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Physicochemistry, Nutrient Levels and Concentrations of Lead and Cadmium in Bones and Muscle Tissues of Synodontis Ocellifer from River Nun, Bayelsa State

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ABSTRACT

The contamination of aquatic ecosystemsby heavy metals from anthropogenic activities is a major threat to aquatic biodiversity and human health. This study therefore assessed the levels of Lead (Pb) and Cadmium (Cd) in the bones and muscle tissues of Synodontisocellifer collected from River Nun, Bayelsa State. Water samples and sediments were also analyzed for physicochemical quality and nutrient levels following standard protocol. Fishes were collected with the aid of local fishers. A total of 15 individual fish were caught from five locations (LA – LE) in triplicates. The bones and muscle tissues were analyzed using graphite furnace Atomic Absorption Spectrometer (AAS). Result showed that physicochemical parameters across all locations were within allowable limit of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) limit. The mean concentration of Pb and Cd in bone and muscle tissues were within the critical limit values of the FAO/WHO. It can be reasonably concluded that the consumption of Synodontisocellifer from the River Nun does not pose any health risk. The monitoring of heavy metals in fish and water quality of aquatic ecosystems should also be sustained to conserve biodiversity and provide a health guide.

Keywords: Physiochemistry, Nutrient, Lead, Cadmium,*Synodontisocellifer*, River Nun, Bayelsa State

1.0 INTRODUCTION

The consumption of fish worldwide, far exceeds the consumption of any other protein source. Apart from its global acceptability, fish provides a better source of digestible protein to humans because of its better biological value (BV), desirable lipids, valuable mineral compounds and vitamins (Darwish *et al,* 2003).Recent records show that a significant 16% of all animal protein consumed worldwide is fish (FAO, 1981). Despite its nutritional importance and acceptability, fish is a commodity that posesa potential health concern because of its ability to bioaccumulate massive amounts of toxic contaminants from its living environment. One group of these toxic contaminants accumulated by fish are heavy metals and their derivatives (Suhaimi*et al*, 2006).

Heavy metals are high density natural components of the Earth's crust being indeed abasic natural constituent of our environment but are also products of industrial human activities and processes. In recent times, environmental pollution by heavy metals has become a chief concern worldwide because of their toxicity even at low concentrations, persistence in nature, bioaccumulation and biomagnifications in the food chain.Pb and Cd for instance are among the main toxic metals of environmental concern. They accumulate in the aquatic food chain including fish and have become a grave subject of public health discuss (Cunningham, *et. al.* 2003).

Pb and Cd belongs to a group of toxic heavy metals which have no function in the physiological processes of living organisms (Adeyeye et al, 1996). Although Cdis used in the steel and plastics industries and Pb is used for battery production, both Pb and cd are released into the environment from tyre wear, fuel combustion, batteries, ceramics and cosmetics (Ogamba*et al,* 2017). Most of the releases of heavy metals into the environment, culminate in the aquatic environment.

The fish *Synodontisocellifer*, commonly known as ocellated synodontis, is a speciesof cat fish native to the rivers of northern and west Africa (Froese & Pauly, 2016). It is plenteous in the River Nun and constitutes a significant amount of the landed fish catch by fishers in the Niger Delta of Nigeria. Given its significant stature in total fish catch and the fact that fishes are intricately associated with their environment, there is a critical need to monitor heavy metal concentration in this fish species in order to determine the safety of its consumption and the ecological health of the environment.

2.0 Materials and Methods

2.1 Study Area

Bayelsa state is one of the Niger Delta states with a major central tributary called River Nun. Amassoma is a riverine community located in Southern Ijaw Local Government area. It has the River Nun as one of itsmajor River. The major occupation of Amassoma people is farming, fishing and trading. The study areahas two prevailing seasons. The dry season (March to October) while the wet season is from November to February.

2.2 Sample Collection

Water samples were collected in triplicate from the 5 locations (LA – LE) in the month of November, 2021. The samples were collected using 1 litre sterilized plastic bottles. Sediment samples were also collected using an Eckman grab. Sediment samples were put in foils before being transported to the laboratory. In addition, ttriplicate samples of fishes were caughtaroundthe 5 sampling stations (LA – LE) with the aid of local fishers. All samples were transported to the laboratory in ice chest. The fish samples wereidentified using standard taxonomical keys (Idodo-Umeh,2003;F.A.O., 1981), as*Synodontisocellifer* before the laboratory analysis.

2.3 Water Quality Analysis

Some water quality parameters were measured*in-situ*.Themeasured parameters included; Temperature, pH, Conductivity, Total Dissolved Solids, and turbidity. The pH, temperature, conductivity, Dissolved oxygen and Total Dissolved Solids (TDS) were determined in situ using portable digital meter (Extech-407510A).Winkler's method was used for dissolved oxygen and BOD_5 (biochemical oxygen demand) analysis; while TSS (total suspended solids) was analyzed using gravimetric method. Hach's turbidimeter model 2100P was used for the measurement of turbidity.

2.4 Analysis of Water Nutrients (NO_3, SO_4, PO_4 and SiO_2)

2.4.1 Nitrate (NO_3)

Water samples from the field was placed into a 20ml volumetric flask, 1 tablet of Nitrest and 1tablet of Nitratest were crushed and added into water sample in the flask. The flask was agitated for 10mins to aid dissolution of the tablets and to fluctuate the mixture for 4mins. 10ml of the supernatant was transferred into a 10ml flask and 1 tablet of Nitricol was crushed, added and properly mixed, and left to stand on the bench for 10mins for colour development. The spectrophotometer was set at 570nm and the percentage transmittance was taken and the concentration of Nitrate (NO_3) in mg/l was read directly from the concentration chart (Wag Tech.).

2.4.2 Sulphate (SO_4)

Hundred milliliter (100ml) water samples were placed in a 250ml conical flask, 5ml of conditioning reagent was added, followed by a spatula full of $BaCl_2.2H_20$ salt and mixedby shaking and swirling. The Jenway 6300 spectrophotometer was set up at 425mm and within 2mins of shaking, the mixture absorption values were taken. The concentration of sulphate in the water sample was read off from a standard sulphate curve drawn from a standard Na_2SO_4 (anh) solution.

2.4.3 Phosphate (PO_4)

The Vanado-Molybdate method was used. Into a 50ml volumetric flask, 30ml of filtered water sample was placed, followed by 10ml of molybdate reagent. This was then made up to the mark with more samples.This was left to stand on the bench for 20mins for colour development. The spectrophotometer was set at 470nm and absorbance values taken. The concentration of PO_4 in the water sample was obtained from a PO_4 standard curve by extrapolation.

2.4.4 Silicon Dioxide (Silica SiO_2)

0.211g of sodium silicate ($Na_2SiO_3.9H_2O$) was weighed into a 1l flask and dissolved in distilled water giving a stock solution of 200ppm.

2.5 Fish Sample Treatment and analysis

Muscle tissues and bone of the fish collected from the respective replicate fish samples were dried using a Memmert U27 type drying oven at a temperature of 70^{o}C for 24 hours. Two grams of the dried muscle tissue and bone samples were each transferred into clean porcelain crucibles and dried to ash in an Oceanic SX-2 type muffle furnace at a temperature of 450^{o}C until the samples were grayish-ash. Samples were left to cool in a desiccator for about 30 minutes. A solution of the ash was prepared by adding 5 ml of 1 N nitric acid (HNO_3) and 10 ml of 1 N hydrochloric acid (HCl). A reagent blank containing acid mixtures used was prepared devoid of sample. The methods for sampling, preservation and analysis followed already established standard protocol as established by theAmerican Standard for Testing Materials (ASTM, 2010) and American Public Health Association (APHA, 2010).

2.6 Heavy Metal Analysis

The treated bone and muscle tissue samples were analyzed for Lead and Cadmium using Atomic Absorption Spectrometer (AAS) (APHA 301A; 5100 PC, Perkin- Elmer, and Boston USA).

2.7 Statistical Analysis

IBM SPSS® Version 23software was used for statistical analysis. The data was analyzed for means and standard deviation. Data was also subjected to Analysis of Variance (ANOVA), while Duncan Multiple Range Test (DMR) was used to compare and separate means. This was done at the 95% confidence limit (P=0.05). The charts were plotted using Excel 2016 tool kit.

3.0 RESULT

Results on the physicochemical quality of water from Tantua river is presented in Table 1. Result on the pH showed values that ranged from 6.61 – 6.78 with highest value in Station LB, while the lowest value was in station LC. There was a significant difference (P<0.05) between the pH values of all locations. The pH values were within the range of allowable values recommended by the World Health Organization. The pH values of this study were lower compared to values reported by Leizou, et al, (2017) who recorded pH values that ranged from 7.45-7.52. Values recorded in this study were found to be similar to those of Inengite*et al*. (2010); Gobo, *et al* (2013) andAghoghovwia and Ohimain (2014) The pH of water is an important ecological factor and provides an important information on many types of geochemical equilibrium or solubility calculation (Prasad *et al*., 2014).
Result on the temperature showed values ranging from 29.43 – 30.86 ^{O}C with the highest value in Station LB, while the lowest value was in station LD (Table 1). Apart from station LE, there was no significant difference (p>0.05) between Stations LA and LD as well as LB and LD. There are no specific regulatory values for temperature but the temperature of water recorded for this study for all locations were within Ambient temperature (25 – 32 ^{O}C) recommended for tropical species. Standard temperature that sustains life should be ambient.

Table 1: Result of Physicochemical Parameters

	pH	Temperature	DO	BOD	Salinity	TDS	TSS	Turbidity	Conductivity
LA	6.77±0.351^{bc}	29.15±0.153^{a}	4.90±0.049^{c}	6.24±0.271^{a}	26.88±0.158^{a}	71.79±0.185^{a}	40.31±0.64^{c}	43.93±0.037^{a}	59.79±0.239^{a}
LB	6.86±0.153^{d}	30.03±0.055^{b}	5.65±0.045^{d}	8.90±0.025^{c}	29.92±0.032^{b}	92.69±0.026^{d}	33.60±0.275^{b}	56.89±0.02^{d}	66.93±0.413^{d}
LC	6.61±0.020^{a}	29.78±0.220^{b}	4.45±0.060^{b}	8.14±0.168^{b}	29.89±0.164^{b}	88.22±0.408^{c}	30.45±0.106^{a}	48.62±0.058^{c}	61.15±0.22^{b}
LD	6.68±0.097^{ab}	29.43±0.173^{a}	4.40±0.030^{b}	8.21±0.20^{b}	31.75±0.603^{c}	79.90±0.78^{b}	42.37±0.202^{d}	65.29±1.210^{e}	65.63±0.46^{c}
LE	6.78±0.020^{cd}	30.86±0.186^{c}	4.08±0.01^{a}	8.10±0.080^{b}	34.42±0.39^{d}	99.21±0.672^{e}	47.92±0.77^{e}	46.90±0.01^{b}	74.02±0.352^{e}

Means±Standard deviation.Means with the same letter superscript along the same column are not significantly different (P>0.05)

Results on dissolvedoxygen (DO) levels showed values that ranged from 4.08 - 5.65 mg/l with significant differences (P<0.05) apart from stations LE and LD. The highest DO level was reported in station LB, while the lowest DO was in station LE (Table 1). The observed DO levels for all stations in the current study were within the recommended permissible limit of 3.0-7.0mg/l for drinking water (Nigerian Industrial Standard (NIS), 2007; WHO, 2011). The values obtained agree with the results of Inengite*et al*. (2010); Williams and Odokuma (2014) and Daka*et al*. (2014). The DO of water may be harmful to aquatic life, especially if lower than 2.0mg/l (Ohimain, et al, 2013). Agedah*et al*(2015) reported DO levels of 10.20±0.283 and 14.22±0.263mg/l for Igbedi and Ogobiri which are along the river Nun axis. Some other rivers in Bayelsa had DO in the ranges of 4.8mg/l – 7.2mg/l for Kolo creek (Seiyaboh*et al*, 2013b), 1.38 – 9.06 and 1.76 – 5.68 mg/l for dry and wet seasons of Epie creek respectively (Izonfuo&Bariweni, 2001).
The Biochemical Oxygen Demand (BOD) levels of the water ranged from 6.24 – 8.90 mg/l with highest value in Station LB, while the lowest value was in station LA (Table 1). Apart from stations LA and LB, there was no significant difference (p>0.05) between the BOD levels of all locations. These results were within the permissible limit (NIS, 2007; WHO, 2011) and agrees with those of Ogamba and Ebere (2017) for the Kolo Creek.
Results on the levels of salinity ranged from 26.88 – 34.42 mg/l with highest value in Station LE, while the lowest value was in station LA. The was significant difference (P<0.05) between the salinity values of all locations. The salinity values were within the range of allowable values recommended for tropical aquatic life.
The level of total suspended solid (TSS) ranged in the river ranged from 30.45 – 47.92 mg/l with significant difference (p<0.05) across all locations. The highest TDS value was recorded in Station LC, while the lowest value was in station LE (Table 1). The total dissolved solid (TDS) ranged in the river ranged from 71.79 - 9.21 mg/l with significant difference (p<0.05) across all locations. The highest TDS value was recorded in Station LE, while

the lowest value was in station LA (Table 1). Notwithstanding, our values are comparable to previous studies of surface water in Bayelsa state. Aghoghovwia and Ohimain, (2015) reported TDS value of 41.5 – 51.0 mg/l in Lower Kolo creek. Epie creek TDS values were 55 - 62 and 33 – 37.33 mg/l in dry and wet seasons respectively (Izonfuo&Bariweni, 2001), and 62.1 – 67.9 mg/l for Tombia axis of the river Nun (Seiyaboh*et al*., 2013).

Result on the levels of turbidity of the water samples ranged from 43.93 - 65.29 NTU, with significant difference ($P<0.05$), across all locations. The highest turbidity value was reported in station LD, while the lowest turbidity value was reported in station LA. This study is comparable to a recent study, which reported turbidity values of 103.752±2.06 NTU upstream the river Nun axis of Agudama-Ekpetima, and 117.002±2.160NTU downstream river Nun (Agedah*et al*., 2015). Other authors who studied surface water in the Niger delta reported turbidity values 62.54 NTU in Igbedi creek (Seiyaboh*et al*., 2013a), 5 – 64 NTU around Tombia bride AgudamaIkpetiama(Seiyaboh*et al*., 2013b), 11.67 – 19.67 and 16.67 – 28.00 NTU, along the Epie creek in dry and wet seasons respectively (Izonfuo&Bariweni, 2001).

The conductivity levels ranged from 59.79 - 74.02 µS/cm with significant difference (P<0.05) across the locations. The values reported in this study, complied with WHO and SON permissible limits of 1000 µS/cm. This value corroborates the range of values reported by other authors who observed 82.30 – 102.0 µS/cm for Kolo creek (Aghoghovwia&Ohimain, 2014), 76.23 umhos/cm for Igbedi creek (Seiyaboh et al., 2013b), 87 – 95 umhos/cm during the construction of Tombia bridge (Seiyaboh*et al*., 2013b).

Results on the levels of nutrients is presented in Figure 1. Nitrate levels ranged from 4.26 – 6.83 mg/l, with lowest and highest values in Locations LD and LA respectively. Also, the levels of sulphate ranged from 4.96 – 5.90 mg/l with lowest and highest values in locations LC and LA respectively (Figure 1).

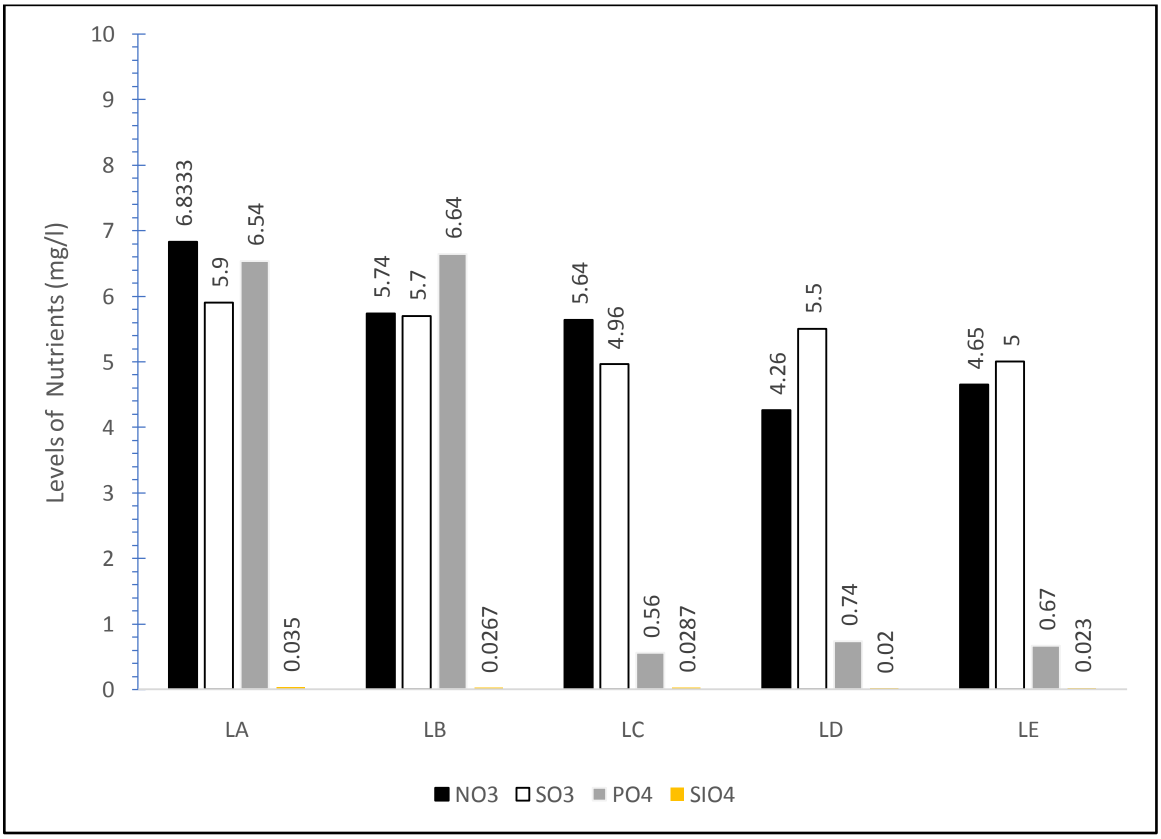

Figure 1: Levels of Nutrients in water

These values of nitrate reported in this study were similar to those observed previously by Seiyaboh*et al*. (2013a), in surface water in the Niger Delta. Runoff and organic matter decomposition in surface water also produced inorganic nutrients such as ammonia, nitrate and phosphates with resultant effects of eutrophication and other serious ecological impairments of such water bodies. Results on the levels of phosphate showed values ranging from 0.56 – 6.54 mg/l, with lowest value in LC and highest value in LA (Figure 1). Phosphate (PO_4^{3-}) can be found as a free ion in water systems and as a salt in terrestrial environments used in detergents as water softeners.

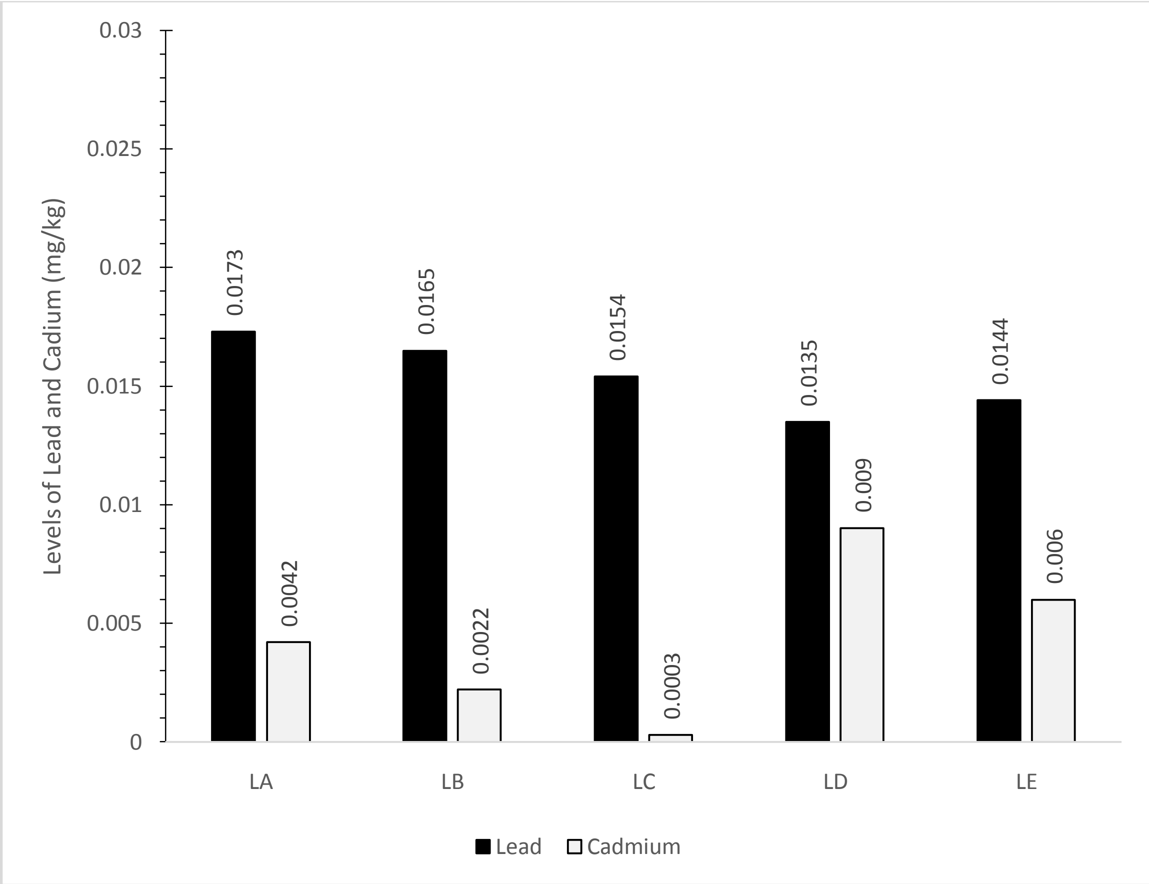

Figure 2: Levels of Lead and Cadmium in Sediment

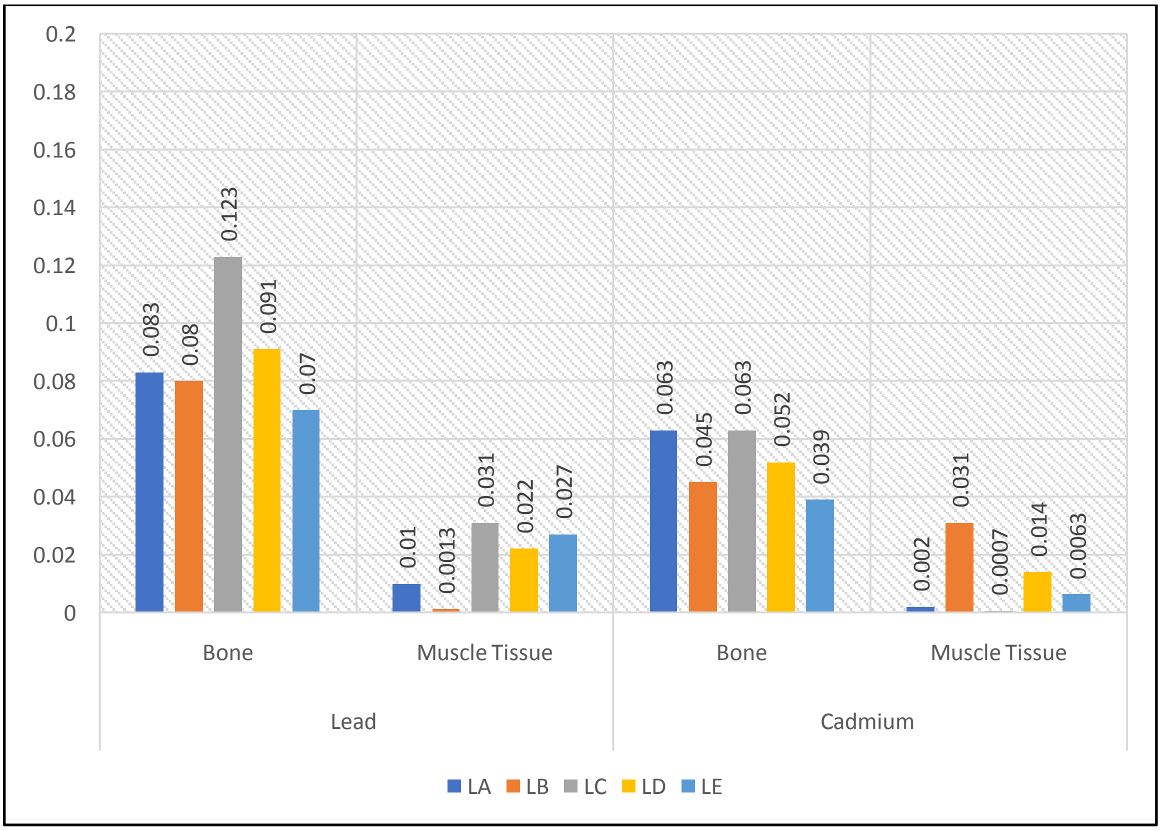

Figure 3: Levels of Lead and Cadmium in bones and muscle tissues

The elevated phosphate concentration in water have been linked to increasing rates of plant growth, changes in species composition and proliferation of planktonic and epiphytic and epibenthic algae, resulting in shading of higher plants (Chapman &Kimstach, 1996). In addition, silicate levels ranged from 0.020 – 0.035 mg/l. The lowest silicate value was reported in Location LD, while the highest silicate value was reported in location LA (Figure 1). Results on the levels of Lead and Cadmium in sediment is presented in Figure 2. Lead levels ranged from 0.135 – 0.0178 mg/l, with lowest and highest values in Locations LD and LA respectively. Also, the levels of Cadmium ranged from 0.003 – 0.006 mg/l with lowest and highest values in locations LC and LE respectively (Figure 2).

The result on the levels of Pb and Cd in bones and muscle tissues of the fish is presented in Figure .3. Result on the levels of Pb in the bone ranged from 0.07 – 0.123 mg/kg, with lowest and highest values in LE and LC (Figure 3). Levels of Pb in the muscle tissue ranged from 0.0013 – 0.031 mg/kg, with lowest value in LB, while the highest value was reported in LC (Figure 3).

Result on the levels of Cd in the bone of the fish ranged from 0.039 – 0.063 mg/kg. The lowest Cd level was reported in location LE, while the highest Cd level was reported in location LC (Figure 3). Levels of Cd in the muscle tissues ranged from 0.0002 – 0.031 mg/kg, with lowest value in LB, while the highest value was reported in LC (Figure 3). Fortunately, the levels of lead and cadmium reported in this study were within the allowable FAO/WHO limit of 0.500 mg.kg (FA0, 1981, WHO, 2007)

The sources of the heavy metal pollutant are mainly from anthropogenic activities and to a lesser extent from natural causes. Generally, when industrial wastes with toxic heavy metals find its way into the aquatic ecosystem it could have an impact on the biotic composition of such water including fisheries. The bioaccumulation of heavy metals in aquatic biota is mainly dependent on the capacity of the organisms to digest the metals as well as the concentration of such metal in the water body, sediment and surrounding soil and the feeding habits of such organism (Eneji*et al*., 2011). The result of this study has revealed that the amount of Pb and Cd in the bones and muscle tissues in the fish species is within the recommended permissible limits and does not possess a significant threat to human health and the environment.

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