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Implication of Dredging on Bioaccumulation of Heavy Metals in Soft Tissues of the Periwinkle *Tympanotonus fuscatus* in Elechi Creek, Niger Delta, Nigeria

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Abstract:

*Selected heavy metal concentration in the soft tissues of the Periwinkle *Tympanotonus fuscatus* was investigated in Elechi Creek, Niger Delta. This was done to ascertain the implication of dredging activities going on in the creek on heavy metals in soft tissues of the periwinkle and the possible consequences on human health. Fresh samples of the periwinkle were hand-picked at low tide from three sampling points (I, II and III) located at 04°41'17.5"N and 006°55'39.8"E, 04°41'23.6"N and 006°55'54.1"E and 04°41'29.5"N and 006°56'10.4"E respectively on the Creek. They were transported to the laboratory, washed, digested and analysed for heavy metals using the Atomic absorption spectrophotometer (AAS). Data were subjected to statistical analysis using the Microsoft Excel® tool pack. Regression analysis was employed in order to determine the correlation between the different heavy metals in periwinkle tissues. Analysis of variance was employed at the 95% confidence level to determine the degree of significance in interactions in heavy metals between stations. Result from the study reveal that the concentration of the heavy metals followed the trend Iron (Fe) > Lead (Pb) > Copper (Cu) > Cadmium (Cd). No significant difference between stations in Pb and Cd concentration but there is a significant difference in Cu concentration between stations I and station II and between stations II and III. There were significant differences between all study stations in Fe concentration. All the metal concentrations in soft tissues were below the internationally safety limit. Biota-sediment accumulation factor (BSAF) in Elechi Creek was low and below limit. This may imply that although dredging may interfere with the habitat of periwinkle resulting in reduced harvest, it has no marked contribution on metal concentration in soft tissues in periwinkle and therefore no additional threat to human safety.*

Keywords: Dredging, heavy metals, bioaccumulation, periwinkle, Elechi creek

1. Introduction

Dredging activities in the Niger Delta is a common practice, considering its topography and the never ending need to reclaim land to fight the perennial intrusions of rivers and rising tides. Also, it is essential to meet the growing need of development and modernization required of evolving cities. It is so wide spread that the vast majority of our inland water shorelines are now mountains of sands. It has provided and will still provide a source of massive income to operators and stakeholders in the sand trade. Sadly, our blessing of having plentiful amounts of sand has become a concern, perhaps a disaster for the environment.

Dredging involves the removal of bottom substrate and may interfere with the wellbeing of benthic organisms. Periwinkle, *Tympanotonus fuscatus* are bottom dwelling organism that graze or feed on bottom substrate. They are capable of burrowing into the mud in their habitat and are basically marine mollusca usually found dominating the brackish water environment (Adebayo et al, 2006). In Nigeria, they occur in lagoons, estuaries and mangrove swamps.

Periwinkles are mass-consumed products, as they provide relatively cheap animal protein in the Niger Delta (Ekanem and Otti, 1997). Due to their sedimentary and bottom feeding habits, periwinkle are good accumulators of heavy metals and polyaromatic hydrocarbons (PAH's) (Wilson et al, 1992, Jack et al, 2005). The movement of bottom substrate and piping during dredging activities may affect the bioavailability and dynamics of heavy metals in the soil. This may in turn determine the heavy metal accumulated in the mollusk. Surprisingly, there is a dearth of research on the effect of dredging on the heavy metal accumulated in periwinkle.

In view of the widespread dredging activities in the Niger Delta there is a germane need to study the mineral toxic composition in its soft tissues in order to ascertain the effect of dredging on composition of heavy metals in the mollusk. This will provide information on the implication of dredging activities in the Niger Delta and act as impetus for regulatory control of our coastal waters as periwinkle is a widely consumed source of protein. The presence of heavy metals in soft tissues in the periwinkle portends grave public health implication.

2. Materials and Methods

2.1. Study Area

The study area consists of three study site in Elechi creek which is a tributary of the New Calarbar River. Elechi Creek is close to the Eagle Island, extending to the Iloabuchi Streetwater bank in Diobu, Port Harcourt. The Eagle Island is located on the South-West of Port Harcourt and bounded on the North by the Rivers State University, Nkpolu, Diobu.

2.1.1 Station 1

Station 1 is located at longitude 04°41'17.5"N and latitude 006°55'39.8"E and is situated directly opposite the back gate of the Rivers State University. It is the main transit point for commuters to ferry across to the settlement on the other side of the creek.

2.1.2 Station II

Station II is located at longitude 04°41'23.6"N and 006°55'54.1"E. It is located toward the perimeter fencing of the Nigerian Agip Oil Company (NAOC). It is sand dump site overlooking the deeper reaches of the creek.

2.1.3 Station III

Station III is located at longitude 04°41'29.5"N and latitude 006°56'10.4"E. It lies towards the bonny river mouth that runs besides the Eagle Island settlement. Local sand excavation is done around this point.

2.2. Sample Collection and Transport

2.2.1. Periwinkle Samples

Samples were randomly collected once between the hours of 9am – 11:30am at low tide at the water shore along the sampling stations. They were put in differently coloured cellophane bags and taken directly to the Institute of Pollution Studies (IPS) laboratory, Rivers State University.

2.2.2. Sediment Samples

Sediment samples were collected using a hand trowel to scoop sediments into polyethylene bags for heavy metal analysis. In each station, triplicate samples were collected and stored in an ice chest before transferring to the laboratory.

2.3. Analysis of Samples for Metals

2.3.1. Periwinkle Sample

Periwinkle samples from the swamps were washed under a running tap to rid the shell of the swamp mud. The washed shells and their contents were put into an aluminum pan and put on a hot plate and the heat turned on. The heat drove the periwinkle out of their shells and picked out into beakers according to their stations.

2.3.2. Sample Digestion (Wet Digestion)

1g each of fresh periwinkles was weighed in a kheljahl digestion flask and placed on the digester block. 20ml aliquot of the digester acid (1:3:1) of conc. Nitric (HNO₃) acid, concentrated H₂SO₄ and concentrated perchloric acid were added into each of the flasks and the heat turned on. This was heated until a clear solution was obtained.

20ml aliquot of distilled water was added to the cooled flask to dilute the acid mixture.

3 numbers 100ml volumetric flask were prepared and fitted with a filtration set and the digested samples were filtered in the 100ml flask and the digestion flask were then washed into the funnels with a further 15ml aliquot of distilled water into the volumetric flask

The flasks were made up to the mark with distilled water and the samples were ready for analysis.

2.3.3. Periwinkle Analysis

The resulting solution was analysed for Fe, Cu, Pb, and Cd using Atomic Absorption Spectrophotometer (AAS model Agilent AA55) after selecting the various wavelengths at which the heavy metals were determined. An analytical blank was prepared in a similar manner. The obtained results were expressed as mg/kg wet weight.

2.4. Sediment Sample Analysis

In the laboratory, five (5) grams of the air-dried samples were weighed out accurately using a sensitive micro-scale for each station. The samples were put in a 250ml beaker and the following chemicals added to each weighed sample. (a) 100ml of distilled water. (b) 1ml of concentrated Nitric acid (HNO₃). (c) 10ml of concentrated Hydrochloric acid.

The beaker containing weighed samples plus acid mixture were then covered with watch glasses and were placed on a hot plate for digestion to be completed. The solutions were not allowed to boil nor bump to avoid splattering. The digestion was continued until the volume was concentrated to about 15ml. It was then allowed to cool to room temperature. The digested samples after cooling were filtered quantitatively into a 50ml volumetric flasks and the volume made up to mark with distilled water. The solutions were then introduced to the AAS equipment for quantitative measurement of the metals.

2.5. Statistical Analysis

Means and standard errors were calculated for all heavy metals values. Regression analysis was employed using the Microsoft Excel® tool pack in order to determine the correlation between heavy metals in soft tissue. Analysis of variance was employed at the 95% confidence level to determine the degree of significance of heavy metals in study stations. Biota-sediment accumulation factor (BSAF) was conducted as follows:

$$BSAF = C_t/C_s \text{----- (1)}$$

Where:

C_t - Relative concentration of a substance in the tissues

C_s - concentration of the same substance in the sediment

3. Result

The result of the study are displayed in Tables 1 – 5 and Figures 1 and 2

Stations	Heavy Metals (mg/kg)			
	Pb	Cu	Fe	Cd
I	0.064 ±0.01 ^a	0.04±0.01 ^a	0.836±0.023 ^a	0.015±0.001 ^a
II	0.055±0.021 ^a	0.07±0.02 ^b	0.301±0.041 ^b	0.017±0.001 ^a
III	0.061±0.022 ^a	0.042±0.01 ^a	0.691±0.021 ^c	0.022±0.002 ^a

Table 1: Mean Heavy Metal Content in Soft Tissue of Periwinkle in Elechi Creek
Source: Field Work, 2019. Means with the Same Letter Superscript Along the Same Row Are Not Significantly Different (P=0.05)

Stations	Heavy Metals (mg/kg)			
	Pb	Cu	Fe	Cd
I	0.024 ±0.01 ^a	0.01±0.01 ^a	0.416±0.003 ^a	0.005±0.001 ^a
II	0.015±0.001 ^a	0.02±0.001 ^a	0.201±0.021 ^b	0.016±0.001 ^a
III	0.011±0.012 ^a	0.022±0.02 ^a	0.211±0.001 ^b	0.014±0.001 ^a

Table 2: Mean Heavy Metal Content in Sediments in Elechi Creek
Source: Field Work, 2019. Means with the Same Letter Superscript Along the Same Row Are Not Significantly Different (P=0.05)

Stations	BSAF (Heavy Metals)			
	Pb	Cu	Fe	Cd
I	2.66	4.0	2.009	3.0
II	3.66	3.5	1.49	1.06
III	5.45	0.18	3.27	1.57

Table 3: Biota-Sediment Accumulation Factor (BSAF) in Elechi Creek

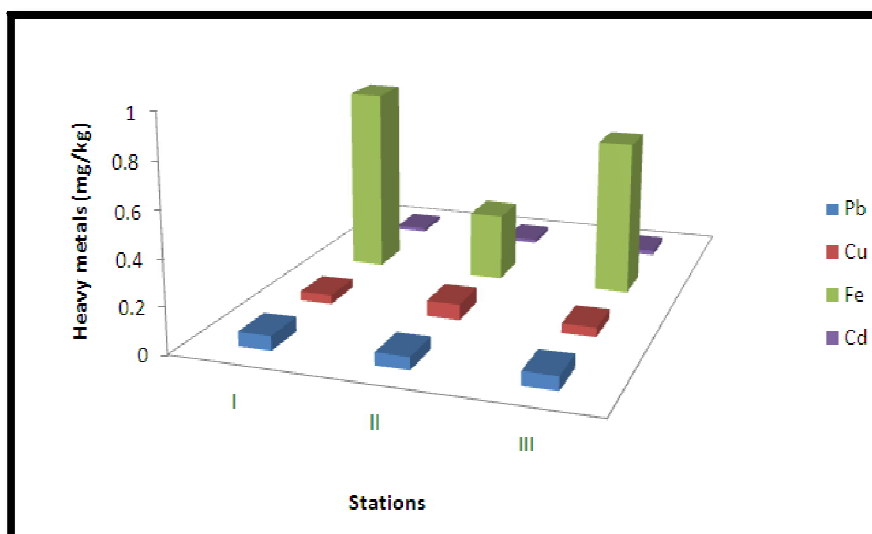


Figure 1: Mean Heavy Metal Content in Soft Tissue of Periwinkle in Elechi Creek

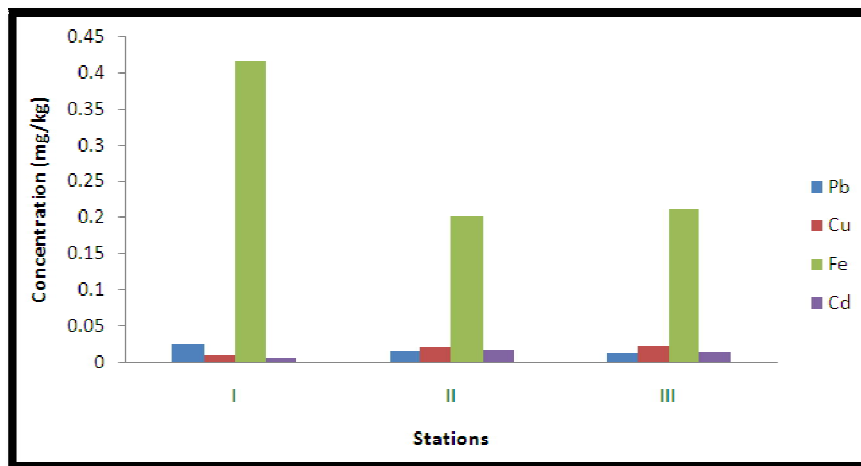


Figure 2: Mean Heavy Metal Content in Sediments in Elechi Creek

Heavy metals	Maximum Permissible Limits (mg/kg)			
	FAO	FAO/WHO	WHO	England
Zn	30	40	100	50
Pb	0.5	0.5	2	2
Cd	0.05	0.5	1	2
Cu	30	30	30	20

Table 4: Maximum Permissible Limits (MPL) International Standard of Heavy Metals in Tissues

		Pb	Cu	Fe	Cd
Pb	Pearson Correlation	1	-.715	.508	-.208
	Sig. (2-tailed)		.492	.660	.867
	N	3	3	3	3
Cu	Pearson Correlation	-.715	1	.238	.832
	Sig. (2-tailed)	.492		.847	.374
	N	3	3	3	3
Fe	Pearson Correlation	.508	.238	1	.736
	Sig. (2-tailed)	.660	.847		.473
	N	3	3	3	3
Cd	Pearson Correlation	-.208	.832	.736	1
	Sig. (2-tailed)	.867	.374	.473	
	N	3	3	3	3

Table 5: Pearson's Correlations for Heavy Metals in Periwinkle
Source: Data Analysis

4. Discussion of Result

The result from this study indicate that the concentration of heavy metals in the soft tissue of periwinkle and sediment followed the order; Fe > Pb > Cu > Cd (Tables 1 and 2).

All the measured parameters of heavy metals in the soft tissue are lower than the maximum stipulated international values (Table 4). This observation of low quantities of heavy metals in soft tissues of periwinkle is consistent with the findings of Obire et al, 2003 but disagrees with the findings of Chindah and Braide, (2003) who observed far larger values in the same creek. The low amount of heavy metals found in the soft tissues of the periwinkle may be due to the fact that the dredging operations may have removed along with the bottom substrates, majority of the heavy metals deposited therein leaving only minute amounts in water for the periwinkle to assimilate. Bioaccumulation is a function of the bioavailability of contaminants in combination with species-specific uptake and elimination processes. Also, the bio availability of contaminants in sediment is a function of the type of chemical and the chemical speciation, as well as the behavior and physiology of the organism (USEPA, 2000). Bower (1979) noted that the extent of bioaccumulation in biota is dependent on the chemical effect of the metal, its tendency to bind to particular materials and on the lipid content and composition of the biological tissues.

The sediments also displayed very low concentration of heavy metals (Table 2). Although sediments accumulate heavy metals than water and may hold more than 99% of total amount of heavy metals present in the aquatic ecosystem (Odiete, 1999, Chindah and Braide, 2003, Fabris, 1994), the removal or displacement of bottom substrate through dredging activities may deplete its bonding and accumulative potentials.

Sediments are dynamic environments with a wide range of interacting processes with variable rates. The rate of mixing in surficial sediment layers by physical processes such as turbulence and bioturbation competes with the rate of sedimentation to determine the depth to which contaminated sediment will be buried. (USEPA, 2000).

There is no significant difference between stations in Pb and Cd concentration, but there is a significant difference in Cu concentration between stations I and station II and between stations I and III. There were significant differences between all study stations in Fe concentration (Table 5). The differences in metal concentrations and sequence in different tissues can be attributed to several factors, such as the affinity of organisms to metals, seasonality, temperature, age, size, body mass, water velocity and dilution and the anthropogenic source input to the water (Ayenimo et al, 2006). Also, Pb showed strong negative correlation with Cd and Cu but positive correlation with Fe. Such antagonistic behavior in metal prevalence has been observed by previous scholars ((Clarkson and Luttge, 1989).Salgare and Acharekar (1992) reported that the inhibitory effect of Mn on the total amount of mineralized C was antagonized by the presence of Cd. Similarly, Cu and Zn as well as Ni and Cd have been reported to compete for the same membrane carriers in plants. The dominance of Fe in tissue, sediment and Biota-sediment accumulation factor (BSAF) in Elechi Creek suggest the preponderance of Fe in the environment. This may be as a result of high content of Fe in the soils of the Niger Delta region or the fact that most of the dredging equipment are made of Fe which on exposure to moisture easily incorporates with the aquatic ecosystem. However, the lower than stipulated BSAF limit suggest that sediment to tissue transfer was not an issue and negligible.

In conclusion, heavy metal concentration in the soft tissues of the periwinkle was lower than the stipulated maximum limit. Also, heavy metal concentrations were also low in sediments. The BSAF was also lower than stipulated maximum limits (USEPA, 2000). Therefore, it can be reasonably adduced that dredging activities in the Elechi creek do not constitute a significant threat to heavy metal poisoning of periwinkles, however care should be taken in its consumption as the risk of bio-magnification is evident. Also, the removal of bottom substrate through dredging will result in the decline in size and amounts of the periwinkle harvested.

5. References

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