidney, liver and gills. With an exception of Lead (Pb) and Chromium (Cr), the levels of elements investigated in the tissues of *Tilapia guineensis* were within the Maximum Acceptable Levels (MAL) proposed for fish by [14] and [15]. The implication is that the concentrations of Pb and Cr in examined edible fish were posing a public health hazard. It is therefore imperative to monitor regularly the levels of toxic contaminants especially the heavy metals in edible species of

Badagry creek, in order to ensure consumer safety.

ETHICAL APPROVAL

Author hereby declares that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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