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Heavy Metal Bioaccumulation in Periwinkle (*Tympanotonus fuscatus*) and Tilapia Fish (*Oreochromis niloticus*) Samples Harvested from a Perturbed Tropical Creek in the Niger Delta, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author NOA designed the study and performed the statistical analysis. Author IEA wrote the protocol and the first draft of the manuscript. Author EPA managed the analyses and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Different scientific studies with useful contributions in biomonitoring different environmental parameters and knowledge of their influences on aquatic ecosystem health and ultimately that of man have evolved through the years, however with scanty toxicological evidences. The present study was designed to investigate the concentrations of heavy metals in edible food of periwinkle and fish harvested from a perturbed creek in Niger Delta, Nigeria reported to constantly receive industrial effluent from two major oil and gas companies. Zn, Fe, Pb, Cu, Cr, Cd and Mn were assessed for 6 months from July – November, 2018. Higher concentrations of heavy metals were obtained with fish bio-accumulating more metals than periwinkle. The bio-availability sequence of metals in periwinkle was Fe>Cu>Mn>Cd>Zn>Cr>Pb and fish Fe>Cu> Zn>Mn>Cd>Cr>Pb. Mean values of Cd, Cr, Cu, Fe and Zn in some months in periwinkle and fish were above WHO/FEPA regulatory limits while Pb and Mn were lower. The study has provided some useful information on

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metal accumulation in the icthyofauna of the creek and call for more toxicological study and biomonitoring of anthropogenic sources on the creek. Results showed the dominance of Cd, Cr, Cu and Fe over other metals in both animals in all months. Cu level was relatively stable throughout the study. Fish bio-accumulated more metals than periwinkle with report of higher concentrations.

Keywords: Bio-monitoring; bioaccumulation; metal; concentration.

1. INTRODUCTION

Heavy metals enter the aquatic ecosystems from a variety of sources that include the rocks and soils directly exposed to surface water, in addition to the discharge of various treated and untreated liquid wastes to the water bodies [1,2]. They are generally defined as metals with relatively high densities, atomic weights, or atomic numbers. They are substances with high electrical conductivity, malleability, and luster, which voluntarily lose their electrons to form cations [3,4]. They possess specific density of more than $5g/cm^3$ and are important group of chemical pollutants of foof food enroute humans [5]. The pollution of the aquatic environment with heavy metals has become a worldwide problem and of scientific concern since metals are not degradable and most posing toxic effects on organisms [6]. Censi et al. 2006; [7,8]. Examples include Cadmium (Cd), Chromium (Cr), Lead (Pb) Manganese (Mn), Mercury (Hg), Nickel (Ni), Thallium (Ti) and Zinc (Zn), Cobalt (Co) etc., that have a particular significance in ecotoxicology, since they are highly persistent [9]. Toxicity is realized when these heavy metal levels are higher than the recommended limits. Other sources of the metals include variety of anthropogenic activities which are affected by seasons [10,8].

It is difficult to remove them completely from the environment once they enter into it [1,11]. These metals in the form of inorganic compounds from natural and anthropogenic sources continuously persist in the aquatic ecosystem where they could pose serious threat to the food chain. They are dangerous to humans because they tend to bio-accumulate in vital organs [12]. Trace elements such as copper, iron and zinc are essential to maintain the metabolism in man while cadmium, chromium, mercury, and lead pose a number of health hazards. Humans are exposed to these metals by ingestion (drinking or eating) or inhalation [13]. High concentration intake of cadmium causes itai ita disease. Chromium compounds are toxins and are known human carcinogens. Lead severely damages the brain and kidneys and ultimately causes death. In pregnant women, high levels of exposure to lead may cause miscarriage. High level exposure can damage the organs responsible for sperm production [14]. Mercury permanently damages the brain, kidneys and developing fetuses, it also causes minamita disease [15,11]. 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 (World Health Organization, 2005; American Public Health Association, 1995). Uta-ewa creek in the Niger Delta region harbors rich collection of biotopes dominated by vast areas of mangrove swamp forest [16]. 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 [17,8] 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 [18].

Tympanotonus fuscatus, commonly known as periwinkle, is a brackish gastropod belonging to the family Potamididae. It is small and is characterized by turreted granular and spiny shell with a tapering end. This organism is endemic in Nigeria and West Africa. As part of the fauna of the mangrove community, it occurs mainly in the tidal mudflats of estuarine ecosystems. The genus Tympanotonus comprises of a single species, which has two varieties -*Tympanotonus fuscatus* var *fuscatus* and *Tympanotonus fuscatus* var *radula*. The potential of this organism as a food source is well documented, together with its medicinal and nutrient capabilities; its bioremediation and accumulation abilities; and the usage of its shell in construction of roads and buildings. Despite the numerous benefits derived from *Tympanotonus fuscatus*, its sustainability is threatened by human activities as a result of urbanization. Humans in quest for development have over time, reduced the habitat of this organism through land reclamation for housing, crop farming and industries. For the marine monitoring studies of sedentary organisms, widely distributed geographical species capable of accumulating metals, so as to reflect the environmental conditions are employed. *Tympanotonous fuscatus* fulfill all the requirements and can therefore act appropriately as a biological indicator of pollution (Fernandes et al. 1997). Its suitability is universally recognized, being included in most of the national environmental monitoring programs of marine and brackish water pollution (Widows et al. 1995). These organisms accumulate most of the contaminants at much higher levels than those found in the water column and they are representative of the pollution of an area, hence can be used to monitor the quality of coastal waters. The gastropods have long been regarded as promising bio-indicators and bio-monitoring subjects. They are abundant in many brackish aquatic ecosystems as in the Niger Delta, being easily available for collection. They are highly tolerant to many pollutants and exhibits high accumulation of them, particularly heavy metals.

Tilapia is the common name for nearly a hundred species of cichlid fish from the tilapiine cichlid tribe. Tilapia are mainly freshwater fish inhabiting shallow streams, ponds, rivers and lakes and less commonly found living in brackish water. Historically, they have been of major importance in artisanal fishing in Africa, and they are of increasing importance in aquaculture and aquaponics. Tilapia serves as a natural, biological control for most aquatic plant problems. Tilapia consumes floating aquatic plants, such as duckweed water meal (*Lemna* sp.), most "undesirable" submerged plants, and most forms of algae [19]. In the United States and countries such as Thailand, they are becoming the plant control method of choice, reducing or eliminating the use of toxic chemicals and heavy metal-based algaecides. Tilapia rarely competes with other "pond" fish for food. Instead, because they consume plants and nutrients unused by other fish species and substantially reduce oxygen-depleting detritus; adding tilapia often increases the population, size and health of other fish. They are used as a source of food for birds. Tilapia can be farmed together with shrimp in a symbiotic manner positively enhancing the productive output of both Arizona stocks tilapia in the canals that serve as the drinking water sources for the cities of Phoenix, Mesa and others. The fish help purify the water by consuming vegetation and detritus, greatly reducing purification costs. Arkansas stocks many public ponds and lakes to help with vegetation control, favoring tilapia as a robust forage species and for anglers. tilapia helps control mosquitoes which carry malaria parasites. They consume mosquito larvae, which reduces the numbers of adult females, the disease's vector (Petr, 2000). Tilapia skin is being used in a new clinical trial to treat burn injuries Tilapia also provides an abundant food source for aquatic predators. Tilapia are important food fish for Nigeria as the constitute high percentage of the total landing on the Nigerian coast (NDES,1999).These important food source constitute a major part of the diet in the Niger Delta region of Nigeria. Studies on the pollution status of some fauna in some parts of Nigeria and around Niger Delta area have been reported [20] Olowoyo, 1998). It is therefore necessary to determine the concentration of Cd, Cr, Cu, Fe, Pb, Mn and Zn in periwinkle (*T. fuscatus*) and tilapia (*O. niloticus*) harvested from Uta-ewa creek.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Uta Ewa Creek is a tributary of Imo River that received effluent from Aluminum Smelter Company (ALSCON) in Ikot Abasi, Akwa Ibom State that is located a distance of 4 miles from the creek. Ikot Abasi is located between longitude 7° and 30'E and 7° and 45'E latitudes 4° and 30' W, 4° and 45'N. Ikot Abasi is one of the Local Government Area of Akwa Ibom State located in a coastal area of Niger delta region of Nigeria. It has a climate that can be differentiated into two seasons; the wet (raining) season begins in April and ends October, having an average annual rainfall varying between 2000mm to 3500 mm and dry season which begins in November and ends in March. The occupation of the people are fishing and farming and the area is semi- rural community in which the inhabitants depend on rain and surface water as the only source of drinking and for domestic purposes. The major source of protein in the area is sea foods (fish, crabs, crayfish, clams and periwinkle). The effluent from Aluminum Smelter Plant and domestic waste water from Housing Estates (Ferrostal camp, Sweato camp, Worker's camp, Berger's Camp and ALSCON Camp) in Ikot Abasi are discharged into this creek [21,8].

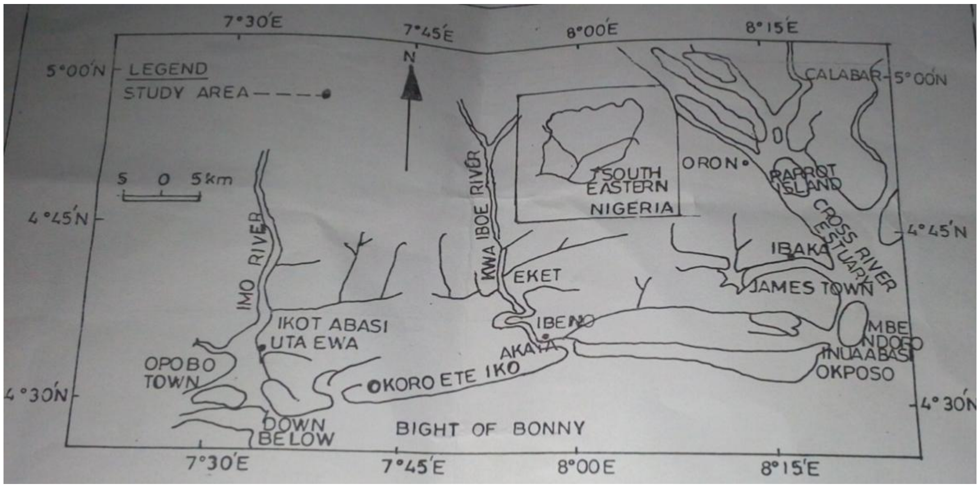

Fig. 1. Map of Uta-ewa River and the tributary

2.2 Sample Collection (Fish)

Samples of tilapia (*Oreochromis niloticus*) used for the analysis were bought from fishermen fishing in Uta-ewa creek. 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 (-10°C) prior to laboratory analysis. Sampling was carried out between July and November.

2.3 Samples Preparation

The samples were removed from the freezer allowed to thaw, the total length (TL) and the aperture length (AL) were measured using measuring board. The total weight of the fish (TW) was measured by weighing with an electronic meter balance. The flesh of the fish was taken using a stainless steel surgical knife, the fish tissue was placed in a foil paper which was then oven dried for 48hrs at 80°C, after being dried for the stated hours it was ground to a powder form using ceramic mortar and pestle and 2mm mesh size was used to obtain a uniform particle size and preserved in a well labeled plastic bottle indicating each month and was kept prior to digestion.

2.4 Sample Collection (periwinkle)

Samples of periwinkle *(Tympanotonus fuscatus*) used for the analysis were bought from the fisher who collected from where the fish were caught from Uta-ewa creek. 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 (-10°C) prior to laboratory analysis. Sampling was carried out between July and November.

2.5 Sample Preparation

The total length (TL) and the aperture length (AL) were measured to the nearest 0.0 cm using measuring board. The total weight of the periwinkle (TW) was measured by weighing with an electronic metler balance. The soft part of the periwinkle was obtained by cracking the shell. The weight of the soft tissue of periwinkle was obtained by weighing with an electronic meter balance and then placed on a foil paper and oven dried at 80°c for 24 hours to obtain a dry tissue. The dried tissue was ground to a powder form with ceramic mortar and pestle, sieved to obtain a uniform particle size using 2 mm mesh size and preserved in a well labeled plastic bottle indicating each month.

2.6 Digestion Procedure

Dry tissue samples of periwinkle and fish respectively weighing 0.5 g were digested with 0.5 ml of concentrated nitric acid (HNO3) the digestion was carried out in a fume cupboard and water bath were switch on to stabilized and attained 100°C using water bath digestion. The completely digested samples were filtered using what-man filter paper and diluted to 100 ml in standard volumetric flask with distilled water. It was analyzed in Atomic Absorption Spectrophotometer (AAS) as described by [22].

2.7 Metal Determination and AAS Condition

The resulting solutions were analyzed for metals using 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 analyzed.

2.8 Statistical Analysis

Data collected were subjected to one-way analysis of variance (ANOVA), and student's t-test was used to assess whether samples varied significantly, possibilities less than 0.05 ($p<0.05$) were considered statistically significant.

3. RESULTS

The mean monthly heavy metal concentration in periwinkle (mg/kg) is shown in Table 1, monthly variations in heavy metals concentration (mg/kg) in periwinkle is shown in Table 2, Total concentration, mean ± standard deviation, and range of heavy metals (mg/kg), in periwinkle is shown in Table 3 and monthly total concentration of heavy metals determined (mg/kg), mean ± standard deviation and range in periwinkle is shown in Table 4. The mean monthly heavy metal concentration in fish (mg/kg) is shown in Table 5, monthly variations in heavy metals concentration (mg/kg) is shown in Table 6, Total concentration, mean ± standard deviation, and range of heavy metals (mg/kg), is shown in Table 7 and monthly total concentration of heavy metals determined (mg/kg), mean ± standard deviation and range is shown in Table 8. The concentration of cadmium ranged from 0.59 to 0.935 mg/kg (mean = 0.68±0.1316 mg/kg) while in fish it ranged between 1.708 and 1.963 mg/kg (mean = 1.82 ± 0.099 mg/kg). There was significant difference in mean concentration of Cadmium in favor of fish ($t = 11.384$, $df = 4$, $p < 0.05$). In periwinkle, the concentration of chromium ranged from 0.312 to 0.821 mg/kg (mean = 0.60±0.257 mg/kg), while in fish it ranged between 0.003 and 0.016mg/kg (mean = 0.0 ± 0.005 mg/kg) ($t = -5.15$, $df = 4$, $P <.077$). There was significant difference in favour of periwinkle.

Copper ranged from 2.016 to 2.367 mg/kg (mean =2.27±0.143 mg/kg) in periwinkle, while in fishes it ranged between 1.829 and 2.558 mg/kg (mean = 2.27±0.354 mg/kg). There was no significant difference in mean concentration between periwinkle and fish ($t = -037$, $df = 4$, $p>.972$). Mean concentration of iron ranged from 1.830 to 3.016mg/kg (mean = 2.36 ± 0.514 mg/kg) in periwinkle, while in fish it ranged between 2.104 and 2.601mg/kg (mean = 2.38±0.189 mg/kg) with no significant difference between the two organisms ($t =0.68$, $df =4$, $p>.949$). In periwinkle, the mean concentration of Pb range from 0.021 to 0.218mg/kg (mean =0.13±0.94 mg/kg) while in fish it range between 0.004 and 0.067 mg/kg (mean =0.04±0.024 mg/kg) ($t = -2.363$, $df = 4$, $P>.077$). There was no significant difference between periwinkle and fishes. Mean concentrations of Manganese range in periwinkle from 1.032 to 0.218 mg/kg (mean = 0.13±0.073 mg/kg) while in fish it range between 1.987 and 2.485 mg/kg (mean = 2.21 ± 0.188 mg/kg) ($t= 10.318$, $df= 4$, $P< .000$) with no significant difference between fish and periwinkle. In periwinkle, the mean concentration of Zinc ranged from 1.083 to 2.292mg/kg (mean = 1.70 ± 0.501 mg/kg) while in fish it range between 1.019 and 2.986 mg/kg (mean = 1.69 ± 0.811 mg/kg). There was no significant difference between periwinkle and fish. The level sequence of mean heavy metal concentration in fish in decreasing order was Fe>Cu>Zn>Mn>Cd>Cr>Pb while in periwinkle it was Fe>Cu>Mn>Cd>Zn>Cr>Pb.

4. DISCUSSION

Findings from this study corroborate other existing literatures on similar investigation, though with very scanty evidences. The mean concentration of cadmium in periwinkle and fish were 0.68±0.1316 mg/kg and 1.82 ± 0.099 mg/kg respectively. These mean values were lower than that recorded by [8]. On heavy metal concentrations in shell and fin fish from Iko river estuary, Southeastern Nigeria, the values were

Table 1. Monthly mean heavy metal concentration in periwinkle (mg/kg)

Months	Sum	Mean	SD	Min	Max
July	7.866	1.123714	0.817936	0.021	2.326
August	8.884	1.269143	0.762886	0.218	2.367
September	8.102	1.157429	0.737724	0.046	2.096
October	9.962	1.423143	1.117883	0.206	3.016
November	9.686	1.383714	1.007064	0.183	2.804

Table 2. Monthly variations in heavy metals concentration (mg/kg) in periwinkle

	Cd	Cr	Cu	Fe	Pb	Mn	Zn
July	0.592	0.735	2.326	2.077	0.021	1.032	1.083
August	0.709	0.803	2.367	1.830	0.218	1.126	1.831
September	0.628	0.821	2.016	2.096	0.046	1.213	1.282
October	0.620	0.312	2.315	3.016	0.206	1.201	2.292
November	0.935	0.331	2.324	2.804	0.183	1.122	1.987

Table 3. Total Concentration, Mean ± Standard Deviation, And Range of Heavy Metals (Mg/Kg), in Periwinkle

Metals		Cd	Cr	Cu	Fe	Pb	Mn	Zn
Sum		3.48	3.00	11.35	11.82	0.67	5.69	8.48
Mean ± standard deviation		0.68± 0.1316	0.60± 0.257	2.27± 0.143	2.36± 0.514	0.13± 0.094	1.14± 0.073	1.70± 0.501
Range	Min	0.592	0.312	2.016	1.830	0.021	1.032	1.083
	Max	0.935	0.821	2.367	3.016	0.218	1.213	2.292

Table 4. Monthly total concentration of heavy metals determined (mg/kg), mean ± standard deviation and range in periwinkle

Months	Total Conc.	Mean ± Std.	Range	
			Min	Max
July	7.866	1.12 ± 0.818	0.021	2.326
August	8.884	1.27 ± 0.673	0.218	2.367
September	8.102	1.16 ± 0.738	0.046	2.096
October	9.962	1.42 ± 1.118	0.206	3.016
November	9.686	1.38 ± 1.007	0.183	2.804

Table 5. Monthly mean heavy metal concentration in fish (mg/kg)

	Sum	Mean	SD	Min	Max
July	10.668	1.524	1.119472	0.003	2.601
August	9.398	1.343	0.969741	0.005	2.302
September	8.922	1.275	0.934568	0.004	2.104
October	11.766	1.681	1.183967	0.006	2.986
November	11.302	1.615	1.121100	0.012	2.578

Table 6. Monthly variations in heavy metals concentration (mg/kg) in fish

	Cd	Cr	Cu	Fe	Pb	Mn	Zn
July	1.863	0.003	2.588	2.601	0.053	2.282	1.278
August	1.775	0.005	1.988	2.302	0.032	2.109	1.187
September	1.963	0.016	1.829	2.104	0.004	1.987	1.019
October	1.769	0.006	2.342	2.404	0.051	2.208	2.986
November	1.708	0.012	2.578	2.487	0.067	2.485	1.965

Table 7. Total Concentration, Mean ± Standard Deviation, And Range of Heavy Metals (mg/kg) in fish

Metals		Cd	Cr	Cu	Fe	Pb	Mn	Zn
Sum		9.08	0.04	11.33	11.90	0.21	11.07	8.44
Mean ± standard deviation		1.82± 0.099	0.01± 0.005	2.27± 0.345	2.38± 0.189	0.04± 0.024	2.21± 0.188	1.69± 0.811
Range	Minimum	1.708	0.003	1.829	2.104	0.004	1.987	1.019
	Maximum	1.963	0.016	2.588	2.601	0.067	2.485	2.986

Table 8. Monthly total concentration of heavy metals determined (mg/kg), mean ± standard deviation and range in fish

Months	Total Conc.	Mean ± Std.	Range	
			Min	Max
July	10.668	1.52 ± 1.119	0.003	2.601
August	9.398	1.34 ± 0.970	0.005	2.302
September	8.922	1.28 ± 0.935	0.004	2.104
October	11.766	1.68 ± 1.184	0.006	2.986
November	11.302	1.62 ± 1.121	0.012	2.578

higher than that recorded by [23] who studied heavy metals in surface water, sediment, fish and periwinkle of Lagos lagoon. The higher concentration of cadmium in fish than periwinkle from Uta-ewa creek may be attributed to higher trophic level of fish ingest many food resources hence bioaccumulating more heavy metals from effluents from Aluminium Smelter Company discharged into the creek [21]. From this study, the mean value of Cd concentration recorded in periwinkle and fish respectively were higher when compared to WHO and FEPA recommended limit of 0.5mg/kg for fish food [28,14]. Cadmium is a by-product of lead and zinc and is used in nickel-cadmium batteries, thus ingestion of cadmium can cause vomiting, abdominal cramps and headache. Consumption of aquatic resources which is concentrated with cadmium from Uta-Ewa can cause serious health hazards.

The mean concentration of chromium in periwinkle and fish respectively were 0.60±0.257 mg/kg and 0.01± 0.005 mg/kg. These were higher than that obtained by Aderinola et al. (2009) who studied heavy metals in surface water, sediment, fish and periwinkle in Lagos lagoon although lower than that recorded by [4] on heavy metal concentration in shell and fin fish from Iko river estuary Southestern Nigeria. The higher mean concentration of Cr in periwinkle than fish from Uta-ewa creek could be attributed to the bottom dwelling and feeding habit of periwinkle than fish that swim in water and seldomly get to the bottom sediment. This was higher than the maximum permissible limit of FEPA and WHO which is 0.003 mg/kg for periwinkle [28,14]. Chromium compound are found in the environment due to erosion of Cr containing rocks. The high Cr concentration may be owing to waste water discharged from agricultural related activities, domestic waste from various housing estate and ALSCON effluent discharged into the creek. Cr is used for wood preservation and is very toxic when inhaled. It can cause asthma. Therefore high concentration of chromium in periwinkle from Uta-Ewa River if consumed may cause serious health hazards. The mean concentration of copper in periwinkle and fish were 2.27±0.143 mg/kg and 2.27±0.354 mg/kg respectively. This record was higher than that obtained by [24] who studied heavy metal in fish organs in North central Nigeria, but lower than that recorded by [8]. The concentration of copper in fishes and periwinkle in Uta-Ewa creek could be attributed to domestic and anthropogenic activities such as oil exploration and refining which can introduce this metal into the water body and eventually sediment from where fauna feed. Mean concentration of copper in periwinkle and fish recorded from Uta-Ewa creek were similar and it was higher than the permissible limit of FEPA and WHO which is 2.0 mg/kg for fish and lower in periwinkle (3.00 mg/kg) (WHO, 1985); [14]. Copper is one of the metals that are essential to human health. Cu combines with certain protein to produce enzymes that act as catalyst to make the body function and it is also necessary for the synthesis of hemoglobin. However, consumption of fishes which is copper concentrated from uta-ewa Creek could pose health hazards.

The mean concentration of iron in periwinkle and fish were 2.36±0.514 mg/kg and 2.38±0.189 mg/kg respectively. This was lower than that of [23] on heavy metal concentration in surface water, sediment, fish and periwinkle from Lagos Lagoon and [25] who studied seasonal variation of heavy metals in selected seafoods from Buguma and Ekerekana creeks Niger Delta. The concentration of iron in periwinkle and fishes from uta-ewa creek could be attributed to fact that this metal is naturally abundant in Nigerian soils where they are leached into the water bodies eventually sediment where the fauna feed [15]. The mean concentrations recorded were higher than the recommended standard limit of 0.5mg/kg for periwinkle and fish (WHO, 1985); [14]. Iron is a necessary element in human diet and it plays significant role in metabolic processes. Thus, iron is an essential heavy metal; however, it has the tendency to become toxic when aquatic organisms from Uta-ewa creek are excessively consumed. The mean concentration of Pb was 0.13 ± 0.94 mg/kg and 0.04±0.024 mg/kg in periwinkle and fish respectively. The United States Environmental Protection Agency has classified lead as being potentially hazardous and toxic to most forms of life [27]. Lead are toxic and they have no significant biological functions they show their carcinogenic effects on aquatic biota and humans even at low exposures. It causes reproductive and development effects This metal has been found to be responsible for quite a number of ailments such as chronic neurological disorders especially in foetuses and children (WHO, 2003). From the results, the concentration of Pb in the samples were lower than the maximum permissible limits by [28,14] therefore Pb may not pose serious health consequence to consumers of these aquatic resources at short term of exposure but could be in the long run, especially as it does not have any metabolic function [26].

The mean concentration of manganese in periwinkle and fish were 0.13 ± 0.073 mg/kg and 2.21 ± 0.188 mg/kg respectively. This was lower than that recorded by Eneji et al. (2011) who studied bioaccumulation of heavy metal in fish organ in north central Nigeria and Olowoyo (2011) and the report was higher in fish than the standard limit of 0.4 mg/kg recommended for fishes but lower in periwinkle with 0.5 mg/kg recommended by FEPA and WHO (WHO, 1985); [14]. The concentration of Mn in Uta-ewa river was attributed to physiological properties that maximizes absorption efficiency from the water. Mn is an essential micronutrient for plant and animals and it is associated with iron deposits, it does not occur naturally as metal in aquatic ecosystem. Manganese results in severe skeletal and reproductive abnormalities in mammals. However, ingestion of fishes from Uta-ewa Creek that is concentrated with manganese may pose serious health hazards. The mean concentrations of Zinc were 1.70 ± 0.501 mg/kg and 1.69 ± 0.811 mg/kg in periwinkle and fish respectively. This record was higher than that of Aderinola et al. (2009) who studied heavy metal in surface water, sediment, fish and periwinkle from Lagos Lagoon but lower than [24] on bio-accumulation of heavy metal in fish organ north central Nigeria. This report was higher than the standard limit of 0.10 mg/kg for periwinkle but lower in fish when compared to 30 mg/kg WHO and FEPA standards (WHO, 1985); [14]. The concentration of zinc in periwinkle and fish from Uta-ewa river was attributed to land use activities such as agricultural system and effluent from residential and ALSCON area. Zinc is an essential trace metal for both plant and animals it is necessary for embryo development and is important to reproductive development. It deficiency may cause retarded growth, therefore, high intake of periwinkle which are Zn concentrated from Uta-ewa river can pose serious health hazards.

5. CONCLUSION

Rising level in anthropogenic perturbations of the aquatic ecosystems has remained a major source of keen concern. Input of heavy metals in such systems has significantly increased due to unregulated activities, majorly from the oil and gas sector and other related activities in use of the aquatic systems for transport activities etc and these have placed a lot of fish and shell fishes and consequently inhabitants of the region at high risk. The present study recommends regular biomonitoring of the creek to check source pollution and encourage government/institutional funding for in-depth research, especially on their oxidative stress responses, metallothioneins, oxygen affinity and thus, toxicological effects. This knowledge may be useful for future assessment of aquatic environment and regulating edible food sources to the markets. The present study has also insightfully highlighted some background level information about edible food in the study river, especially with lacuna of literature. The worrisome levels of some of the metals studied necessitate a call for more investigation and regulation of their anthropogenic sources especially.

ETHICAL APPROVAL

As per international standard written ethical permission has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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