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SEASONAL ANALYSIS OF HEAVY METALS IN PERIWINKLE (*Tympanotonus fuscatus*) ALONG FORCADOS RIVER: A FACTOR OF MARINE POLLUTION IN DELTA STATE, NIGERIA

S. M. Awani[1] and J. L. Igben[2]

[1]Department of Environmental Management and Toxicology,
University of Delta, Agbor, Delta State.
[2]Department of Environmental Management and Toxicology,
Western Delta University, P.M.B. 10, Oghara, Delta State.
Corresponding Author: sm.awani@unidel.edu.ng

ABSTRACT

This study investigates the seasonal variation of selected heavy metals (Zn, Pb Fe, Cr, Mn and Cd) in edible tissues of periwinkle (*Tympanotonus fuscatus*) as a measure of pollution of the Forcados River in Delta State, Nigeria. Samples of periwinkle were obtained from the Forcados estuarine during the dry and wet seasons of 2021. The tissues were extracted sequentially to determine the zinc, lead, iron, chromium, manganese and cadmium concentration using Perkin Elmer Atomic Absorption spectrophotometer and expressed as mg / kg dry weight. Tables and the Pair-wise Student's t-test were used to analysed data. The study reveals that mean concentrations of heavy metals are as follows: 35.918 Zn, 0.066 Pb, 0.1Cd, 150.450 Fe, 0.004 Cr and 150.158 Mn. in the following order; Fe > Mn > Zn > Cd > Pb > Cr. Seasonal difference of heavy metal presence was significant ($t= 1.741$, $df=5$, $p<0.05$). Mean values of all heavy metals except cadmium were above the permissible safety level, thus indicating that periwinkles were unsuitable for human consumption. It is recommended that the river upstream be put to sustainable use in order to reduce pollution, thus protecting the aquatic resources from stress induced by bioaccumulation of heavy metals.

Keywords: Delta State, Forcados River, Heavy metals, Marine pollution, Periwinkle.

INTRODUCTION

Human activities in the Niger Delta including urbanisation, agriculture, industrialisation and waste disposal contaminate water bodies. Consequently, all life-forms that directly or indirectly depend on lakes, rivers, oceans, aquifers, reservoirs and groundwater are adversely impacted. Such life-forms include shelled and fin fishes and other aquatic organisms such as mudskippers, snakes, crabs, mollusc, periwinkles and other reptiles. Periwinkles (*Tympanotonus fuscatus*) are a typical example of shelled fish which is found predominantly in brackish water habitats, having mangrove plants (Bob-Emmanuel, 2012). It belongs to the family *Potamididae*, which is characterized by turreted granular and spinning shell with tapering end. This organism is endemic in Nigeria and West Africa (Idopise-Abasi, 2020).

The genus *Tympanotonus*, comprises of a single species, which has two varieties – *Tympanotonus fuscatus var fuscatus* and *Tympanotonus fuscatus var, radula*. Specifically, *Tympanotonus fuscatus* concentrate under the roots and decaying red mangrove trees and small collection of quiet waters where the substratum is rich in decaying organic matter and muddy (Jamabo and Chindi, 2010). Among different aquatic organisms, shellfish e.g. periwinkle (*Tympanotonus fuscatus*) and clam (*Egeriaradiata*) migrate from their habitats due to their feeding habits and the nature of their habitats (Adebayo-Tayo and Okpo, 2010). As water flows through these habitats, it is contaminated by pollutants such as herbicides, pesticides, heavy metals and plastics. Consequently, the fine sediments dominant in inter-tidal and sub-tidal estuarine system are important short-term and long-term sink for these contaminants and therefore estuaries are one of the most polluted ecosystems (NOAA, 2017).

Heavy metals generally referred to those metals which possess atomic mass specific density of more than 5g/cm^3 and adversely affect the environment and living organisms (Jarup, 2003). They are stable and persistent environmental contaminants of aquatic environments. They occur in the environment both as a result of natural processes but deposits of anthropogenic origin increase their levels and creates environmental problems in coastal zones and rivers (Dural *et al.*, 2007).

Furthermore, pollution of the aquatic environment by heavy metals has become a worldwide problem and of scientific concern because they are not degradable and most of them have toxic effects on organisms (Oronsaye *et al*., 2010). Examples of heavy metals are Arsenic (AS), Cadmium (Cd) Chromium (Cr), Cobalt (C0), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (N:), Thallium (Ti), Zinc (Zn) and Iron (Fe), which particularly significance in toxicology, since they are highly persistent (Storelli *et al.*, 2005). Toxicity occurs when these heavy metal levels are higher than the recommended limit, and is different for individual element in environmental media (Oguzie and Izevbigie, 2009). When released into water bodies, metals may either be deposited in the sediments or stay in the water column (Simpson and Spadaro, 2016), which causes concern due to their persistence, toxicity, bio-accumulation capacity in aquatic organisms (Islam *et al*. 2015), and consequent impact on the quality of the ecosystem. The enrichment of heavy metals in the organisms through the food chain is a threat to humans (Lei *et al.* 2016).

Various studies have been undertaken in the Niger Delta, the study area inclusive, to determine heavy metal concentrations in periwinkle. Some of these studies were carried out in Qua Iboe River Basin, Ibeno, Akwa Ibom, (Andem *et al.*, 2013), Elechi Creek, River State, (Davis *et al.*, 2006), Warri River, Delta State, (Ayenimou *et al.*, 2005, and Nwanbueze *et al*, 2011), Egboko River, Warri, Delta State, (Ikemjimba and Sakpa, 2014), Nembe in Nembe Local Government Area and Lobia in Southern Ijaw Local Government Area of Bayelsa State (Ogamba *et al*, 2016). Nevertheless, little information is available on the bio-accumulation of heavy metals in periwinkle (*Tympanotonus fuscatus*) collected from Forcados estuary, Delta State. Therefore, there is the need to assess the seasonal level of heavy metals in *Tympanotonus fuscatus* collected from Forcados estuary. Hence, this study focuses on seasonal analysisof heavy metals in periwinkle **(***Tympanotonus fuscatus***)** along Forcados River as a result of marine pollution in Delta State.

MATERIAL AND METHODS

Study Area

The study area, Forcados River is located in Burutu Local Government of Delta State. It flows from hinterland of the state into the Atlantic Ocean through an estuary. The river receives wastes and effluents of complex nature from multifarious industries concentrated in the upstream zone; namely, Shell Petroleum

Development Company (SPDC) tank farm, Nigerian Agip Oil Company (NAOC) flow station and from tidal water coming in from Atlantic Ocean. The study site is in the lower part of the river, inundated diurnally by tidal water from the Ocean and freshwater from the hinterland. The chosen site is situated on 5^0 18' North and 5^0 31' E geographic co-ordinates as indicated in Fig. 1.

(Ojile *et al.*, 2014). The marine environment is polluted as a result of the incessant disposal of waste such as human faeces, petroleum product from engine boats, dirt from the market and surface run-off into Forcados River.

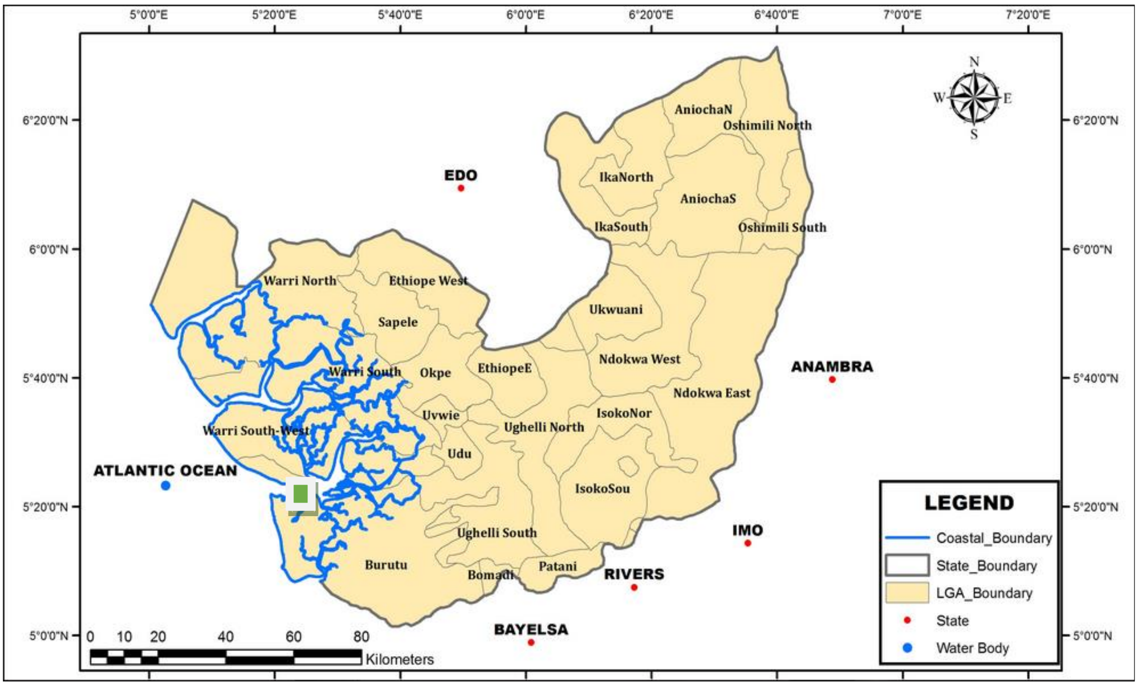

Figure 1: Map of Delta state showing sampled point. (Adapted from GAMERS, 2017)

The main vegetation type of the area is mangrove swamp forest, dominated by red mangrove (*Rhizophora racemosa*) which constitute more than ninety percent (90%) of the saline swamp and a few stands of white mangrove (*Avicennia africana*), *Rhizophora mangle* and *Languncularia racemosa* scattered among the red mangroves and thrive in less water logged places (Egbenrogbe *et al.*, 2000). The main occupation of the people of the area are fishing and trading. Other occupations include oil and gas development, transportation of people and petroleum products by boats and vocational activities

Sample collection

Samples of the test organisms (shellfish) were collected at low tide in January 2021 and September 2021 by an arrangement with local fishermen along the Forcados River estuary. The live samples of periwinkle were put in plastic containers containing estuarine water and transported to the laboratory in an ice chest.

Laboratory Preparation

In the laboratory, the periwinkle samples were thoroughly washed with tap water and allowed to drain. The soft tissues were removed from the shell with the help of a clean sterile steel pin. The tissues of the organism, were dried in hot oven 105^0C for 8 hours to remove moisture and attain a constant weight. The dried samples were ground to powder with a plastic mortar and pestle, passed through 0.5mm mesh sieve, and stored in well-annotated plastic containers for digestion.

Digestion of Periwinkle Tissue

A modified method of De Wolf *et al*. (2000) was used for the digestion of periwinkle tissues. Two grammes of periwinkle was weighed into 50ml mixture of 10% nitric acid and 100% per chloric acid (2:1) boiled at 95^0C on a hot plate in a reflux system to obtain a clear solution, which was then evaporated to near dryness in a fume cupboard and the cooled residue was dissolved in 0.5M nitric acid, and filtered into 50ml standard flask up to the mark of diluted Nitric acid (0.5M) using a Whitman N.0 40 filtered paper. The same procedure was used for the blank. The digested samples in periwinkle were analyzed, for the selected heavy metals using atomic absorption spectrophotometer (UNICAP SOLAAR 969 MODEL). The concentration of the element in the periwinkle was calculated and recorded.

Data Analysis

The data collected for the study were collated and frequencies, means and range of occurrences workout and presented in tables. The hypothesis that there is no significant difference in the concentration of heavy metal in the dry and wet season was tested using the Pair-wise Student's t-test. The data analysis was facilitated by the use of the Statistical Package for Social Science (SPSS) version 23.0

RESULTS AND DISCUSSION

Table 1 presents the seasonal concentration of heavy metals in the tissues of periwinkles considered in the study

Table 1: Seasonal Concentration of Heavy Metals in Periwinkles

Heavy metal	Total observed Dry Season Concentration (mg/kg)	Total observed wet season concentration (mg/kg)	Range	Mean concentration (Mg/kg)	FAO/WHO permissible heavy metal limit in food (mg/kg)
Zn	43.071	28.765	28.765- 43.071	35.918	30
Pb	0.068	0.063	0.063-0.068	0.006	0.5
Cd	0.161	0.039	0.039-0.161	0.1	0.1
Cr	0.005	<0.002	<0.002-0.005	<0.004	0.003
Mn	407.121	299.816	299.816-407.121	353.469	30
Fe	395.434	300.399	300.399-395.434	347.917	263

FAO = Food and Agricultural Organisation; WHO =World Health Organisation.

Table 1 indicates that the mean concentration of zinc in periwinkle was 35. 918 ± mg/kg, which was higher than that of Idopise- Abasi (2020) study. The authors' study showed a heavy metal concentration of 1.70 ± 0.50 mg/kg in periwinkle from Uta -Ewa Creek, Imo River's estuary, South Eastern Nigeria. It is also higher than that of Nwankwo and Nlemanya (2019) who assessed heavy metal concentrations in periwinkle from Cawt-bone Channel, Okrika and Bodo Rivers State Nigeria. The mean concentration value obtained from this study is also higher than the FAO/WHO (1989) limit of 30mg/kg in food. The higher intake of zinc by mother can be danger to unborn or new born children because it can be pass through blood or milk to child and pose serious health hazard (Adekeye *et al.*, 2011). Extensive exposure to zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Excessive exposure to zinc chloride can cause respiratory disorder.

The higher concentration of zinc in periwinkle from Forcados River estuary could attributed to land use activities such as agricultural system and effluent from residential and industrial area. The mean concentration of iron in periwinkle was 347.917 ± mg/kg, which was higher than that of Idopise-Abasi (2020) study which was2.36 ± 0.51mg/kg. It is also higher than that of Nwankwo and Nlemanya (2019). The mean concentration is also higher than Javed and Usmani, 2013; Taweel *et al.*, 2013 and FAO/WHO (1989) value of 263mg/kg. In food, iron is a necessary element in human diet and it plays significant role in metabolic processes. Iron has the tendency to become toxic when periwinkle from Forcados River estuary is excessively consumed. The high concentration of iron (Fe) in periwinkle from Forcados River estuary could be attributed to the fact that this metal is naturally abundant in Niger Delta soils and presence of Delta Steel Company at Ovwian-Aladja, where effluents laden with iron are discharged or leached into surface water bodies taken to Forcados River estuary and eventually gets into bottom sediment where *Tympanotonus fuscatus* ingest it along with food it feed on (Ademoroti, 1996). The means concentration of manganese (Mn) in periwinkle was 353.469 ± mg/kg which was higher than that of Nwankwo and Nlemanya (2019), Okirika (2,46mg/kg) Cawt-bone Channel (3.89mg/kg and Bodo (2.01mg/kg). it is also higher than that of IdopiseAbasi, (0.13 ± 0.07mg/kg). The manganese concentration obtained from this study 353.469 ± mg/kg is also higher than the FAO/WHO limit of 30mg/kg in food. Manganese (Mn) is an essential micronutrient for plants and animals and it is associated with iron deposit, it does not naturally occur alone as single metal in aquatic environment. Deficiency in manganese results in symptoms such as severe skeleton and reproductive abnormalities in mammal. However, ingestion of manganese in excessive concentration, may pose serious health hazard. Heavy, metals such as, Fe, Zn and Mn found in periwinkle could be metalloenzymes, which are important in the metabolic activities of the periwinkle. The increase in zinc and iron, agrees with the works of moslen et.al. 2017 on Bonny estuary, Nigeria; Ikejimbah and Sakpa, 2014 on Egboko River, Warri, Nigeria; and Ijeomah *et.al*., 2015 on Non – vertebrate wildlife species in oil polluted sites in Delta State, Nigeria. The mean concentration of cadmium in periwinkle was 0.1 ± mg/kg, which was higher than that of Nwankwo and Nlemanya (2019), (0.011mg/kg for Cawtbone channel, Okirika 0.008mg/kg and Bodo 0.003 mg/kg). It is however, lower than that of Idopise-Abasi (0.68 ± 0.132). The mean concentration is lower than the FAO/WHO (1989) limit of 2.0mg/kg in food.

Considering the accumulation property and long biologic half-life of cadmium, the concentration measured in this study is a serious cause for concern. The toxic effects of cadmium in food are largely related to long – term exposure at very low concentration (Etonihu *et al*., 2013). Low dietary concentration of cadmium, zinc and iron have been shown to promote absorption of cadmium (Bellinger *et al.*, 2014 Cadmium has been reported to cause liver and kidney dysfuncti0n as well as softening of bones following long–term exposure (Oguguah *et al.*, 2017). Cadmium is a by-product of zinc and lead and is used in nickel – cadmium batteries. Renal tubular damage is probably the most common adverse effect of cadmium toxicity (Obianiume and Roberts, 2009). It has been shown that chronic exposure to cadmium compounds can damage the renal proximal tubular epithelial cells. The resultant dysfunctional proximal tubule manifests as low molecular weight proteinuria, glocosuria, aminoaciduria, and phosphaturia, (Thijssen *et al.*, 2007; Karimi *et al.*, 2012). The ability of cadmium to accumulate in kidney cells makes it harmful to the nucleus and other cell organelle (Karimi *et al.*, 2012) cadmium is often characterized by deleterious alterations in such biomarkers as plasma transaminases and alkaline phosphatise. Distortions in histological architecture of the liver have been demonstrated (Elias *et al*, 2013). The mean concentration of chromium in periwinkle was <0.004 ± which was higher than one of the values got by Nwankwo and Nlemanya (2019) (i.e. 001mg/kg at Cawt-bone Channel) and lower than two of their values (i.e. Okirika 0.034mg/kg and Bodo 0.022 mg/kg) in River State. The mean concentration is higher than the FAO/WHO (1989) limit of 0.003mg/kg in food. Chromium is an essential element that potentiates insulin action and enhance carbohydrate, lipid and protein metabolism at a maximum intake level of 0.025mg/day, equivalent to 0.0041mg/kg body weight per day for an average adult of 60.71kg (WHO, 1996; EFSA, 2014). However, exceeding this limit leads to bioaccumulation and toxicity that can result in hepatitis and ulcer. (Orisakwe *et al.*, 2015).

The mean concentration of lead (Pb) in periwinkle was 0.006mng/kg which was equal to the value obtain at Okirika, higher than the value obtain at Cawt-bone (0.001mg/kg and lower than the value obtained at Bodo (0.007mg/kg) in the study carried out by Nwankwo and Nlemanya (2019). It is lower than that of Idopise-Abasi (0.13 ± 0.94mg/kg). The mean concentration value from this study is lower than the FAO/FEPA 0.3mg/kg. Lead (Pb) is the second element on the top twenty lists of the most poisonous heavy metals. It targets orga ns are bones, brain, blood, kidneys, thyroid gland, reproductive and cardiovascular system, (Homady *et al.*, 2002; Massadehet *et al.*, 2004). The implication of this finding is that periwinkle collected from Forcados River estuary do not pose significant adverse health impact with respect to lead poisoning but there is a serious cause for concern considering the fact that in 2010 the WHO withdraw the provisional tolerable weekly intake for lead (Pb) on the grounds that it is not possible to set an intake value that is protective for health (UNEP/ OCHA, 2010).

Furthermore, the heavy metals that exceeded the FAO/WHO maximum acceptable limits in periwinkles essential area were micronutrient (Fe, Mn, Zn and Cr). High levels of iron (i.e. Heme and non-heme iron) are potentially toxic, causing iron poisoning. However, hepcidin hormone, regulates the rate of iron absorption from the digestive trat into the blood that carry iron to tissues and cells. A few disorders that suppress hepcidin production (e.g. hereditary hemochromatosis) can lead to build up of iron in tissue and organ. This condition will generate reactive oxygen species (ROS) and excess ROS induce oxidative stress by inhibition of anti-oxidant enzyme which can cause damage to several cellular components, resulting in organs dysfunction but this is rare. Humans absorb only about 1% to 5% of dietary manganese because of the role of manganese as a co-factor for several enzymes; low intakes might increase the risk of illness. Iron deficiency increases manganese absorption and can therefore exacerbate symptoms of manganese toxicity but in this case, people eating periwinkle collected from Forcados River estuary will not have iron deficiency. There is no evidence that shows manganese toxicity from high dietary manganese intakes. Manganese toxicity mainly affects the central nervous system and cause tremors, muscle spasm, etc. This study clearly indicated significant accumulation of heavy metals Fe, Mn, Zn and Cr in edible tissues of periwinkle collected from Forcados River estuary because they were higher than FAO/WHO permissible limit. The present study suggests that consumption of periwinkle collected from Forcados River estuary Nigeria poses toxicological risk with respect to Fe, Mn, Zn and Cr poisoning.

The mere fact that periwinkle does not mean all will be absorbed, metallothionein (MT), an intercellular metal binding protein (enzyme) regulate zinc absorption within narrow ranges and calcium and phosphorus in the milk can help bind the excess zinc and prevent the stomach and intestines from absorbing it. The nonessential heavy metals (Pb and Cd) that has no known biological functions in the body are below the FAO/WHO (2010) maximum permissible limit hence they will not pose threat to the consumer on short term but it will have been better they are below detectable limit because of long term threat magnification in the ecosystem.

To test the hypothesis that there is no significant difference in the concentration of heavy metal in the dry and wet season, the pair-wise Student's t-test was used. The result showed a't' value of 1.741 with 5 degree of freedom is significant at 0.05 confidence level as depicted in Table 2. Therefore, there is significant seasonal difference in the concentration of heavy metals in tissues of periwinkles along the Forcados River.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair DRY – WET	36.12967	50.83025	20.75136	-17.21341	89.47275	1.741	5	.142

CONCLUSION

This study investigated the seasonal variation of selected heavy metals in edible tissues of periwinkle (*Tympanotonu sfuscatus*) as a measure of pollution of the Forcados River in Delta State, Nigeria. It reveals that mean concentrations of heavy metals due to that anthropogenic activities such as urban domestic waste discharge and industrial effluents have contributed to heavy metal pollution of Forcados River estuary.

Following from the above, the study recommends regular monitoring of fragile ecosystems such as the Forcados River estuary in order to determine the cause of declining fish (shell and fin fish) population experienced by fishermen. In addition, there is need for adequate enforcement of existing regulations to ensure that the usage of the water body for disposal of waste is minimised in order to protect the aquatic resources from stress created by bioaccumulation of heavy metals in thus, preventing food poisoning.

REFERENCES

Adebayo-Tayo, B.C., Okpo, M.A. (2010). Microbiological, Proximate and heavy metal concentration in *Penaeus Sp.* (shrimp) and *calllinectes Sp*. (crabs) from creeks in Niger Delta, Nigeria. *Af. J. Food Agric. Nutr. Dev.* (8): 3047 – 64.

Adekeye, E.A., Ojo, M.A., Ajayi, O.O. (2011). Contributions of metal welding workshops to environmental pollution in Akure metropolis, Ondo state, Nigeria. *Journal of Environmental Issues and Agriculture in developing countries*, 3(1): 1-7.

Ademoroti C. M. A. (1996).*Environmental Chemistry and Toxicology*. First Edition, Ibadan, Foludex Press Limited, 80 p.

Andem, A.B., Udofia, U.U., Okorafor, K.A. and George, U.U. (2013). Bioaccumulation of some heavy metals and total hydrocarbon in the tissues of periwinkle (*Tympanotonus fuscatus*) in the intertidal regions of Qua Iboe River Basin, Ibeno, Nigeria. *Greener Journal of Biological Sciences*, 3 (7) 253 – 259.

Ayenimo, J.G., Adeeyinwo, C. E. and Amoo, I.A. (2005). A preliminary investigation of heavy metals in periwinkles of Warri River, Nigeria. *Journal of Applied Sciences* 5: 813 – 815.

Bob-Manual, F.G. (2010). A preliminary study on the population estimation of the periwinkles (*Tympanotonus Fuscatus)* (Linnaeus, 1758) and pachymelaniaaurita (Muller) at the Rumuolumeni mangrove swamp creek, Niger Delta, Nigeria. *Agriculture and Biological Journal of Biological Sciences*, 2 (1): 42 – 47.

Davies, O.A., Allison, M.E. and Uyi, H.S. metals in water, sediment and periwinkle (*Tympanotonus fuscatus var radula*) from Elechi Creek, Niger Delta. *African Journal of Biotechnology*. 5 (10): 968 – 973.

De Wolf, H., Backeljau, T., and Blust, B. (2000). Heavy element accumulation in periwinkle Littorinalittorea along pollution gradient in Scheldt estuary.

Science of Total Environment, 262 (1-2) 111 – 121.

Dural, M., Goksu, M.Z.L., and Ozak A.A. (2007).Investigation of Heavy metal levels in economically important fish species captured from the Tuzla Lagoon, 102, , 415 – 421.

EFSA J. [Internet]. 2014. Mar. [Cited Sep 16] 12 (3): Article 35 95 [261 p.] Available from: http: //doi.org/10.2903/j.efsa.2014. 35 95

Elias, A., Oputiri, D., andOru – Bo, P.G. (2013). Hepatotoxicity of cadmium Br. *J. Pharmacol. Toxicol*. 4(6): 222 – 23,

FAO (1983). Compilation of legal limits for hazardous substances in fish and fishery products. *FAO fishery circular* No. 464: 5 -100.

FAO / WHO (1989). Evaluation of certain food additives and the contaminants mercury, lead and cadmium. *WHO Technical Report Series* No. 505, 1989.

GAMERS, (2017). Geospatial Analysis Mapping and Environmental Research Solutions.

UNEP / OCHA (2010). Lead pollution and poisoning crises: environmental emergency response missi9on Zamfara State, Nigeria. Retrieved from: https: //www. Unocha.org /publication / lead – pollution – and poisoning – crises – response mission – Zamfara.

Homady, M., Hussein, H., Jires, A., Manasheh, A., Ai – Nair, F., Khleifat, K. (2002). Survey of some heavy metals in sediments from vehicular services stations in Jordan and their effects on social aggression in pre-pubetal male mice. *Environmental Research*, 89, 43 – 49.

Ijeomah, H.M., Edet, D.I., Oruh, E.K. (2015). Assessment of Heavy Metals in Tissues of selected Non-vertebrate Wildlife species in Oil polluted sites of Delta State, Nigeria. *Agriculture and Biology Journal of North America,* 6 (2); 63 – 73.

Idopise-Abasi E. A. (2020). Assessment of heavy metal concentrations in periwinkle (Tympanotonusfuscatus) samples from Uta-ewa creek, Imo River estuary, south eastern Nigeria. *J. Aquatic Mar Biol.* 2020; 9 (2): 32 – 35 Doi: 10. 15 406 ?jamb. 2020. 09. 002 74.

Ikejimba, C.C. and Sakpa, S. (2014). Comparative study of some heavy metal concentrations in water and Tympanotonusfuscatus var radula samples of Egbokodo River, Warri, Nigeria. *International Journal of Modern Biological Research,* 2, 7 – 15.

Islam, M.S., Ahmed, M.K; Hoque, M.F. Habibullah – AI – Mamum, M. (2015). Preliminary assessment of heavy metal contamination in surface sediments from a river in Bangladesh. *Environ Earth Sci.* 73: (4): 1837 – 1848.

Jamabo, N. and Chindi, A. (2010). Aspects of the ecology of Tympanotonusfuscatus car fuscatu (Linnaeus, 1758) in the Mangrove swamps of the upper Bonny River, Niger Delta, Nigeria. *Current Research Journal of Biological sciences*, 2 (1): 42 – 47.

Jarup, L. (2003). Hazards of heavy metal contamination. *Br. Med. Bull*. 68 (1): 167 – 182.

Javed, M. and Usmani, N. (2013). Assessment of heavy element (CU, N, Fe, Cu, Mn, Cr, Zn) pollution in effluent dominated rivulet water and their effect on glycogen metabolism and histology of Mastacembelusarmatus*Springer Plus* Vol. 2 No. 1, pp 390. http: //doi.org/10.1186/2193-1801-2-390.

Karimi, M.M., Sani, M.J; Mahmudabadi, A.Z, Sani, A.J. and Khatibi, S.R. (2012). Effect of acute toxicity of cadmium in mice kidney cells. *Iranian J.Toxicol.* 6 (18): 691-698.

Massadeh, A., Tahat, M., Jaradat, Q., AI – Momahi, L., (2004). Lead and cadmium contamination in roadside soils in Libid city, Jordan: a case study. *Soil and sediment contamination*, formerly Journal of soil contamination, 13 (4), 347 – 359.

National Oceanic and Atmospheric Administration (NOAA) http: // ocean service. Noaa. Gov// education / kits/ estuary //b htm/ Best view/internal explorer.

Nwanbueze, A.A., Nwanbueze, E.O. and Okonkwo, G.N. (2011). Levels of petroleum hydrocarbons and some heavy metals in tissues of Tympanotonusfuscatus periwinkles from Warri River of Niger Delta area of Nigeria. *J. App. Sc. Environ Manage*. 15 (1): 75 – 78.

Nwankwo, C. and Nlemanya, C.M. (2019). Assessment of periwinkle (Tymapnotonusfuscatus) in crude oil and Non crude oil contaminated Areas of Rivers State, Nigeria. *Journal of health and Environmental Research*, 5 (2): 32 – 40.

Oguguah NM, Onyekach: M, Ikegwu J. (2017). Concentration and human health implications of trace metals in fish of economic importance in Lagos Lagoon, Nigeria. *J. Health pollute* [Internet]. Mar [cited 2020 Sep 16]; 7 (13): 66 – 72. Available from: https: // doi:. Org/10.5696/ 2156 – 9614 – 7 -1.

Orisakwe O. E, Mbagwu H O, Ajaezi GC, Edet UW, Uwana P U. (2015). Heavy metals in seafood and farm produce from Uyo, Migeria: Levels and health implications. *Sultan Qaboos Univ Med J.* May; e 275 – 82.

Oronsaye, J. A. O., Wangboje, O. M., and Oguzie, F. A. (2010). Trace metals in some benthic fishes of Ikpoba River dam, Benin City, Nigeria, *African Journal of Biotechnology*. 9 (51) 8860 – 8864.

Oguzie, F. A., Izevbigie, E. E. (2009). Heavy metals concentration in the organs of the silver catfish, Chrysichthysnigrodigitatus (Lacepede) caught upstream of the Ikpoba river and the reservoir in Benin city. *Bioscience*

Research communications, 21:189 – 197.

Ogamba, E.N., Izua, S.C and Oribu, T. (2015). Water quality and proximate analysis of Eichhorniacrssipes from River Nun, Amassoma Axis, Nigeria. *Research Journal of Phytomedicine*, 1(1): 43 – 48.

Thijssen, S. Maringwa, J., Faes, C. Lambrichts, I and Van Kerkhove, E. (2007). Chronic exposure of mice to environmentally relevant low doses of cadmium lead to early damage, not predicated by blood or urine cadmium levels. *Toxicol.* 299: 145 – 156.

Taweel, A., Shuhaimi – Othman, M., and Ahmad, A.K. (2013). "Assessment of heavy elements in tilapia fish (Oreochromis niloticus) from the langat River and Engineering Lake in Bangi, Malaysia, and evaluation of the health risk from tilapia consumption", *Ecotoxicology and Environmental Safety*, vol.93, pp.45 – 51.

WHO / FAO (2010) summary and conclusion. Joint FAO / WHO expert committee of food additives (JECFA (JECFA / 73/ SC)73rd meeting.