HEAVY METALS ACCUMULATION IN WATER, SEDIMENT AND FISH (Chrysichthys nigrodigitatus AND Sarotherodon melanotheron) AT IGBEDE RIVER, LAGOS NIGERIA

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ABSTRACT
The contamination of freshwaters due to several harmful substances, like metals, through inputs from anthropogenic sources, industrial and agricultural activities, domestic sewage, groundwater leaching and runoffs from agriculture has devastating effects on plants and animals. The Igbeke River, located around Ojo local council area of Lagos state is one of such fresh water bodies. Investigation into the accumulation of heavy metals in the water, sediment and two fish species (Chrysichthys nigrodigitatus and Sarotherodon melanotheron) from Igbege river in Lagos State, Nigeria between March, 2013 and August, 2013 was carried out in order to ascertain the pollution status of the river. The results revealed different levels of accumulation of Pb, Cd, Cr, Cu, Zn and Fe in the fish, water and sediment. The results showed that sediment contained a higher concentration of the metals than the water and fish samples with Zn recording the highest value in sediment (68.467±49.524 mg/kg) against 43.798 ± 31.875 mg/L, 6.367±4.254 mg/kg and 3.108±1.869 mg/kg in water and the two fish species. Statistical analyses of the mean levels indicated that the distribution of the metals in the samples followed the order Zn>Cu>Fe>Pb>Cd>Cr for sediment; Zn >Cu>Fe>Cr>Pb for water; Fe>Zn>Cu>Pb>Cr for Chrysichthys nigrodigitatus and Fe>Zn>Cu>Pb>Cr for Sarotherodon melanotheron. Cd was not detected in water and fish samples. The concentration of Pb, Cd and Cr in water, sediment and fish samples were within limit permitted by Federal Environmental Protection Agency (FEPA) and World Health Organization (WHO). However, the concentration of Cu, Zn and Fe in the samples was above the recommended standard which poses threat to human health as well as the living aquatic resources inhabiting this habitat.

Keywords: Pollution, Heavy metals, Fish, Igbeke River, Lagos

INTRODUCTION
Rapid industrialization and urbanization during the last few decades have initiated some grievous environmental concerns (Rauf et al., 2009). Alteration of water chemistry through heavy metals as been key issues in the developing countries due to increase population and urbanization as against water quality standard (Karabassi et al., 2007; Akoto et al., 2008; Ahmed et al., 2010). The contamination of freshwaters due to several harmful substances, like metals, through inputs from anthropogenic sources, industrial and agricultural activities, domestic sewage, groundwater leaching and runoffs from agriculture has devastating effects on animals (Donohue et al., 2006). Pollution such as discharge of untreated domestic sewage, municipal wastes and industrial effluents into our coastal water have also affect not only the bioform but also the aquatic environment which they inhibit (Khadse et al., 2008; Venugopal et al., 2009; Sekabira et al., 2010).

Industrial effluent containing heavy metal are been discharge directly or indirectly into the aquatic environment (Ogbiebiu and Ezeunara, 2002). Majority of obnoxious and toxic chemicals are dumped into the aquatic water bodies and water that can act as a source of these chemicals and several toxic agents. Therefore, the occurrence of toxic chemicals and environmental pollutants contaminate the aquatic ecosystems that would affect the physical condition and endurance rate of fish (Sweet and Zelikoff, 2001).

Metals persist in the environment and become bio-concentrated and bio-amplified along the food chain. During their transfer, heavy metals undergo several transformations due to dissolution, adsorption and precipitation (Akcay et al., 2003). This ultimately alter their nature, behaviour and bioavailability in the aquatic environments (Nicolau et al., 2006) and this may be responsible for high concentrations of these
metals in predators such as sharks and eagles (Wang and Chen, 2009). Some research findings have shown that heavy metals in aquatic environment could accumulate in biota especially fish as they are the most common aquatic organisms at higher tropic level (Olaifa et al., 2004).

The presence of heavy metals in the aquatic environment in trace concentration is important for normal development of the organisms (Kori-Siakpere and Ubogu, 2008). They could be detected in the aqueous medium and in the bottom. Some however, are completely deleterious and need to be monitored continuously in the bodies of organisms as they are capable of bioaccumulation, resulting to morbidity and often mortality of organisms (Ayotunde et al., 2011 and 2012; Ada et al., 2012). The effect of heavy metals on human health has stimulated a lot of research in this area. Some of which include the works of Satarug et al. (2000), Muchuweti et al., (2006), and Adeleke et al. (2012).

The interest in the environmental levels of heavy metals is a global one because of the potential hazards of these elements to the health of animals, humans and plants when they exist at elevated levels (Oyekunle et al., 2012).

In fish, the toxic effects of heavy metals may influence physiological functions, individual growth, reproduction and mortality (Hayat et al., 2007). High concentration of manganese has been detected in the gills of various fish species which showed that the main route of manganese uptake was through the gills because little absorption of this metal occurred through the gut via the food (Hayat et al., 2007). Also, long-term exposure to water borne cadmium at sub-lethal concentrations has been shown to decrease growth in juvenile and adult rainbow trout, Oncorhynchus mykiss (Hayat et al., 2007). Fish constitutes an important and cheap source of animal protein to human beings and a large number of people depend on fish and fishing activities for their livelihood (Srivastava, 2008). Fish can absorb metals directly from water via gills and through ingestion of contaminated food. Upon ingestion, metals are accumulated in fish liver, gills and other organs including lipids, muscle and membranes. Heavy metals concentrated in fish gills and liver tissues. Metals can also be deposited in lipids of biological membranes and muscles causing a major concern for human nutrition (de Pinhoa et al., 2002).

Most of the rivers in this part of the country have become heavily polluted due to haphazard and extravagant pouring of industrial wastes into them, thus making it unfavourable for aquatic life including fish which is highly nutritious and much sought after foods (Chindah et al., 2008). The Igbede River serves many purposes for people in the community. Fish (Chrysichthys nigrodigitatus and Sarotherodon melanotheron) from the river is sold as food in various markets around the Igbede community and the river serves as a source of drinking water for the people in the community. It is therefore important to determine the levels of heavy metal contamination present in the water, sediments and fish and ascertain that these fall within set standards for human consumption. Realizing this, heavy metal levels in the tissues of aquatic animals need to be occasionally monitored to ensure that the level do not constitute health hazards to consumers. The study is to determine the level of heavy metals in water samples, sediment and in flesh of Chrysichthys nigrodigitatus and Sarotherodon melanotheron collected from Igbede river.

MATERIALS AND METHODS

DESCRIPTION OF STUDY SITE

Lagos State is one of the most populated state in Nigeria having about fifteen million people and located on the geographical grid reference of longitude 3° 5E, Latitude 7° 20N. It is one of the eight states located in the coastal zone of Nigeria. The Igbede river lies between Longitude E3°9.7333', Latitude N6°27.939'. Cities, towns and places near Igbede include Etegbin, Egan, Okokomaiko and Ilogbo Elegba. The closest major cities include Lagos, Ikorodu, Shagamu and Abeokuta (Fig1). The river drains predominantly agricultural lands, industrial zones (comprising of haulage, construction and dredging activities), residential and commercial areas as well as transport for fisher folk and also a dumpsite for residence and for other wastewaters. Domestic waste discharges and makeshift latrines are evident in the river banks. These sources are most likely going to introduce noxious metals into the water bodies. (Adekoya et al., 2006).
Figure 1: Map showing Igbede River
COLLECTION OF SAMPLES
COLLECTION OF WATER SAMPLES
The Igbede river was sampled for six months (March 2013-August 2013). Water samples were collected each month in litre capacity plastic containers with each indicating the month of collection at the study site. Sampling was carried out between 7am and 10am on each sampling day. The plastic bottle was dipped into water to collect the samples and was taken to the laboratory for physico-chemical and heavy metals analysis.

COLLECTION OF SEDIMENTS SAMPLES
Sediments samples were collected at the study site for six months (March 2013-August 2013). Grab was used to collect samples of sediment and packed in pre cleaned polyethylene bags and transported to the laboratory for heavy metals analysis.

COLLECTION OF FISH SAMPLES
The fish samples (Chrysichthys nigrodigitatus) and (Sarotherodon melanotheron) were purchased directly from the fishermen at the river between 7am-10am each sampling day. They were selected for analysis based on their popularity among local consumers. The collected fish were of consumable or “market” size. The fish were packed in ice box and were transported to the laboratory for heavy metals analysis.

DETERMINATION OF PHYSICAL PARAMETERS
DETERMINATION OF AIR TEMPERATURE (°C)
Air temperature was measured in situ at the study site, using a mercury-in-glass thermometer by first drying the bulb with a dry cotton cloth. The thermometer was then held up in air at eye level for five minutes while the bulb was shaded from direct solar radiation to measure the air temperature and readings were noted in degree Celsius (°C).

DETERMINATION OF WATER TEMPERATURE (°C)
The mercury-in-glass thermometer was used to measure the water temperature, by dipping the thermometer into a transparent 1 litre container containing water collected at the sampling site for five minutes and temperature readings were recorded in degree Celsius (°C) while the thermometer was still dipped inside water.

DETERMINATION OF TRANSPARENCY (cm)
This was determined with the use of a 20cm diameter black and white secchi disc attached to a rope. The disc was lowered into the water until it disappeared from view. It was then handled until it reappeared. The two points, where it disappeared and reappeared, were noted. The average of these two values was recorded as the measure of transparency in centimeters (cm).

ANALYSIS OF CHEMICAL PARAMETERS
DETERMINATION OF pH
pH is the term used to express the intensity of the acid or alkaline condition of a solution. The pH values were determined by the Electrometric Method using the Cole Parmer Test. The pH meter was calibrated and standardized. Three pH buffers (pH 4.0, 7.0, and 10.0) were used for the calibration. Each sample pH was determined at 25 °C with the calibrated water and immersing the probe into the water sample.

DETERMINATION OF SALINITY (%)
Salinity was determined using Saline test Salinity Meter (Hanna Instrument HI 98203). The meter was calibrated by immersing the probe in a solution of reagent grade sodium chloride. The reading was noted and recorded after a few seconds when the display was stabilized. After calibration, the salinity of each sample was determined by immersing the probe into it for a few seconds and observed readings expressed in parts per thousand (%).

DETERMINATION OF CONDUCTIVITY (µS/cm)
This is determined by using Philips PW9505 conductivity meter with a range of 3µS/cm to 100,000 µS/cm. An automatic temperature compensation unit was calibrated using known standards. The probe was rinsed with each calibration solution before being standardized. The sample conductivity was then determined by dipping the probe into an aliquot of the sample and each sample reading was recorded in µS/cm.
DETERMINATION OF DISSOLVED OXYGEN (DO) (mg/L)
Dissolved Oxygen (DO) is the amount of oxygen found by determination in a sample of water at the time of collection. This was estimated by Titrimetric (Iodometric) method using the Azide Modification procedure 4500°C.

DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND (BOD) (mg/L)
The Winkler method was used to determine the oxygen content of the bottles at the end of the five days and the average calculated. The difference between this average and the initial concentration of the dissolved oxygen content of the first bottle is the Biochemical Oxygen Demand.

CHEMICAL OXYGEN DEMAND (COD) (mg/L)
The Chemical Oxygen Demand was estimated using closed Reflux method 522°C. The digestion tube containing the aliquot sample (2.5ml) and reagents were placed in a block digester, preheated to 150°C and refluxed for 2 hours. The tubes were removed from the block digester and cooled to room temperature and then transferred quantitatively to a titration vessel. 1 drop of Ferrous indicator was added and the mixture was titrated with standard 0.0166 or 0.1M Ferrous Ammonium Sulphate (FAS) to a reddish brown end point. A blank containing the reagents and distilled water was carried through the procedure. COD was calculated using the formula below and was expressed in mg/L.

Chemical Oxygen Demand (mg/L) =
\[
(ml \text{ FAS used for blank} - ml \text{ FAS used for sample}) \times \text{Molarity of FAS} \times 8,000
\]
ml sample

DETERMINATION OF HEAVY METALS
Determination of heavy metals was done using Atomic Absorption Spectrophotometer (AAS). Preparation of metal standards / Stock Standard Solutions (10mg/L) were prepared by dissolving the appropriate metal or salt in appropriate solvent and diluting to known volume as described by APHA, (1995).

STATISTICAL ANALYSIS
The results obtained were analysed using the Statistical Program for Social Sciences (SPSS). There two-way analysis of variance (ANOVA) was used to estimate if there was any significant between and within the groups of data obtained.

RESULTS
PHYSICO-CHEMICAL PARAMETERS OF WATER SAMPLES
The physico-chemical parameters are presented in Table 1. The mean air temperature is 28.000±3.413 and water is 28.830±2.995 as shown in Table 1. This is within tolerable requirement for tropical fish except in March and April where there is slight increase in temperature which apparently was recorded during the peak dry season.
The pH ranged between 6.34 and 9.12 during the sampling period. The highest value (9.12) was recorded in March and the lowest value (6.34) was recorded in April. The mean pH of 7.378±1.216 was recorded for water samples and it falls within the WHO limit of 6.50 – 8.50 for drinking water (WHO, 2008) except for March which was slightly alkaline. Salinity has a mean value of 7.170±3.034; highest value was recorded in April while the value remains constant from June to August. Transparency appears to be high in March, April and May but reduced in subsequent months only to rise up again in August with a mean value of 168.240±40.182 (Table 1). Conductivity fluctuated with a high value in July and different values in other months. Dissolved Oxygen values shows minimal variation during the sampling period, highest value (8.36mg/L) recorded in the month of June which is a rainy season with a mean value of 7.923±1.221 (Table 1). The Biochemical Oxygen Demand ranged between 3.80mg/L and 5.77mg/L. Highest value (5.77mg/L) was recorded in April, 2013 while the lowest value (3.80mg/L) was recorded in May, 2013 with a mean value of 5.206±2.528 (Table 1). The Chemical Oxygen Demand ranged between 28.63 mg/L and 39.67mg/L. The highest value (39.67mg/L) was recorded in April, 2013 while the lowest value (28.67mg/L) was recorded in August 2013 and has a mean value of 33.522±4.618.
HEAVY METALS CONCENTRATION IN WATER SAMPLES

The heavy metals analyzed in the water samples at the sampling site include: Lead (Pb), Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn) and Iron (Fe). Zinc had the highest mean value of $43.798 \pm 31.875$ while Lead recorded the lowest mean value of $0.118 \pm 0.028$. Cadmium was not detected. Lead was not detected in March and April but was later detected in May and subsequent months (Table 2).

Table 1: The physical and chemical parameters of water samples within the period of study

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temp.(°C)</td>
<td>28.000</td>
<td>3.413</td>
<td>20.000</td>
<td>33.000</td>
</tr>
<tr>
<td>Water Temp.(°C)</td>
<td>28.830</td>
<td>2.995</td>
<td>21.000</td>
<td>33.000</td>
</tr>
<tr>
<td>pH</td>
<td>7.378</td>
<td>1.216</td>
<td>5.600</td>
<td>10.03</td>
</tr>
<tr>
<td>Salinity(%)</td>
<td>7.170</td>
<td>3.034</td>
<td>3.000</td>
<td>13.000</td>
</tr>
<tr>
<td>Transparency(cm)</td>
<td>168.240</td>
<td>40.182</td>
<td>22.000</td>
<td>205.000</td>
</tr>
<tr>
<td>Conductivity(μS/cm)</td>
<td>346.670</td>
<td>299.143</td>
<td>138.000</td>
<td>998.000</td>
</tr>
<tr>
<td>DO(mg/L)</td>
<td>7.923</td>
<td>1.221</td>
<td>4.700</td>
<td>9.900</td>
</tr>
<tr>
<td>BOD(mg/L)</td>
<td>5.206</td>
<td>2.528</td>
<td>3.360</td>
<td>14.780</td>
</tr>
<tr>
<td>COD(mg/L)</td>
<td>33.522</td>
<td>4.618</td>
<td>28.010</td>
<td>41.960</td>
</tr>
</tbody>
</table>

Table 2: Heavy metals concentration of water sample at Igbede river within the period of study (mg/L).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Mini</th>
<th>Maxi</th>
<th>FEPA</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.118</td>
<td>0.283</td>
<td>0.060</td>
<td>0.150</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Cadmium</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.247</td>
<td>0.187</td>
<td>0.010</td>
<td>0.490</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>13.398</td>
<td>9.854</td>
<td>0.020</td>
<td>24.680</td>
<td>1.50</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>43.798</td>
<td>31.875</td>
<td>0.010</td>
<td>68.350</td>
<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Iron</td>
<td>7.565</td>
<td>5.579</td>
<td>0.010</td>
<td>14.320</td>
<td>0.300</td>
<td>0.10</td>
</tr>
</tbody>
</table>
HEAVY METALS CONCENTRATION IN SEDIMENT SAMPLE AT IGBEDE RIVER WITHIN THE PERIOD OF STUDY.

Zinc recorded the highest mean value of 68.467±49.524 in the sediment sample while Chromium had the lowest mean value of 0.250±0.800. Iron concentration decreases from March to April and increases sharply in May with slight variation from May to August. Cadmium was not detected in March and April but was detected in May and the subsequent months (Table 3).

HEAVY METALS CONCENTRATION IN FISH SAMPLES

The heavy metals concentrations in the two fish species are shown in Tables 4 and 5. Lead mean concentration varied from 0.294±0.147 in Chrysichthys nigrodigitatus and 0.338±0.256 in Sarotherodon melanotheron. Cadmium was not detected in both fish samples. Chromium mean value of C. nigrodigitatus was 0.294±0.146 and 0.048 ±0.786 was in S. melanotheron. The value for Copper was 5.392 ± 3.478 in C. nigrodigitatus and 2.118±1.175 in S. melanotheron. Zinc mean value varied from 6.367±4.254 in C. nigrodigitatus and 3.108 ±1.869 in S. melanotheron. For Iron the mean concentration was 8.583 ±3.208 in C. nigrodigitatus and 7.328 ±3.453 in S. melanotheron.

A comparison of the heavy metals concentration in the fish in this study showed that levels of Copper, Zinc and Iron were higher in C. nigrodigitatus and S. melanotheron. Little variation occurred in the concentration of Lead and Chromium between both fish. (Table 4 and 5). Statistical analysis (ANOVA) of metal levels in both fish showed significant differences (P < 0.05). The seasonal variations of heavy metals in Water, Sediments, and fish samples within the sampling period are presented in figure 6.

Table 3: Heavy metals concentration in sediment samples at Igbede river within the study period (mg/kg).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Mini</th>
<th>Maxi</th>
<th>FEPA</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.599</td>
<td>0.433</td>
<td>0.010</td>
<td>1.101</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.473</td>
<td>0.557</td>
<td>0.390</td>
<td>0.550</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.250</td>
<td>0.800</td>
<td>0.900</td>
<td>0.360</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>59.023</td>
<td>42.369</td>
<td>0.680</td>
<td>97.200</td>
<td>1.50</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>68.467</td>
<td>49.524</td>
<td>0.080</td>
<td>105.250</td>
<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Iron</td>
<td>32.386</td>
<td>19.688</td>
<td>2.160</td>
<td>48.990</td>
<td>0.30</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Table 4: Heavy metals concentration in *Chrysichthys nigrodigitatus* at Igbede River within the period of study (mg/kg)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Min</th>
<th>Maxi</th>
<th>FEPA</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.294</td>
<td>0.147</td>
<td>0.010</td>
<td>0.450</td>
<td>2.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Cadmium</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.294</td>
<td>0.146</td>
<td>0.7000</td>
<td>0.480</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>5.392</td>
<td>3.478</td>
<td>0.690</td>
<td>9.520</td>
<td>3.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>6.367</td>
<td>4.254</td>
<td>0.750</td>
<td>11.450</td>
<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Iron</td>
<td>8.583</td>
<td>3.208</td>
<td>4.130</td>
<td>15.26</td>
<td>0.30</td>
<td>0.10</td>
</tr>
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</table>

Table 5: Heavy metals concentration in *Sarotherodon melanotheron* at Igbede river within the period of study (mg/kg)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Min</th>
<th>Maxi</th>
<th>FEPA</th>
<th>WHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0.338</td>
<td>0.256</td>
<td>0.000</td>
<td>0.640</td>
<td>2.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Cadmium</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.048</td>
<td>0.786</td>
<td>0.000</td>
<td>0.220</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>2.118</td>
<td>1.175</td>
<td>0.470</td>
<td>4.110</td>
<td>3.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.108</td>
<td>1.869</td>
<td>0.700</td>
<td>6.230</td>
<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Iron</td>
<td>7.328</td>
<td>3.453</td>
<td>3.490</td>
<td>15.100</td>
<td>0.30</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Figure 6: Seasonal variations of heavy metals in Water, Sediments, and fish samples within the sampling period.
DISCUSSION
The Igbede River in Ojo, Lagos has been subjected to contaminating materials capable of initiating the impairment of the water quality. Investigation into the accumulation of heavy metals in the water, sediment and two fish species (Chrysichthys nigrodigitatus and Sarotherodon melanotheron) at Igbede River in Lagos State, Nigeria between March, 2013 and August, 2013 was carried out in order to ascertain the pollution status of the river. The present investigation has revealed metals such as zinc (Zn), copper (Cu) and iron (Fe) and were generally high with mean values of \( 43.798 \pm 31.874 \), \( 13.398 \pm 9.8854 \) and \( 7.565 \pm 5.579 \) (Table 2) respectively when compared with recommended values for fresh water (FEPA 2003, and WHO 2008). These values in the surface water could be adduced to anthropogenic activities going on around the river. This is similar to the report of Adeniyi et al., (2007) based on their research at Agboyi creek segment near the Lagos lagoon recorded higher levels of metals in water and sediments samples. Metabolic rate and physiological processes are controlled by water temperature. As metabolic activities increase with an increase in temperature, fish demand for oxygen increases. In this study, The mean dissolved oxygen of \( 7.923 \pm 1.221 \) mg/l recorded in the sampling station buttressed the recommendation of the Federal Ministry of Environment, that DO level of 3.4 mg/l is required for fish growth. This is also in agreement with the work of Agboola et al. (2008) and Adeboyi et al. (2009) who reported the mean DO level of 4.81 mg/l in Badagry creek and 4.5 mg/l in Kuramo lagoon, Nigeria respectively. Comparatively, the DO level in Igbede river is well above the minimum (Table 1) 5.0 mg/l from the report of Awosika et al. (2002) and the 6.0mg/l standard suggested by FEPA (1999) for the survival of fish and other aquatic organisms. However, Dissolved oxygen remained slightly stable throughout the sampling period. pH values of \( 7.378 \pm 1.216 \) recorded within the sampling period was within the range recommended limit of FEPA (6.0-9.0) for freshwater.

Water samples showed a general increase in the concentrations of zinc (Zn) copper (Cu) and iron (Fe), while there was a decrease in those of lead (Pb), cadmium (Cd) and chromium (Cr). This was higher than the result obtained by Williams et al., (2007) at Igbede River, Lagos, Nigeria. The levels of zinc (Zn), copper (Cu) and iron (Fe) in the water samples generally exceed the WHO limits for drinking water. The concentrations of lead (Pb) and chromium (Cr) in the water samples fall within the limit set by FEPA and WHO, this is similar with the work of Williams et al., (2007) at Igbede river. Continual consumption could lead to accumulation with adverse health implications (Kjellstroem, 1986). Metals from the surface water could be a contributing source to the levels in animals’ hence continual assessment is highly essential. Cadmium (Cd) was not detected in the water samples. The highest concentration of heavy metal investigated was recorded in the sediment which has been reported to serve as major repository of heavy metal in aquatic system (Olowu et al., 2010a; Adeniyi and Yusuf, 2007; Maaboodi et al., 2011).

The metal levels in sediments were higher than those in the surface water and organisms. Animals are known to take up and accumulate heavy metals from contaminated soils (Pulford and Watson, 2003). Hence detection in fish samples was not surprising.

This study has confirmed that sediments are important hosts for toxic metals. It has been shown that sediment permit the detection of heavy metals that may be either in absent or in low concentration in the water column. The occurrence of enhanced concentrations of heavy metals in sediments such as that obtained from Igbede river can be a good indication of man induced pollution rather than by natural enrichment through geological weathering.

Zinc (Zn) recorded the highest concentration levels in the sediment and water samples. Zinc (Zn) is an essential element for normal growth, reproduction and longevity of animals (Sultana and Roa, 1998). Mining, smelting and sewage disposal are the major sources of zinc pollution (Skidmore, 1964). Zinc (Zn) is
efficiently regulated by wildlife and tissue concentrations are not reliable indicators of exposure (Beyer and Storm, 1995). However, Eisler (1993) reported that elevated concentrations of waterborne zinc (Zn) has adverse effects on growth, survival, behavior, and reproduction of sensitive fishes, with early life stages being the most sensitive. The predominance of zinc (Zn) may suggest anthropogenic influence possibly from municipal sources. Also, it has been reported that excessive zinc (Zn) affects the hepatic distribution of other trace metals in fish (Tchounwou et al., 1996). This, no doubt, would affect tissue metal concentrations as well as certain physiological processes. Zinc (Zn) generates toxicity to fish by interfering with calcium homeostasis (Hogstrand and Wood, 1996). In the present study, zinc (Zn) mean concentration for all samples analyzed was far above the maximum acceptable limit of zinc (Zn) set by FEPA and WHO. Studies have shown that, zinc (Zn) could be toxic to some aquatic organisms such as fish (Alabaster & Lloyd, 1980). Although zinc (Zn) has been found to have low toxicity to man, prolonged consumption of large doses can result in some health complications such as fatigue, dizziness and neutropenia (Hess & Schmidt, 2002).

Iron (Fe) concentrations in the sediments were relatively high (32.39±19.69), but this is lower than the values obtained by Adekoya et al., (2006) and Williams et al., (2007) (1,633.42±206.79 and 1,633.42±238.78) respectively at the same sampling site. This could be due to natural processes instead of anthropogenic activities as iron (Fe) occurs abundantly in the natural environment and may come from background levels in the sediments. According to Sholokovitz (1978), Wilson et al. (1986) and Din (1992), metal levels that originate from natural processes such as erosion and flocculation of metals may cause elevated levels in sediments and biota unrelated to anthropogenic sources. Studies of the transport of heavy metals by major rivers in the world indicate that substantial quantities of iron (Fe) are transported daily and associated with suspended sediments in these rivers (Clark, 1986). Since Igbeye river is adjoining to Lagos lagoon it may have been enriched with iron (Fe) as a result of transportation. The amount of iron (Fe) found in the fish samples could be attributed to iron (Fe) rich haemoglobin and secondarily to the suspended particulates that might have been ingested along with its food. The amount of iron (Fe) recorded in the fish samples (8.58mg/l and 7.33mg/l) for Chrysichthys nigrodigitatus and Sarotherodon melanotheron were lower than those reported by Unyimadu et al., (2008) in the fish from Badagry (17.88mg/l) and Somboi river (12.43mg/l), Nigeria. Iron (Fe) is more of dietary supplement than a pollutant. The knowledge of the forms in which iron (Fe) is made available to aquatic species provides information on its vulnerability and establishes a relationship between iron (Fe) in the sediment, fish and water. Excess of iron (Fe) in humans is known to cause haemorrhagic necrosis and sloughing of areas of mucosa in the stomach with extension into the submucosa (WHO, 1996).

Levels of contaminants in aquatic animals are of particular interest because of the potential risk to humans who consume them. Heavy metals toxicity in fish is frequently the result of a long term low level exposure to pollutants compound in the aquatic environment. However, the aquatic ecosystem has been reported to be the ultimate recipient of heavy metals pollution (Biney et al., 1991). Heavy metals were bioaccumulated in varying levels in both fish samples. Zinc (Zn) was the most bioaccumulated metal. There exist slight variation in the accumulation pattern of both fishes with zinc (Zn), copper (Cu) and iron (Fe) being more accumulated while chromium (Cr), lead (Pb) and cadmium (Cd) were least accumulated by both fish species.

However, Chrysichthys nigrodigitatus accumulated higher levels of zinc (Zn), copper (Cu), and iron (Fe) than Sarotherodon melanotheron, while levels of chromium (Cr), lead (Pb) were also higher that of Sarotherodon melanotheron and cadmium (Cd) was not detected in both fish samples. The differences in the metals accumulation levels of fishes could be linked to differences in their metabolic rates. It has been reported that different organisms have different
metabolic rates and food requirements and amounts. Organisms with high food intake tend to accumulate more metals (Araoye, 2002). The higher concentration of the metals in *Chrysichthys nigrodigitatus* may be connected to the larger sample of the fish when compared to the average size of *Sarotherodon melanotheron* samples. Araoye (2002) listed size of organism as one of major factors influencing bioaccumulation. Generally in all the samples analyzed for this study the accumulation of essential elements namely: zinc, and copper, iron were the largest. The essential elements such as zinc are regulated to maintain certain homeostatic status in fish (Chen and Chen, 1999). On the contrary, the non-essential elements, such as cadmium, chromium and lead, have no biological function or requirement and their concentrations in the samples examined were generally low as seen in (Tables 2, 3, 4 and 5) which agreed with the result of Thompson (1990). Though, most of these non essential metals are present in Igbede River in low concentrations, one may not rule out the fact that the metals may be substantial in the river but the values were low because all the metals taken up are not accumulated since fish have the ability to regulate their body metal concentration to a certain extent.

Statistical analyses of the mean levels indicated that the distribution of the metals in the samples followed the order Zn>Cu>Fe>Pb>Cd>Cr for sediment; Zn>Cu>Fe>Cr>Pb for water; Fe>Zn>Cu>Pb>Cr for *Chrysichthys nigrodigitatus* and Fe>Zn>Cu>Pb>Cr for *Sarotherodon melanotheron*. The investigation showed that Igbede River in Ojo, Lagos is fairly contaminated by heavy metals and that the levels of contamination of the fish in the river indicate that their consumption may cause serious health hazards to man.

**CONCLUSION**

This study has shown that zinc (Zn), copper (Cu) and iron (Fe) were high in the water, sediment and fish samples collected from Igbede river, while the levels of lead (Pb), chromium (Cr) and cadmium (Cd) in the samples were within permissible limits set by FEPA and WHO. These heavy metals may be transferred to man on consumption and may be hazardous to health because of their cumulative effect in the body.

The concentration of these parameters of pollution contained in the study area indicated that the River is fairly polluted. The possible sources of these parameters of pollution are diverse: originating from anthropogenic / natural and point sources. Elevated levels of metals in water have been implicated as risk to human health and the "health" of the aquatic system. The continuous monitoring of metal pollution of the river system is essential. Activities that predispose point source and diffuse contamination should be discouraged by the appropriate governmental agencies. It can be conclusively deduced from this study that fish has the tendency to bio-accumulate metals in a polluted environment. Thus the indiscriminate consumption of fish from a polluted water body should be discouraged. Federal government should enact laws that will ensure industries make use of standard waste treatment plants for the treatment of their wastes.

Further investigation on the pollution of Igbede river is highly recommended in view of the importance of the river as a source of supply of fish to the increasing population of Lagos State.

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