Health Risk Index Assessment of the Impacts of Coastal Activities on *Tympanotonus fuscatus* Obtained from Qua Iboe River Estuary, South - South, Nigeria

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Abstract: Trace metal pollution of aquatic environments in the Niger-delta region of Nigeria is on the increase due to increased urbanization, industrialization, population explosion and crude oil exploration. Environmental pollution associated with heavy metal concentrations is an emerging issue in most developed and undeveloped countries. Qua Iboe River Estuary has been reported to be open to several inputs from industrial and agricultural activities within the environment. This research was therefore carried out to determine the levels of trace metal concentrations in tissues of *Tympanotonus fuscatus* obtained from Qua Iboe River, Estuary, South-South, Nigeria. Six hundred samples of periwinkles were collected for a period of twelve months (May, 2015 – April, 2016) from three sampling stations (Iwuokpom, Mkpaknak and Iwuochang) in the intertidal region of the estuary and were analyzed using Atomic Absorption Spectrophotometer. Mean values of parameter in wet and dry seasons were as follows: Cadmium (0.02 ± 0.00and 0.02±0.01 mg/kg), Chromium (0.02 ± 0.00and 0.02 ± 0.00mg/kg), Copper (133.79 ± 4.82and 158.1 ± 5.08 mg/kg), Iron (540.71 ± 11.55 and 551.18 ± 7.11 mg/kg), Lead (0.14 ± 0.01and 0.20 ± 0.03 mg/kg), Cobalt (0.21 ± 0.05and 0.45 ±0.04 mg/kg) and Zinc (39.39 ± 1.78 and 41.39 ± 0.59mg/kg) respectively. The mean values of trace metal concentrations in the tissues of the analyzed *Tympanotonus fuscatus* species sample from Qua iboe River Estuary, Ibeno showed a remarkable pattern. This follows the trend: Fe > Cu > Zn > Co > Pb > Cd > Cr. Vanadium and Arsenic were below detectable limit throughout the study period. The elemental concentrations of trace metals observed in the tissues of *T. fuscatus* during the study were above WHO permissible limit for all the studied trace metal exception of Chromium (Cr). Transfer factor index showed evidence of bioaccumulation of trace metals in the tissues of the studied organism. This implies that periwinkles from Qua Iboe River, estuary is not safe for human consumption as a food source for consumers who delight in this delicacy. *T. fuscatus* are mud dwellers and have shown evidence of bio-accumulation; therefore consumption of trace metal contaminated sea foods like periwinkle may pose lots of health hazards. However, this study emphasizes the essence of constant monitoring of trace metal levels in tissues of edible aquatic organisms to prevent sub-lethal poisoning to man as the final consumer of this seafood's along the food chain.

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1. Introduction

Pollutants affect organisms, and thus organisms are indicative of the nature and degree of pollution. Some benthic Organisms absorb specific contaminants from the sediments and show evidence of bioaccumulation. Such benthic organisms can be used as ecological indicators of the environment that, when measured, quantifies magnitude of stress, habitat characteristics, degree of exposure to a stressor, or ecological response to exposure. Health risk assessment refers to environmental conditions that determine the quality of living organisms that inhabits the various ecosystems and their suitability for human consumption.

There is an inverse correlation between environmental pollution and health and wellbeing of the populations. Urbanization and advancement in industrialization have ushered in a host of synthetic hazardous chemicals into the environment. Many synthetic chemicals used in agriculture and food preservation are chronic poisons and carcinogens that find their way into the aquatic environment via runoff. Their production, usage and disposal have created complex environmental pollution problems. It might be possible to find remedies to point-source pollutants but it is rather difficult to monitor and find suitable remedies for non-point disposal problems.

Aquatic systems might be extensively contaminated with heavy metals released from anthropogenic activities (Vutukuru, 2005; Drilligen, 2001). Heavy metals contamination may have devastating effects on the ecological balance of the recipient environment and diversity of aquatic organisms (Farombi *et al.,* 2007; Vosyline and

Jankaite, 2006; Ashraj, 2005). Over the past decades the increasing use of metals in industry is causing serious environmental pollution through effluent emanating from inappropriate disposal of wastes from industries. Among the myriad of organic and inorganic substances released into the aquatic ecosystems, heavy metals have received considerable attention owing to their toxicity and potential bioaccumulation in many aquatic species (Cupta and Mathus, 1983).

Studies on heavy metal accumulation in tissues of aquatic organisms can be very important and interesting particularly in the field of environmental sciences and other related discipline. The alarming rate of disease associated with impacts of heavy metals and the potential effects of heavy metal on the aquatic biota have made it of concern on the need to measure the accumulation of heavy metals; particularly certain metals which pose an imminent health hazard to humans (George *et.al*, 2013).

Periwinkles are widely consume in the Niger Delta Region as a cheap source of animal protein and are one of the many delicacies in the Nigeria cuisines. *Tympanotomus fuscatus* is a mollusk of high economic value found in the Qua Iboe River Estuary. Many aquatic organisms, for examples periwinkles have the ability to accumulate and bio-magnify contaminants like trace metals, polycyclic aromatic hydrocarbons and total hydrocarbon in the environment (George, 25). Therefore, the purpose of this research was to quantify the levels of some trace metals (Cd, Cr, Cu, Fe, Pb, Co, Zn, Vn and Ar) in tissues of *Tympanotonus fuscatus* obtained from Qua Iboe River Estuary, South- South, Nigeria as to ascertain their suitability for human consumption, also to create awareness that will provide information on the impact of coastal activities on aquatic biota.

2. Material and Methods

2.1 Description of study area

Qua Iboe River Estuary is located within latitude 4º 40´30´´N and longitude 7º 57´0´´E on the South Eastern Nigeria Coastline (Fig. 1). It is one of the largest fishing settlements on the Nigerian coastline. The climate is typically tropical, hot and humid, with a long wet season lasting from March to October and a shorter dry season that lasts from November to February. The Qua Iboe River Estuary (QIRE) is comprised of tidal creeks (most notably Stubb creek and Douglas creek), lagoons, wetlands, and tributaries fringed with mangrove vegetation made up of species of *Avicennia, Rhizophora* and *Nypa*. The coastal vegetation of the area is mainly thick mangrove swamp. The estuary is also rich with abundance of edible aquatic biota. The dominant shellfishes in the estuary include mangrove oyster, periwinkle, big fisted swimming crab and mussel. These shellfishes are widely consumed by the coastal and estuarine communities in the Niger Delta as a delicacy and dietary protein supplement.

2.2 Sampling Stations

Three sampling stations were chosen along the intertidal region of the estuary. The co-ordinates of the sampling stations were also taken using Geographic Positioning System (GPS).

2.2.1 Station 1

Station 1 is a pure mangrove plots comprising of *Avicennia africana* cohabiting with *Achrostichum aureum*. This station is located at Iwuokpom between latitude 4^0 32´ N and longitude 7^0'58' E.

2.2.2 Station 2

Station 2 is mixed mangrove vegetation comprising *Nypafruticans, Avicennia africana, Rhizophora mangle* and *Achrostichum aureum*. This station is located at Mkpanak between latitude 4^0 34´ 09.9'' N and longitude 7^0 58' 32.8'' E.

2.2.3 Station 3

Station 3 is a characteristic of mono-specific mangrove vegetation subjugated by *Nypa fruticans* interlaced with few stands of *Elaise guineensis*. The station is located at Iwuochang between latitude 4^0 32´ N and longitude 7^0 55'E.

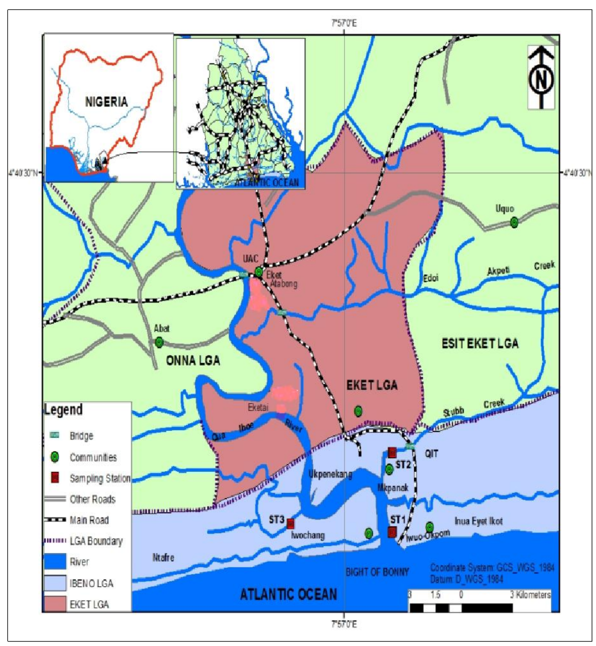

Fig1: Map of Study Area

2.3 Collection of Periwinkle *(Tympanotonus fuscatus)* Samples

Six hundred samples of Periwinkle (*T. fuscatus*) were collected from May, 2015 to April, 2016 at three different sampling stations usually between 7:00am and 12.00noon of each sampling month.

2.4 Analysis of Trace Metals in Samples

Periwinkles samples were washed and frozen at -5 °C until they were ready for analysis. Later, periwinkles were deshelled and the soft tissues air-dried at room temperature for two weeks. The air-dried soft tissues were grounded to powder form, sieved, weighed and ashed at 77 °C for two hours in a furnace. Ten grams (10 g) of ashed tissues of *T. fuscatus* were digested with 20 ml of concentrated Nitric acid (HNO_3) to bring the metal into solution and then transfer to 100 ml plastic can for Atomic Absorption Spectrophotometer (AAS) analysis. Heavy metals were determined using Atomic Absorption Spectrophotometer (model GBC scientific AASGF 3000) according to APHA, (1998).

2.5 Health risk assessment

Health risk assessment of humans consuming *T. fuscatus* obtained from Qua Iboe River Estuary was evaluated using transfer factor index (T_F). The transfer factor index is an approach based on the sediment - shellfish transfer factor that provides a straightforward, constructive method for assessing heavy metal accumulation for the purpose of health risk assessment of humans consuming the shellfish. The sediment - shellfish transfer factor (T_F) of the biological accumulation coefficient (BAC), which expresses the ratio of contaminants concentration in shellfish to the concentration in sediment, was used to characterize quantitatively the transfer of an element from sediment to fish (Rodriguez, *et. al*. 2002; Tome *et.al*. 2003) using the formular;

$T_F = M_{tissue} / M_{sediment}$

Where,

M_{tissue} is the metal concentration in shellfish tissue

$M_{sediment}$ is the metal concentration in sediment.

2.6 Statistical analysis

Mean values (±SE) of triplicate experiment were taken for each analysis. One-way analysis of variance (ANOVA) and Least Significant Difference (LSD) test were employed to separate significant differences in mean values. The probability level was set at p = 0.05.

3.0 Results

Table 1 shows the wet and dry season range and mean values of parameters observed during the study duration. Significant seasonal variations were observed in the studied parameters. However, it was observed that some of the studied parameters were below the WHO permissible limit for seafood, exception of Cadmium, Cobalt, Iron, Zinc and Copper whose values observed during the study duration were above the threshold limit for aquatic seafood consumption. Arsenic and Vanadium were below detectable limit during the study period (Table 1). Significant seasonal variations were observed for Cd, Cu, Fe, Pb, Co and Zn ($p<0.05$) exception for Chromium ($p>0.05$).

Computed transfer factor index values for all heavy metals determined in *Tympanotonus fuscatus* are presented in Figure 2a – 2c. The highest transfer factor index for Cadmium was 0.23 in July, 2015 while the least was 0.07 in January, 2016. Transfer factor index of 0.12 was recorded as the highest for Chromium in June, 2015 while the least was 0.03 in July, 2015. The highest transfer factor index for Copper was 139.84 in February, 2016 while the least was 88.18 in June, 2015. Iron recorded a highest index of 5.67 in August, 2015 while the least was 3.83 in February, 2016. Transfer factor index for Zinc were greater than 1 in all cases. The index ranged between 3.33 in December, 2015 to 1.56 in July, 2015. Generally, the indices computed for Lead were low ranging from 0.46 in November, 2015 and March, 2016 to 0.17 in July, 2015. Throughout the study period Vanadium and Arsenic was below detectable limit (BDL) in all cases except for Cobalt which was present in the organisms but absent in the sediment, thereby hindering the computation of transfer factor indices for Cobalt during the study.

Table 1: Seasonal Range, Mean Variation, Standard Error of Trace Metal Concentration (mg/kg) in *Tympanotonus fuscatus* obtained from Qua Iboe River Estuary for wet and dry Season (May, 2015 – April, 2016)

Parameter	Units	Range (Wet Season)	Range (Dry Season)	Mean ± S.E (Wet Season)	Mean ± S.E (Dry Season)	WHO Permissible Limit
Cadmium	mg/kg	0.01 – 0.03	0.02 – 0.04	0.02 ± 0.00	0.02 ± 0.01	0.01
Chromium	mg/kg	0.01 – 0.04	0.01 – 0.04	0.02 ± 0.00	0.02 ± 0.00	0.05
Copper	mg/kg	120.80 – 154.12	140.40 – 176.20	133.79 ± 4.82	158.1 ± 5.08	1.0
Iron	mg/kg	520.20 – 596.80	526.20 – 580.00	540.71 ± 11.55	551.18 ± 7.11	0.3
Lead	mg/kg	0.10 – 0.23	0.12 – 0.26	0.14 ± 0.01	0.20 ± 0.03	0.05
Cobalt	mg/kg	0.10 – 0.43	0.30 – 0.57	0.21 ± 0.05	0.45 ± 0.04	-
Zinc	mg/kg	34.20 – 46.01	40.30 – 44.02	39.39 ± 1.78	41.39 ± 0.59	3
Vanadium	mg/kg	BDL	BDL	BDL	BDL	-
Arsenic	mg/kg	BDL	BDL	BDL	BDL	0.01

Where: S.E = Standard Error, WHO = World Health Organisation, BDL = Below Detectable Limit

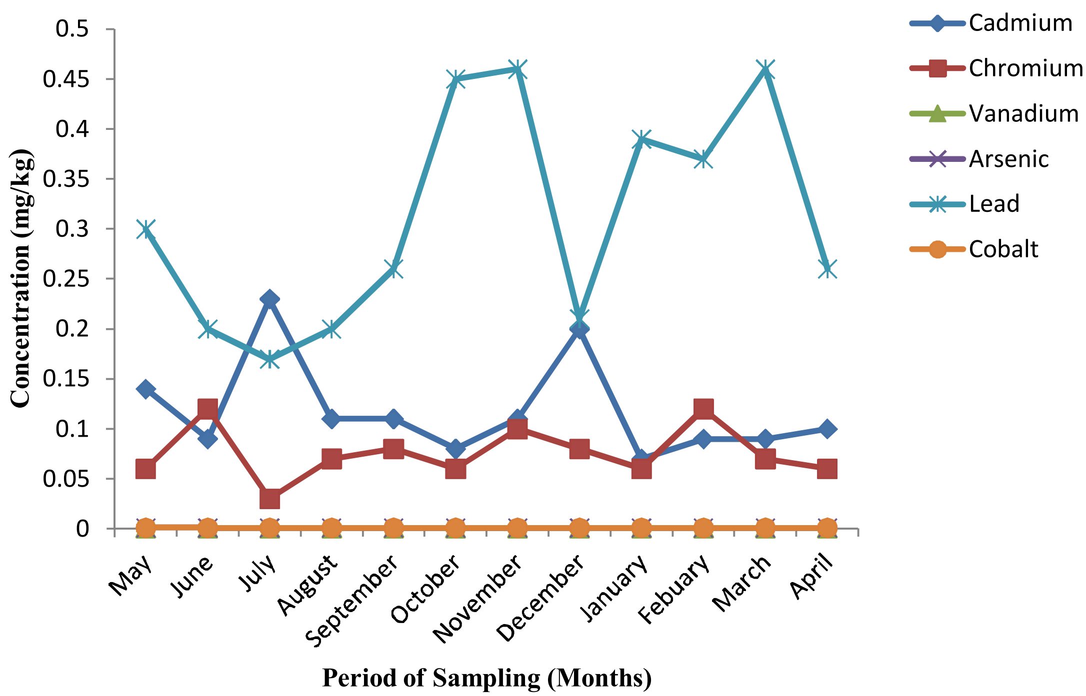

Fig. 2a: Transfer factor threshold for *Tympanotonus fuscatus* obtained from Qua Iboe River Estuary.

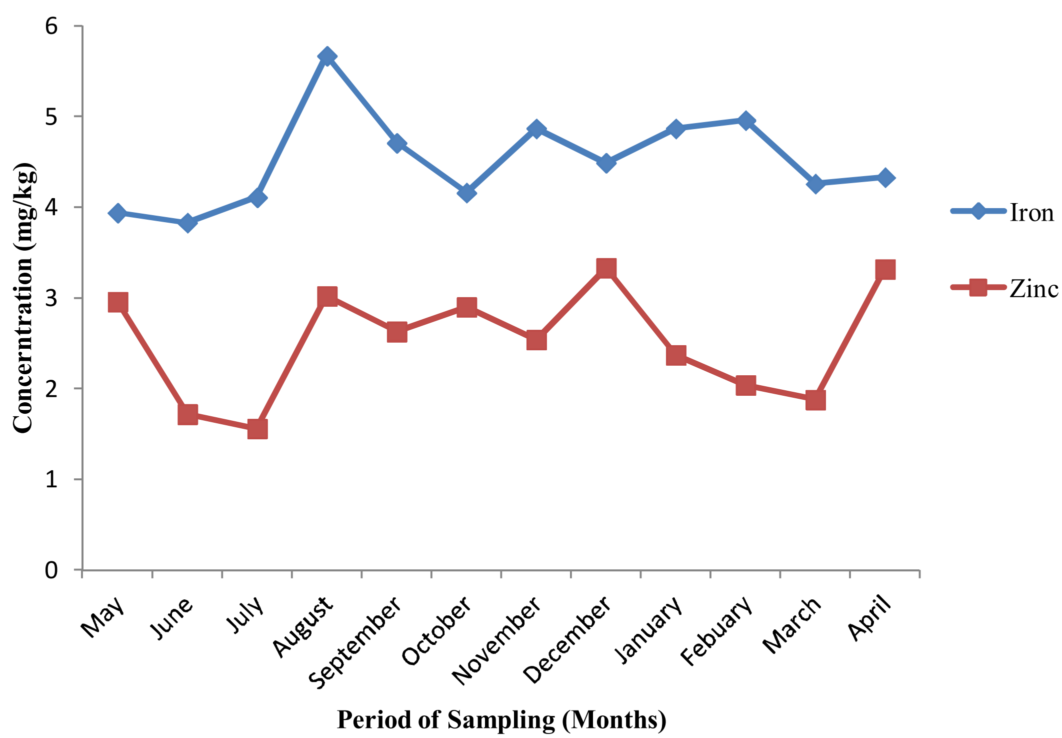

Fig. 2b: Transfer factor threshold for *Tympanotonus fuscatus* obtained from Qua Iboe River Estuary.

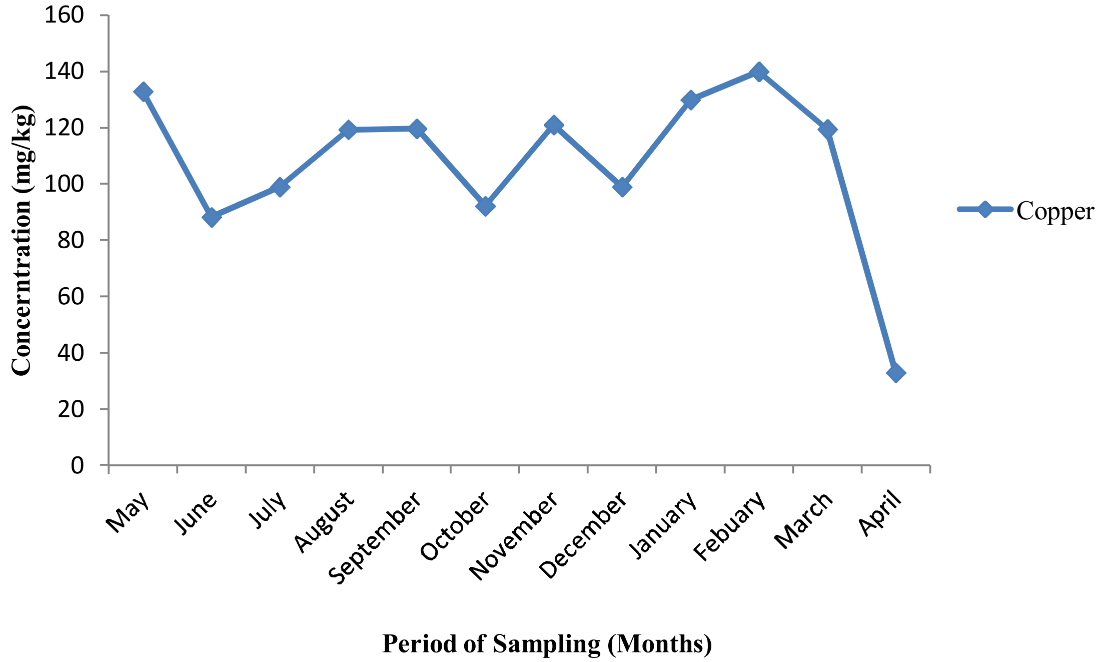

Fig. 2c: Transfer factor threshold for *Tympanotonus fuscatus* obtained from Qua Iboe River Estuary

4.0 Discussion

Pollution of aquatic ecosystems by heavy metals is an important environmental problem as heavy metals pose serious threats to human health when transfer through bio-accumulated organism like *T. fuscatus* via the food chain. This assertion agrees with the findings of (Guo *et al*., 1997; Omoregie *et al*., 2002). However, the consumption of periwinkle in the Niger Delta region of Nigeria is considered very common owing to the fact that it's less expensive and easily affordable mostly by the inhabitants of riverine communities and other rural dwellers.

The mean values of trace metal concentrations in the tissues of the studied organism obtained from Qua iboe River Estuary, Ibeno showed a remarkable pattern. This follows the trend: Fe > Cu > Zn > Co > Pb > Cd > Cr. Vanadium and Arsenic were below detectable limit throughout the study period. However, the observed accumulation of heavy metals such as Iron (Fe), Copper (Cu), Zinc (Zn), Cobalt (Co), Lead (Pb), Cadmium (Cd), and Chromium (Cr) in the test organisms could be from the sediment and were relatively low in some of the trace metals but relatively higher for Fe, Cu and Zn during the study duration. Certain factors may have influenced the differential uptake of metals in the test organisms. Generally, elemental concentrations of trace metals in tissues of organism depends not only on anthropogenic and lithogenic sources but also on the textural characteristics such as organic matter, mineralogical composition, nature of the sediment and depositional environment of the sediments (Pourang, *et.al*. 2005). Fine sediments (mud) dominate Qua Iboe River Estuary (QIRE) and trace metals are believed to be more associated with smaller grain size particles. This assertion was supported by (Saeed and Shaker, 2008) who stated that the concentration of metals in sediment depends on the amount of organic compound and its particle size. Other factors that affect the abundance of metals in tissues of aquatic organisms include the trace metal content of the rock and parent material of soil formation. This assertion is consistent with the findings of (Yi, *et.al*. 2011).

This study demonstrated evidence of bioaccumulation of heavy metals in the tissues of *Tympanotonus fuscatus* from Qua Iboe River Estuary, Ibeno. Levels of trace metal concentration recorded during the study for Fe, Cu, Zn, Co, Pb and Cd were however, observed to be higher than the recommended tolerance levels for human safety (Davies *et al*. 2006; WHO, 2011) except for Cr which was below threshold limits.

Transfer factor (T_F) is a competent technique developed to assess the level of metal in living system as a fraction of soil total. Previous studies have indicated that uptake of metals differ from one metal to another and from one species to another and within or between environments (Rashed, 2001; Abdel-Baki**,** *et al***.,** 2011). This is evidence in the result of findings as variation was observed in their rate of uptake of heavy metal and also, the accumulation was metal dependent. The presence of metals in high levels in benthic environment does not indicate a direct toxic risk to benthic organisms, if there is no significant accumulation of metals by these organisms (kamaruzzaman, *et. al*. 2010). In the present study, transfer factors (T_F) of nine (9) metals from sediment to *Tympanotonus fuscatus* were computed. The results indicated that transfer factors from sediment to *T. fuscatus* were below 1.00 for Cd, Cr, Vn, Ar, Pb and Co which implies that there was no bioaccumulation of these metal from sediment to *T. fuscatus*, except Cu, Fe and Zn which had a transfer factor value greater than 1.00 implying that bioaccumulation of these metal occurred from sediment to *T. fuscatus***.** This result agrees with the reports of previous studies by (Rashed, 2001; Abdel-Baki**,** *et al***.,** 2011). This index helps in understanding the routes of uptake of heavy metals in the studied organisms. Accumulation of metals only begins when organisms are faced with high concentration in the surrounding medium (Abdel-Baki**,** *et al***.,** 2011). Having a good understanding of the accumulation factor (T_F) is important in predicting the relative contributions of abiotic media as a source of heavy metals accumulation in shellfish and the accumulation efficiency for any particular pollutant in any shellfish organ. In addition, such information is crucial in making accurate risk assessment for seafood safety purposes and its possible health consequences to humans.

However, the high level of iron recorded in the tissues of *T. fuscatus* is well understood as it was earlier reported by several authors that the study area and other parts of Nigerian soil and sediment are highly rich in Iron (Udosen, *et. al*. 2007; Issa, *et. al*. 2011; Opaluwa, *et. al*. 2012). Most of the pipelines used in conveying oil from the platform to the treatment sites are made up of iron, ferro-chromium materials and alloys of zinc and iron which when corroded can result in the release of these metals into the aquatic ecosystem. Moreover, the concentration of Fe in sediment may be due to the nature of the soil along the aquatic ecosystem and high levels of iron in Nigerian soils have been reported by (Oluwu, *et.al*. 2010, WHO, 1993). The source of iron concentration in aquatic ecosystem is generally believe to emanate from the earth crust or lithogenic, zinc derives its concentrations from lithogenic and anthropogenic source while copper is generally attributed to anthropogenic activities which include (mining, mine leaching, metal plating, domestic and industrial waste). Copper is an essential trace element. In plasma, copper is carried by copper-transport protein, caeruloplasmin. Increase copper levels in human tissues lead to acute chronic diseases, such as thyrotoxicosis, malignancy and biliary cirrhosis.

The result of this study shows imminent problems of contamination in Qua Iboe River Estuary, Ibeno which suggest evidence of coastal activities. The High concentration of Fe, Cu and Zn recorded in this study and also, evidence of bioaccumulation using transfer factor index calls for concern as *Tympanotonus fuscatus* obtained from Qua iboe River Estuary is not suitable for human consumption. This study emphasizes the essence of constant monitoring of trace metal levels in tissues of edible aquatic organisms to prevent sub-lethal poisoning to man as the final consumer of this seafood's along the food chain.

5.0 Conclusion

The elemental concentrations of trace metals observed in the tissues of *T. fuscatus* during the study were above permissible limit for all the studied trace metal exception of Chromium which was below the threshold limit as recommended by WHO. Transfer factor index for *T. fuscatus* showed evidence of bioaccumulation of heavy metals in the tissues of this organism. Copper, Iron and zinc had a transfer factor index > 1. From the result of findings, the water quality of Qua Iboe River Estuary is seriously impacted by coastal activities resulting from indiscriminate discharge of domestic waste, industrial waste, agricultural run-off and sewage disposal into the estuary. The high concentrations of iron, copper and zinc in the study organism calls for concern as this may result in deleterious health effects to consumers of these shellfishes overtime. *T. fuscatus* is a common commercial shellfish consumed in Nigeria, notably the Niger Delta Region by most rural dwellers and riverine communities owing to their cheap source. However, this study emphasizes the essence of constant monitoring of trace metal levels in tissues of edible aquatic organisms to prevent health related issues to man as the final consumer of this seafood's.

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