International Journal of Fisheries and Aquatic Research
www.fishjournals.com
ISSN: 2456-7248, Impact Factor: RJIF 5.44
Received: 01-03-2021, Accepted: 02-04-2021, Published: 07-05-2021
Volume 6, Issue 2, 2021, Page No. 15-23

Heavy metal bioaccumulation in periwinkle (*Tympanotonus fuscatus*) and sediments from Jaja creek, Southeastern Nigeria

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Abstract
The accumulation of seven heavy metals; cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (pb), manganese (Mn) and zinc (Zn) in periwinkle (*Tympanotonus fuscatus var radula*; shell and soft tissues) and sediments collected from monthly samples along Jaja creek course was studied. Jaja creek receives effluents discharges from heavily industrialized and highly populated settlements. The sediments and periwinkles were processed and analyzed for heavy metals and the results showed that the sediments concentrated more heavy metals than the periwinkles, while the periwinkles accumulated more of these metals than the sediments. Cr was the highest concentrated heavy metals in both the normal and depurated periwinkles. The biological concentration factor (BCF) revealed that periwinkles have high potential to concentrate heavy metals in their shells and soft tissues, which is directly proportional to their sizes. However, the observed heavy metals concentrations in these aquatic organisms are below the recommended limits for human consumption. Therefore, this study advocates for environmental surveillance of the Jaja creek in order to achieve optimum sediment quality as well as contaminant-free periwinkles to safe guard human health and vitality.

Keywords: bioaccumulation, heavy metals, sediment, periwinkle, tissue, Jaja creek

Introduction

Heavy metals are produced from a variety of natural and anthropogenic sources; they are intrinsic natural constituents of our environment. 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 (Khlifi and Hamzachaffai, 2010). They possess specific density of more than 5 g/cm^3 and are important group of chemical pollutants of air, water and food enroute humans (World Health Organization, 2000). Examples of heavy metals are Arsenic (As), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Lead (Pb) Manganese (Mn), Mercury (Hg), nickel (Ni), Thallium (Ti) and zinc (Zn) (AOAC, 1990; ATSDR, 2005). In fluvial environment, however, metal pollution can result from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal or industrial waste products (Dawson and Macklin, 1998; Edward *et al*., 2013). Apart from the natural sources, several anthropogenic sources also contribute to metal concentration in the environment (Ewa-Oboho, 1994). In recent times, industrial and mechanical activities have raised natural concentrations causing serious environmental problems (APHA, 2003).

Aquatic environment is one of the receiving ends for pollutants, particularly heavy metals which are ploughed back into the food chains through bio-accumulation in planktons and invertebrates to fishes and finally biomagnified in man (Edward *et al*., 2013). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology since they are highly persistent and all have the potential to be toxic to living organism (ATSDR, 2005). There is a considerable concern about human health aspects of metal cycling in polluted water bodies that are in proximity to human settlements (Akinrotimi *et al*., 2009; WHO, 2000). Heavy metals Concentrations in aquatic ecosystem are usually monitored by measuring their concentration in water, sediments and associated biota. They generally exist in low levels in water and attain considerable concentration in sediments and periwinkle (USEPA, 1996; Ladipo *et al.*, 2012).

Sediments are important sinks for various pollutants like pesticides and heavy metals and also play a significant role in the remobilization of contaminants in aquatic systems under favourable conditions and in interactions between water and sediments (Rashed, 2001, Eneji *et al*., 2011). The periwinkle that inhabits contaminated sites is generally exposed to very high contamination of these pollutants because many of them process sediment as food source and thus can be susceptible to bioaccumulation and can potentially threaten the health of many species at the top of the food chain, especially fishes, birds, and humans (WHO, 1985; Ademoroti, 1996; Wright and Mason, 1999; FEPA, 2003 Oronsaye *et al*., 2010) [1]. Many aquatic organisms like periwinkle have the ability to accumulate and bio-magnify contaminants like heavy metals, polycyclic aromatic hydrocarbons and PCB in the environment (Ekwere *et al.*, 1992; Aderinola, *et al*., 2009; Chindah *et al*., 2009; Alaa and Osman, 2010; Oronsaye *et al*., 2010; Andem *et al.*, 2013) [6]. The ingestion of these contaminants may affect not only the productivity and reproductive capabilities of these organisms, but ultimately affect the health of man that depends on these organisms as a major source of protein (Allen, 1995; Idodo-Umeh, 2002, UNEP, 2002 Oguzie, 2003; Davies *et al*., 2006; Olowoyo, 2011).

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 (FAO, 1981; Chindah and Osuamke, 1994). It is a mollusk of high economic value in the Niger Delta (NDES, 1999; NDDC, 2004). It is a deposit feeder and bio-indicator of heavy metals and hydrocarbon pollutions in the marine environment (USEPA, 1996; NDES, 2000; Otitoju and Otitujo, 2013) Gastropod molluses, especially *Tympanotonus fuscatus* fulfil all the requirements for marine monitoring studies and can therefore act appropriately as a biological indicator of pollution (UNEP, 2002; Udotong *et al*., 2008, Aderinola *et al.*, 2009). Its suitability is universally recognized, being included in most of the national environment monitoring programmes of marine and brackish water pollution (FEPA, 2003; WHO, 2003, APHA, 2005). 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 index 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 exhibit high accumulation of them, particularly heavy metals.

The pollution of aquatic environment with heavy metals has become a worldwide problem and most of them have toxic effects on organism. In Jaja creek periwinkle and sediments risk exposure to heavy metals from untreated agricultural, urban and industrial effluents. This may results in bio-accumulation of heavy metals in man using water and eating aquatic fauna from this river since its tributaries pass through populated residential areas, towns, industrial and agricultural sites. Researches on heavy metals concentration in sediments and periwinkle have been carried out in some Niger Delta waters. However there is still insufficient scientific literature on the subject matter in Jaja creek hence this study is conducted to ascertain the levels of concentration of these metals, namely; cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe) in sediments and these commercial species (*Tympanotonus fuscatus*) in Jaja Creek, South eastern Nigeria, and possibly to determine potentially hazardous levels to humans.

Materials and Methods

Description of Study Area

Jaja creek is a tributary of Imo River which receives effluents from Aluminum Smelter Company (ALSCON) in Ikot Abasi, Akwa Ibom State and located a distance of 4 miles from the creek. Ikot Abasi is located between longitude 7º and 30ˋE and 7º and 45'E latitudes 4º and 30ˋ W, 4º and 45ˋN. Ikot Abasi is one of the Local Government Areas 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 which begins in April and ends in October, having an average annual rainfall varying between 2000 mm 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 effluents 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 the Jaja Creek (Ekpo and Ukpong, 2014)

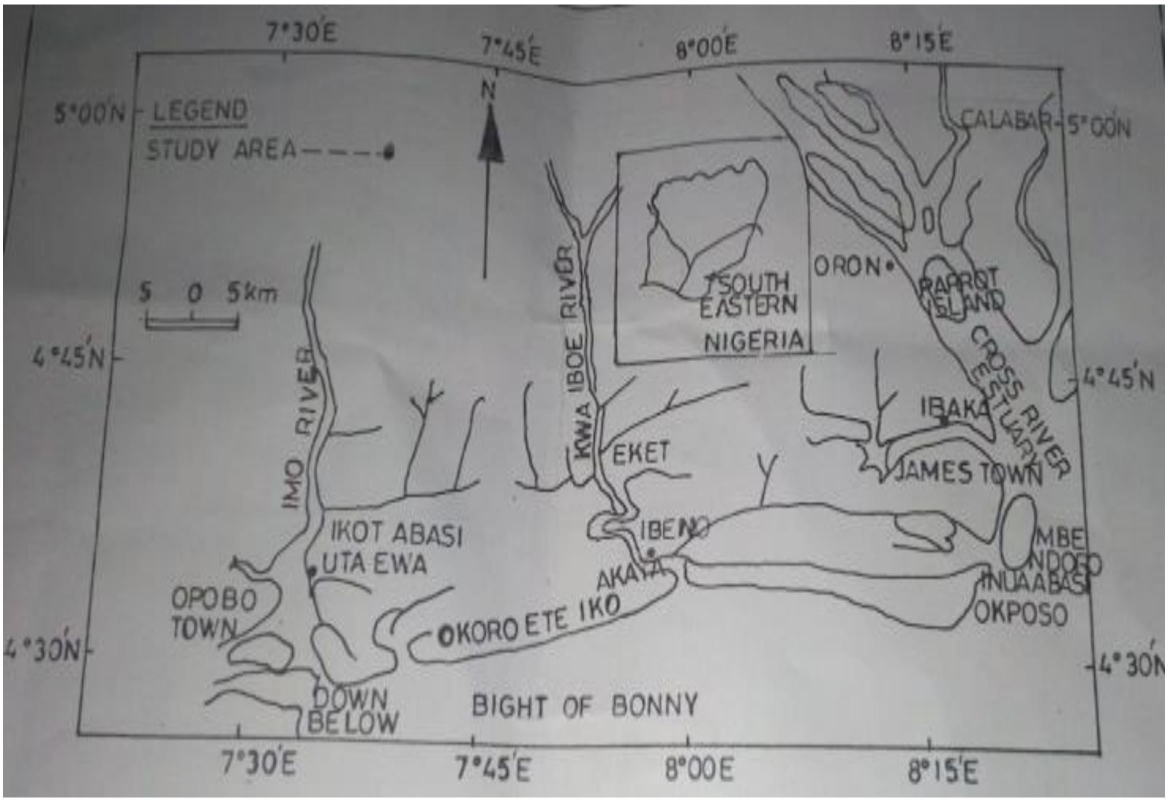

Fig 1: Map of Jaja Creek and the tributary

Samples Collection

Sediment Collection

The sediment samples were collected using plastic trowel from the river bed; samples were placed in polythene bags and transported to Zoology Laboratory, Akwa Ibom State University. Samples were oven – dried and preserved in well labeled plastic bottles and kept awaiting analysis.

Periwinkle Collection

Samples of periwinkle (*Tympanotonus fuscatus*) used for analysis were collected from where the sediments were scoped. The collection was done with the help of the local fisher folks. All samples were immediately stored in an icebox (-10 ^oC) and transported to the laboratory.

Fig 2: Samples of *Tympanotonus fuscatus*

Laboratory Analysis

In the laboratory, the samples were thoroughly washed with distilled water to free them of sediments. The total length (TL) and aperture length (AL) were measured to the nearest 0.1cm using a measuring board. The weight (TW) was measured by weighing with an electronic meter balance to the nearest 0.01g. The specimen was then broken and di-shelled using stones, thus the fresh soft tissue was weighed, wrapped in a foil paper and set in an oven to dry. The samples were dried to a constant weight in an oven at 80^oC for twenty four (24) hours making it brittles enough for grinding. Each dried sample was then weighed and ground to a powder form with plastic mortar and pestle, sieved to obtain a uniform particle size and preserved in well labeled plastic bottles indicating each month. The sediment was also oven-dried, sieved and preserved in well labeled plastic bottle indicating each month and kept awaiting analysis.

Assessment of Heavy Metal Analysis

Digestion Procedure

The method used was (ASTM I971 – 95) (Standard practices for digestion of samples for assessment of metals by Atomic Absorption Spectrophometry) (flame atomization or plasma emission spectroscopy).

Periwinkle Digestion

About 2 g of the dried ground samples were weighed and separately placed in a 125 ml beaker with about 100 ml of distilled water and 0.5 ml of nitric acid (HNO_3). The mixtures were heated on hot plate in a well – ventilated hood until the volume was reduced to 20 ml, which was near dryness, thus making sure the sample did not boil by controlling the temperature of the hot plate. On noticing the white fumes, the beaker was removed from the hot plate, allowed to cool and then filtered using Whatman No. 1 filter paper. The samples were quantitatively transferred to a 50 ml volumetric flask and adjusted to mark by adding de-ionized water and made up the volume of 50 ml.

Sediment Digestion

5.0 g of prepared sediment sample for each month was digested with 15.0 cm^3 nitric acid, 20.0 cm^3 perchloric acid and 15.0 cm^3 of hydrochloric acid and placed on a hot plate for 3 hours. On cooling, the digest was filtered into a 100.0 cm^3 volumetric flask and made up to the mark with distilled water. Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn), Lead (Pb), Manganese (Mn) and Iron (Fe) were assessed from prepared periwinkle and sediment samples respectively using UNICAM solar atomic absorption spectrometer 969 model.

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.

Statistical analysis

The results obtained from the analysis were subjected to descriptive statistics and expressed as mean ± standard deviation and compared to maximum permissible limits of the metals. Bioaccumulation Factor (BAF) was calculated to assess the level of heavy metal accumulation in the tissue of the organism using the formula below:

$$\text{BAF} = \frac{\text{Concentration of metals in periwinkle (mg/kg)}}{\text{Concentration of metals in sediment (mg/kg)}}$$

Where; BAF can be expressed as the ratio of the concentration of a chemical in an organism to the concentration of the chemical in the surrounding environment.

Results and Discussion

Results

Monthly concentration of heavy metals in the samples of sediments and periwinkle from Jaja creek are presented in Table 1 and Table 2, respectively. From June to November, copper level showed actual fluctuations with the highest concentration in July and the lowest concentration in November. Iron, zinc, and chromium displayed similar fluctuations as copper with a steady increase from June and peaked at July, they further decreased steadily throughout the remaining months. Cadmium, lead and manganese exhibited a similar trend with the highest concentration in August and lowest concentration in November, except that lead recorded the lowest concentration in June and July. From the seven metals, copper displayed the least fluctuation in concentration throughout the study period with a range of 1.506 to 2.204 mk/kg with a difference of 0.698 mg/kg. Fe ranged from 1.372 to 1.892 mg/kg with a difference of 0.520 mg/kg. Manganese ranged from 0.841 mg/kg to 1.204 mg/kg with a difference of 0.363 mg/kg. Cd ranged from 0.213 mg/kg to 0.624 mg/kg with a difference of 0.411 mg/kg. Zn ranged from 0.423 mg/kg to 1.083 mg/kg with a difference 0.66 mg/kg. Cr ranged from 0.002 mg/kg to 0.025 mg/kg with a difference of 0.023 mg/kg. Pb ranged from < 0.001 to 0.084 mg/kg with a difference of 0.083 mg/kg. Chromium displayed the lowest range difference in all the metals in sediments extracted from Jaja creek. In decreasing order, the sequence of differences in heavy metal concentrations have been derived below; Zn> CU > Fe > Cd> Mn> Pb> Cr.

From June to November in (Table 2), copper had its actual fluctuation level with highest concentration in August and lowest concentration in June. Pb displayed similar fluctuations as copper with a steady increase from June and peaked at August; they decreased and increased throughout the remaining months. Zn and Fe exhibited a similar trend with highest concentration in October and lowest concentration in June and August respectively; while Cr and Mn exhibited a similar trend with higher concentration in September and lowest concentration in October and July respectively Cd exhibited a different trend with highest concentration in November and lowest concentration in June. From, the seven metals, copper displayed the least fluctuations in concentration throughout the study period with a range of 2.010 to 2.367mg/kg with a different of 0.357mg/kg. Fe ranged from 1.830 to 3.016 mg/kg with a difference of 1.186 mg/kg. Zn ranged from 1.023 to 2.292 mg/kg with a difference of 1.269 mg/kg. Cr ranged from 0.312 to 0.821 mg/kg with a difference of 0.509 mg/kg, Cd ranged from 0.592 to 0.935 mg/kg with a difference of 0.343 mg/kg. Pb ranged from 0.014 to 0.218 mg/kg with a difference of 0.204mg/kg. Mn ranged from 1.032 to 1.213mg/kg with difference of 0.181 mg/kg. Manganese displayed the lowest range difference in all the metals in periwinkle extracted from Jaja Creek. In decreasing order, the sequence of difference in heavy metal concentration is as follows Zn> Fe> Cr > Cu > Cd > Pb > Mn.

Table 1: Monthly variations in heavy metals concentration (Mg/Kg) in sediment

Months	Metals						
	Cd	Cr	Cu	Fe	Pb	Mn	Zn
June	0.478	0.021	2.003	1.673	0.001	1.204	0.863
July	0.523	0.025	2.204	1.892	0.014	0.984	1.083
August	0.624	0.004	2.002	1.767	0.0841	1.084	0.582
September	0.497	0.01	1.968	1.624	0.035	1.03	0.672
October	0.324	0.005	1.712	1.532	0.023	0.925	0.52
November	0.213	0.002	1.506	1.372	0.015	0.841	0.423

Table 2: Monthly variations in heavy metals concentration (Mg/Kg) in periwinkle

Months	Metals						
	Cd	Cr	Cu	Fe	Pb	Mn	Zn
June	0.598	0.446	2.01	2.302	0.014	1.204	1.023
July	0.592	0.735	2.326	2.077	0.021	1.032	1.083
August	0.709	0.803	2.367	1.83	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	2.92
November	0.935	0.331	2.324	2.804	0.183	1.122	1.987

Total concentration, mean and standard deviation and range of heavy metals in sediment and periwinkle tissue are presented in (Table 3) and (Table 4), respectively. Cadmium ranged from 0.213 to 0.624 mg/kg with a mean of 0.44 ± 0.149 mg/kg in sediment while it ranged from 0.592 to 0.935 in periwinkle with a mean of 0.68 ± 0.132. Chromium ranged between 0.002 and 0.025 mg/kg with a mean of 0.01 ± 0.009 mg/kg in sediment and ranged between 0.312 and 0.821 mg/g with a mean of 0.57 ± 0.24 mg/g in periwinkle

Copper ranged from 1.506 to 2.204 mg/kg with a mean of 1.89 ± 0.284 in sediment and ranged between 2.01 and 2.367 mg/kg with a mean of 2.22 ± 0.166 in periwinkle. Iron ranged from 1.372 to 1.892 mg/kg with a mean of 1.64 ± 0.181 in sediment and ranged between 1.83 and 3.016 mg/kg with a mean of 0.35 ± 0.460 in periwinkle. Lead ranged from 0.001 to 0.084 mg/g with a mean of 0.002 ± 0.029 in sediment and ranged between 0.014 and 0.218 mg/kg with a mean of 0.11 ± 0.097 in periwinkle. Manganese range d from 0.841 to 1.204 mg/kg with a mean of 1.01 ± 0.126 in sediment and range between 1.032 and 1.213 mg/kg in periwinkle with a mean of 1.14 ± 0.070. Zinc ranged from 0.423 to 1.083Mg/Kg with a mean of 0.69 to 0.243 in sediment and ranged between 1.023 and 2.292 mg/kg with a mean of 1.58 ± 0.525 in periwinkle. Periwinkle recorded higher mean concentration in all the heavy metals studied except manganese. In decreasing order, the sequence of mean concentration in sediment was as follows: Cu > Zn > Fe > Cd > Mn > Pb > Cr while that of periwinkle was, Zn > Fe > Cr > Cu > Cd > Pb > Mn.

Table 3: Total concentration, mean ± standard deviation, and range of heavy metals (Mg/Kg), in sediment

Metals	Cd	Cr	Cu	Fe	Pb	Mn	Zn
Sum	2.668	0.067	11.395	9.86	0.172	6.068	4.143
Mean ± Standard Deviation	15.97 ± 36.84 0.44 ± 0.149	3.06 ± 5.61 0.01 ± 0.009	0.36 ± 0.93 1.89 ± 0.248	146.69 ± 77.69 1.64 ± 0.181	17.94 ± 30.79 0.02 ± 0.029	BDL BDL 1.01 ± 0.126	334.32 ± 199.23 0.69 ± 0.243
Minimum	0.213	0.002	1.506	1.372	0.001	0.841	0.423

Range	Maximum	0.624	0.025	2.204	1.892	0.084	1.204	1.083

Table 4: Total concentration, mean ± standard deviation, and range of heavy metals (Mg/Kg), in periwinkle

Metals		Cd	Cr	Cu	Fe	Pb	Mn	Zn
Sum		4.082	3.448	13.358	14.e125	0.688	6.898	9.498
Mean ± Standard Deviation		15.97 ± 36.84 0.68 ± 0.132	3.06 ± 5.61 0.57 ± 0.238	0.36 ± 0.93 2.22 ± 0.166	146.69 ±77.69 2.35 ± 0.460	17.94 ± 30.79 0.11 ± 0.097	BDL BDL 1.14 ± 0.070	334.32 ± 199.23 1.58 ± 0.525
Range	Minimum	0.592	0.312	2.01	1.83	0.014	1.032	1.023
	Maximum	0.935	0.821	2.367	3.016	0.218	1.213	2.292

Monthly total concentration, mean ± SD and ranged of heavy metal concentration in sediment and periwinkle are presented in Table 5 and Table 6. In June, heavy metal concentration in sediment ranged between 0.001 and 2.003 mg/kg with a mean of 0.89 ± 0.781 while it ranged from 0.014 to 2.302 mg/kg (Mean = 1.01 ± 0.831) in periwinkle. In July, heavy mental concentration in sediment ranged between 0.014 and 2.204 mg/kg with a mean off 0.96 ± 0.856 while it ranged from 0.021 and 2.326 mg/kg with a mean of 1.12 ± 0.818 in periwinkle. In August, heavy metal concentration is sediment ranged from 0.004 and 2.002 mg/kg with a mean of 0.88 ± 0.779 while it ranged from 0.218 and 2.367 mg/kg with a mean of 1.27 ± 0.763 in periwinkle.

In September, heavy metal concentration in sediment ranged from 0.01 and 1.968 mg/kg with a mean of 0.84 ± 0.753 while it ranged from 0.046 and 2.096 mg/kg with a mean of 1.16 ± 0.738 in periwinkle. In October, heavy metal concentration in sediment ranged from 0.005 and 1.712 mg/kg with a mean of 0.72 ± 0.693 while it ranged from 0.206 and 3.016 mg/kg with a mean of 1.42 ±1.118 in periwinkle. In November, heavy metal concentration ranged from 0.002 and 1.506 in sediment with a mean of 0.63 ± 0.626 while it ranged from 0.183 and 2.804 mg/kg with a mean of 1.39 ± 1.007 in periwinkle.

For heavy metal concentration in sediment, the highest ranged value was recorded in the month of July. Mean value difference of 2.190 while lowest in the Month of November, with a ranged difference of 1.504. While in periwinkle, the highest range value was recorded in the Month of October with a mean value of 2.810 in the Month of September mean value. In the decreasing order, the monthly range differenced in sediment is as follows: July > June > August > September > October > November while in periwinkle, we have: October > November > July > June > August > September.

Table 5: Monthly total concentration of heavy metals determined (mg/kg), mean + SD and range in sediment

Months	Total Concentration	Mean ± Standard Deviation	Range	
			Min	Max
June	6.252	23.135 ± 52.50 0.89 ± 0.981	0.001	2.003
July	6.712	37.275 ± 52.50 0.96 ± 0.856	0.014	2.204
August	6.478	31.736 ± 46.60 0.88 ± 0.779	0.004	2.002
September	5.836	57.936 ± 10.20 0.84 ± 0.753	0.001	1.968
October	5.041	81.541 ± 95.71 0.72 ± 0.693	0.005	1.712
November	4.372	97.92 ± 120.21 0.63 ± 0.626	0.002	1.506

Table 6: Monthly total concentration of heavy metals determined (Mg/kg) mean + SD and range in periwinkle

Months	Total Concentration	Mean ± Standard Deviation	Range	
			Min	Max
June	7.597	23.135 ± 43.19 0.89 ± 0.981	0.014	2.302
July	7.866	37.275 ± 52.50 0.12 ± 0.818	0.021	2.326
August	8.884	31.736 ± 46.60 0.27 ± 0.763	0.218	2.326
September	8.102	57.936 ± 10.20 0.1.16 ± 0.738	0.46	2.096
October	9.962	81.541 ± 95.71 1.42 ± 1.118	0.206	3.016
November	9,. 686	97.92 ± 120.21 1.39 ± 1.007	0.183	2.804

Mean concentration of heavy metals in sediment and periwinkle tissue and their Bioaccumulation factors (BAF) presented in Table 7. Based on bioaccumulation factor, the sequence of bioaccumulation of heavy metals by periwinkle was as follows; Cr > Pb > Zn > Cd > Fe > Cu > Mn. Chromium recorded the highest BAF while Mn had the lowest BAF value. Monthly concentration of heavy metals in sediment and periwinkle tissues and their bioaccumulation factors (BAF) is presented in Table 8. The highest BAF occurred in the month of November at 2.22 mg/kg lowest occurred in the month of July at 1.22 mg/kg in the decreasing order, the BAF values sequence was as follows; November > October > September > August > June > July.

Table 7: Mean Concentration of heavy metals in sediment and periwinkle tissue and their bioaccumulation factors (BAF)

Heavy Metals	Parameters		
	Periwinkle	Sediment	Bioaccumulation (BAF)
Cr	0.57 ± 0.238	0.01 ± 0.009	57.00
Pb	0.11 ± 0.097	0.03 ± 0.029	3.667
Zn	1.58 ± 0.526	0.69 ± 0.244	2.29
Cd	0.68 ± 0.132	0.44 ± 0.149	1.545
Fe	2.35 ± 0.461	1.64 ± 0.181	1.433
Mn	0.11 ± 0.097	1.01 ± 0.126	1.138
Cu	2.23 ± 0.166	1.90 ± 0.248	1.174

Table 8: Monthly concentration of heavy metals in sediment and periwinkle tissues and their bioaccumulation factors (BAF)

Months	Parameters		
	Periwinkle	Sediment	BAF
November	1.38	0.62	2.22
October	1.42	0.72	1.97
September	1.16	0.83	1.39
August	1.27	0.88	1.28
June	1.09	0.89	1.22
July	1.12	0.96	1.17

Discussion

In sediment, the mean concentration of Cd was 0.44 mg/kg. This was lower than those recorded by Ekpo and Ukpong (2014), on assessment of heavy metals concentration in water, sediment and some common sea foods from Jaja creek of Ikot Abasi; Sarker *et al*., (2016) [49] on heavy metals concentration in sediment, Bangley River but higher than those recorded by Edward *et al*. (2013) on determination of heavy metal concentration in fish samples, sediment and water from Odo-Ayo River in Ado- Ekiti, Ekiti State, Nigeria; Ekeanyanwu *et al*., (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State, Davies *et al*., (2006) on Bioaccumulation of heavy metals concentration in water, sediment and periwinkle from Elechi Creek, Niger Delta. In periwinkle the mean concentration of Cd concentration was 0.68mg/kg. This was lower than those recorded by Abiaobo *et al*. (2017), on heavy metal concentration in periwinkle in Iko River Estuary, Nigeria, Ekpo and Ukpong (2014) on assessment of heavy metal concentration in water, sediment and some common sea foods and periwinkle from Uta Ewa creek of Ikot Abasi, Akwa Ibom State but higher than those recorded by Howard *et al.* (2008) on trace metals in tissues and shells of periwinkle from the Mangrove swamps of the Bukuma oil field, Niger Delta and Sarker *et al.* (2016) [49] in periwinkle from Bangley River. The mean concentration of Cd in periwinkle samples collected from Jaja Creek was above the WHO maximum permissible limits of 0.003 mg/kg for periwinkle. Cadmium is a highly toxic non-essential heavy metal and it does not have a role in biological process in living organisms. Thus even in low concentration, cadmium could be harmful to living organisms (Tsui and Wang, 2004). The high levels of Cd present in the periwinkle from Jaja creek may be due to effluent from ALSCON discharged into the creek. The mean concentration of cadmium recorded in periwinkle was higher than the mean concentration in sediment samples which shows that there was bioaccumulation of this metal.

The mean concentration of Chromium in sediment was 0.011 mg/kg. This was lower than those recorded by Ekpo and Ukpong (2004) on assessment of heavy metals concentration in water, sediment and some common sea foods from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State, Ekeanyanwu *et al.*, (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie river and Oguta lake in Imo State, Sarker *et al.* (2016) [49] on heavy metal concentration in sediment, Bangley River but on bioaccumulation of heavy metals in water, sediment and periwinkle from Elechi Creek, Niger Delta. In periwinkle the mean concentration of Chromium was 0.57mg/kg. This was lower than those recorded by Ayenimo *et al.* (2005), on preliminary investigation of heavy metals in periwinkle from Warri River; Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea food from Uta Ewa Creek of Ikot Abasi, Akwa Ibom state and Sarker *et al.* (2016) [49] on concentration of heavy metals in periwinkle from Bangley River but higher than that recorded by Abiaobo *et al*., (2017), on heavy metal concentration on periwinkle from Iko River Estuary, Nigeria. The mean concentration of Chromium in periwinkle was higher than the mean concentration in sediment samples. Cr levels were above the WHO and FEPA standard limits of 0.05mg/kg for periwinkle (WHO, 1985; FEPA, 2003). Cr plays an important role in glucose metabolism and its bioaccumulation in fish has been reported to cause impaired respiratory and osmoregulatory functions through structural damage to gills epithelium (Heath, 1991). The concentration of Chromium in sediment and periwinkle could be attributed to waste water discharged from the agricultural related activities, domestic wastes from various Housing Estate discharged and ALSCON effluent discharged into the creek.

In sediment the concentration of Cu was 1.90mg/kg. This was lower than that which was recorded by Sarker *et al.* (2016) [49] on heavy metal concentration in sediment from Bangley River but higher than those recorded by Ekpo and Ukpong (2004) on assessment of heavy metals concentration in water, sediment and some common sea foods from Uta Ewa Creek of Ikot Abasi; Edward *et al.* (2015) on determination of heavy metal concentration in fish samples, sediment and water from Odo-Ayo River in Ado- Ekiti, Ekiti State, Nigeria; Ekeanyanwu *et al.* (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State. In periwinkle the mean concentration of Cu was 2.23 mg/kg. This was lower than those recorded by Abiaobo *et al*. (2017), on heavy metal concentration in periwinkle in Iko River Estuary, Nigeria and Ayenimo *et al.* (2005), on preliminary investigation of heavy metals in periwinkle from Warri River but higher than those recorded by Sarker *et al.* (2016) [49] on concentration of heavy metals in periwinkle in Bangley River; Ekpo and Ukpong (2014) on assessment of heavy metal concentration in water, sediment and some common sea foods and periwinkle from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State, Howard *et al.* (2008) on trace heavy metals in the tissues and shell of *T. fuscatus Var radula* from the mangrove swamps of the Bukuna oil field, Niger Delta.

Copper recorded in periwinkle samples was higher than that of sediment samples showing that bioaccumulation occurred. Cu is an essential element that serves as a cofactor in a number of enzymes system and necessary for the synthesis of haemoglobin (Sivaperumal *et al*., 2007) but very high intake of Cu can cause adverse health problems for most living organisms. The concentration of Cu exceeded WHO and FEPA standard limits of 2.0mg/kg in periwinkle (WHO, 1985; FEPA, 2003). The high level of Copper observed in periwinkle collected from Jaja Creek may be due to the presence of domestic waste, Agricultural and Industrial waste from ALSCON discharged into the Creek (Ekpo and Ukpong, 2014). In sediment, the mean concentration of Iron was 1.64 mg/kg, this was lower than those recorded by Edward *et al*. (2013), on determination of heavy metal concentration in fish samples, sediment and water from Ado-Oyo River, Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea food from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State, Sarker *et al.* (2016) [49] on concentration of heavy metals in sediment from Bangley River but higher than those recorded by Ekeanyanwu *et al.* (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State. In periwinkle the mean concentration of Fe was 2.35mg/kg, this was lower than those recorded by Abiaobo *et al.* (2017), on heavy metal concentration in periwinkle in Iko River Estuary, Nigeria; Ayenimo *et al.* (2005) on preliminary investigation of heavy metals from

Warri River, Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea foods and periwinkle from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State and Sarker *et al.* (2016) [49] on concentration of heavy metal in periwinkle, Bangley River. Although Iron is a necessary element in human diet and play significant role in metabolic process, the concentration of Fe recorded in *T. fuscatus* collected from Uta Ewa Creek exceeded the WHO and FEPA recommended standard limits of 0.5 mg/kg in periwinkle (WHO, 1985; FEPA, 2003).

The mean concentration of Fe recorded in periwinkle was higher than the mean concentration that was recorded in sediment obtained from Jaja Creek showing bioaccumulation. The high concentration of Fe in the periwinkle could be due to the bottom-dwelling and bottom-feeding habits which make it to be in contact with considerable Fe laden sediment. This finding agreed with that of Ladipo *et al.* (2012) on fish and periwinkle from Lagos Lagoon. The high concentrations of Iron in periwinkle could further associated with the fact that this metal is naturally abundant in Nigerian soils (Ademoroti, 1996) [1]. In sediment the mean concentration of lead was 0.03 mg/kg. This was lower than those recorded by Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea food from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State, Edward *et al.* (2013), on determination of heavy metal concentration in fish samples, sediment and water from Ado-Oyo River, Owuli *et al.* (2013), on heavy metal concentration in sediment from Eagle Island River, Port Harcourt but higher than those recorded by Sarker *et al.* (2016) [49], on concentration of heavy metal in sediment from Bangley River, Davies *et al.* (2006), on bioaccumulation of heavy metals in water, sediment and periwinkle from Elechi Creek, Niger Delta and Ekeanyanwu *et al*. (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State. In periwinkle the mean concentration of Pb was 0.11mg/kg.

This was lower than those recorded by *Abiaobo et al.* (2017), on heavy metal concentration in periwinkle in Iko River Estuary, Nigeria; Ekpo and Ukpong (2014) on assessment of heavy metal concentration in water, sediment and some common sea food and periwinkle from Jaja Creek of Ikot Abasi, Akwa Ibom State, Owuli *et al.* (2014), on heavy metal concentration in periwinkle from Eagle Island River, Port harcourrt, Howard *et al.* (2008) on trace heavy metals in the tissues and shell of *T. fuscatus Var radula* from the mangrove swamps of the Bukuna oil field, Niger Delta but higher than that recorded by Ayenimo *et al.* (2005), on preliminary investigation of heavy metal in periwinkle from Warri River. The mean concentration of lead in periwinkle samples collected was higher than the mean concentration recorded in sediment sample showing bioaccumulation. The mean concentration of Pb in periwinkle sample collected from Jaja creek exceeded the WHO and FEPA standard limit of 0.01 mg/kg (WHO, 1985; FEPA, 2003). Pb is a toxic element with no biological functions and possesses carcinogenic effect on aquatic biota and humans. Pb toxicity is known to cause musculo-skeletal, renal ocular, neurological, immunological, reproductive and developmental effects (Schuster, 2004).

In Sediment the mean concentration of Manganese was 1.01mg/kg. This was lower than that which was recorded by Ekpo and Ukpong (2014), on assessment of heavy metal concentration on water, sediment and some common sea food from Uta Ewa Creek of Ikot Abasi, Akwa Ibom State but higher than those recorded by Edward *et al.* (2013), on determination of heavy metal concentration in fish samples, sediment and water from Ado-Oyo River; Ekeanyanwu *et al.* (2005) on monitoring of metals in *Tilapia niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State. In periwinkle the concentration of Manganese was 1.15 mg/kg. This was lower than that of Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea food from Uta Ewa creek of Ikot Abasi, Akwa Ibom State. The mean concentration of Mn recorded in periwinkle was higher than the mean concentration in sediment which shows that there was bioaccumulation. The mean concentration of Mn exceeded the WHO and FEPA standard limits of 0.5 mg/kg in periwinkle (WHO, 1985; FEPA, 2003). This may be due to the presence of domestic waste, Agricultural and Industrial waste from ALSCON discharged into the creek.

In sediment the mean concentration of Zinc was 0.69mg/kg. This was lower than those recorded by Edward *et al.* (2013), on determination of heavy metal concentration in fish samples, sediment and water from Ado-Oyo River, Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea foods but higher than those recorded by Sarker *et al.* (2016) [49], on concentration of heavy metals on sediment from Bangley River, Ekeanyanwu *et al.* (2005) on monitoring of metals in *T. niloticus* tissues, bottom sediment and water from Nworie River and Oguta lake in Imo State. In periwinkle the mean concentration of Zinc was 1.58 mg/kg. This was lower than that of Abiaobo *et al.* (2017), on heavy metal concentration in periwinkle in Iko River Estuary, Nigeria; Ekpo and Ukpong (2014), on assessment of heavy metal concentration in water, sediment and some common sea foods but higher than those recorded by Howard *et al.* (2008) on trace heavy metals in the tissues and shell of periwinkle from the mangrove swamps of the Bukuna oil field, Niger Delta and Sarker *et al.* (2016) [49], on concentration of heavy metals on sediment from Bangley River.

The mean concentration level of Zn in periwinkle sample was higher than the mean concentration in sediment sample, which shows that there was bioaccumulation. The concentration level of Zn recorded in periwinkle sample collected from Jaja creek exceeded WHO and FEPA recommended standard limit of 0.10mg/kg (WHO, 1985; FEPA, 2003). The higher values of Zn observed in periwinkle collected from Jaja creek may be due to the presence of Agricultural runoff, chemicals and Zinc-based fertilizers by farmers and industrial effluent from ALSCON and domestic waste discharged into the creek as well as the bottom dwelling and habit of periwinkle. The highest monthly mean concentration of heavy metals in sediment was recorded in July and lowest in November, this could be attributed to July being the peak of wet season, it may be possible that storm water from adjacent environment and runoff may be contributing to the higher level of heavy metals observed in sediment in July than November which is just the beginning of dry seasons. The highest monthly mean concentration of heavy metals in periwinkle tissue was observed in October while June recorded the lowest.

This high concentration might be attributed to the fact that the level of heavy metals in sediment was as well high in sediment as sediment is the major depository of heavy metal in the aquatic ecosystem. (Odieke, 1999). Moreover October marks the setting in of dry season hence water current is reduced and more materials are settled at the sediment where the periwinkles live permanently and feed from. According to Canterford *et al.* (1978), it is useful to express results in terms of biological accumulation factor (BAF) when comparing the order of uptake of metals. The observed high BAF indicates that periwinkle has a high potential to accumulate heavy metals in soft tissue (Ademoroti, 1996, Odiete, 1999) [1]. The order of heavy metals BAF values in this study was Cr>Pb>Zn>Cd>Fe>Cu>Mn while the sequence of monthly BAF values was Nov>Oct>Sept>Aug>Jun>Jul.

Conclusion

The results of this study provide valuable information on the heavy metals in sediments and periwinkle (*Tympanotonus fuscatus*) obtained from Jaja creek of Imo River in Ikot Abasi Local Government Area, Akwa Ibom State, Nigeria. The mean concentration of heavy metals Cd, Cr, Cu, Fe, Pb, Mn and Zn observed in sediments and periwinkle were above the maximum permissible limits recommended by regulatory agencies and depending on daily intake by consumers, might constitute risk for human health. Findings from this study can be used by regulatory agencies for inclusion into policy formations to safeguard the health of individuals who rely on aquatic resources from the creek for means of livelihood.

Recommendations

Since this study has revealed the levels of each of the heavy metal, for prevention of food poisoning resulting from heavy metal toxicity in periwinkle, it is recommended that:

- Effort should be made on ensuring that these concentrations are reduced or not exceeded.
- In view of the importance of periwinkle to diet of the Coastal inhabitant in particular and Nigerians in general, it is necessary that biological monitoring of the periwinkle meant for consumption should be done regularly to ensure continuous safety of food.
- Safe disposal of domestic sewage and industrial effluents should be practiced and where possible recycling should be done to avoid these metals and other form of pollutants from going into the environment.
- There should be continuous environmental pollution monitoring to avoid heavy metal hazard.

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