Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 98 (2018) 77-88 EISSN 2392-2192

Potential Ecological Risk Index and Metals Residue in Tropical Brackish Water Snail (*Pachymelania byronensis* Wood, 1828) of the Lower Niger River Basin, Nigeria

T. O. Ikpesu* and **C. O. Ezenwaka**

Department of Biology, Federal University Otuoke, Bayelsa State, Nigeria

*E-mail address: tomohwofasa@yahoo.com

Phone: +2348032312141

ABSTRACT

The potential ecological risk index (RI) was employed to evaluate water quality and sediment pollution of heavy metals in the fish Town Rivers, Nigeria. The propensity of the presence of the heavy metals residue in a common brackish water snail (*Pachymelania byronensis*) that serves as food for human was also examined. Fine-grained surficial sediments from natural depositional zones were collected using Ekman dredge, pooled together and analyzed for the present of heavy metals. The snail samples were randomly hand-picked from the edge of the Rivers or attached to the substrata from August, 2017 to January, 2018 depicting wet season (August - October) and dry season (November - January). A total of 144 *P. byronensis* (24 per station) were sampled for this investigation. The concentrations of the heavy metals concentration in the sediments and snail tissues were analyzed using graphite furnace absorption spectrometry. The order of occurrence of the metal in the snail is Zn > Cu > Fe > Pb > Cd and their levels remain within their permissible safe levels for human consumption as stipulated by the various regulatory bodies. The risk factor for the metals in the sediments revealed that the Rivers is moderately at risk, which may not pose serious environmental threat and health risks to the resident organisms, but may be magnify along the trophic level. Therefore, sensitization of the inhabitants becomes inevitable, since the level is at threshold, above which may be detrimental.

***Keywords*:** Potential ecological risk index, Water, Sediments, Rivers, Heavy metals, Snail, *Pachymelania byronensis*

(Received 06 April 2018; Accepted 21 April 2018; Date of Publication 22 April 2018)

1. INTRODUCTION

Population explosion especially in the developing world has called for rapid solution for availability of requisites food sources to avoid starvation and malnutrition. Some of the food classes, such as carbohydrates is readily available, but protein difficult especially people living in the rural area and the disadvantageous (Adesehinwa and Ogunmodede, 1995).

Some food substances are readily available, but their health status has not been seriously considered. Food substance may have what it takes to meet the nutritional requirements of human, but may be contaminated as results of factors mainly human or as a result of natural modification of the natural environment. Many aquatic animals especially the molluscs are readily available in Niger River basin possesses the potential to contribute to meeting this increasing demand for seafood and there are many species that are not well utilized (Chellaram *et al*., 2014). Nutrition and food safety are inextricably connected, particularly in places where food supplies are insecure. Food safety incorporates not only the prevention of gastro-intestinal illnesses caused by microbes such as bacteria and viruses, but also the prevention of harm from chemical contamination and the ingestion of undesirable physical contaminants such as persistent organic pollutants (Miraglia *et al.*, 2009). The assessment of risks and benefits of intake of seafood has been divisive by bodies and agencies. Nutritionists consider these products to be an important source of high-quality essential nutrients (Lagade *et al.,* 2015).

Toxicologists believed that seafood is a major vector for toxic substances such pesticides, bacteria loads and metals pollutants (Ruttens *et al*., 2012; Bilandzic *et al*., 2014).

The health status of molluscs are primarily dependent on the nature of the aquatic habitat, which is the determinant of the quality of life the animal is subjected to that may influence the quality of meat produce by the animal of a given size. They are considered as culinary delicacies, with squid, oysters, mussels, abalones and other marine snails among the most popular (Mason *et al*., 2014).

Photo 1. *Pachymelania byronensis* (Wood, 1828)

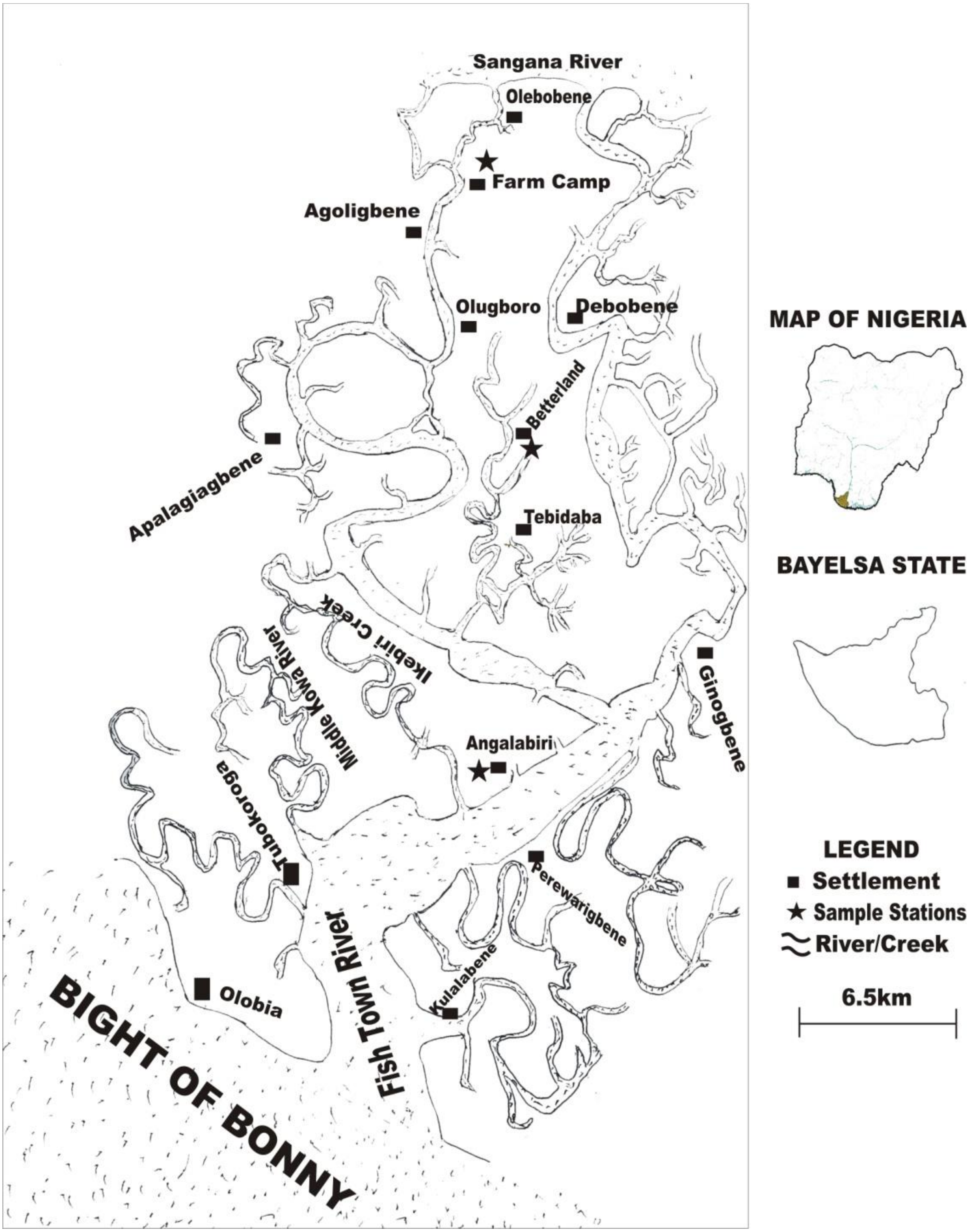

Figure 1. The map of the study river showing the sampling station

Pachymelania byronensis (Photo 1) is a gastropod mollusc that lives in a low saline environment and a detritus feeder with the possibility of taken heavy metal while feeding. Therefore, the objective of this research is to evaluate the potential ecological risk index of the Fish town Rivers and the metal residue in this gastropod.

Description of the Study Area

Fish Town River is a tributary of River Niger, Nigeria (Fig. 1). The River flows through various settlements. The River is highly affected by human activities. The River is an important transportation route into the cities such as Yenagoa, the capital of Bayelsa State and Warri in Delta State. Boats that are used as source of transportation are coated with heavy metals that are easily washed into the water bodies. Similarly, the spillages from the petroleum products from engine coat the water surface, inhibiting the river's oxygen intake by aquatic organisms. Three stations were chosen based on frequency of occurrence of the snail and human activities. The stations are (Angalabiri, Better land and Farm camp) along the river is. They are found attached to substrates at the edge or in the shallow region where they experience fluctuating tides.

2. MATERIALS AND METHODS

Hydro-chemical Parameters

The following hydro-chemical parameters; Salinity, temperature, dissolve oxygen, total hardness, pH, Turbidity, Total dissolve solid, Chemical oxygen demand, Nitrate, Phosphate of the different stations within the fish Town Rivers were measured along with the samplings and was taken monthly.

Potential Ecological Risk Index

To examine the potential ecological risk for the heavy metals, the sediment sample was analyzed using the method proposed by Hakanson (1980). The bed sediment was analyzed to provide a useful measure of the potential bioaccumulation of heavy metals in the snail.

The sediment samples were collected using Ekman dredge. Fine-grained surficial sediments from natural depositional zones were collected from the three stations during low-flow conditions. Composites samples from several depositional zones within each sample station were pooled together.

New latex gloves were worn when the snails were collected for processing. Snail with mean weight (5.00 + 0.10 g) and length and (2.10 + 0.13 cm) were randomly hand-picked from the Rivers and the River's bank from August, 2017 to January, 2018, depicting wet season (August - October) and dry season (November - January). A total of 144 *P. byronensis* (24 per station) were sampled for this investigation. At the end of each sampling period, they were collected in a sterile bag placed in an ice cooler to maintain a temperature of approximately 4 °C, and transported to the biology Laboratory in the Department of Biological Sciences at Federal University Otuoke, where they were washed with potable water and sterilized (70% ethanol) and kept in well ventilated aquaria for each analysis.

Sediments Samples

The sediment samples were allowed to air-dry in the laboratory at room temperature and, sieved through 63- m mesh nylon-sieve cloth. Twenty five (25) ml of distilled water was added followed by 10 ml of HNO_3 (analytical grade) and 3 ml of concentrated hydrochloric acid (HCl). The suspension was filtered (Whatman filter Merck, 0.45 µm) and the filtrate was diluted by distilled water to a final volume of 50 mL and stored in a cleaned sample bottle for analysis

Snail Samples

The foot muscle and viscera were mechanically extracted, weighed and oven dried at 110 °C to constant weight, thereafter homogenized and macerated in a metallic blender and passed through 160 µm sieve. 0.5 g sample was weighed and transferred to the glass tube and mixed with 5 mL of HNO_3 (analytical grade) and 3 mL of concentrated hydrochloric acid (HCl). After 10 minutes of mixing, 1 mL of H_2O_2 was added.

The samples were placed on a digestion block. Heating process start at 40 °C for 1 hour (to prevent vigorous reaction) and increased to 100 °C for another 2 hours. The digested samples were cooled to room temperature and diluted to 25 mL with HNO_3 (0.3%) (Canlı and Atlı, 2003). The diluted solutions were filtered through Whatman No. 1 filter papers into pre–cleaned beakers. The filtrates were stored in previously cleaned sample bottles for analysis.

Samples Analysis

The concentrations of the heavy metals were analyzed using Graphite furnace absorption spectrometry (GFAAS Model AAnalyst300) (Eaton and Franson, 2005). Digested samples were analyzed for levels of Iron, Lead, Zinc, Copper and Cadmium.

Statistical Analysis

The data are expressed as means ± standard error. The Student's *t*-test and analysis of variance (ANOVA) were used to test for significance at the 0.05 and 0.01 levels of probability for the seasons and the stations, respectively

3. RESULTS

Physicochemical Parameters of the Fish Town Rivers

The average of the limnological parameters of the Rivers throughout the sampling period were; salinity; 33.80 ± 1.20%, temperature; 25 ± 0.60 °C, total dissolve solid; 1003± 3.20 mg/l total dissolve oxygen;5.70 ± 0.20 mg/l, chemical oxygen demand; 39.20 ± 0.50, pH; 6.80 ± 0.20, turbidity; 7.20 ± 1.12, phosphate mg/l; 5.30 ± 0.30, nitrate; 19.20 ± 0.20, total hardness; 475 ± 4.80, faecal coliform 13/ 100 ml of water (Table 1)

Table 1. Range of the concentrations of the hydro-chemical parameters at three sites along the Fish Town Rivers, Nigeria; sampled monthly from August, 2017 to January, 2018.

Parameters Recommendation	Angalabiri	Better land	Farm camp	DPR/FMEnv
Salinity (%)	28.60 – 33.20	24.40 – 38.10	25.80- 31.10	**35**
Water Temperature (°C)	23.10–26.2 30	21.50–25.20	18.20–23.20	30
Total dissolve solid (mg/l)	890–1140	830–1110	1100–1550	2000 (USEPA; 100–1000)
Dissolve oxygen (mg/l)	3–6	4 – 6	4–7	5
Chemical oxygen demand (COD)	32–43	30–41	30–43	40
pH	6.0–7.5	7.0–7.8	6.1–7.2	6.5-9.2
Turbidity	4.2–11	4.0–9.0	6.1–10.0	10
Phosphate (mg/l)	4–7	3–6	5–7	5
Nitrate	17–21	19–21	17–23	20
Total hardness	300–450	320–470	350–508	100–500
Faecal coliform CFU/Ml)	20–80	10–30	5–15	zero/ 100ml of water

Potential ecological risk index of the Fish own Rivers

To establish the level of toxicity of heavy metals pollution in this brackish water, the potential ecological risk index calculated using the concentrations of the heavy metals in the bottom sediment as the pivotal for the derivation of the health status of the rivers revealed that he risk index of the metals are low to moderate except copper that is high (Table 2)

Table 2. Potential ecological risk index of Fish Town River, lower Niger River Nigeria.

	Pb	Cd	Zn	Cu
Wet season	23.10 ± 0.70	0.70 ± 0.60	7203 ± 1.10	1050 ± 5.20
Dry season	29.10 ± 0.20	0.42 ± 0.30	1101 ± 3.20	992 ± 1.10
C^i_o	26.10 ± 0.45	0.56 ± 0.45	4152 ± 2.15	1021 ± 3.15
C^i_n	25	0.5	80	30
T^i_r	5	30	1	5
C^i_f	1.044	1.12	51.90	34.03
E^i_r	5.22	33.60	51.90	170.15
RI ($\sum E^i_r$)	**260.87**			

where:

$RI = \Sigma E^i_r$; the sum of all the risk factors for heavy metals in sediment

$E^i_r = T^i_r \times C^i_f$; the monomial potential ecological risk factor

T^i_r = toxic-response factor for a given substance; Pb = 5, Cd = 30, Zn = 1 and Cu = 5 (Hakanson, 1980)

$C^i_f = C^i_o / C^i_n$; the monomial contamination factor

C^i_n = a reference value for metals; Pb = 25, Cd = 0.5, Zn = 80 and Cu = 30

C^i_o = the concentration of metals in sediment

Note that the risk index; when RI < 150 (low risk index) D grade; RI > 150 < 300 (moderate risk) C grade; RI > 300 < 600 (high risk) B grade; RI > 600 (very risky) A grade

Heavy metals concentrations

The seasonal assessment of the edible tissues of *P. byronensis* at the selected stations of the Fish Town River Niger Delta ecological zone revealed the presence of iron, lead, cadmium, zinc and copper (Table 3 & 4).

Spatial variation revealed that there was a fluctuation in the concentrations of the heavy metal in the investigated snail. However, seasonally, higher concentrations were recorded in the dry season in all the samples examined. The average concentrations of the metals for the wet seasons were; Fe (299 ± 0.68), Pb (2.80 ± 0.50), Cd (1.30 ± 0.25), Zn (2701 ± 1.40) and Cu (816 ± 2.15) and dry season were; Fe (392 ± 3.20), Pb (9.07 ± 0.50), Cd (2.83 ± 0.20), Zn (323 ± 3.10) and Cu (926 ± 2.90).

Comparison with the recommendation limit by various regulatory bodies; all the sampled metals were within the recommendation limit except the USEPA recommendation limit for the zinc for both season and FEPA recommendation for only dry season (Table 3 & 4)

Table 3. Comparison the heavy metal burden *P. byronensis* sampled from Fish Town River, lower Niger River Nigeria during the wet season (µg / L) with the Recommendation limits

	Fe	Pb	Cd	Zn	Cu
Station 1	315 ± 1.20[a]	2.50 ±0.20 [a]	1.15 ± 0.20 [a]	2480 ± 5.30[a]	800 ±11.30[a]
Station 2	248 ± 3.10[a]	3.60 ± 0.10[a]	0.30 ± 0.10[a]	3015 ± 2.10[a]	890 ± 7.30[a]
Station 3	276 ± 2.50[a]	2.30 ± 0.50[a]	2.10 ± 0.12[a]	2620 ± 4.90[a]	760 ± 3.20[a]
Average	299 ± 2.27	2.80 ± 0.27	1.30 ± 0.14	2701 ± 4.10	816.7± 7.26
RCMN Limit					
FEPA	300	10	03	3000	1000
USEPA	300	15	05	500	1300
WHO	300	10	03	--	2000

RCM: Recommendation; Means with the same superscript within the column are not significantly ($p > 0.05$) different

Table 4. Comparison the heavy metal burden *P. byronensis* sampled from Fish Town River, lower Niger River Nigeria during the dry season (µg / L) with the Recommendation limits

	Fe	Pb	Cd	Zn	Cu
Station 1	403 ± 3.10[a]	12.90 ± 1.30[a]	2.30 ± 0.30[a]	4106 ± 3.70[a]	850 ±11.30[a]
Station 2	411 ± 7.20[a]	8.12 ± 0.60[a]	2.11 ± 0.20[a]	2611 ± 5.80[a]	910 ± 7.30[a]
Station 3	367 ± 3.20[a]	6.30 ± 0.30[a]	4.10 ± 0.80[a]	3014 ± 7.10[a]	1020 ± 3.20[a]
Average	392 ± 4.50	9.07 ± 0.73	2.83 ± 0.20	3243 ± 5.53	926 ± 5.20
RCMN Limit					
FEPA	300	10	03	3000	1000
USEPA	300	15	05	500	1300
WHO	300	10	03	--	2000

RCM: Recommendation; Means with the same superscript within the column are not significantly ($p > 0.05$) different

4. DISCUSSION

Hydro-chemical Parameters

The influence of man's activities on natural ecosystem has altered the balance between biotic and abiotic factors that culminate into imbalance in the natural composition. In this investigation however, the salinity of the fish Town Rivers is within the limit for the estuarine environment (35 ppt). The temperature fluctuates and less than the recommendation limit set by the various regulatory bodies (EPA, 2003). Total dissolve solid, total dissolve oxygen, chemical oxygen demand, phosphate, nitrate and the total hardness were within the limit for aquatic life (EPA, 2012)

The risk index

The potential ecological risk for single regulatory indexes for the Fish Town Rivers (E^i_r) showed that Pb and Cd are very low, Zn is moderate and Cu moderately high. The general risk factor for the metals revealed that the Rivers is moderately at risk; 150 >RI< 300 (Table 3). The Intensive human activities and negligences such as the leakage from engine, sewage discharges and illegal refinery that leaks oil into the water ways must have caused the risk reported in this study. Sewage as risk index was previously reported by Peiru *et al* .(2018),where sewage discharge caused by urban life from large cities such as Shijiazhuang, Handan and Xingtai lead to the eutrophication that affected water quality in Haihe River Basin, China.

Heavy Metals Concentrations

The order of occurrence of the metal in the snail is Zn > Cu > Fe > Pb > Cd. The metals concentrations were less than the recommendation limit set by the various regulatory bodies (Table 3 & 4). Their levels remain within their permissible safe levels for human consumption as stipulated by the Commission of the European Communities (2001). The metals reported in this study could be attributed to the heavy metals in the sediment, since the snail is a detritus feeder. By implication the distribution of heavy metals in sediment can provide evidence of anthropogenic influence on aquatic systems and convenience in assessing the potential risks associated with the metal residues in the snail (Zhang *et al*., 2014)

The higher concentrations observed in the dry season could be attributed to the fact that high temperatures increase the activity of aquatic organism such as metabolic rate and feeding sessions (Nussey *et al.*, 2000). Corroborated this findings was the works of Oguzie (2003), Obasohan and Eguavoen (2008) on fresh water fishes.

Zinc was the highest metal observed in the snail. Similar observations were reported in *Clarias gariepinus* (Coetzee et al., 2002), *Channa punctatus* (Murugan *et al*., 2008) and *Labeo rohita* (Javed and Usmani, 2011). The Zn concentration reported is within the requirement for health growth. Low zinc content in snails reported in this study implies that the snail is non-toxic to health (Simpson, 1990)

The present of copper, though not to toxic level in the snail may be due to contamination of the Rivers caused by human activities. Though, it is an essential part of several enzymes and it is necessary for the synthesis of hemoglobin, which carries oxygen round the body of a living organism. Cu is also necessary for growing infant as it is essentially needed. Its deficiencies in infants can lead to anemia and proteinuria (ATSDR, 2005). However, excess Cu could be detrimental causing necrotic changes in the liver and kidneys and long term exposure can cause nausea, vomiting, stomach cramps, or diarrhea (ATSDR, 2005).

Moderate level of Fe was observed in this study and it was the third most occurrence metal investigated. It is importance to note that high doses of iron are often associated with gastrointestinal disorder, diarrhea and vomiting (Javed and Usmani, 2011)

The concentration of Pb observed in this study could be attributed to the oil spills from boats that are used for regular transportation in this region. The only mean of transportation in this region is by speed boats. These boats leak oils into the water as they are not service as at when due. Similarly, the illegal refineries cited very close to the Rivers may cause input of oil.

Cadmium was the least metal observed and was within the acceptable limits (Table 3 & 4). High concentration of Cd is highly detrimental to aquatic organisms and animals higher at the trophic level. Its chronic toxicity impair the kidney, causes; poor reproductive capacity, hypertension, tumours and hepatic dysfunction (Waalkes, 2000)

5. CONCLUSION

The risk factor for the metals in the sediments revealed that the Rivers is moderately at risk, which may not pose serious environmental threat and health risks to the resident organisms, but may be magnify along the trophic level. Therefore, sensitization of the inhabitants becomes inevitable, since the level is at threshold, above which may be detrimental to aquatic life and human at the top of the trophic level.

References

[1] Adesehinwa, A.O., and Ogunmodede, B. K. (1995): Swine feeds and practical feed composition techniques. Paper Presented at National Agricultural Extension and Research Liaison Service. National pig production workshop, National Cereal Research Institute, Moor Plantation, Ibadan.

[2] ATSDR. (2005): Agency for toxic substances and disease registry. Clifton Road, Atlanta: Division of Toxicology.

[3] Bilandzic, N., Sedak, M., Dokic, M., Varenina, I., Kolanovic, B.S., Bozic, D., Brstilo, M. and Simic, B. (2014): Determination of zinc concentrations in foods of animal origin,212fish and shellfish from Croatia and assessment of their contribution to dietary intake. *Journal of Food Composition and Analysis*, 35, 61–66

[4] Canli, M. and Atli, G. (2003): The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb and Zn) levels and the size of six Mediterranean fish species. *Environment Pollution*, 121: 129–136

[5] Chellaram, C., Anand, T.P., Praveen, M.M., Murugaboopathi, G., Sivakumar, R., Arvind, B. and Krithika, S. (2014): Self-life studies on an underutilized sea food from southeast coast of India. *APCBEE Procedia*, 8, 114–118.

[6] Coetzee, L., du Preez, H.H., Van Vuren, J.H. (2002). Metal concentrations in *Clarias gariepinus* and *Labeo umbratus* from the Olifants and Klein Olifants river, Mpumalanga, South Africa: zinc, copper, manganese, lead, chromium, nickel, aluminium and iron. *Water SA* 28: 433–448. doi: 10.4314/wsa.v28i4.4917

[7] Eaton, A.D. and Franson, M.A. (2005): Standard Methods for the Examination of Water and Waste water, American Public Health Association

[8] EC. (2001): Commission Regulation (EC) No. 466/2001 of 8 March 2001. *Official Journal of European Communities* 1.77/1

[9] EPA. (2012). Channel Processes: Bedload Transport. In Water: Science & Technology. Pp. 81

[10] Hakanson L. An ecological risk index for aquatic pollution control. A sedimentological approach. *Water Res.* 1980; 14: 975–1001. doi:10.1016/0043-1354(80)90143-8

[11] Javed, M and Usmani, N. (2011): Accumulation of heavy metals in fishes: a human health concern. *Int J Environ Sci*. 2: 659–670.

[12] Lagade, V.M., Taware, S.S. and Muley, D.V. (2015): Seasonal variation in the biochemical constituents, percentage edibility and condition index of the estuarine clam, *Soletellina diphos* (Linnaeus, 1771) (Mollusca: Bivalvia: Veneroida: Psammobiidae). *International Journal of Zoological Research*, 11(4), 127–139.

[13] Mason, S. L., J. Shi, A. E. Bekhit, and R. Gooneratne. (2014): Nutritional and toxicological studies of New Zealand *Cookia sulcata*. *J. Food Composit. Anal.* 36: 79–84.

[14] Miraglia, M., Marvin, G.A., Kleter, P., Battilani, C., Brera, E., Coni, F., Cubbada, L. Croci, B. De Santis, L. Filippi, R.W.A, Hughes, M.Y. Noordam, M. Pisante, G. Piva, A. Prandini, L. Toti, G.J. van der Born, A. (2000). *Food and Chemical Toxicology* 47, 1009-1021.

[15] Nussey, G., Van Vuren, J.H., Du Preez, H.H. (2000): Bioaccumulation of chromium, manganese, nickel and lead in the tissues of the moggel, *Labeo umbratus* (Cyprinidae), from Witbank Dam, Mpumalanga S. Africa. *Water SA* 26(2): 269–284

[16] Obasohan, E.E. and Eguavoen, O.I. (2008): Seasonal variations of bioaccumulation of heavy metals in a freshwater fish (*Erpetoichthys calabaricus*) from Ogba River, Benim City, Nigeria. *African Journal of General Agriculture*, 2008; 4: 153–163.

[17] Oguzie, F.A. (2003): Heavy metals in fish, water and effluents of lower Ikpoba River in Benim City, Nigeria. *Pakistan Journal of Science and Industrial Research* 46(3): 156–160.

[18] Peiru, K., Xian, C., Ranhao ,S. and Liding, C. (2018): The Synergic Characteristics of Surface Water Pollution and Sediment Pollution with Heavy Metals in the Haihe River Basin, Northern China, *Water* 10, 73; doi:10.3390/w10010073

[19] Ruttens, A., Blanpain, A.C., Temmerman, L.D. and Waegeneers, N. (2012): Arsenic speciation in food in Belgium Part 1: Fish, molluscs and crustaceans. *Journal of Geochemical Exploration*, 121, 55–61.

[20] Simpson, R. D. (1990): Investigation of biological factors of snails in relation to commercial snail farming and the marketing of snails in Australia as food. Project No. UNE9A. University of New England, Armidale. Austrialia

[21] Waalkes, M.P. (2000): Cadmium carcinogenesis in review. *Journal of Inorganic Biochemistry* 79(1): 241–244

[22] Zhang, C., Yu, Z.G., Zeng, G.M., Jiang, M., Yang, Z.Z., Cui, F., Zhu, M.Y., Shen, L.Q., Hu, L. (2014). Effects of sediment geochemical properties on heavy metal bioavailability. *Environment International* 73, 270–281.