Risk Index Evaluation of the Levels of Trace Metals in *Callinectes amnicola* Obtained from Qua Iboe River Estuary, South - South, Nigeria

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Abstract: Trace Metals concentration in *Callinectes amnicola* Obtained from Qua Iboe River estuary, South - South, Nigeria was studied from (May, 2015 – April, 2016). Samples were collected monthly from three locations (Iwuokpom, Mkpanak and Iwuochang) and analyzed using standard procedures. Mean values of parameter in wet and dry seasons were as follows: Cadmium (0.01±0.00 and 0.01±0.01 mg/kg), Chromium (0.00±0.00 and 0.00±0.00 mg/kg), Copper (12.94±0.41 and 13.49±0.55 mg/kg), Iron (43.83±1.27 and 42.94±1.80 mg/kg), Lead (0.03±0.00 and 0.02±0.00 mg/kg), Cobalt (0.04±0.01 and 0.06±0.01 mg/kg) and Zinc (14.66±0.67 and 16.22±0.23 mg/kg) respectively. Vanadium and arsenic were below detectable limits throughout the study duration. The elemental concentrations of trace metals observed in the tissues of *C. amnicola* during the study were above WHO permissible limit for Iron, Copper and Zinc. Transfer factor index showed evidence of bioaccumulation of heavy metals in the tissues of the studied organism. Trace metal pollution of aquatic ecosystem in Nigeria, notably the Niger Delta Region is on the increase due to augmented industrialization, population explosion, urbanization and crude oil exploration. *C. amnicola* are mud dwellers and may possibly bio-accumulate heavy metals. However, the studied organism showed evidence of bioaccumulation, therefore continuous consumption of contaminated aquatic foods like *C. amnicola* from Qua Iboe River Estuary may pose sub-lethal or chronic health problems to humans as the final consumers.

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1. Introduction

Normally, water is never pure in a chemical sense. It contains impurities of various kinds dissolved as well as suspended. These include dissolve gasses (H_2S, CO_2, NH_3, N_2), dissolved minerals (Ca, Mg, Na, Salts), suspended matter (clay, silt, sand) and microbes. These are natural impurities derived from the atmosphere, catchment areas and the soil. They are in very low amount and normally do not pose any threat to water quality and could have some positive effects in improving the quality of water. However, the increase in the concentrations of these impunities emanating from series of human activities may adversely affects the quality of water and make it unfit for use.

Water pollution is also caused by the presence of undesirable and hazardous materials and pathogens beyond threshold limit recommended by international standards. Much of the pollution is due to anthropogenic activities like discharge of sewage, effluents and wastes from domestic and industrial establishments, particulate matter, metals and their compounds due to mining and metallurgy, fertilizer and pesticide runoffs from agricultural activities. Polluted water bodies diminish and / or destroy aquatic fish population and make them unusable for recreation, consumption and other domestic activities. They also pose serious environmental health risks.

Callinectes amnicola belong to the phylum: Arthropoda, class: malascostraca, order: Decapoda, family: Portunidae, genus: Callinectes and species: amnicola. It is important seafood consume by many inhabitants in Nigeria, notable the Niger Delta region as a delicacy in most of their meals. Increase in human population and technological revolution has led to tremendous impacts in our environment, hence, the need for monitoring to ensure safety of the consumption of this seafood owing to pollutants emanating from anthropogenic activities. Trace metals are high priority pollutants because of their relatively high toxic and persistent nature in the environment. These metals in the form of inorganic compounds from natural and anthropogenic sources continuously enter the aquatic ecosystem where they could pose serious threat to the food chain (Otitoju and Otitoju, 2013).

The blue crab *Callinectes amnicola* also known as the big fisted swim crab is one of the most common swimming crab found in the brackish wetlands and lagoons in Nigeria (Solarin, 1998). They inhabit muddy bottoms in mangrove area and river mouths (Defelice *et. al* 2001). Crabs are one of the most important food organism caught in the coastal (inshore) fishery and lagoons in West Africa (Lawal-Are and Kusmiju, 2000). The aim of this study is therefore to augment the rather scanty information on the levels of trace metal concentration in *Callinectes amnicola* obtained from Qua Iboe River Estuary, South-South, Nigeria.

2. Material and Methods

2.1 Description of the study areas and sample collection

Species of big fisted swim crab (*Callinectes amnicola)* commonly found in the Niger Delta region of Nigeria were collected from three different landing sites in Qua Iboe River Estuary (Fig. 1) located within latitude 4º 40´30´´N and longitude 7º 57´0´´E on the South Eastern Nigeria Coastline. The studied areas include; Iwuokpom, Mkpanak and Iwuochang all in Ibeno Local government area of Akwa Ibom State. The sea food samples were transported in clean polyethylene bags to Devine concept laboratory, Port Harcourt were they were washed with deionized water to remove all dirt particles and frozen at -5 °C until they were ready for analysis.

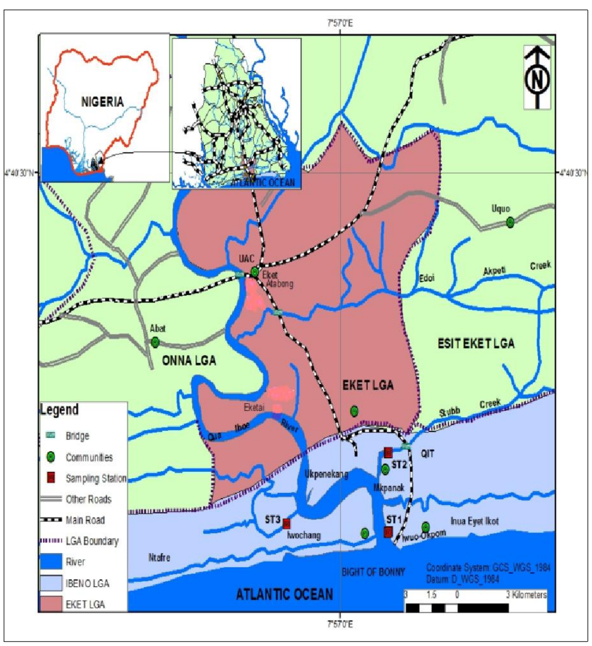

Fig 1: Map of Study Area

2.2 Analysis of Samples

In the laboratory the soft tissues of *C. amnicola* was 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 was digested with 20 ml of concentrated 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).

2.3 Health risk assessment

Health risk assessment of humans consuming *C. amnicola* 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.

2.4 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 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, Cr, Cu, Pb, Co and Zn ($p<0.05$) exception for Iron ($p>0.05$).

Computed transfer factor index values for all heavy metals determined in *Callinectes amnicola* are presented in Figure 2a – 2b. The highest transfer factor index for Cadmium was 0.12 in February, 2016 while the least was 0.01 in April, 2016. Transfer factor index of 0.02 was recorded as the highest for Chromium in December, 2015, January, February and March, 2016 while the least was 0.00 in April, 2016. The highest transfer factor index for Copper was 11.9 in May, 2015 while the least was 8.88 in July, 2015. Iron recorded a highest index of 0.45 in August, 2015 while the least was 0.29 in June and December, 2015. Zinc had a highest transfer factor index of 1.35 in April, 2016 while the least was 0.55 in July, 2015. Generally, the indices computed for Lead were low ranging from 0.08 as the highest value in October, 2015 to 0.03 in June and July, 2015 and January and February, 2016. 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 *Callinectes amnicola* 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	0.00 – 0.03	0.00 – 0.04	0.01 ± 0.00	0.01 ± 0.01	0.01
Chromium	mg/kg	0.00 – 0.00	0.00 – 0.01	0.00 ± 0.00	0.00 ± 0.00	0.05
Copper	mg/kg	11.10 – 13.80	11.28 – 15.50	12.94 ± 0.41	13.49 ± 0.55	1.0
Iron	mg/kg	40.30 – 47.65	35.35 – 47.35	43.83 ± 1.27	42.94 ± 1.80	0.3
Lead	mg/kg	0.02 – 0.04	0.02 – 0.02	0.03 ± 0.00	0.02 ± 0.00	0.05
Cobalt	mg/kg	0.01 – 0.08	0.02 – 0.09	0.04 ± 0.01	0.06 ± 0.01	-
Zinc	mg/kg	12.30 – 16.30	15.30 – 16.88	14.66 ± 0.67	16.22 ± 0.23	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

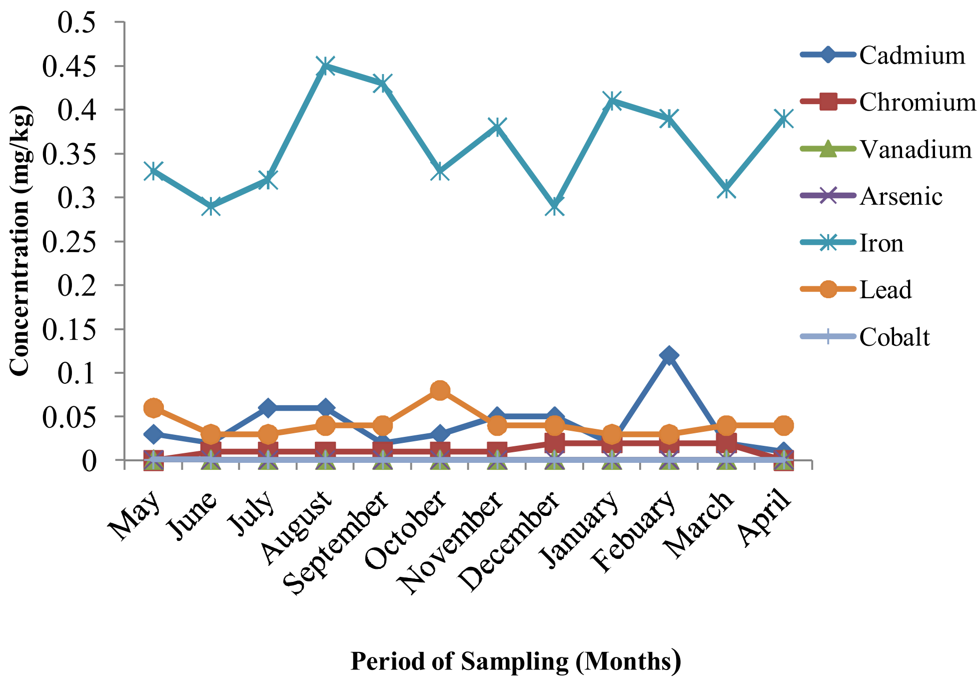

FIG. 2a: Transfer factor threshold for *Callinectes amnicola* obtained from Qua Iboe River Estuary

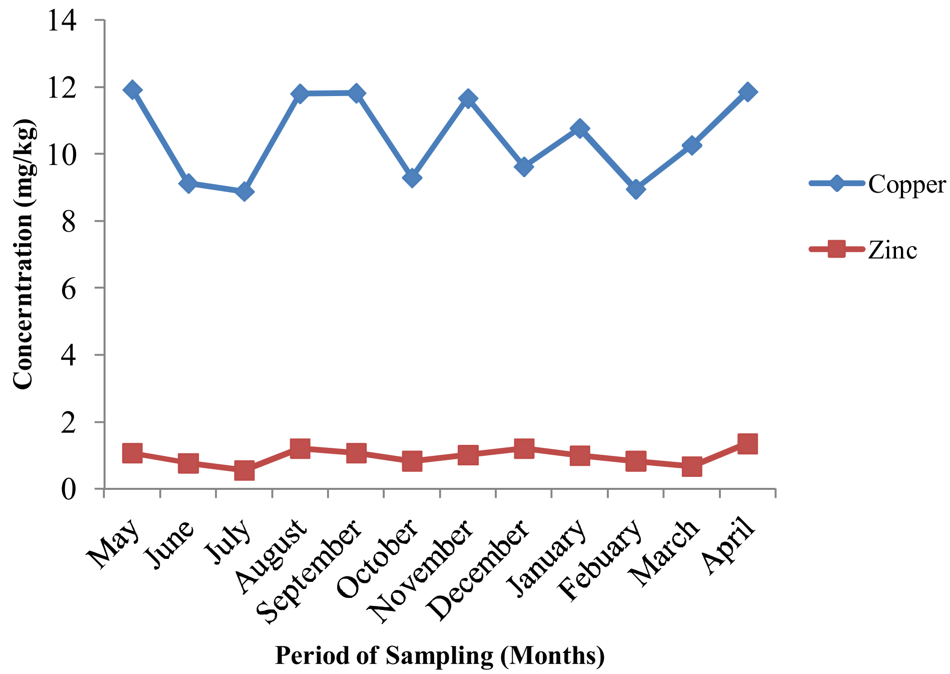

FIG. 2b: Transfer factor threshold for *Callinectes amnicola* obtained from Qua Iboe River Estuary

4.0 Discussion

The mean value of heavy metal concentrations in the tissues of the analyzed *Callinectes amnicola* species obtained from Qua iboe River Estuary, Ibeno showed an interesting pattern. This follows the trend: Fe > Zn > Cu > Co > Pb > Cd > Cr respectively. Vanadium and Arsenic were below detectable limit throughout the study period. Fe concentration was observed to be higher in the tissues of the studied organism as compared to other metal pairs. WHO (1993) postulated that Fe is one of the most abundant metals in the earth's crust, found in natural fresh waters at levels ranging from 0.5 to 50 mg / L. Fe present in water may be as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during the process of water distribution. Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg / day (WHO, 1993). The high concentration of Zinc in the tissues of *C. amnicola* can be attributed to dissolution of zinc from oil pipelines fixed across the water body by oil companies. Similar trend was reported by (WHO, 1993).

However, the observed concentrations of trace metals such as Iron (F), Zinc (Zn), Copper (Cu), Cobalt (Co), Lead (Pb), Cadmium (Cd), and Chromium (Cr) in the test organisms could be from the sediment and were relatively low in this study except for Fe, Zn and Cu. Certain factors may have influenced the differential uptake of metals in the test organism. This study demonstrated evidence of bioaccumulation of heavy metals in the tissues of *Callinectes amnicola* from Qua Iboe River Estuary, Ibeno. Levels were however, observed to be below the recommended tolerance levels (Davies *et al.* 2006; WHO, 2011) except for Fe, Zn and Cu which were above threshold limits. Similar trend of heavy metal contamination in *T. fuscatus* have been reported by George (2015).

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 *Callinectes amnicola* were computed. The results indicated that transfer factors from sediment to *C.*

amnicola were below 1.00 for Cd, Cr, Fe, Pb and Co which implies that no bioaccumulation of these metal occurred from sediment to *C. amnicola*, except Cu and Zn which had a transfer factor value greater than 1.00 which implies that bioaccumulation of these metal occurred from sediment to *C. amnicola*. 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.

The result of this study shows imminent problems of contamination in Qua Iboe River Estuary, Ibeno which is attributed to anthropogenic activities. This emphasizes the importance of constant monitoring of rivers and other water bodies receiving effluents in order to forestall cumulative effects of pollution in the river which may lead to sub-lethal consequences in the aquatic fauna and clinical poisoning to man.

5.0 Conclusion

The elemental concentrations of trace metals observed in the tissues of *Callinectes amnicola* during the study were within permissible limit for cadmium, chromium, cobalt and lead while iron, copper and zinc were above the threshold limit as recommended by WHO. Transfer factor index for *C. amnicola* showed evidence of bioaccumulation of heavy metals in the tissues of this organism. Copper and zinc had a transfer factor index > 1. From the result of findings, the sediment quality of Qua Iboe River Estuary is seriously impaired 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 *C. amnicola* calls for concern as this may result in deleterious health effects to consumers of these shellfishes overtime. *Callinectes amnicola* is an important commercial shellfish consumed in most parts of the world including Nigeria, notably the Niger Delta Region. Therefore, if there is continuous alterations in aquatic environment as would be expected due to anthropogenic activities, it will results in deleterious ecological effects to aquatic biota at the long term. This study vindicate the essence of continuous monitoring of our water bodies as this will help to give vital information on the status of water bodies in Nigeria and to expedite remedial measures in the event of pollution.

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