Variability in Levels of Heavy Metals in Water and Fish (*Chrysichthys nigrodigitatus*) tissues from Badagry Creek, Nigeria

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Abstract

The occurrence of metals viz., lead (Pb), zinc (Zn), copper (Cu), iron (Fe), cadmium (Cd) and chromium (Cr) in water and fish (*Chrysichthys nigrodigitatus*) samples collected bi-monthly from nine stations (water) and 3 designated landing sites (fish) of Badagry creek were investigated using atomic absorption spectrophotometer (AAS) method. With an exception of cadmium, metals concentration was lower in the water samples and higher in the fish tissues, indicating a bioaccumulation tendency of fish. Concentration levels in water were found in decreasing order of magnitude Cr > Pb > Fe > Zn > Cu > Cd. However, metals investigated except Cu (highest concentration in the liver) had highest concentrations in the fish gills, which could be related to the uptake pathway. The relatively lower wet season Cu, Pb, Cr and Cd in water could be attributed to a dilution effect of rainfall. Although, presently the mean concentrations of all the heavy metals except Pb in this study were moderate and within the Federal Environmental Protection Agency (FEPA) permissible standard limit for aquatic life , the elevation of metal concentrations in this creek is inevitable under the prevailing conditions of increasing urbanization, industrialization and other forms of modernization in

Badagry and environs. Nevertheless, it is imperative to ensure regular monitoring of heavy metal loading in this creek and other water bodies with a view to safeguard public health.

Keywords: Chrysichthys nigrodigitatus, Heavy metals, Bioaccumulation, Atomic absorption spectrophotometer

1. Introduction

Many human activities (such as mining, sewage discharge, overuse of chemicals, industrial waste from ports and refineries etc.) have a negative impact on several biological processes and there is no doubt that these will continue to affect the functioning of highly productive coastal ecosystems

Water pollution by heavy metals as a result of human activities is causing serious ecological problems in many parts of the world. This situation is aggravated by the lack of natural elimination processes for metals. As a result, metals shift from one compartment within the aquatic environment to another, including the biota, often with detrimental effects. Marine animals including fish concentrate toxins in their tissues and over time the toxins can accumulate and eventually kill the animals (Bhattacharya *et al.,* 1994). Furthermore, where sufficient accumulation of the metals in biota occurs through food chain transfer, there is also an increasing toxicological risk for humans. Toxicity levels depend on the type and form of metals, its biological role, and the type of organisms that are exposed to it (Akan *et al.,* 2010). According to Adepoju-Bello and Alabi, (2005), heavy metals can cause serious health effects with varied symptoms depending on the nature and the quantity of the metal ingested.

The assessment of metal pollution is an important aspect of most water quality assessment programs. The Global Environment Monitoring System (GEMS) programme GEMS/WATER includes ten metals: Al, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn. Arsenic and Se (which are not strictly metals) are also included. The United States Environmental Protection Agency (USEPA) considers eight trace elements as high priority: As, Cd, Cu, Cr, Pb, Hg, Ni and Zn. Most other countries include the same metals in their priority lists.

Badagry creek is one of the coastal waters in the Barrier Lagoon complex, Nigeria. The creek is one of the most ecologically important lagoon systems in Nigeria. The fish population from Badagry creek exhibits relatively high diversity and species richness. According to Agboola *et al.* (2008), among notable and highly demanded fish species in the creek included Cat fish (*Chrysichthys nigrodigitatus*), Bonga (*Ethmalosa fimbriata*) and Tilapia (*Tilapia zillii*). Furthermore, good markets for fish have led to full exploitation of fish resources in Badagry creek. These fishes are frequently and largely eaten in Badagry and environs, so their toxic metal content should be of concern to human health. The present study was therefore, carried out in view of the paucity of information about heavy metals in the fish from this region. In this paper, the levels of Pb, Cd, Cu, Fe, Zn and Cr in water samples and in tissues of Cat fish (*Chrysichthys nigrodigitatus*) are reported. The results of this study will help in generating data needed for the assessment of toxic metal intake from this source.

2. Materials and methods

2.1 Study Sites

Badagry Creek, Nigeria is located between longitude 2 ⁰42 ¹and 3 ⁰23 ¹E and latitude 6 ⁰23 ¹and 6 ⁰28 ¹N. It is part of the 260 km-long lagoon system stretching from Cotonou in Republic of Benin to the Niger Delta, although centered in Lagos state. 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. The creek is shallow with irregular topography. The average water depth of Badagry creek is about 3.5 m The Creek is approximately equidistant from the entrances of Lagos and Cotonou harbours. As a result, it is influenced by tides and floods from the Lagos Lagoon and Cotonou harbour through Lake Nokue and Lake Porto-Novo (Anyanwu and Ezenwa, 1988).

2.2 Climate of the Creek

The Badagry creek is exposed to two distinct seasons namely the wet and the dry. Rainy season lasts from May to October and dry season lasts from November to April. Although, the month of August falls into wet season, usually a sharp drop in rainfall (downpour) is experienced (August break). The rainfall of Badagry is largely influenced by the southwest trade winds from the Atlantic Ocean and the dust-laden northeast trade (dry) winds from the Sahara desert become dominant during the dry months producing hazy weather conditions.
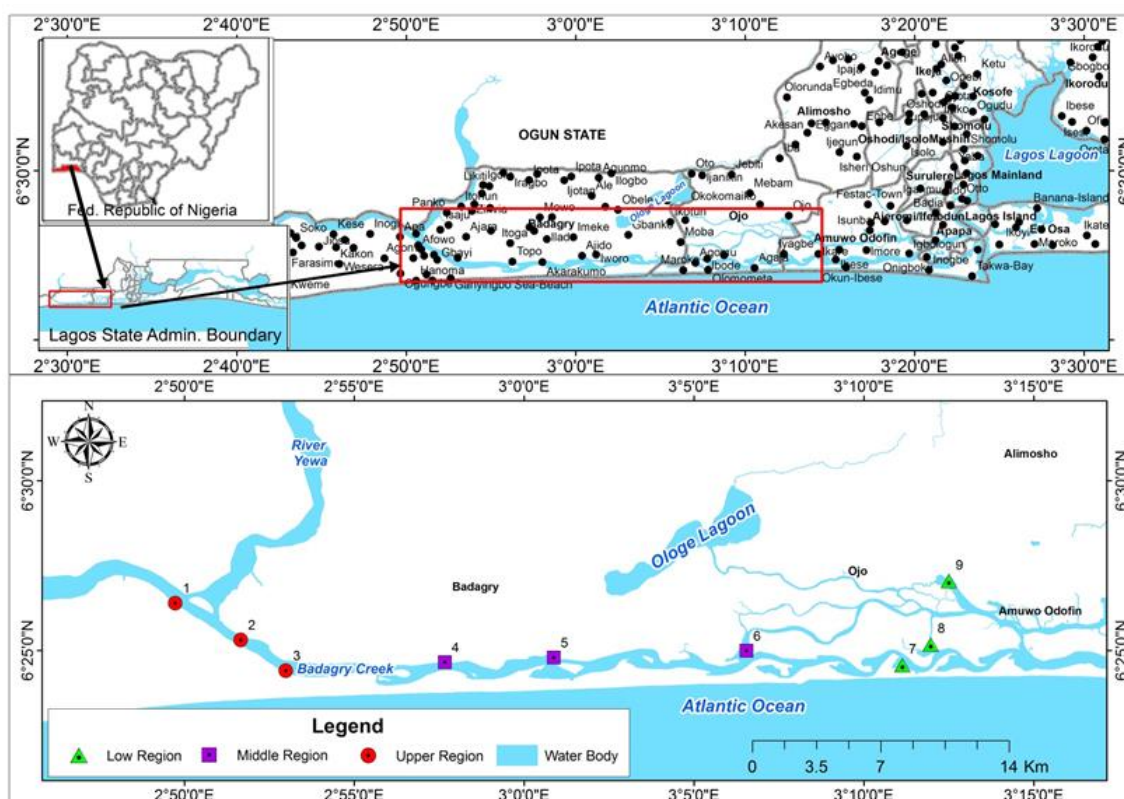

Figure 1. Map of Badagry Creek and environs with the sampling stations

1 - Apa; 2 - Igbaji; 3 - Yovovan jetty (Badagry*); 4 - Akarakumo; 5 - Ajido*; 6 - Irewe; 7 - Igbolobi; 8 - Iyagbe; 9 - Ojo*

*Selected Fishermen landing site in each of the zones for Fish collection

2.3 Water and Fish Sampling

The sampling strategies adopted for this study was stratified random sampling in which the creek was divided into three zones based on geographic locations and logistical characteristic: The upper, middle and lower zones (ISO, 2006). In each of the zones, three stations were randomly selected and chosen based on the major community settlement along the Badagry creek, thus giving a total of nine stations within the creek (Figure 1). The sampling was conducted between November 2011 and September 2013 covering 2 Dry and 2 Wet seasons. Water samples were taken bi-monthly throughout this period at the designated stations for analysis.

Water samples were collected just below the water surface at each station in acid-washed and pre-cleaned high density polyethylene (HDPE) bottles labelled according to the sampling station. 0.5 ml concentrated HNO_3 (reagent grade, Spectrosol, England) was added to each set of sample, and samples were transported to the Nigerian Institute for Oceanography and Marine Research central laboratory and refrigerated until analysis. The time lapse between sample collection, preservation and analysis was a week for each set of samples.

The fish species (*Chrysichthys nigrodigitatus*) were collected from the landings from fishermen at an established major fishing landing sites in each of the zones (Upper zone: Badagry; Middle zone: Ajido; Lower zone: Ojo). The fishes (six to eight average-sized specimens) were purchased from the fishermen who caught the fish at the designated zones. The fish were transported in a cooler containing ice to Nigerian Institute for Oceanography and Marine Research and refrigerated until dissection.

2.3.1 Preparation and Digestion of Water Samples

25ml of preserved water samples were measured into a conical flask, 10ml of aqua regia (concentrated HNO_3) was added. Thereafter the mixture was evaporated to 5ml on a hot plate in fume cupboard at 120^0C. The digested sample in the conical flask was allowed to cool and later filtered through Whatman filter paper no. 41 into 25 ml volumetric flask and made up to the volume using de-ionize water. Then it was transferred to plastic vial waiting to be aspirated for metal analysis in an AAS and quantified against known standards (APHA, 1998).

2.3.2 Preparation and Digestion of Fish Samples

The preserved specimens (*Chrysichthys nigrodigitatus*) were thawed and wipe dry before laboratory analysis. All laboratory equipment for usage was cleaned with HNO_3 prior to sample preparation. Fish were dissected with a dissecting set between the pectoral fin and vent of each fish. The muscle tissues of the finfishes were extracted. Likewise, the separated organs of the fishes (livers, gills, kidneys) were extracted.

The separated organs extracted were put in petri-dishes to dry at 120^oC until reaching a constant weight. Thereafter, 2g of separated organs were placed into digestion flasks and ultrapure Conc. HNO_3 and H_2O_2 (2:1 v/v) was added. The samples were left overnight at

room temperature. The digestion flasks containing the mixture were then heated to 130°C on a hot plate 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 (APHA, 1998). The reaction vessels and watch glasses were rinsed with distilled water to recover any residual metals inside 25 ml volumetric flask and made up to the mark with de-ionize water.

2.3.3 Determination of Element Concentrations

Metal concentrations (Pb, Cr, Cu, Cd, Zn and Fe) in the water and fish (*Chrysichthys nigrodigitatus*) specimen sampled for each set of samples were measured after samples had been digested using standard digestion procedure (APHA, 1998) with AAS by comparing their absorbance's with those of standards (solutions of known metal concentration) using an Alpha-4 cathode on AAS. For data quality, factory prepared AAS standard solutions were run as samples for accuracy check after every five measurements.

2.4 Statistical Analyses

The SPSS 15.0 for windows evaluation version was used to analyze the data obtained. Data were subjected to one way Analysis of variance (ANOVA) to examine differences with respect to sampling stations (zones) and seasons, a probability of $p < 0.05$ was considered significant. A post hoc Tukey Test was used to discern which means differed in concentration when there was a significant difference.

3. Results

3.1 Levels of Metals in Water

Iron varied from below the detection limit (BDL) to 5.87mg/l, with a grand mean of 1.87 $\pm$ 0.52mg/l (Table 2). The highest (2.10 $\pm$ 1.13mg/l) and lowest (1.35 $\pm$ 1.15mg/l) mean Fe concentration were obtained at middle zone and lower zone, respectively (Table 1). Wet season average iron value of 2.10 $\pm$ 1.35mg/l was higher than 1.62 $\pm$ 0.44 mg/l for dry season (Table 3). Results of ANOVA analysis showed significant differences in Fe values between seasons ($p < 0.05$). Copper ranged between below the detection limit (BDL) and 0.83mg/l, with the grand mean of 0.25 $\pm$ 0.04mg/l (Table 2). Mean Cu concentration varies slightly among zones, and was least (0.21 $\pm$ 0.18mg/l) at the lower zone and highest (0.25 $\pm$ 0.19mgL^{-1}) at the middle zone (Table 1). Seasonal trend (Table 3) revealed dry season had higher copper mean (0.28 $\pm$ 0.25mg/l) than wet season (0.18 $\pm$ 0.12mg/l). Statistical analysis on the results revealed that Cu values between seasons differed significantly ($p < 0.05$).

Lead levels varied from 0.17mg/l to 19.18mg/l throughout this study. The highest (4.40 $\pm$ 3.03mgL^{-1}) and lowest (2.58 $\pm$ 2.63mgL^{-1}) mean Pb content was recorded at middle zone and lower zone respectively (Table 1). Seasonally (Table 3), Pb value was higher (3.89 $\pm$ 3.73 mg/l) in the dry season than in wet season (2.89 $\pm$ 1.58mg/l). However, ANOVA on the results showed no significant differences in Pb values between zones ($p > 0.05$) and seasons ($p > 0.05$).

Zinc ranged from below the detection limit to 4.25mg/l, with a grand mean of 0.28 $\pm$

0.38mg/l (Table 2). Zn mean, (Table 1) increased slightly from the lower zone (0.18 $\pm$ 0.05mg/l) to the upper zone (1.29 $\pm$ 1.33mg/l). However, wet season (Table 3) mean Zn concentration (0.84 $\pm$ 0.83mg/l) was higher than the dry season of 0.52 $\pm$ 0.57mg/l. Zn mean values differed significantly across zones (p < 0.05), but the difference was not seasonally significant (p > 0.05).

Chromium varied from 0.89mg/l to 35.47mg/l throughout the study. Mean Cr content (Table 1) increased from the upper zone (8.28 $\pm$ 4.35mgL^{-1}) in this study to the lower zone (10.78 $\pm$ 8.07mgL^{-1}), with a grand average value of 9.82 $\pm$ 2.60mgL^{-1} (Table 2). Season-wise (Table 3), the dry season Cr mean value (10.70 $\pm$ 7.27mg/l) was higher than the wet season value of 8.94 $\pm$ 4.93mg/l. However, ANOVA showed there were no significant difference in Cr mean values between zones (p > 0.05) and seasons (p > 0.05).

Cadmium levels were generally very low and were between below the detection limit and 0.48 mg/l. Mean Cd varies slightly among zones, with the lowest (0.12 $\pm$ 0.11mg/l) at upper zone and highest (0.14 $\pm$ 0.09mg/l) at middle zone (Table 1). Cd grand mean in this study was 0.15 $\pm$ 0.05mg/l (Table 2). Seasonally (Table 3), Cd mean value in dry season (0.16 $\pm$ 0.12mgL^{-1}) was higher than in the wet season (0.11 $\pm$ 0.06mgL^{-1}). However, between the sampling zones and seasons, the Cd concentrations did not differ significantly (p > 0.05).

Considering the mean concentrations of the studied metals, the order of magnitudes (highest to lowest) was Cr > Pb > Fe > Zn > Cu > Cd.

Table 1. Spatial (Zone) variation (Means $\pm$ standard deviation) of Metals in Badagry Creek water (November, 2011 - September, 2013)

Parameters	UPPER ZONE	MIDDLE ZONE	LOWER ZONE	P value
Fe (mg/l)	2.09 $\pm$ 0.90a	2.10 $\pm$ 1.13a	1.35 $\pm$ 1.15a	> 0.05
Cu (mg/l)	0.23 $\pm$ 0.22a	0.25 $\pm$ 0.19a	0.21 $\pm$ 0.18a	> 0.05
Pb (mg/l)	3.18 $\pm$ 3.13a	4.40 $\pm$ 3.03a	2.58 $\pm$ 2.63a	> 0.05
Zn (mg/l)	1.29 $\pm$ 1.33a	0.21 $\pm$ 0.07b	0.18 $\pm$ 0.05b	< 0.05
Cr (mg/l)	8.28 $\pm$ 4.35a	10.41 $\pm$ 6.11a	10.78 $\pm$ 8.07a	> 0.05
Cd (mg/l)	0.12 $\pm$ 0.11a	0.14 $\pm$ 0.09a	0.13 $\pm$ 0.11a	> 0.05

Table 2. Grand mean ± standard deviation of Metals in Badagry Creek water (November, 2011 - September, 2013)

Parameters	Mean ± SD	FEPA 1991 (Aquatic life limit)
Fe (mg/l)	1.87 ± 0.52	1.0
Cu (mg/l)	0.25 ± 0.04	1.0
Pb (mg/l)	3.39 ± 1.35	< 1
Zn (mg/l)	0.28 ± 0.38	5
Cr (mg/l)	9.82 ± 2.60	10
Cd (mg/l)	0.15 ± 0.05	< 1

FEPA: Federal Environmental Protection Agency

Table 3. Seasonal Variation (Mean ± Standard Deviation) of Metals in Badagry Creek water (November, 2011 - September, 2013).

Parameters	Dry season	Wet season	P value
Fe (mg/l)	1.62 ± 0.44	2.10 ± 1.35	< 0.05
Cu (mg/l)	0.28 ± 0.25	0.18 ± 0.12	< 0.05
Pb (mg/l)	3.89 ± 3.73	2.89 ± 1.58	> 0.05
Zn (mg/l)	0.52 ± 0.57	0.84 ± 0.88	> 0.05
Cr (mg/l)	10.71 ± 7.27	8.94 ± 4.93	> 0.05
Cd (mg/l)	0.16 ± 0.12	0.11 ± 0.06	> 0.05

3.2 Levels of Metals in Fish Species Tissues

Metal concentrations in the muscle, liver, gill and kidney of the investigated fish species (*Chrysichthys nigrodigitatus*) from the three zones of Badagry creek are shown in Tables 4 - 6.

The values vary at different zones of the creek. Fe in the finfish muscles ranged from 15.14 to 187.32mg/kg. The lower zone had the highest mean Iron value (73.74 ± 56.77mg/kg) while upper zone recorded the lowest mean content (29.44 ± 8.75mg/kg). Detectable Cu content varied between 0.06mg/kg and 1.49mg/kg with a grand mean of 0.67 ± 0.29mg/kg. The highest (0.83 ± 0.49mg/kg) and lowest (0.46 ± 0.49mg/kg) Cu mean concentration were obtained at the middle and lower zones respectively. Pb concentrations were from 7.09 to 25.76mg/kg. Lower zone with the highest Lead mean value (18.38 ± 5.21mg/kg) while the least mean content (10.21 ± 1.80mg/kg) was obtained at the upper zone. Zn levels varied from 10.55 to 26.52mg/kg with a grand mean of 15.92 ± 2.82mg/kg. The lowest (13.08 ± 2.36mg/kg) and highest (19.29 ± 4.36mg/kg) Zn average content were obtained at the upper and lower zones respectively. Cr content varied from 18.64mg/kg to 229.34mg/kg, with highest (156.11 ± 44.68mg/kg) and lowest (40.624 ± 18.19mg/kg) mean concentration recorded at lower and upper zones respectively. Cd was below detection limit in the muscle of *Chrysichthys nigrodigitatus*. Metals in fish muscle with an exception of iron and lead revealed higher dry season mean values. Statistical analyses on metal concentration in the muscle except Cu showed significant differences between the zones (p < 0.05). However,

between the seasons, with an exception of Cr, the concentrations did not differ significantly. The rank of mean metal concentration in the muscle tissues in decreasing order of magnitude was: Cr > Fe > Zn > Pb > Cu > Cd.

In the liver of *Chrysichthys nigrodigitatus,* Fe concentration ranged from 19.45 to 564.92mg/kg with a grand mean of 174.51 $\pm$ 56.58mg/kg. Fe mean content was highest at the upper zone (337.89 $\pm$ 115.14mg/kg) and lowest (75.12 $\pm$ 56.71mg/kg) at the middle zone. Upper zone had highest Cu mean (3.89 $\pm$ 4.08mg/kg) while the lowest mean (1.40 $\pm$ 1.91mg/kg) was recorded at the middle zone. Pb content in the fish liver was from 7.34 to 27.27mg/kg, with a grand Pb mean of 15.10 $\pm$ 2.64mg/kg. Pb mean content was least at the upper zone (10.73 $\pm$ 2.01mg/kg) and highest (19.55 $\pm$ 4.56mg/kg) at the lower zone. Zn content varied between 3.52 and 25.74mg/kg. The highest (17.49 $\pm$ 5.48mg/kg) and lowest (7.94 $\pm$ 4.81mg/kg) Zn mean content were obtained at lower and middle zones respectively. Cr level ranged from 14.00 to 251.56mg/kg, with a grand mean of 103.29 $\pm$ 30.81mg/kg. Cr mean value was highest at the lower zone (153.26 $\pm$ 65.81mg/kg) and lowest (63.96 $\pm$ 43.98mg/kg) at the upper zone. Cd was not detected in the liver of the finfish (*Chrysichthys nigrodigitatus)* investigated. With an exception of copper and Cr, wet season metal mean concentrations were higher than dry season values. Metal concentrations (Cr exception) in the fish liver did not vary between the seasons. Between the sampling zones, with an exception of Cu, the concentrations did not differ significantly.The metal ranking in finfish liver was Fe > Cr > Pb > Zn > Cu > Cd.

Concentration of Fe in *Chrysichthys nigrodigitatus* gills ranged from 60.42 to 342.57mg/kg. Fe mean values was highest (241.62 $\pm$ 55.35mg/kg) at the upper zone and least (171.45 $\pm$ 66.49mg/kg) at the lower zone. Cu varied between 0.14 and 5.98mg/kg, with a grand average of 1.64 $\pm$ 0.92mg/kg. The highest (2.67 $\pm$ 1.96mg/kg) and the lowest (0.64 $\pm$ 0.28mg/kg) Cu mean content in gill were recorded at the upper and middle zones respectively. Pb fluctuated between 9.95 and 31.06 mg/kg. Pb mean content was highest (20.87 $\pm$ 2.67mg/kg) at the middle zone and lowest (12.79 $\pm$ 1.97mg/kg) at the upper zone. Zn level was from 19.86 to 40.01mg/kg. Lower zone had the highest Zn mean value (30.06 $\pm$ 5.66mg/kg) while the least (25.74 $\pm$ 4.48mg/kg) was obtained at the middle zone. Cr content varied from 41.52 to 279.31mg/kg with a grand average of 115.61 $\pm$ 29.47mg/kg. The highest Cr mean value (190.52 $\pm$ 65.63mg/kg) and the lowest (67.95 $\pm$ 21.00mg/kg) were obtained at the lower and upper zones respectively. Cd in fish gill ranged from below the detection limit to 0.15mg/kg. The highest (0.13 $\pm$ 0.06mg/kg) and lowest (0.10 $\pm$ 0.04mg/kg) Cd mean values were obtained at the upper and middle zones respectively. With an exception of Cd, metals dry season mean values were higher than the wet season. The ranking of metals concentration in gill was Fe > Cr > Zn > Pb > Cu > Cd. Metal concentrations with an exception of Cu and Cr, in the fish gill did not vary between the seasons. However, between the sampling zones, metal concentration except Cd showed significant differences (p < 0.05).

In fish kidney, Fe content ranged from 26.36 to 109.54mg/kg, with a grand mean of 66.66 $\pm$ 11.94mg/kg. The highest and lowest Fe mean values were obtained at upper (82.275 $\pm$ 17.592) and lower zones (58.077 $\pm$ 23.320) respectively. Detectable Cu levels varied from 0.04 to 3.70mg/kg. Lower zone had the highest mean Cu concentration (1.54 $\pm$ 1.23mg/kg) while

lowest (0.11 ± 0.09mg/kg) was obtained at upper zone. Pb fluctuated between 6.89 to 27.45mg/kg. Spatial trend showed lower and upper zones with the highest (20.83 ± 4.90mg/kg) and lowest (10.15 ± 2.00mg/kg) Pb mean concentration respectively. Zn content range was from 5.31 to 16.10mg/kg. Spatially, lower zone had the highest Zn average value (11.89 ± 3.03mg/kg) while the middle zone obtained the lowest mean of 7.81 ± 1.37mg/kg. Cr varied from 17.52 to 273.77mg/kg with a grand average of 86.30 ± 22.15mg/kg. The lowest (29.13 ± 11.77mg/kg) and highest (176.15 ± 65.50mg/kg) Cr mean values were recorded at the upper and lower zones respectively. Cd content was from below detection limit to 0.13mg/kg in the fish kidney. Cd levels were below detection limit in the fish kidney at both the upper and middle zones throughout the study. Generally, wet season metals mean contents in kidney with an exception of Fe and Cr were higher than the dry season mean values. Metal concentrations with an exception of Cd showed significant differences between the zones. However, Fe, Cu and Cd did not differ between seasons ($p > 0.05$). Metals concentration ranking in finfish kidney was Cr > Fe > Pb > Zn > Cu > Cd.

Table 4. Spatial distribution (Mean $\pm$ standard deviation) of Heavy metal concentration in different tissues of (Chrysichthys nigrodigitatus) fish species from Badagry Creek (November, 2011 - September, 2013)

Metals	Fish tissues	Upper Zone	Middle Zone	Lower Zone	P value
Fe (mg/kg)	muscle	29.44 ± 8.75b	34.05 ± 9.52 b	73.74 ± 56.77 a	< 0.05
	liver	337.89 ± 115.14a	75.11 ± 56.71c	110.52 ± 58.58 b	< 0.05
	gill	241.62 ± 55.35a	205.63 ± 46.13b	171.45 ± 66.49c	< 0.05
	kidney	82.27 ± 17.59 a	59.64 ± 11.98b	58.07 ± 23.32b	< 0.05
Cu (mg/kg)	muscle	0.53 ± 0.36a	0.82 ± 0.49a	0.46 ± 0.49a	> 0.05
	liver	3.89 ± 4.07a	1.40 ± 1.91a	2.93 ± 3.16a	> 0.05
	gill	2.67 ± 1.96 a	0.64 ± 0.28c	1.91 ± 1.51 b	< 0.05
	kidney	0.11 ± 0.09b	0.48 ± 0.33b	1.54 ± 1.23a	< 0.05
Pb (mg/kg)	muscle	10.21 ± 1.80b	16.74 ± 3.11ab	18.38 ± 5.21a	< 0.05
	liver	10.73 ± 2.01b	15.02 ± 2.54 ab	19.55 ± 4.56a	< 0.05
	gill	12.79 ± 1.97b	20.87 ± 2.67a	20.51 ± 5.88a	< 0.05
	kidney	10.15 ± 2.00 b	13.60 ± 4.18b	20.83 ± 4.90a	< 0.05
Zn (mg/kg)	muscle	13.08 ± 2.36b	15.39 ± 2.75b	19.29 ± 4.34a	< 0.05
	liver	15.97 ± 5.72a	7.94 ± 4.81b	17.49 ± 5.48 a	< 0.05
	gill	28.61 ± 4.65 ab	25.74 ± 4.48 b	30.06 ± 5.66 a	< 0.05
	kidney	7.84 ± 2.19b	7.81 ± 1.37b	11.89 ± 3.03a	< 0.05
Cr (mg/kg)	muscle	40.62 ± 18.19 c	86.18 ± 38.18 b	156.11 ± 44.68a	< 0.05
	liver	63.96 ± 43.98 c	92.65 ± 51.27 b	153.26 ± 65.81a	< 0.05
	gill	67.95 ± 21.00 b	88.35 ± 29.97 b	190.52 ± 65.63 a	< 0.05

	kidney	29.13 ±11.77 c	53.61 ±13.58 b	176.15 ±65.50a	< 0.05
Cd (mg/kg)	muscle	BDL	BDL	BDL	
	liver	BDL	BDL	BDL	
	gill	0.13 ±0.06 a	0.10 ±0.04 a	0.11 ±0.03 a	> 0.05
	kidney	BDL	BDL	0.11 ±0.07	

Means value along the same row with same superscript are not significantly different at p < 0.05

BDL: Below detection limit

Table 5. Grand Mean ± standard deviation of Heavy metal concentrations in different tissues of (Chrysichthys nigrodigitatus) fish species from Badagry Creek (November, 2011 - September, 2013)

Metals	Fish tissues	Mean ±SD
Fe (mg/kg)	Muscle	45.74 ±20.89
	Liver	174.51 ±56.58
	Gill	206.23 ±21.79
	Kidney	66.66 ±11.94
Cu (mg/kg)	Muscle	0.67 ±0.29
	Liver	2.77 ±1.32
	Gill	1.64 ±0.92
	Kidney	0.85 ±0.74
Pb (mg/kg)	Muscle	15.11 ±2.01
	Liver	15.10 ±2.64
	Gill	18.06 ±2.70
	Kidney	14.86 ±3.36
Zn (mg/kg)	Muscle	15.92 ±2.82
	Liver	13.80 ±2.84
	Gill	28.14 ±3.61
	Kidney	9.18 ±1.52
Cr (mg/kg)	Muscle	94.30 ±25.84
	Liver	103.29 ±30.81
	Gill	115.61 ±29.47
	Kidney	86.30 ±22.15
Cd (mg/kg)	Muscle	BDL
	Liver	BDL
	Gill	0.11 ±0.04
	Kidney	0.11 ±0.07

BDL: Below detection limit

Table 6. Seasonal variation (Mean ± standard deviation) of Heavy metal concentrations in different tissues of (*Chrysichthys nigrodigitatus*) fish species from Badagry Creek (November, 2011 - September, 2013).

Metals	Fish tissues	Dry season	Wet season	P value
Fe (mg/kg)	muscle	43.43 ±23.88	48.05 ±19.41	> 0.05
	liver	171.67 ±68.22	177.35 ±48.67	> 0.05
	gill	207.26 ±68.70	205.21 ±37.92	> 0.05
	kidney	66.90 ±14.32	66.42 ±10.41	> 0.05
Cu (mg/kg)	muscle	0.57 ±0.09	0.46 ±0.13	> 0.05
	liver	3.93 ±0.71	1.32 ±0.28	> 0.05
	gill	1.96 ±1.15	0.97 ±0.28	< 0.05
	kidney	0.43 ±0.22	0.70 ±0.68	> 0.05
Pb (mg/kg)	muscle	14.51 ±1.85	15.72 ±2.14	> 0.05
	liver	14.84 ±2.72	15.36 ±2.79	> 0.05
	gill	18.32 ±2.25	17.80 ±3.29	> 0.05
	kidney	12.76 ±2.86	16.96 ±2.45	< 0.05
Zn (mg/kg)	muscle	15.93 ±3.58	15.91 ±2.17	> 0.05
	liver	12.72 ±2.93	14.88 ±2.52	> 0.05
	gill	28.50 ±3.99	27.78 ±3.52	> 0.05
	kidney	8.59 ±1.33	9.77 ±1.57	> 0.05
Cr (mg/kg)	muscle	115.18 ±18.44	73.43 ±9.10	< 0.05
	liver	125.51 ±23.96	81.07 ±18.14	< 0.05
	gill	140.39 ±17.43	90.82 ±11.49	< 0.05
	kidney	104.92 ±11.07	67.67 ±11.16	< 0.05
Cd (mg/kg)	muscle	BDL	BDL	
	liver	BDL	BDL	
	gill	0.09 ±0.03	0.12 ±0.02	> 0.05
	kidney	0.10 ±0.03	0.13 ±0.00	> 0.05

BDL: Below detection limit

4. Discussion

The relatively higher metals concentration in fish tissues as compared to water in this study was in agreement with opinion of Chale, (2002) that concentrations of trace metals in fish tissues were always higher than that of water. Generally, heavy metals exist in low levels in water and attained considerable concentration in sediments and biota (Naminga and Wilhm, 1976).

The mean concentrations of metals (Fe, Cu, Zn, Cr and Cd) in water and finfish from Badagry creek in this study though slightly lower, compared favourably with previous studies (Okoye, 1989; Oyewo 1998; Don-Pedro *et al.,* 2004 and Adeniyi and Yusuf, 2007) in the Lagos lagoon complex and adjoining water bodies. However, Pb concentrations in water and finfish in the present study were higher than the Nigeria coastal waters background levels and permissible limits. The high Pb concentration in water and finfish observed in this study may be attributed to increasing automobile traffic emissions from lead tetraethyl in gasoline and emissions from heavy duty electric generators used in the industry to the environment. Pb is a great threat to life if present in substantial quantity because it is toxic even at low concentrations and has no known function in biochemical processes (Burden *et al.,* 1998). The probable sources of Cd in surface water as recorded in this study may be attributed to leaching from Ni - Cd batteries, run off from agricultural soils where phosphate fertilizers are used and other wastes (Pate *et al.,* 2001).

The relatively lower wet season Cu, Pb, Cr and Cd in water could be attributed to a dilution effect of rainfall. Although, presently the mean concentrations of all the heavy metals except Pb in this study were moderate and within the permissible standard limit of FEPA, (1991), the elevation of metal concentrations in the creek is inevitable under the prevailing conditions of increasing urbanization in Badagry and environs. In comparison among metals studied in this creek water, Cr concentrations were highest in the water samples. Similar finding was reported in Awassa and Koka Rift Valley Lakes, Ethiopia (Dsikowitzky *et al.,* 2012).

Fish attracted a lot of attention as bio indicators for monitoring aquatic pollution, due to their relatively large body size, long life cycle, position in the aquatic food chain and their use for human consumption (Zhou *et al.* 2008). The fish investigated for heavy metals in the present study Cat Fish (*Chrysichthys nigrodigitatus*) is a commercially exploited species and occur frequently in Nigeria coastal waters. Accordingly, a couple of studies about heavy metal levels in different tissues of this fish species were published (Oyewo, 1998; Asuquo *et al.,* 2004; Ladigbolu *et al.,* 2011 and Opaluwa *et al.,* 2012).

The high value of Fe observed in *C. nigrodigitatus* in this study compared to other metals may be due to increase in total dissolved iron in the creek. The values of Fe in the fish organs were in the order: Gill > Liver > Kidney > Muscle. High concentration of Fe had been reported in fish organs (El-Naggar *et al.,* 2009) and was reported as the most abundant in *C. nigrodigitatus* compared to other fishes evaluated (Asuquo *et al.,* 2004). However, the concentrations obtained for Fe in this study were higher compared to values reported for this fish in Ibeshe, Lagos lagoon (Ladigbolu *et al.,* 2011).

All the metals investigated in the fish species except Cu (highest concentration in the liver) had highest concentrations in the gills part. This observation may be attributed to the fact that the gills helps in respiration and filtration of water. Kebede and Wondimu (2004) reported higher Pb concentrations in the gills compared with the muscles in *O. niloticus* from Lake Awassa and Lake Ziway. In fish, gills are considered to be the dominant site for contaminant uptake because of their anatomical and/or physiological properties that maximize absorption efficiency from water. In the present study, Cr contents were generally higher in the gills and

livers than in the muscles. This observation agrees with those of Amundsen *et al*., (1997) freshwater fish species from the border region between Norway and Russia.

5. Conclusion

This study has established the current levels of some metals in water and Cat fish (*Chrysichthys nigrodigitatus*) in Badagry Creek ecosystem. Based on information gathered, all investigated metals except Pb were within the permissible standard limit for aquatic life. The implication is that Pb is posing an environmental risk in this water body and calls for in-depth monitoring.

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