Physico-chemical Parameters and Heavy Metals Distribution in Selected Shell Fishes along the Opuro-Ama Creek in Rivers State of Nigeria

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Authors' contributions

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

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ABSTRACT

The study was conducted to determine the heavy metals concentration in selected shell fishes (*U. tangeri, C. amnicola, T. fuscatus, P. monodon*), sediment and water. The samples were collected from a fishing port along the Opuro-ama Creek in Rivers State of Nigeria. analysis for Manganese (Mn), Iron (Fe), Cobalt (Co) and Zinc (Zn) were done using *Atomic Absorption Spectrophotometer*. The order of metal accumulation in these shellfishes, sediment and water were; *C. amnicola* (Fe > Zn > Cu > Co > Mn); *U. tangeri* (Fe > Zn > Cu > Co > Mn); *T. fuscatus* (Fe > Cu > Zn > Co > Mn); *P. monodon* (Fe > Co > Zn > Cu = Mn); Sediment (Fe > Zn > Co > Cu > Mn); Water (Fe > Cu > Mn > Co = Zn). There was statistical difference ($p<0.05$) in metals concentration in the soft tissues in all the shellfish. From the results, the concentration of the metals in the tissues of all the shell fishes, the interstitial water and the sediment sampled from the creek were within the permissible limit recommended by the Department of Petroleum Resources (DRP), Environmental Protection Agency (EPA) and World Health Organization (WHO) except for Fe which was above the recommended limit. The physicochemical parameters of the interstitial water such as pH, Temperature, Conductivity, Total Dissolved Solids (TSS) Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), and Salinity were within the acceptable levels in the guidelines for drinking]. Although Chemical Oxygen Demand (COD) and the Total Suspended Solids (TSS) were

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slightly higher than the recommended limit of these metals by Department of Petroleum Resources (DRP). This indicates that if theses metals are not checked, they may increase the potential for bioaccumulation in the shellfishes and the creek as well. Therefore, there is need for regular monitoring of this creek to avoid future deterioration.

1. INTRODUCTION

Environmental pollution, natural or man-made is assuming enormous proportions, increasing considerably day by day, with the advent of civilization, industrialization and urbanization [1]. Most of the world's air, water and land are now mostly contaminated by chemical wastes from domestic, industrial processes, including those of crude oil and gas [2] Consequently, the aquatic ecosystems act as one of the major receptacle ecosystems for various contaminants generated through the unregulated release of effluents from mines, smelters, industries, excessive usage of agrochemicals, and from aerial deposition [3]. In Nigeria, the input of environmental pollutants in aquatic systems is a common phenomenon. It is a common believe that aquatic systems have an unlimited capacity to absorb increasing amount and variety of waste substances and energy from our civilization [4]. Aquatic environment pollution as a result of heavy metals has been a critical issue all over the world, this is because they are indestructible and most of them have toxic effects on organisms [5]. Fin and shell fishes have been widely used as bio-indicators to monitor heavy metals concentrations in the coastal environment, due to their wide range of distribution, and also their important position in the food chain. Among the different kinds of pollutants, heavy metal pollution needs to be dealt with on top priority considering both its fast rate of accumulation in the aquatic medium and the impact of its toxicity on the organisms along the food chain and its biomagnification impacts [6]. Giving the potential environmental exposure of the Opuro-ama creek to heavy metal contamination by virtue of its position as recipient creek to many other tributaries in the Niger Delta region, it is pertinent to evaluate the likely effect of its pollution on the inhabitants and communities which depend on it for their livelihood in terms of fishery resources and other services.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out from three stations along the Opuro-ama creeks in Asari-Toru Local Government Area of Rivers State ((Fig. 1). The Creek is a joint tributary of the Sombraro Estuary, Located Southeast of the Niger Delta between longitude 04°48′0 ″N and latitude 006°50′16″E. It shares boundaries with Sa-ama and Abalama Creek. These creeks system consists of the main channel and associated feeder creeks linking Opuro-ama, Sa-ama, Abala-ama, Te-ama, Sangama Degema, Krakrama and other riparian communities. In this ecosystem, the main fish families are Lutjanidae, Clupeidae, Cichlidae and Claroteidae, but the Claroteidae (silver catfish) and Cichlidae (tilapias) are most common. [7]. Whereas the tidal mudflats species include the gobies, periwinkles, crabs, mudskippers, only to mention a few.

The mangrove vegetation of the area comprises *Rhizophora racemosa, R. mangle and R. harrisonii* (red mangrove). Other mangrove species in the area are *Avicennia germinans* (white mangrove), *Laguncularia racemosa* (black mangrove) and *Conocarpus erectus* (button wood). There is also presence of mangrove associates such as *Acrostichum aureum* (mangrove fern) and *Paspalum vaginatum* (mangrove sedge). Other human threats to these creeks mangrove swamp include artisanal channelization, Illegal refining and bunkering activities, sand dredging and deliberate cutting of mangroves at the community landing corridors for 'security reasons etc.

2.2 Collection of Samples

A total of twenty representative samples per station at each sampling campaign were obtained within a sampling period (January to June, 2018) to provide for statistical variation. The healthy species were collected from the creeks.

2.3 Shell Fish

The swimming crabs (*Callinectes amnicola*) was caught using a drag net while the Mud flat crab (*Uca tangeri*) was collected randomly from their hide out holes in the mud flat using creek using a crab trap. Periwinkle (*Tympanotonus fuscatus*) was handpicked from the mud flat too. while the

Tiger shrimp (*Penaeus monodon*) was caught using a drag net. Sampling was carried out from three different sample stations across the creek. The collected sample was persevered in a cooler of one pound of crushed ice for each two pounds of fish before transported to the laboratory for heavy metal concentration using atomic absorption Spectrometer.

2.4 Sediment Sample

A bottom sediments samples were collected in a composite form from three different stations using an Ekman grab sampler and kept in a plastic container which had been previously treated with 10% nitric acid for 24 hours and rinsed with de-ionized water.

2.5 Water Sample

Three pits were dug randomly on the intertidal flat of each sample station and allowed for the accumulation of the interstitial water. After fifteen minutes, the interstitial water would be collected in-situ using water collection bottle.

2.6 Determination of Heavy Metals

The Cobalt (Co), Copper (Cu), Iron (Fe), Zinc (Zn), Magnesium (Mn) were determined using the Atomic Absorption Spectrophotometer (AAS) method.

2.7 Determination of Physico-chemical Parameters

The interstitial water samples were collected using Schott glass bottles. The pH, interstitial water temperature, salinity, conductivity, total suspended solids (TSS), total dissolved solids (TDS) of the water were measured using an in-situ handheld multi-meter (Milwaukee Model pH600 and Laboratory Benchtop meter 860033-model). Dissolved oxygen (DO) was measured using a Milwaukee dissolved oxygen meter (MW 600 Model). Biochemical Oxygen Demand (BOD) was determined by the 5-day BOD test (APHA, 2005). Chemical Oxygen Demand (COD) was determined using the Closed Reflux Method 5220C with a higher concentration of potassium dichromate solution. All parameter determined were method recommended by APHA 2340C (1995) standards.

2.8 Statistical Analysis

Data will be analyzed using a one-way ANOVA and Duncan's multiple range and results will be tested for statistically significant differences at the 0.05.
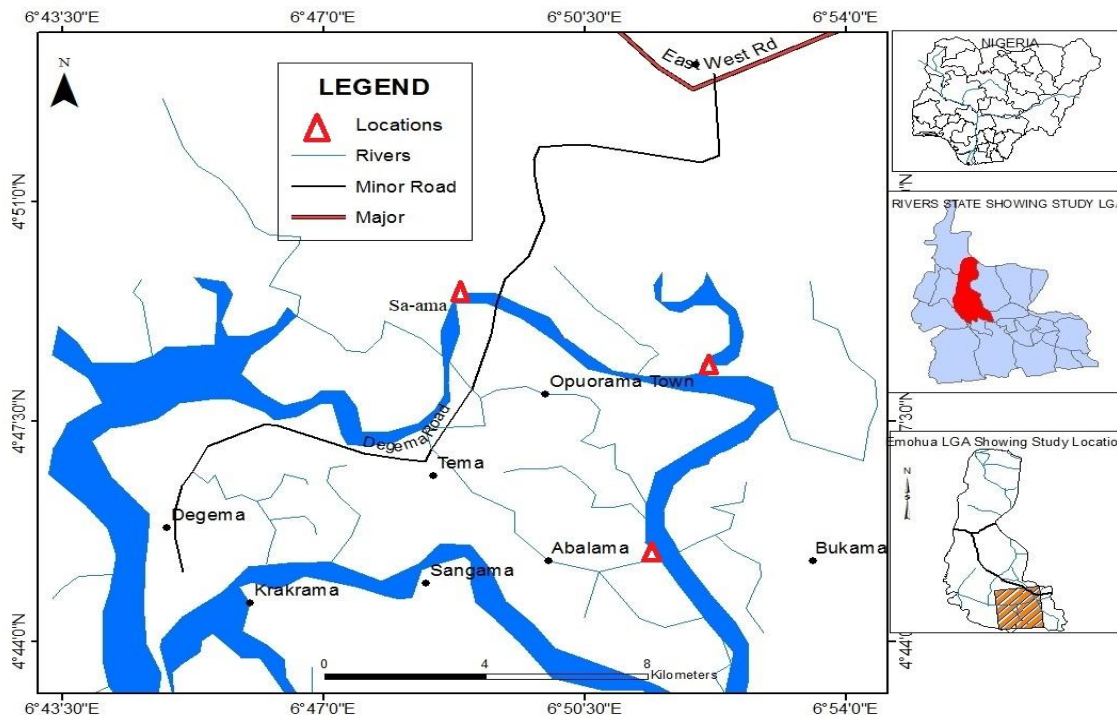

Fig. 1. Showing the Sampling Area

3. RESULTS AND DISCUSSION

Results of physico-chemical parameters presented in Table 1 while that of the heavy metals distribution, bioaccumulation factors and bioaccumulation patterns are represented in Table 2 to 7 and Figs. 2 to 6.

3.1 Physicochemical Parameter of the Interstitial Water

The physicochemical parameters of the interstitial water samples collected from the Opuro-ama creek during the study period are shown in Table 1. The mean pH concentration ranges from 6.40–6.80 with a mean value of 6.57±0.06. The overall water temperature observed at the period of study ranged from 29.70–30.0(^{o}C) with a mean value of 30.0±.057(^{o}C) while the conductivity was between 19.6–22.7 (μS/cm) with a mean value of 21.62±0.06(μS/cm) and TDS concentration ranged from 16.0–17.43(μS/cm) with a mean value 16.61±0.10(μS/cm). The Total Dissolved Solids (TSS) concentration ranged from 94.0–140.7(μS/cm) with a mean value of 111±0.58 Solids (μS/cm) while the mean values of BOD observed was between 0.53–0.87 (Mgl^{-1}) mean value of 0.68±0.033(Mgl^{-1}). The low DO values were between 3.0-3.2(Mgl^{-1}) with a mean value of 3.2±0.058(Mgl^{-1}) and the Salinity values observed was between 11.50 –11.70 (ppt) with a mean value of 11.69±0.09(ppt) during the study. The Chemical Oxygen Demand (COD) values range from 52.0–73(μS/cm) with a mean value of 64.6±0.88(μS/cm).

The mean temperature value measured was within the range of 27-30°C recommended [8]. This was also within the acceptable range by [9,10]. This was also similar to results reported by [11,12] in of Lagos Lagoon, Lagos, Nigeria. The overall mean pH measured was 6.57 within the range of 6.5 – 8.5 as being ideal for supporting aquatic life by [9,1013,14] reported similar results from Ogunpa River at Bodija. The reported in the study, which is within the acceptable limit for freshwater bodies, was similar to those reported by [1] along the Tin Can Island in Lagos, Nigeria. The mean DO measure in station one (3.2 mg/l) was below the recommended level of 6-7.5mg/L for the culture of freshwater organisms. This could be due to the high organic contents from anthropogenic activities peculiar to the study area. Similar value was reported by [15] in the interstitial water quality of soft-bottom flats at Bodo creek. the mean DO value was within the recommended

levels [12]. The BOD was also within the recommended values of ideal to supporting aquatic life by [9,13]. This result did not agree with the assertion by [16] who reported that the higher the concentration of BOD, the lower the concentration of DO. Total Dissolved Solids (μS/cm), Conductivity (μS/ cm^{-1}) and Salinity (ppt) were also within the permissible limit of [9,10,13]. Similar observations were reported in the adjoining creeks and lagoons in Lagos and its environments by [17,18]. Although Chemical Oxygen Demand (COD) and the Total Suspended Solids (TSS) were slightly higher than the recommended limit by [9,10]. The high COD values were indication of the presence of organic and inorganic pollutants, respectively. This could be attributed to the domestic sewage from various activities of human residing around the studied area, reception of effluents containing [19]. Similar result was reported by [20] in southeast coast of India.

3.2 Heavy Metals Composition

Tables 2 Shows the heavy metals concentration in some selected Shellfishes samples from Opuro-ama Creek. The level of Coper in the shellfishes was highest in *T. fuscatus* (0.43±0.02 mg/l) followed by *U. tangeri* (0.35±0.02 mg/l) and *C. amnicola* (0.34±0.01 mg/l) and the least was observed in *P. monodon* (0.02±0.02 mg/l). There was significant variation (p<0.05) across the different medium. Although, no significant difference p>0.05was observed between *U. tangeri and C. amnicola*; and between surface water (0.03±0.02 mg/l and Sediment (0.04±0.02 mg/l). *U. tangeri* (0.45±0.02 mg/l recorded the highest level of Zinc concentration while *P. monodon* (0.02±0.02 mg/l) recorded the least. There was significant difference p<0.05 between *P. monodon* and the other shellfishes, although no significant difference p>0.05 was observed between *U. tangeri, T. fuscatus and C. amnicola*. The highest values of Cobalt were recorded in *C. amnicola* (0.06±0.02mg/l), *T. fuscatus* (0.06±0.01mg/l) and sediment (0.06±0.01mg/l) respectively while the least value was recorded in the water (0.01±0.01 mg/l). *P. monodon,* Water and *U. tangeri* were significant difference p<0.05 from *C. amnicola, T. fuscatus*and sediment. The concentration of Ironin the shellfishes was highest in sediment (3.70±0.02 mg/l) followed by *U. tangeri* (3.5±0.02 mg/l) and the least was recorded in water (2.57±0.02 mg/l) and there was significant difference p<0.05 across the different medium. The highest concentration of Manganese was recorded in *U. tangeri*

(0.03±0.02mg/l) while the least were recorded in C*. amnicola, T. fuscatus, P. monodon,* sediment and water (0.02±0.01mg/l). There was no significant difference p>0.05was observed across the different media.

From the study, the heavy metals recorded varied from species to species. The species *T. fuscatus* and *T. coronata* were found to have higher values of Cu while the least was recorded in the interstitial water. This assertion agrees with the findings of [21]. who compared heavy metals in *Anadara granosa* and *periwinkle* in Malaysia. Similar result was reported by [4] attributed higher heavy metals in periwinkle to its shape and life history of some commercially important shell in Port-Harcourt. Mean values of Zinc recorded in this study were highest *U. tangeri* and least in the interstitial water. The values from all the shell fish species including the sediment and water were within the acceptable limits of [9 and 13]. The values from this study were lower when compared to the values obtained in some shell fishes from lagoon systems in the Southern Gulf of Mexico which were higher than the values of Zinc obtained in some shell fishes considered by [22]. The high concentration on cobalt which was observed C*. amnicola, T. fuscatus* and the sediment could be attributed to the water chemistry, duration of exposure to contaminants to the sediment leading to the increase in the concentrations of contaminants in their habitat, feeding habits or season of sampling [23]. High concentration on cobalt which was observed *C. amnicola, T. fuscatus* could be related to their specific and feeding habits and the bioconcentration capacity of each species [24]. Iron (Fe) levels observed in these shell fishes, sediment and water obtained in this work were all above acceptable limits of acceptable limits of for human consumption of 0.1 and 0.5µg/g as reported by [9,13]. The result was not in accordance with [25], who stated that the median iron concentration in rivers was reported to be 0.7 mg/litre. He also stated that in anaerobic groundwater where iron is in the form of iron (II), concentrations will usually be 0.5–10 mg/litre. Concentrations of iron in drinking-water are normally between 0.1-0.5mg/litre [9,13]. Although higher in countries where various iron salts are used as coagulating agents in water-treatment plants and where cast iron, steel, and galvanized iron pipes are used for water distribution [26]. The accumulations of metals were generally found to be different shell fish species were higher than the value recorded in the sediment and the interstitial water except for manganese was not significantly different across board. The concentration on manganese which was observed in *C. amnicola, T. fuscatus, T. fuscatus, P. monodon, sediment and the water* were within the acceptable limits of [9,13].

3.3 Concentration factors of Heavy Metals in Sediments and Water

The shell fishes have been reported to be good accumulators of organic and inorganic pollutants which are later transferred to other animals including man through the food web chain. The concentration factors of metals in shell fishes accumulation of metals was in the order of magnitude; *C. amnicola*: Zn>Cu> Fe>Co>Mn, *U. tangeri*: Zn>Cu>Co>Fe>Mn, *T. fuscatus*: Zn>Cu>Co>Mn>Fe, *P. monodon*: Co> Zn>Fe>Mn>Cu. Zn and Cu were better accumulated in *C. amnicola, U. tangeri* and *T. fuscatus.* However, some of the metals such as Fe and Co were better bioaccumulated in *P. monodon*.

Bioaccumulation of these metals was generally higher in *C. amnicola, U. tangeri* and *T. fuscatus* when water was the medium of evaluation with metals such as Zn and Cu. The magnitude of bioaccumulating in these shellfish may be higher in the organisms as a result of interaction of the fishes with higher metal concentrations in water which typifies their filter feeding habit. The order of magnitude of metal accumulation in these shellfishes from sediment was in the sequence; *C. amnicola*: Cu ≥ Zn ≥ Co = Mn ≥ Fe, *U. tangeri*: Cu ≥ Zn > Mn ≥ Fe ≥ Co, *T. fuscatus*: Cu ≥ Zn ≥ Co = Mn ≥ Fe, *P. monodon*: Fe ≥ Mn ≥ Co ≥ Cu ≥ Zn. The bioaccumulation patterns observed in the present study shows that even in similar media, different organisms may accumulate of different contaminants and there may be specific factors influencing the selective bioaccumulation of these metals in the organisms. However, according to [27], the rate of bioaccumulation of heavy metals in aquatic organisms depends on the ability of the organisms to digest different metals and the concentration of the metals in the river. The Bioaccumulation factor may have to do with the concentration of the heavy metal in the surrounding sediments as well as their feeding habits [28]. Other factors such as lipid content in the tissue of the fishes, age of fish and mode of feeding may be significant factors that affect the accumulation of these heavy metals in shellfishes.

Table 1. Physico-chemical quality of the interstitial water samples

Parameters	Min-Max	Mean -SE	WHO (2011)	DPR (2002)	EPA (2017)
Temperature (°C)	29.70 - 30	30.0±.057	24.8-30	22.32-25	27 – 30
pH	6.40 - 6.80	6.57±0.06	6.5-8.5	6.5-8.5	6.5 - 8.5
DO (Mgl^{-1})	3.0 -3.2	3.2±0.058	6	5	7.5
Salinity (ppt)	11.50 -11.70	11.69±0.09	120	600	-
BOD (Mgl^{-1})	0.53 - 0.87	0.68±0.033	10	10	5 – 7
Conductivity (µS/ cm^{-1})	19.6 - 22.7	21.62±0.06	400	-	200 - 1000
Total Dissolved Solids (µS/cm)	16.0 - 17.43	16.61±0.10	2000	2000	1000 - 2000
Total Suspended Solids (µS/cm)	94.0 - 140.7	111±0.58	500-1000	30	30
Chemical Oxygen Demand (µS/cm)	52.0 - 73	64.6±0.88	40	10	-

Note: *World Health Organization (WHO)
*Department of Petroleum Resources (DRP)
*Environmental Protection Agency (EPA)

Table 2. Heavy Metals composition in some selected shell fishes along the Opuro-ama in Creek

Heavy Metals (µg/g)	*C. amnicola*	*U. tangeri*	*T. fuscatus*	*P. monodon*	Sediment	Water	WHO (2011)	EPA (2017)
Cu	0.34±0.01[b]	0.35±0.02[b]	0.43±0.02[a]	0.02±0.02[c]	0.04±0.02[c]	0.03±0.02[c]	2.0	3.0
Zn	0.43±0.02 [a]	0.45±0.02 [a]	0.40±0.02[a]	0.04±0.02[c]	0.12±0.02[b]	0.01±0.02[c]	3.0	3.0
Co	0.06±0.02[a]	0.05±0.02[b]	0.06±0.02[a]	0.05±0.02[b]	0.06±0.02[a]	0.01±0.01[c]	-	-
Fe	2.77±0.02[cd]	3.20±0.02[b]	2.80±0.02[c]	3.10±0.02[b]	3.70±0.02[a]	2.57±0.02[d]	0.1	0.5
Mn	0.02±0.01[a]	0.02±0.02[a]	0.02±0.01[a]	0.02±0.01[a]	0.02±0.01[b]	0.02±0.01[a]	0.05	0.02

Note:* In each column, mean with a common letter are not significantly different (P>0.05).
*World Health Organization (WHO)
*Department of Petroleum Resources (DRP),
*Environmental Protection Agency (EPA)

Table 3. Patterns of heavy metals concentrations in the shellfishes, sediment and water

Medium	Metal accumulation pattern
U. tangeri	Fe>Zn>Cu>Co>Mn
T. fuscatus	Fe>Cu>Zn>Co>Mn
P. monodon	Fe>Co>Zn>Cu=Mn
C. amnicola	Fe>Zn>Cu>Co>Mn
Sediment	Fe>Zn> Co> Cu>Mn
Water	Fe>Cu>Mn>Co=Zn

Table 4. Concentration factors of metals in the shell fishes with reference to water

Medium	Cu	Zn	Co	Fe	Mn
C. amnicola/water	11.3	43.0	1.0	1.1	1.0
U. tangeri/water	11.6	45.0	5.0	1.25	1.0
T. fuscatus/water	14.3	40.0	6.0	1.08	1.1
P. monodon/water	0.7	4.0	5.0	1.21	1.0

NB: Concentration in (mg kg^{-1})

Table 5. Bioaccumulation patterns of heavy metals in the shell fishes with reference to water

Medium	Metal accumulation pattern
C. amnicola	Zn>Cu> Fe>Co=Mn
U. tangeri	Zn>Cu>Co> Fe>Mn
T. fuscatus	Zn>Cu>Co>Fe>Mn
P. monodon	Co>Zn> Fe>Cu=Mn

Table 6. Concentration factors of metals in the shell fishes with reference to sediment

Medium	Cu	Zn	Co	Fe	Mn
C. amnicola/ sediment	8.5	3.58	1.0	0.75	1.0
U. tangeri/ sediment	8.75	3.75	0.83	0.86	1.0
T. fuscatus/ sediment	10.75	3.3	1.0	0.75	1.0
P. monodon/ sediment	0.5	0.3	0.83	1.2	1.0

NB: Concentration in (mg kg^{-1})

Table 7. Bioaccumulation patterns of heavy metals in the shell fishes with reference to sediment

Medium	Metal accumulation pattern
C. amnicola	Cu>Zn>Co=Mn>Fe
U. tangeri	Cu>Zn>Mn>Fe>Co
T. fuscatus	Cu>Zn>Co = Mn>Fe
P. monodon	Fe>Mn > Co>Cu>Zn
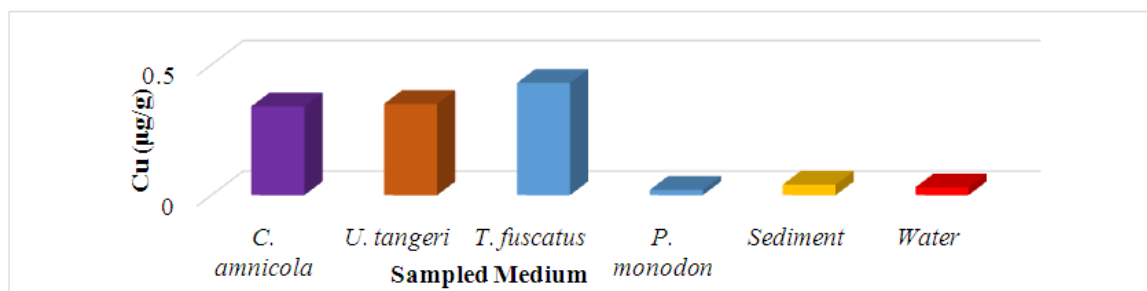
Fig. 2. Comparative values of Cu in Some Selected Shell Fishes from a fishing Port along the Opuro-ama in creek
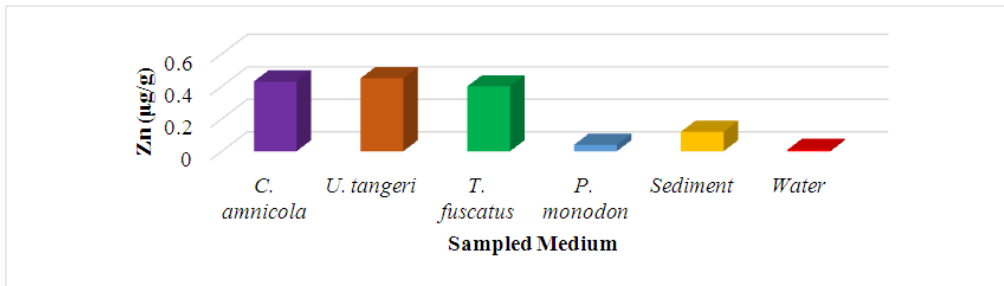
Fig. 3. Comparative values of Zn in Some Selected Shell Fishes from a fishing port along the Opuro-ama in Creek
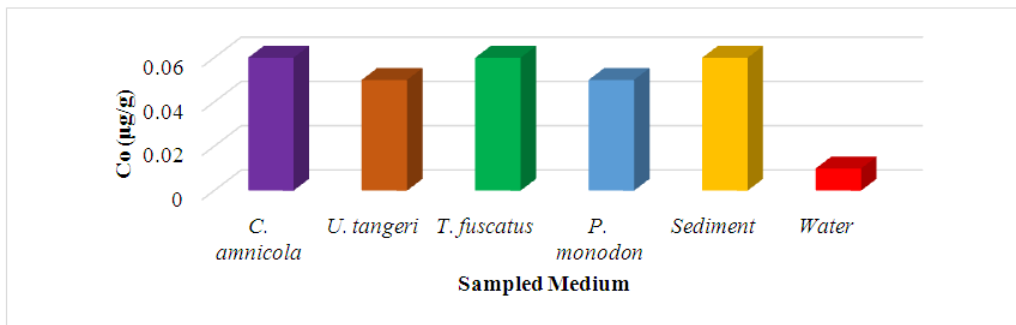

Fig. 4. Comparative values of Co in Some Selected Shell Fishes from a fishing Port along the Opuro-ama in Creek
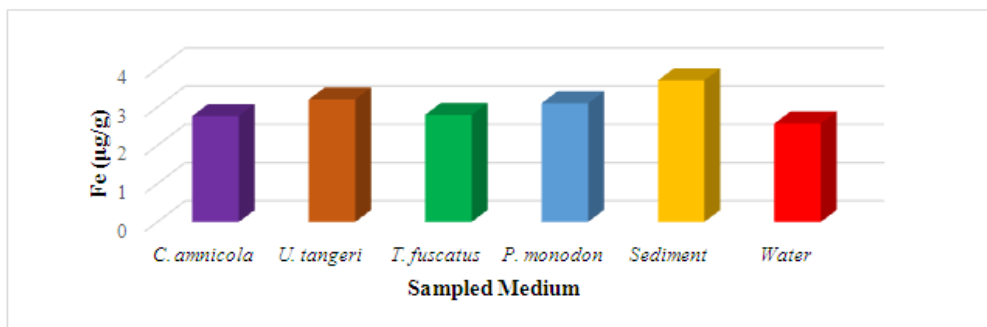

Fig. 5. Comparative values of Fe in Some Selected Shell Fishes from a fishing Port along the Opuro-ama in Creek
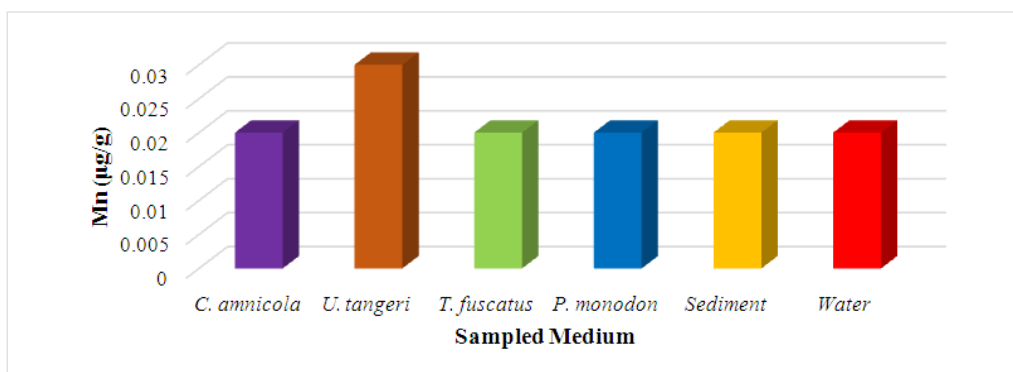

Fig. 6. Comparative values of Mn in Some Selected Shell Fishes from a fishing port along the Opuro-ama in Creek

Similar studies have reported similar bioaccumulation patterns of metals in different organisms in the Bonny/New Calabar River Estuary [27,29,28] and elsewhere in the Niger Delta [1]. Heavy metals have multiple effects in aquatic ecosystems depending on the oxidation state, formation of complexes and biotransformation of elemental species. Health effects of heavy metals such as Fe, Mn, Co, Cuand Znin humans have been demonstrated in acute toxicity, neurotoxicity and nephrotoxicity [7]. The concentration factors result of heavy metals revealed in this study shows that there was bioaccumulation in the different media but at a low rate [30]. Bioaccumulation Factor value of Zn and Cu were better accumulated in *C. amnicola*, *U. tangeri* and *T. fuscatus*. However, some of the metals such as Fe and Co were better bioaccumulated in *P. monodon*. The study indicated that sediment accumulated more heavy metals than water. This is in line with results reported works by [31]. They stated that in most cases, sediment is reported to be the main sink of metals, with more than 99% of the total amount of metals present in the aquatic body (Eja *et al.*, (2003). This value was not in line with reported by [32] in *Tympanotonus fuscatus var radula* obtained from the upper reaches of the Bonny estuary.

The concentration factors in some were of the shellfish species were<1 for all the studied heavy metal. Likewise, heavy metal bioaccumulation from water (BAF) showed <1 for all except Zn (8.09 to 11.71 mg kg⁻) and as (2.00 mg kg⁻). This study observed that these trace metals were accumulated in the tissue of the fish more than they are actually present in the water. This singular potential should qualify the mudskipper to be categorized in the league of some well-known bioindicator species like the bivalves, crabs and shrimps identified as standard bioindicators of aquatic pollution owing to their capability to bioaccumulate and bioconcentrate organic pollutants in tissues in addition to target organs at levels higher than background concentrations [33]. Although tissue may not to be an active site for bio-accumulation, the findings in this study may imply that at chronic exposures in minute concentrations, fish tissues could concentrate heavy metals that exceed the permissible limits for human consumption with severe health implications. Zn concentration was below [34] permissible limit of 40 mg kg⁻in the muscle. The tissue of fish is the edible part, and the concentrations of the heavy metal in it are of health concern. The selective accumulation of some metals as observed in this study implies that the affinity for the accumulation of heavy metal in tissues varies from fish to fish and may be metal-specific. Research on temporary variation in *Periophthalmus papillion* obtained from Azuabe Creek in the upper Bonny Estuary observed heavy metal concentrations in the flesh of mudskippers to levels above [34] permissible limits and concluded that mudskippers have the ability to bioaccumulate and bio-magnify metal pollutants without physical stress. These make them potentially dangerous to the consumers, and by extension, all other tolerant commercial species fished from these water bodies.

Some reported effect of these metals (Fe, Zn, Cu, Co, Mn) in aquatic environments include tissue damage, genotoxicity and growth reduction. Mollusks and crustaceans are more sensitive than other organisms [35]. Although the results of surface water concentrations of heavy metals observed in the present study agrees with the general opinion of low-level heavy metal concentrations in surface water in the study area and Niger Delta [36] metals such as Fe was higher than stipulated limits by [9,13] and require continuous monitoring to detect uncertain increases as a result of anthropogenic activities and avert possible health implications of these metals on consumers of the seafood from the water body in this study area.

4. CONCLUSION

The results showed that the concentration of the metals in the tissues of all the shell fishes, the interstitial water and the sediment sampled from the creek were within the permissible limit recommended Environmental Protection Agency (EPA) and World Health Organization (WHO). Except for Fe which was above the recommended limit. There was an overall statistical difference ($p<0.05$) in metals concentration in the soft tissues in all the shellfish. The physicochemical parameters of the interstitial water were also within the acceptable levels in the guidelines for drinking water by Department of Petroleum Resources (DRP), Environmental Protection Agency (EPA) and World Health Organization (WHO).

5. RECOMMENDATION

There is need for regular monitoring of the metallic level in this creek to avoid future deterioration should therefore be periodically

checked to avoid increase in the potential for bioaccumulation of these metals in the shellfishes and the creek water as well.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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