P-ISSN: 2305-6622; E-ISSN: 2306-3599
International Journal of Agriculture and Biosciences
www.ijagbio.com; editor@ijagbio.com

Research Article

Comparative Analyses of Metal Pollutants Trans-Bioaccumulations in *Sarotheredon melanotheron* and *Chrysichthys nigrodigitatus* from Porto-Novo Lagoon Ecosystem

Babalola O Adeniyi[1*] and Fiogbe D Emile[2]

[1]Department of Fisheries Technology, Lagos State Polytechnic, Ikorodu, Lagos State, Nigeria
[2]Laboratory of Research on Wetlands, Department of Zoology University of Abomey Calavi, Benin Republic
***Corresponding author:** sola_aug@yahoo.com; edfiogbe@yahoo.fr

Article History: Received: February 17, 2018 Revised: May 24, 2018 Accepted: June 11, 2018

ABSTRACT

Comparative analyses of metal pollutants trans-bioaccumulation in *Chrysichthys nigrodigitatus* and *Sarotheredon melanotheron* organs and tissues from Porto-Novo Lagoon was carried out during rainy and dry seasons. Metal pollutants such as Hg, Cd, Cu, Zn, Cr, Fe, Mn, Pb, Ni, Va, and MH_3Hg were found in measureable amounts in the tissues and organs of the test animals using Atomic Absorption Spectrophotometer equipment. The mean range of all metal pollutants found in the tissues and organs between July 2014 and June 2015 are given. *C. nigrodigitatus:* Gill (29.23-230.67mg/kg), Liver (46.25-318.22 mg/kg), Bone (75.65-247.20mg/kg), Gut (19.98-208.09mg/kg) and Muscle (186.72-245.25mg/kg) and for *S. melanotheron*: Gill (158.10-357.70 mg/kg), Liver (270.67-1931.73 mg/kg), Bone (27.61-130.40 mg/kg), Gut (272.61-1247.05 mg/kg) and Muscle (104.50-6133.46 mg/kg). There is significant difference at 5% level in the means of metal pollutants in tissues and organs of *S. melanotheron and C. nigrodigitatus* during the study periods. Laboratory and statistical analyses conducted on metal pollutants bioaccumulations in the organs and tissues of the test animals shows that *Sarotheredon melanotheron* had the highest means values of metal pollutants bioaccumulation than *Chrysichthys nigrodigitatus* due to its filter feeding ability and the bio accumulation of these metal pollutants in the test animals are above regulatory permissible limits. It is therefore recommended that *S. melanotheron* and *C. nigrodigitatus* from Porto-Novo Lagoon are not safe for human consumption.

Key words: Trans-bioaccumulation, *Chrysichthys nigrodigitatus*, *Sarotheredon melanotheron*, Metal Pollutants, Porto-Novo lagoon

INTRODUCTION

The apparent deteriorating quality of the environment in its different components with the attendant pollution of environmental media such as air, soil is a major problem that is destroying the ecosystem. These Pollutants, whatever their origin or nature can have adverse impacts on different ecosystems. A collection of metal pollutants are known to enter water bodies by discharge from municipalities, industries, and farmlands and when it occurs singly or combined may be hazardous at a certain level when they exceed their threshold limit and becomes metal pollutants to the biotic and abiotic elements of the environment (Olorunda *et al*., 2007).

The sources of these pollutants are majorly from effluents discharge from industries and metropolitan cities. These pollutants have been the leading worldwide cause of death and diseases in both human and animals (Daniel, 2006). The rate of bio-accumulation of metal pollutants in aquatic organisms depends on the capacity of the organisms to metabolize the metals and the concentration of such metals in the aquatic environment (Horowitz, 1985).

Metal pollution of ecosystems in particular watercourses is a crucial issue for the development of the coastal country. Similarly, watercourse such as Porto-Novo Lagoon is vital for the economic and social development of the riparian community.

Fishes have been known as a good bio-accumulator of organic and inorganic pollutants (Ishaq, *et al*., 2011). Moreover, most organisms lack the ability to metabolize and excrete trace metals on absorption and these metals accumulate in the cells and tissues of exposed organisms and may be magnified along food chains (Bryan and

Cite This Article as: Adeniyi BO and FD Emile, 2018. Comparative analyses of metal pollutants trans-bioaccumulations in *Sarotheredon melanotheron* and *Chrysichthys nigrodigitatus* from Porto-Novo lagoon ecosystem. Inter J Agri Biosci, 7(3): 122-128. www.ijagbio.com

Langston, 1992). This phenomenon however, has been characterized by a number of previous works on environmental pollution and assessment.

The catfish, *Chrysichthys nigrodigitatus* (Lacépède), belongs to the family of Bagridae and it is widely distributed in fresh and brackish waters in West Africa (Muyideen. *et al.*, 2010; Holden and Reed, 1991). *C. nigrodigitatus* is important both in ecological and economic terms, playing a salient role in determining the nature and structure of the aquatic ecosystem and is valued as food for man; serving as a delicacy for the common man as it is cherished for its daintiness and reasonably price (Andem, *et al.*, 2013).

The black-chinned tilapia, *Sarotherodon melanotheron* (Cichlidae) is another major fish found in West African coastal waters. Cichlids are mostly freshwater species but *S. melanotheron*, however, is generally found in estuaries and lagoons and occasionally in the mouth and the lower course of coastal basins. The fish is a filter feeder and also feeds on a wide range of plankton. No clear food preference between juveniles and adults, the juvenile fish had a preference for the Cyanophyceae, Chlorophyceae, and Rotifera, whilst the adults generally preferred Cladocera, Bacillariophyceae, and Cyanophyceae (Ofori-Danson and Kumi, 2016).

Food and feeding habitats of *C. nigrodigitatus* and *S. melanotheron* from Porto-Novo Lagoon ecosystem and the roles they play in the trophic chain makes these fin fishes important aspect of pollution study especially in bioaccumulation of metal pollutants in their tissues and organs.

The biological effect of trace metals in the lagoon ranges from beneficial stimulation to harmful retardation and death (Law and Singh, 1991). It is therefore, necessary to assess the impact of metal pollutants bioaccumulations in some commercially important fish species from Porto-Novo Lagoon in order to assess the risks to human health.

MATERIALS AND METHODS

Description of study site

Porto-Novo Lagoon is located in Porto-Novo town which is the capital of Benin Republic located at the extreme southeastern part of the country and having a coordinate of Latitude 6o 29' 36"N longitude 2o 2' 18"E (Figure 1).Yehouenou *et al.*, 2013 as cited by Babalola and Fiogbe, 2016.

The complex Porto-Novo Lagoon is one of the largest lakes in West Africa with high productivities and exploitation and run parallel to the coast behind the dune systems (Yehouenou *et al.*, 2013). The lagoon is triangular in shape, spans an area of approximately 30 km^2 in the deep waters and 20 km^2 in the shallow waters. It is 6km in length (West-East) and its width diverges between 2 and 4 km.

Sampling duration

Fish samples were collected for the duration of 12 months, between July and December 2014 representing hydrological rainy season and between January and June 2015 representing the hydrological dry season. These data were combined together as annual data by estimating their means.

Structure and Specimen Assessment Survey

The study site was visited one day in a month. Fish samples (*C. nigrodigitatus* and *S. melanotheron*) (Fig.s 1 and 2) were purchased from landing sites at the study site. Fish Samples were properly coded and the fish taxonomy used was also generated. During the study period, n=36 of *C. nigrodigitatus* and n=36 of *S. melanotheron* representing 3 replicates with average size of 50g per fish were sampled and analyzed for 12 months. Parameters of interest used are 11 metal pollutants which made up parts of FAO (1981), WHO (1989), FEPA (1991) and EPA (2016) recommendations. Chains of custody of all samples taken were duly observed.

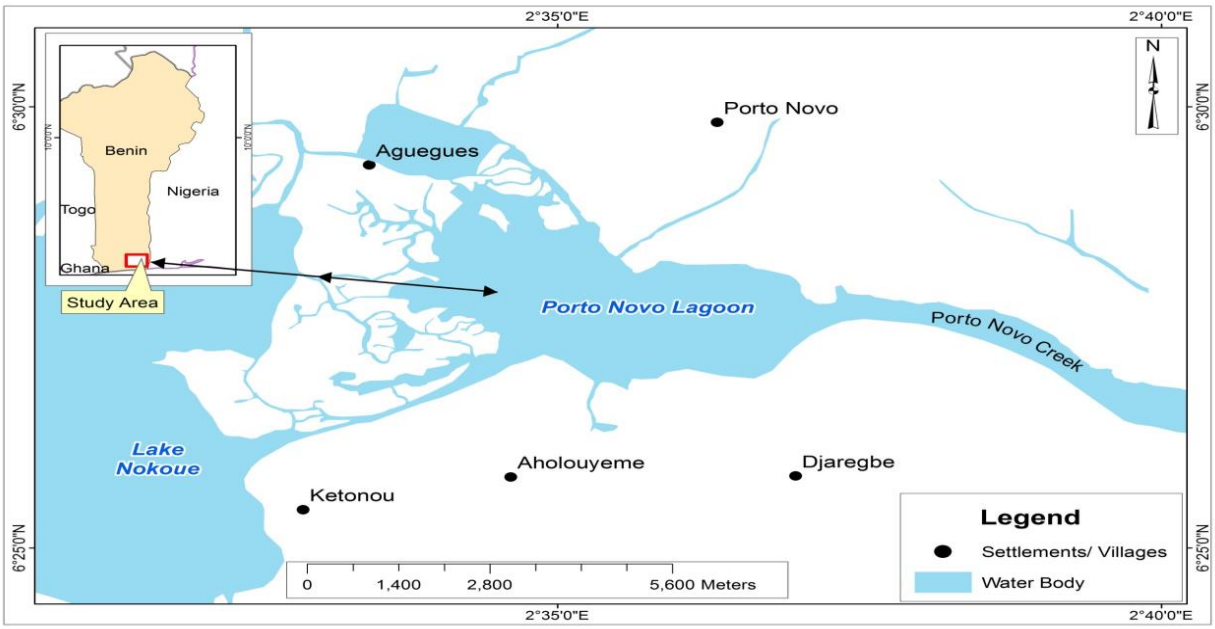

Fig 1: Location of the study (Source: Babalola and Fiogbe, 2016).

Fig. 1: *C. nigrodigitatus*

Fig. 2: *S. melanotheron*

Techniques for metal pollutants detection

The digestion determination of metal pollutants in fisheries resources tissue/organ followed the methods described by APHA (2006) for all the metal pollutants with slight modification for mercury with the use of Cold-Vapour-AAS instead of Flame-AAS. The weight of 5g of fish sample was put it in a conical fask of about 250ml capacity and 25ml of digesting reagent (Nitric acid and Hydrogen peroxide) in ratio 1:1was added and placed on a hot Fig. under the fume cupboard. The heat was applied at a temperature, not more than 120^0c. When the sample is about 5ml in the conical fask it was brought down and allowed to cool and filtered the sample using the Whatman I filter paper into a 50ml standard volumetric flask after cooling. Make up the volume to mark and set the sample for Flame-AAS (calibrated) for Trace Metals reading. The metal pollutants concentration was calculated thus (IAEA, 1998).

$$C(\mu g / g) = (Cd - Cb) / W = xVxF$$

C = Concentration of element in original sample (µg g-1 dry weight); C = Concentration of element in sample solution (µg mI-1) d; C = Mean concentration of element in reagent blanks (µg mI-1) b; V = Volume of dilution of digested solution (mI); W = dry weight of sample; F = Dilution factor, if needed (=1 in the case of no additional dilution other than that resulting from digestion procedure).

Extraction of methyl mercury from the fisheries resources tissue/Organ

The sample was thawed and thoroughly mixed. 5g each of tissue/organ of fish sample was weighed into a contaminant free 150 mI Pyrex Berzelius beaker and mixed with 20g of anhydrous sodium sulfate (Na_2S04, CAN granular, Supelco 2-0296) which have been previously dried by heating to 140 oC overnight. The mixture was stirred frequently, until it is dry and free flowing, containing too large lumps. The beakers were numbered with the appropriate sample number and weighed, 15 µg/L of decachlorobiphenyl purchased from Accustandard USA, was added as the surrogate internal standard. The extraction columns (330 mm x 23 mm I.D each fitted with removable Teflon stopcock) was prepared by inserting a small glass wool (Corning Pyrex brand) plugged into the bottom of each chromatographic column and then the column was rinsed twice with 15 mL of petroleum ether. Air was removed from the glass wool by lightly tapping it with a clean glass stirring rod. A Zymark concentration tube, 200 mL with 1 mL endpoint was placed under each column and the appropriate labels were transferred to these tubes.

The sample mixture was poured into the column after which 50 mI of DCM was added to the sample beaker stirred and transferred to the column. The solvent was allowed to pass through the column, but as it begins to elute into the concentration tube, the stopcock was closed, at this point, the column was lightly stirred with a glass rod to remove trapped air. Elution is then continued at the rate of 1-2 mL per minute until the solvent level reaches the beginning of the sample mixture. Another 50 mL of DCM will be added and elution will be continued at the same rate. The columns will be allowed to drain completely, after the second 50 mL of solvent will be added. The stop cocks are rinsed with DCM to wash any residue lipid and analytes into the concentration tube. The eluent was concentrated by placing the Zymark concentrator tubes in the Turburvap Kadurna-Danish concentrator.

The concentrator water bath was kept at 40 oC and the argon sweep gas (purified grade) pressure will be set at 10-12 psi with the Turburvaps control knobs. The sample was concentrated to 1 mL and solvent exchanged to isooctane. The extract will be transferred to a 10 ml graduated tube with isooctane. The method of lipid analysis by Sloan *et al.*, (2006) will be used prior to clean up by column chromatography, a volume of sample extract equivalent to 1 g of tissue will be pipette into a pre-weighed (after acetone rinsing and drying) aluminum drying pan. Pre-weighing was to the nearest 0.1 milligrams. The extract was allowed to evaporate under static conditions in a fume hood for 2 hours. The pan again will be weighed to the nearest 0.1 milligrams and the percent extractable lipid will be computed as 100 x (1-weight of residual lipid) (Ademoroti, 1996). Quality control/Quality assurance was observed at all stages of analysis e.g. procedural blanks, five-point calibration (r^2 = 0.99), recovery studies and triplicate analysis, and analysis of Certified Reference Materials (fish from IAEA, 1998).

Statistical analysis

The data collected from fish landing site for six months in 2014 hydrological period and six months in 2015 hydrological period from Porto-Novo Lagoon were analyzed and described using Exploratory Data Analysis (EDA) Two-way analysis of variance (ANOVA) test otherwise called Randomized Complete Block Design (RCBD) using Duncan Post Hoc tests for the homogeneous subset was used.

RESULTS

Metal Pollutants in Tissues and organs of *Chrysichthys nigrodigitatus*

Table 1 shows average value of metal pollutants in the tissues and organs of *Chrysichthys nigrodigitatus* (Fig. 1) from Porto-Novo Lagoon ecosystem in July, August, September, October, November, and December. There is no significant difference in the means of metal pollutants in the tissues and organs of *Chrysichthys nigrodigitatus* but there is a significant difference in the metal pollutants from July to December 2014 at 5% level of significance.

The quantitative bio-accumulation of each metal pollutant in the tissues and organs of *C. nigrodigitatus* are stated in the order of magnitude; from highest to lowest. Fe=81.431±44.558a mg/Kg, Cr=46.615±15.094b mg/Kg, Zn=45.399±30.127b mg/Kg, Pb=39.710±22.184b mg/Kg, Mn=10.673±7.556cmg/Kg, Ni=9.499±2.550c mg/Kg, Cu=3.689±7.606c mg/Kg, Cd=1.103±0.164c mg/Kg, Va= 0.022±0.004c mg/Kg, Hg=0.003±0.002c mg/Kg, MH Hg=0.002±0.001c mg/Kg. The mean range values of all the metal pollutants that bio-accumulates in the tissues and organs of *C. nigrodigitatus* from July to December was reported as 16.974±*25*.39 mg/Kg-28.927±42.9mg/Kg.

During the months of January to June, *C. nigrodigitatus* from Porto-Novo Lagoon ecosystem bio-accumulates metal pollutants in their tissues and organs from highest to lowest in the following sequence as shown in Table 1. Fe=50.142±64.900a mg/kg, Ni= 17.789±29.702 mg/kg, Zn=7.567±5.021 mg/kg, Mn= 3.877±3.168 mg/Kg, Cr=2.735±4.245b mg/kg, Pb= 1.481±3.176b mg/Kg, Cu=0.985±1.144b mg/kg, Cd= 0.042±0.091b mg/Kg, Va=0.004±0.001b mg/Kg, Hg= 0.001±0.001b mg/Kg, MH Hg= not detection (nd). The mean range values of all the metal pollutants that bio-accumulates in the tissues and organs of *C. nigrodigitatus* from January to June were reported *(*1.816±3.275b mg/Kg -22.295±±51.42a mg/Kg). There is no significant difference in the means of metal pollutants in the tissues and organs of *C. nigrodigitatus* but there is a significant difference in the months from January to June, (2015) at 5% level of significance. The concentrations of metal pollutants in the tissues and organs of aquatic animals are discussed according to international regulatory bodies on aquatic pollution. WHO and EEC (Yehouenou *et al.*, 2013), EU regulations and EPA (Samir, 2008).

Metal Pollutants in the tissue/organ of *Sarotherodon melanotheron*

The seasonal analysis of metal pollutants in *Sarotherodon melanotheron* tissues and organs (Fig. 2) is shown in Table 2. The data shows that all metal pollutants detected were present in assessable concentrations and varied in between the two seasons and tissues and organs (gill, liver, bones, gut, and muscle) of *S. melanotheron.* A factor of variance analysis was employed during the study periods. There is no significant difference in the means of metal pollutants in the tissues and organs of *S. melanotheron* but there is a significant difference in each metal pollutants from July-December at 5% level of significance while there is no significant difference in the means of metal pollutants in the tissues and organs of *S. melanotheron* and in each metal pollutants from January-June at 5% level of significance.

Table 1: Total and Mean (± SD) of metal pollutants (mg kg-1 wet weight) in *Chrysichthys nigrodigitatus* from Porto-Novo lagoon and the permissible limits

Hydrological Period	Tissue/ Organ	Hg	Cd	Cu	Zn	Cr	Fe	Mn	Pb	Ni	Va	MH_3Hg
JULY-DEC 2014	Gill	0.001	1.33	0.4	47.27	54.76	78.38	10.90	26.80	10.80	0.028	0.001
(Rainy season)	Liver	0.002	1.23	17.30	44.70	61.36	140.16	2.23	42.97	8.24	0.025	0.0012
	Bone	0.001	1.04	0.15	90.41	48.7	39.28	22.12	35.47	10.00	0.023	0.0011
	Gut	0.006	0.96	0.11	38.65	21.62	110.83	12.30	17.70	5.89	0.017	0.0031
	Muscle	0.002	0.97	0.50	5.97	46.74	38.52	5.82	75.61	12.57	0.019	0.0013
	Total	0.012	5.53	18.46	227	233.18	407.17	53.37	198.55	47.5	0.112	0.0077
	Mean (± SD)	0.0024 ± 0.002^{c}	1.106 ± 0.16^{c}	3.69 ± 7.6^{c}	46.64 ± 15.1^{b}	46.64 ± 15.1^{b}	81.43 ± 44.6^{a}	10.67 ± 7.6^{c}	39.71 ± 22.2^{b}	9.50 ± 2.5	0.02 ± 0.004^{c}	0.0015 ± 0.001^{c}
JAN-JUNE 2015	Gill	0.001	0.001	1.21	7.88	0.26	13.68	5.925	0.086	0.185	0.005	0.0003
(Dry season)	Liver	0.001	0.204	2.88	7.45	10.23	23.36	0.372	0.372	1.373	0.004	0.0002
	Bone	0.001	0.002	0.13	15.07	0.86	39.46	2.487	0.054	17.579	0.004	0.0002
	Gut	0.003	0.001	0.52	6.44	0.326	9.797	2.328	0.037	0.528	0.003	0.0005
	Muscle	0.001	0.001	0.19	1.00	2.006	164.42	8.275	0.067	69.282	0.003	0.0002
	Total	0.007	0.209	4.93	37.84	13.682	250.717	19.387	0.616	88.947	0.019	0.0014
	Mean (± SD)	0.0014 ± 0.001^{b}	0.042 ± 0.09^{b}	0.986 ± 1.14^{b}	2.736 ± 4.25^{b}	2.736 ± 4.25^{b}	50.143 ± 64.9^{a}	3.877 ± 3.17^{b}	0.123 ± 0.14^{b}	17.789 ± 29.7^{b}	0.004 ± 0.001^{b}	0.0003 ± 0.0001^{b}
WHO /FAO (mg/day) Limit		0.5	0.1	3.0	60.0	50	43.0	2.0-9.0	0.214	2.45	0.5	0.0033
USFDA Limit (mg kg-1)		0.5	0.5	70	30	N/A	N/A	5.4	0.5	N/A	N/A	0.001
EU regulation (mg kg-1) Limit		0.5	0.05	N/A	N/A	N/A	N/A	N/A	0.4	N/A	N/A	0.0016
NRS (mg kg-1) Limit		0.5	N/A	0.5	N/A	N/A	N/A	N/A	0.5	N/A	N/A	0.0005

*N/A=Not Available.

Table 2: Total and Mean (± SD) of metal pollutants (mg kg-1 wet weight) in *Sarotheredon melanotheron* from Porto- Novo Lagoon and the Permissible limits

Hydrological Period	Tissue/ Organ	Hg	Cd	Cu	Zn	Cr	Fe	Mn	Pb	Ni	Va	MH_3Hg
JULY-DEC 2014 (Rainy season)	Gill	0.0047	1.21	0.806667	54.62667	21.665	258.7733	1.099	15.245	4.241667	0.017917	0.0012
	Liver	0.0052	1.126667	14.06	37.16	38.125	148.2933	0.378333	27.25	4.253333	0.016833	0.0013
	Bone	0.0029	0.986667	0.643833	27.49167	32.30167	23.797	0.151667	32.58333	12.43333	0.011667	0.001
	Gut	0.0039	0.843333	6.66	26.69333	27.99667	180.2583	0.126667	19.31833	10.7	0.008167	0.001
	Muscle	0.0031	0.925	0.756667	16.5667	16.41667	26.64	0.154667	30.25667	12.77	0.011667	0.001
	Total	0.0198	5.091667	22.92717	162.5384	136.505	637.7619	1.910334	124.6533	44.39833	0.066251	0.0055
	Mean (± SD)	0.004 ± 0.001[b]	1.018 ± 0.149[b]	4.585 ± 5.885[b]	32.508 ± 14.352[b]	27.301 ± 8.557[b]	127.552 ± 101.705[a]	0.382 ± 0.414[b]	24.931 ± 7.376[b]	8.880 ± 4.301[b]	0.013 ± 0.004[b]	0.001 ± 0.000[b]
JAN-JUNE 2015 (Dry season)	Gill	0.0016	0.0025	1.109	2.08	1.733	102.77	49.207	0.1067	1.079	0.006	0.0004
	Liver	0.0017	0.0011	1.6989	2.16	1.002	1906.25	18.538	1.01	1.063	0.006	0.0004
	Bone	0.0012	0.0036	0.234	1.63	0.2461	16.275	9.058	0.076	0.079	0.004	0.0003
	Gut	0.0013	0.0046	1.6484	1.67	982.25	196.48	1.709	ND	63.286	0.0027	0.0003
	Muscle	0.0011	0.0122	0.302	1.89	5205	914.42	6.251	0.0184	5.563	0.004	0.0003
	Total	0.0069	0.024	4.9923	9.43	6190.231	3136.195	84.763	1.2111	71.07	0.0227	0.0017
	Mean (± SD)	0.001 ± 0.000[b]	0.005 ± 0.004[b]	0.998 ± 0.71[b]	1.886 ± 0.237[b]	1238.046 ± 2257.93[a]	627.239 ± 798.79[a]	16.953 ± 19.05[b]	0.242 ± 0.43[b]	14.214 ± 27.51[b]	0.005 ± 0.001[b]	0.000 ± 0.000[b]
WHO /FAO (mg/day) limit		0.5	0.1	3.0	60.0	50	43.0	2.0-9.0	0.214	2.45	0.5	0.0033
USFDA Limit (mg kg-1)		0.5	0.5	70	30	N/A	N/A	5.4	0.5	N/A	N/A	0.001
EU regulation (mg kg-1) limit		0.5	0.05	N/A	N/A	N/A	N/A	N/A	0.4	N/A	N/A	0.0016
NRS (mg kg-1) limit		0.5	N/A	0.5	N/A	N/A	N/A	N/A	0.5	N/A	N/A	0.0005

*N/A=Not Available ** ND= Not Detected.

The bio concentrations of each metal pollutant in the tissues and organs from July to December follow the arrangement from highest to the least of Fe>, Zn>, Cr>, Pb>,Ni>, Cu >, Cd >, Mn >, Va >, Hg >, MH3Hg, and from January to June, it follows this trends, Cr >, *Fe* >, *Mn* >, *Ni* >, *Zn* >, *Cu* >, *Cd* >, *Pb* >, *Va* >, *Hg* >, *MH Hg* as shown in Table 2. The results revealed the spatial distribution of metal pollutants in the organs and tissue of *S. melanotheron* from Porto-Novo Lagoon ecosystem. The mean ranged between 0.001±0.000b mg/kg-127.552±101.705a mg/kg of metal pollutant in the tissues and organs was observed. Table 2 shows mean values of metal pollutants in tissues and organs of *S. melanotheron* during the study period.

DISCUSSION

Chrysichthys nigrodigitatus plays a key role in both environmental and economic terms. It is very important in determining the nature and structure of the aquatic environment and is valued as food for man for its delicacy and reasonably price (Andem *et al.*, 2013). The mean range values of all the metal pollutants that bio-accumulates in the tissues and organs of *C. nigrodigitatus* from July to December is 16.974±25.39 mg/Kg - 28.927±42.9 mg/Kg while from January to June is 1.816±3.275 mg/Kg - 22.295±51.42 mg/Kg. Pollution of aquatic ecosystems by metal pollutants has been observed in *Sarotheredon melanotheron*. The mean range values of all the metal pollutants that bio-accumulates in the tissues and organs of *S. melanotheron* from July to December is 9.500±11.58 mg/Kg - 32.517±76.837 mg/Kg while from January to June is 2.510±5.295 mg/Kg - 557.587±1565.5 mg/Kg. This implies that the driving force behind seasonal variation in metal pollutants concentration in the organs and tissue of *C. nigrodigitatus* and *Sarotheredon melanotheron* is the hydrological pattern.

The seasonal variations of metal pollutants in *S. melanotheron* tissue and organ caught from complex Porto-Novo Lagoon ecosystem shows that all metal pollutants detected were present in quantifiable concentrations and varied in between the two seasons, tissue and organ of *S. melanotheron*, which is apparent in 3-factor variance analysis used during the study periods. The ingestion of zooplankton and algae such as Cyanophyceae, Chlorophyceae, Rotifera, Cladocera, Bacillariophyceae, and Cyanophyceae that forms major food basis for *S. melanotheron* through filter feeding at different trophic levels might be responsible for different concentrations of metal pollutants in the organs and tissues (Francis and Belinda, 2007& Ofori-Danson and Kumi, 2016). These food items occurring at different feeding zones could perhaps responsible for metal pollutants trans-bioaccumulation in the tissues and organs of *S. melanotheron*.

Comparatively, different species of metal pollutants bio accumulates in varying degrees of concentrations in different organs and tissues of *Sarotheredon melanotheron* and *Chrysichthys nigrodigitatus* respectively. In rainy season *Sarotheredon melanotheron* bioaccumulates Iron (Fe) in high concentrations in the gill (258.7733 mg/kg) than liver (148.2933 mg/kg), gut (180.2583mg/kg), bone and muscle respectively and high concentrations of Fe during dry season in the muscle (914.42 mg/kg), gill (102.77 mg/kg), liver (1906.25 mg/kg), bone (16.275 mg/kg).

This occurrence of high concentrations of Iron (fe) especially in the gills is due to filter feeding ability of *S. melanotheron* which is aided by hydrodynamic nature of

the lagoon water from precipitation and run-off and strong speciation influence of geochemistry and bioavailability of metal pollutants in the Lagoon (Beliles, 1979). Also, the first point of entry of metal pollutant occurs through the gills. Gills are composed of a layer of flat epithelial directly related to the gills membrane vessels carried by the bloodstream, spreading them to other organs. This explained the fact that gills contain mucus which its main constituent is a glycoprotein where metals will be bound to the metallothionein protein (Overnell and Sparla, 1990).

Similarly, *Chrysichthys nigrodigitatus* bioaccumulates Fe and other metal species in different organs and tissue in the following sequence, gills (Fe=78.38mg/kg), liver (Fe=140.16mg/kg) and gut (Fe=110.83mg/kg) while bone had high concentrations of Zn (90.41mg/kg) also, Muscle had high concentrations of Pb (75.61mg/Kg), all occurs during the rainy season. However, during the dry season, it follows the trend, Gill (13.68mg/kg), liver (23.36mg/kg), bone (39.46mg/kg), gut (9.797mg/kg) and muscle (164.42mg/kg). The concentrations of metal pollutants in *C. nigrodigitatus* organs and tissue may be due to the position it occupies in the food web and cohabitation zone in an aquatic habitat. *C. nigrodigitatus* is a demersal species that spend most of their lifetime in benthic sedimentation zones of lagoon ecosystem and the heterogeneous natures of lagoon sediments with propensity for trapping and settling a wide range of metal pollutants. *C. nigrodigitatus* is an omnivorous fin fish that feed on seeds, insects, bivalves (macroinvertebrates) and detritus as stated by Holden and Reed, (1991). Feeding on these metal pollutants- laden macro-invertebrates and detritus could result in bio magnification of the metal pollutants concentrations in their organs and tissues as reiterated by Ajani *et al.*, 2002.

The corresponding high and low concentrations of all the metal species in different tissues and organs of *C. nigrodigitatus and S. melanotheron* is perceived be as a result of the type of macro-invertebrates and detritus *C. nigrodigitatus and S. melanotheron* feeds on, the size and age and the biological need of the test aquatic animals (Laleye *et al*., 1995). Also, heterogeneous nature of the lagoon sediment which serves as repository for most metal pollutants and the abundance of naturally occurring metal pollutants in the sediment such as Fe, Cr and Zn could also aid the metal pollutants bio-concentrations and the attraction tendency of Fe by silt in the sediment (Campbell and Stokes, 1985)

Conclusion and Recommendation

The laboratory and statistical analyses conducted on metal pollutants bioaccumulation in the organ and tissue of test aquatic animals shows that *Sarotheredon melanotheron* had the highest mean values of metal pollutants bioaccumulation than *Chrysichthys nigrodigitatus* because *Sarotheredon melanotheron* been a filter feeder has a voracious appetite for wide variety of food items in the trophic chain that are disposed to metal pollutants accumulation. This great appetite for food varieties also abetted its early reproductive maturation compared to *Chrysichthys nigrodigitatus.* Consequently, the concentrations of metal pollutants in the edible parts of *Sarotheredon melanotheron* are higher than that of *Chrysichthys nigrodigitatus.* It is therefore recommended that *Sarotheredon melanotheron* and *Chrysichthys nigrodigitatus* from Porto-Novo Lagoon ecosystem are not safe for human consumption based on USFDA and EU regulatory limit.

REFERENCES

Ajani EK, BO Omitoyin, F Adebusoye and F Ajani, 2002. "Bioaccumulation of Copper, Lead and Zinc in the organs and tissue of Tilapia zillii in Eleyele Lake, Nigeria" Nigeria J Forest, 32: 76-80.

Andem B, A Kalu, O Victor and B Paul, 2013. "Ecological impact assessment and limnological characterization in the intertidal region of calabar river using benthic macroinvertebrates as bioindicator organisms. Int J Fish Aquatic Stud, 1: 8-14.

APHA, 2006. APHA Governing Council, 2016-2017 Report of the APHA Science Board October 16, 2017

Babalola O Adeniyi and FD Emile, 2016. Metal pollutants distribution and bioaccumulation in two ecological important fisheries resources; chrysichthys nigrodigitatus and callinectes latimanus from novo lagoon ecosystem, Benin Republic. Int J Agric Innov Res, 5 ISSN (Online) 2319-1473.

Beliles AA, 1979. The lesser metals. Toxicity of Heavy Metals in the Environment. (Ed.F.W.Oehme) Part II. Marcel Dekker Inc.: New York, pp.565-597.

Bryan G and W Langston, 1992. "Bioavailability, accumulation, and effects of heavy metal in sediments with special reference to United Kingdom estuaries". A review. Plymouth Marine Laboratory, Citadel Hill, Plymouth PL1 2PB, UK.

Campbell PGC and PM Stokes, 1985. Acidification and toxicity of metals to aquatic biota. Can J Aquat Sci, 42: 2034-2049.

Daniel PH, 2006. Investing in tomorrow's Liquid Gold http://finance.yahoo.com/columnist/article/trenddesk/ 19 April 2006/pp3748.

EPA, 2016. Water Quality Standards: Regulations and Resources. Retrieved from https://www.epa.gov/wqs-tech.

FAO, 1981. Review of the state of aquatic pollution of East Africa inland water.

Federal Environmental Protection Agency (FEPA), 1991. Guideline and Standard for Environmental Pollution Control in Nigeria. FG. Press 238pp.

Francis O and O Belinda, 2007. Ecological Studies and Biology of Callinectes amnicol (Family: Portunidae) in the Lower Reaches of Warri River, Delta State,Nigeria World J Zool, 2: 57-66.

Holden M and W Reed, 1991. West African Freshwater Fish, Longman Publishers Ltd., Singapore. p68.

Horowitz Arthur JA, 1985. Primer on trace metal-sediment chemistry. United States Geological Survey water-supply paper, pp: 84-2277.

IAEA, 1998. Assessment of levels and "Health-Effects" of airborne particulate matter in mining, metal refining and metal working industries using nuclear and related analytical techniques IAEA, Vienna, 2007 IAEA-TECDOC-1576 ISBN 978–92–0–110407–6 ISSN 1011–4289.

Ishaq S Eneji, RS Ato and PA Annune, 2011. Bioaccumulation of Heavy Metals in Fish (Tilapia

zilli and Clarias Gariepinus) Organs from River Benue, North-Central Nigeria. Pak J Anal Environ Chem, Vol. 12, No. 1& 2.

Lalèyè P, J Philippart and P Poncin, 1995. Biologie de la reproduction de Deux espèces de Chrysichthys (Siluriformes, Bagridae) du Lac Nokoue et de la Lagune de Porto-Novo auBénin. J Afric Zool, 109: 213-224.

Muyideen O, L Oluwabamise, J Sangoleye and BM Seriki, 2010. Morphometry and diet of Chrysichthys nigrodigitatus (Lacépède) in Epe Lagoon, Nigeria; Afric J Biotechnol, 9: 7955-7960.

Ofori-Danson PK and GN Kumi, 2009. Food and feeding habit of Sarotherodon melanotheron, Rüppell, 1852 (Pisces: Cichlidae) in Sakumo Lagoon, Ghana. West Afric J Appl Ecol, 10: 9-18.

Olorunda O, O Olowoparija, O David, K Samuel, O Mercy and S Adams, 2007. Monitoring and Modeling Techniques of Environmental Pollution (1st. ed). His Mercy Publishers, P. 296. ISBN: 978-075-725-2.

Overnell J and AM Sparla, 1990. The binding of cadmium to crab cadmium metallothionein: Apolarographic investigation. Biochem J, 267: 539-540.

Samir M Saeed and IM Shaker, 2008. Assessment of Heavy Metals Pollution in Water and Sediments and their Effect on Oreochromis niloticus in the Northern Delta Lakes: 8th International Symposium on Tilapia in Aquaculture, Egypt.

WHO, 1989. Heavy metals-environmental aspects. Environment Health Criteria No.85, World Health Organization, Geneva, Switzerland.

Yehouenou EAP, R Adamou, PJ Azehoun, PA Edorh and T Ahoyo, 2013. Monitoring of Heavy Metals in the complex "Nokoué Lake - Cotonou and Porto-Novo Lagoon ecosystem during three years in the Republic of Benin. Res J Chem Sci, 3: 12-18.