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Assessment of Heavy Metals Concentration in Shell and Fin Fish from Iko River Estuary, Southeastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Heavy metals (HM) concentration in croaker (*Pseudotolithus typus*) and periwinkle (*Tympanotonus fuscatus*) from Iko River estuary, Southeastern Nigeria were carried out between June and December, 2015 using UNICAM 939 Atomic Absorption Spectrophotometer (AAS). The results in (mg/kg) showed different levels of Cd (cadmium), Cr (chromium), Cu (copper), Fe (iron), Pb (lead), Ni (nickel) and Zn (zinc) in croaker and periwinkle. The order of heavy metals accumulated by *P. typus* and *T. fuscatus* were Cu > Zn > Fe > Cd > Pb > Cr >Ni and Fe > Cu > Zn > Pb > Cd > Cr > Ni, respectively. The results showed that Cu and Fe recorded highest concentration in Croaker and periwinkle respectively while Ni concentration was least in both organisms. Both organisms bio-concentrated considerable levels of heavy metals, however, the bio-concentration of periwinkle was significantly higher than croaker. The concentration of Cd, Cu and Fe in both organisms were higher than the WHO/FEPA (World Health Organisation/ Federal Environmental Protection Agency) recommended MPL (maximum permissible limits), while the levels of Cr, Pb, and Ni were below the standards and Zn concentration was within MPL. The results suggest that Iko River estuary has high pollution loads of these metals in fishes and could pose a health hazards to man.

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Consequently, close monitoring of heavy metal loads in this water body is recommended with a view to minimizing the risks to health of the population that depend on the river for their water and fish supply.

Keywords: Heavy metals; Tympanotonus fuscatus; Pseudtolithus typus; atomic absorption spectrophotometer; concentration; Iko River estuary; Nigeria.

1. INTRODUCTION

Iko River estuary in the Niger Delta region habours rich collection of biotopes dominated by vast areas of mangrove swamp forest [1,2]. However, this region with its complex ecological form is being subjected to considerable environmental pollutants from agricultural, industrial and domestic activities as well as oil exploration and exploitation. This has resulted in the release of pollutants (hydrocarbons and heavy metals), capable of polluting the terrestrial and aquatic ecosystems [3,4,5]. Heavy metals have been reported to have negative effect on metabolic processes in general and may influence the nutritional and biological status of aquatic resources [6,1].

Aquatic fauna such as periwinkle and fish are rich sources of nutrients; however, their nutritional values may be affected based on the environment in which these organisms live [7,8]. *T. fuscatus*, the West African Mud Creeper, a gastropod mollusc is a species of snail in the family Potamididae living in brackish water. It is the only extant species in the genus *Tympanotonus* [9]. *T. fuscatus* is one of the fisheries products common to the coastal areas of Nigeria, most especially Akwa Ibom State. They are found at the inter-tidal zone of brackish water, creeks, estuaries, and lagoons in the Niger Delta area [10]. It is of economic importance as it serves as a source of protein to many Nigerians, source of income to the collectors and marketers, thus forming an important industry in the entire Niger Delta region of the country. Furthermore, the shells of these periwinkles are used in place of gravels in the building industry, as decorative arts and in the production of animal feed [11,4]. *P. typus* is a species of croaker or bar, ray-finned fish in the family Sciaenidae [12]. It inhabits coastal waters from shorelines to at least 70 m, but may be more common in deeper waters to 150 m. It is found over muddy and sandy bottoms, uncommon in rocky areas, it feeds on worms, crustaceans and small fishes and spawns off estuaries [11,10]. Croakers are important food fish for Nigeria as they constitute about 40% of the total landings on the Nigerian coast [4]. These important food sources constitute a major part of the diet in the Niger Delta region of Nigeria, however, these organisms may bioaccumulate heavy metals in considerable amount in tissues over a long time which may be detrimental to the health of inhabitants of this area that consume them. The study of toxic and heavy metals in Iko River estuary is more important in comparison to other pollutants owing to their non bio-degradable nature, accumulative properties and long biological half-lives. It is difficult to remove them completely from the environment once they enter into it [13,14]. 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. Heavy metals are dangerous to humans because they tend to bioaccumulate in vital organs [15,16]. Trace elements such as copper, iron and zinc are essential to maintain the metabolism of the human beings. Heavy metals such as cadmium, chromium, mercury, and lead pose a number of health hazards to humans. Humans are exposed to these metals by ingestion (drinking or eating) or inhalation (breathing) [17]. High concentration intake of cadmium cause itai ita disease. Chromium compounds are toxins and are known human carcinogens. Lead severely damages the brain and kidneys and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High level exposure can damage the organs responsible for sperm production [18]. Mercury permanently damages the brain, kidneys and developing fetuses, it also causes minamita disease [13,15]. Nickel is an allergen and a potential immunodulatory and immunotoxic agent in humans. Excessive intake of zinc may lead to toxic effects such as carcinogenesis, mutagenesis and tetratogenesis as a result of its bioaccumulation [19,20]. Studies on the pollution status of some fauna in some parts of Nigeria and around Niger Delta area have been reported [21,22,23,2]. It is therefore necessary to determine the concentration of Cd, Cr, Cu, Fe, Pb, Ni and Zn in periwinkle (*T. fuscatus*) and Croaker (*P. typus*) harvested from

Iko River estuary with the following objectives: to determine the concentrations of these heavy metals in *T. fuscatus* and *P. typus* respectively; to determine which of the species bioaccumulate more of these metals and to compare the levels of these metals with recommended international maximum permissible limits thereby creating awareness on potential health risks of human consumption of these species of aquatic resources.

2. MATERIALS AND METHODS

2.1 The Study Area

Iko River estuary is located in Eastern Obolo Local Government Area, Akwa Ibom State, in the Niger Delta region, Nigeria. The area lies within latitude 4°^{0}30' N and 4°45' N, and longitude 7°35' E and 7°40' E (Fig. 1) [24,25,26]. The river has a shallow depth ranging from 1.0 m to 7.0 m at flood and ebb tide. Iko River takes its rise from Qua Iboe River catchments and drains directly into the Atlantic Ocean at the Bight of Bony [24].

The adjoining Creeks, channels and tributaries from the Iko River estuary are significant in the provision of suitable breeding sites for the diverse aquatic resources that abound in the area, good fishing ground for artisan fishers as well as petroleum exploration and production activities [27,7]. The shoreline of Iko River estuary is fringed with mangrove and nipa vegetation, tidal mudflat and pheumnatophores of *Avicenia* exposed during low tide. The macrophytes are composed of the native red mangrove; *Rhizophora racemosa*, *R. harrizonii*, *R. Mangle*, black mangrove (*Avicenia africana*) and *Laguncularia racemosa* and the exotic nipa (*Nipa fruticans*) [28,29].

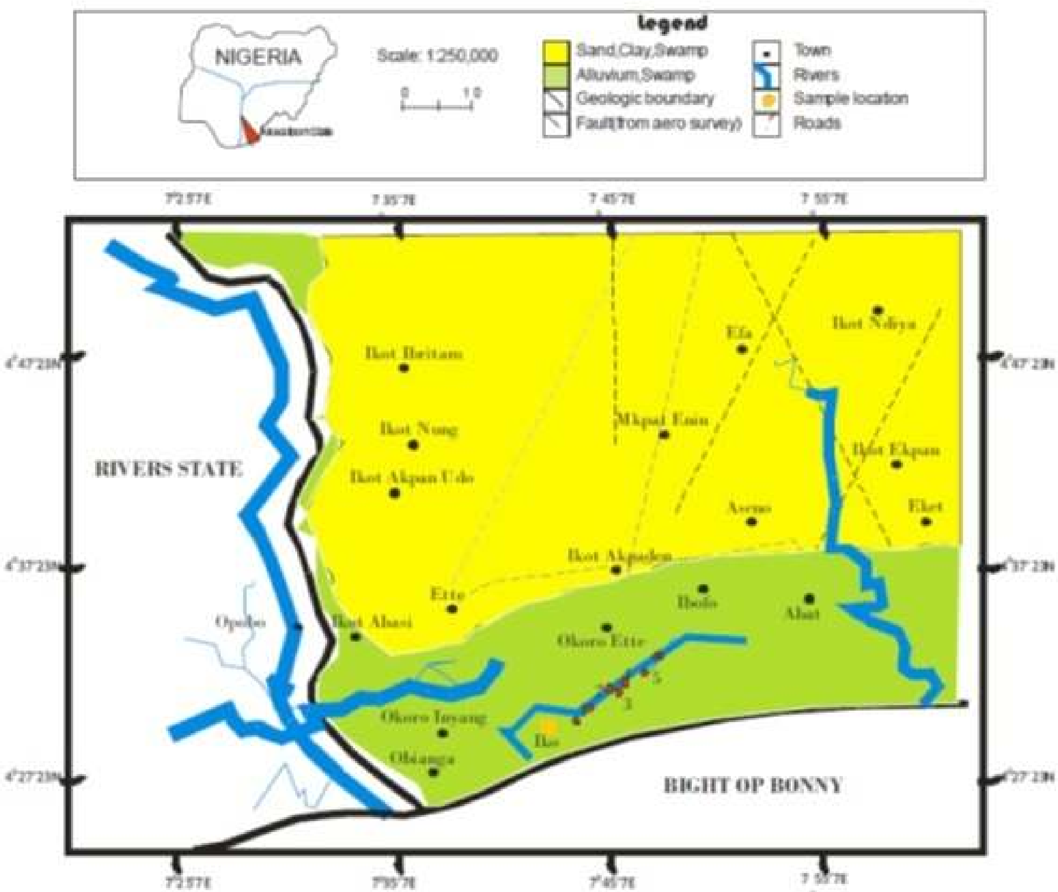

Fig. 1. Location of sampling site on the map of Eastern Obolo, Akwa Ibom State, Southeastern Nigeria

2.2 Sample Collection

Samples of periwinkle (*T. fuscatus*) and Croaker (*P. typus*) used for the analysis were bought from fishers fishing in Iko River estuary (Fig. 1). The samples were thoroughly washed with the sea water, placed in separate labeled cellophane bags and preserved in ice cooled box. The samples were later transported to the Zoology Unit Laboratory, Department of Biological Sciences, Akwa Ibom State University and stored in the freezer at - 4℃ prior to laboratory analysis. Sampling was carried out between June and December, 2015.

2.3 Sample Preparation

The samples were removed from the freezer allowed to thaw, the flesh of the fish was taken using a stainless steel surgical knife while flesh tissue of the periwinkle was gotten by cracking the shells. The samples were oven dried at 80℃ for 24 hours after which they were separately ground to powder form using ceramic mortar and pestle.

2.4 Digestion Procedure

Dry tissue samples weighing 2.0 g were digested with 6 ml of concentrated nitric acid (HNO_3) and 1 ml of 30% hydrogen peroxide (H_2O_2). The digestion was carried out in a microwave digester using microwave digestion. The completely digested samples were filtered using what-man filter paper and diluted to 25 ml in volumetric flask with distilled water.

2.5 Metal Determination and AAS Condition

The resulting solutions were analyzed for metals using UNICAM 939 Atomic Absorption Spectrophotometer equipped with MS Window application software. The AAS determines the presence and concentration of metals such as in liquid sample. The AAS instrument looks for a particular metal by use of ultra-violet light (UV-Light). When the sample of interest is aspirated into a flame, any metal present in the sample absorbs some of the light thus reducing its intensity. The instrument measures the change in intensity into an absorbance. As concentration goes up, absorbance goes up as well. AAS has high sensitivity which means that solution with concentration as low as part per million (PPM) range can be analysed [30,31.21,20].

2.6 Statistical Analysis

Differences in HM concentrations between *T. fuscatus* and *P. typus* were analyzed using t-test and were used to assess whether concentrations varied significantly between species. Possibilities less than 0.05 ($P < 0.05$) were considered statistically significant.

3. RESULTS

Table 1 depicts overall total concentrations, range and mean of heavy metals (mg/kg) determined in flesh tissues of croaker *(P. typhus)* and periwinkle *(T. fuscatus)* from Iko River estuary.

Cadmium ranged from 0.26 – 0.88 mg/kg with a total concentration of 3.9 mg/kg (mean = 0.56 ± 0.22 mg/kg) in *P. typus* whereas it ranged from 2.08 – 5.13 mg/kg with a total concentration of 30.02 mg/kg (mean = 4.29 ± 1.03 mg/kg), in *T. fuscatus* .Chromium varied between BDL and 0.291 mg/kg with a total concentration of 0.84 mg/kg (mean = 0.12 ± 0.11 mg/kg) in *P. typus* while it varied between 0.13 and 0.66 mg/kg with total concentration of 2.96 mg/kg (mean = 0.42 ± 0.21 mg/kg) in *T. fuscatus* . In *P. typus*, Copper (Cu) ranged between 26.03 and 48.26 mg with a total concentration of 258.11 mg/kg (mean = 36.87 ± 7.78 mg/kg), whereas it varied from 48.22 – 75.11 mg/kg with total concentration of 458.45 mg/kg (mean = 65.49 ± 9.46 mg/kg) in *T. fuscatus*. The concentration of Fe ranged from 6.28 – 8.39 mg/kg with a total concentration of 50.34 mg/kg (mean = 7.19 ± 0.84 mg/kg) in *P. typhus* while they were 110.03 – 315.08 mg/kg with a total concentration of 1727.32 mg/kg (mean = 246.76 ± 72.21 mg/kg) in *T. fuscatus*. Lead ranged from BDL – 1.0 mg/kg with total concentration of 3.8 mg/kg (mean = 0.54 ± 0.37 mg/kg) in *P. typhus* while it ranged from 4 – 15 mg/kg with total concentration of 69.0 mg/kg (mean = 9.86 ± 4.10 mg/kg) in *T. fuscatus*. The concentration of Ni varied between BDL and 0.14 mg/kg with a total concentration of 0.32 mg/kg (mean = 0.05 ± 0.06 mg/kg) in *P. typus* whereas it varied between 0.12 and 0.58 mg/kg with a total concentration of 2.35 mg/kg (mean = 0.34 ± 0.16 mg/kg) in *T. fuscatus*.

Table 1. Overall total concentration, range and mean of heavy metals (mg/kg) determined in flesh tissues of croaker *(Pseudotolithus typhus)* and periwinkle *(Tympanotonus fuscatus)* from Iko River estuary

Parameters	Species	*P. typus*	*T. fuscatus*
	Total concentration	3.9	30.02
Cd	Range	0.26 – 0.88	2.08 – 5.13
	Mean ± Sd	0.56 ± 0.22	4.29 ± 1.03
	Total concentration	0.84	2.96
Cr	Range	BDL – 0.29	0.13 – 0.66
	Mean ± Sd	0.12 ± 0.11	0.42 ± 0.21
	Total concentration	258.11	458.45
Cu	Range	26.03 – 48.26	48.22 – 75.11
	Mean ± Sd	36.87 ± 7.78	65.49 ± 9.46
	Total concentration	50.34	1727.32
Fe	Range	6.28 – 8.39	110.03 – 315.08
	Mean ± Sd	7.19 ± 0.84	246.76 ± 72.21
	Total concentration	3.8	69.0
Pb	Range	BDL – 1.0	4 – 15
	Mean ± Sd	0.54 ± 0.37	9.86 ± 4.10
	Total concentration	0.32	2.35
Ni	Range	BDL – 0.14	0.12 – 0.58
	Mean ± Sd	0.05 ± 0.06	0.38 ± 0.16
	Total concentration	152.74	380.3
Zn	Range	16.75 – 28.33	30.15 – 70.32
	Mean ± Sd	21.82 ± 4.30	54.33 ± 13.07

Sd = Standard diviation

The concentrations of Zn ranged from 6.75 – 28.33 mg/kg with a total concentration of 152.74 mg/kg (mean = 21.82 ± 4.30 mg/kg) in *P. typhus* while they ranged from 30.15 – 70.32 mg/kg with a total concentration of 380.3 mg/kg (mean = 54.33 ± 13.07 mg/kg) in *T. fuscatus*. There were significant differences ($p< 0.5$) in heavy metal concentration between the species in favour of *T. fuscatus* in all the metals analyzed except chromium where there was no significant increases between them.

4. DISCUSSION

There were significant differences ($p< 0.5$) in heavy metals concentration between the species in favour of *T. fuscatus* in all the metals analyzed except chromium where there was no significant increases between them. However, Cu and Fe were bio-concentrated more than any other metals determined in *P. typus* and *T. fuscatus* respectively as contained in Table 1. The concentration of Ni were the least in both organisms. Generally, the level sequence of heavy metals studied in decreasing order were: Cu > Zn > Fe > Cd > Pb > Cr > Ni and Fe > Cu > Zn > Pb > Cd > Cr > Ni for fish and periwinkle respectively. The sequences are similar to that of [23] on fish and periwinkle from Warri coastal water and [32] on fish and periwinkle from Lagos Lagoon. Furthermore, the sequence of non-essential metals in fish and periwinkle are worthy of note, in fish it was Cd > Pb, this agreed with the sequence reported by [32] but opposite the record of [23]. In periwinkle, it was Pb > Cd, this agreed with the sequence obtained by [32] and contrary to that of [23]. Non-essential metals do not present any function for metabolism or organisms' physiology. The concentration of Cd and Pb in periwinkle in particular and fish in general may be used as an indication of the level of metal pollution of the water body from which they were caught [13,23,32]. The bio-concentration of Cd, Cu, Fe, Pb, Ni and Zn in periwinkles than croaker may be due to the fact that they reside permanently in bottom sediment, have poor mobility and are typically in direct contact with sediment [13,2]. It may as well be due to differences in physiology and bottom feeding habits of periwinkles which are likely to ingest considerable heavy metal laden sediment than the fish which swim in water and partially feeds on sediment [14,33,16].

The high concentration of heavy metals may be due to agricultural, industrial, domestic as well as other anthropogenic activities such as oil exploration, exploitation and refining which can introduce these metals into the water body and eventually sediment from where fauna feed [3,34.20,15,22,35]. Moreover, the high concentration of heavy metals such as Fe in fish and periwinkle could be due to the fact that this metal is naturally abundant in Nigerian soils where they are leached into the water body and eventually sediment from where the fauna feed directly (periwinkle) or indirectly (fish) [13,35,16,17].

Cd, Cu and Fe levels recorded in fish and periwinkle samples in this study were higher when compared to [19,18] maximum permissible limits and the consumption of these species could cause health hazard to man, hence people are advised to make moderate use of these aquatic fauna to forestall chronic exposure to these pollutants. This emphasizes the importance of constant monitoring of aquatic ecosystems 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. The mean concentrations of Cr, Pb and Ni were below the recommended limits whereas that of Zn was within the limits, hence these metals may not be an immediate problem in Iko River estuary but may pose a lot of environmental problems if they are not checked. There is a need for regular public health checks on the levels of heavy metals among the communities that border the sampled river in order to avoid a possible future toxic exposure. Measures should also be put in place to control the treatment and discharge of effluent into the water body. The consumption of seafood continues to increase worldwide, due to their beneficial effects on human health. But they are food to be monitored for three main reasons: on the one hand, they are excellent pollutant sensors, including metals, on the other hand, the concentration attaches to the organs; and a world consumption of fish and shell fish is very high. Hence the value of this valuable study.

5. CONCLUSION

P. typus and *T. fuscatus* could have the tendency to bio-accumulate with preference for some metals, however, the bio-accumulation of periwinkle was significantly higher than croaker. This could further demonstrate that the organisms possess bio-indicator attributes for monitoring metals in aquatic systems.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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