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HEAVY METAL CONCENTRATIONS IN THE WEST AFRICAN CLAM, *Egeria radiata* (Lammark, 1804) FROM McIver MARKET, WARRI, NIGERIA.

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ABSTRACT

Samples of *Egeria radiata* were purchased from local dealers in McIver market, Warri, Nigeria, to investigate the presence and concentrations of some heavy metals in order to ascertain the suitability of the clam for human consumption. Analyses using Atomic Absorption Spectrophotometer (AAS) show that *E. radiata* accumulated some heavy metals with the following sequence of concentration: Iron > Nickel> Lead > Copper > Arsenic > Manganese > Chromium > Cadmium > Mercury. The variability of heavy metals concentration observed in *E. radiata* during the period of study was affected by rainfall amount. A negative relationship between changes in rainfall and body weight of clams show that the higher the rainfall the lower the mean dry weight. Individual heavy metal differed significantly ($P<0.05$) in concentration. However, heavy metal concentrations did not vary significantly ($P>0.05$) by months. Out of the nine heavy metals found in *E. radiata* tissues, lead and cadmium were higher than the WHO/FAO set limit. *E. radiata* sold in McIver market during this period of study were contaminated with lead and cadmium and therefore not fit for consumption.

KEYWORDS: *Egeria radiata*, Heavy metals, McIver, Warri, Nigeria.

INTRODUCTION

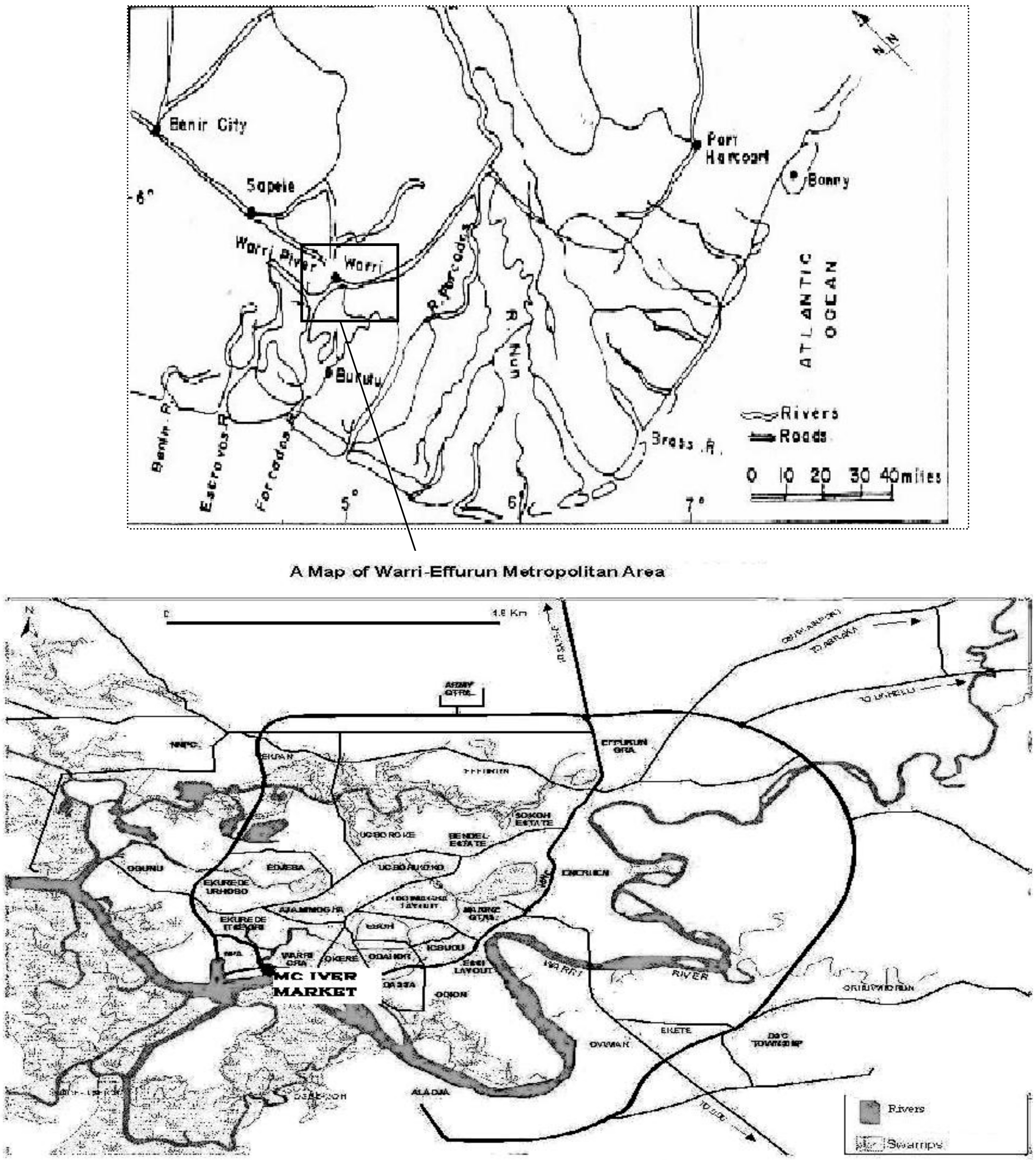
Human mediated industrial activities have increased in recent times leading to the introduction of many potentially hazardous inorganic compounds into the environment (Udonsen, 1998). These inorganic compounds are heavy metals which are non- biodegradable and dangerous due to their innate ability to constantly remain within the ecosystem (Hernandez-Hernandez *et al.,* 1990). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and on the diversity of aquatic organisms (Ashraj, 2005). Aquatic organisms have been reported to accumulate heavy metals from various sources including sediments, soil, erosion and discharges of waste water. Aquatic organisms acquire trace elements from food, suspended particles or directly from the water (Carvalho and Fowler, 1993). Some heavy metals are essential in trace concentrations for the maintenance of body metabolism, growth and general well being of living organisms. However, at higher concentrations heavy metals can lead to poisoning.

Nwabueze (2011) stated that shell fishes in general including clams are good indicators of the levels of contamination of water bodies due to their filter feeding habits and contact with bottom sediment. The clam, *Egeria radiata* commonly referred to as the West African clam occurs in fresh water bodies (Davies and Wuller, 1986). Clams characteristically lie buried from just beneath the surface to depths of about 0.6 m (2 feet). Ayenimo *et al.* (2005) attributed heavy metal contamination of aquatic organisms in Warri area to the presence of industries in Warri. *E. radiata* is present in water bodies around Warri and is a common shell fish in the popular McIver Market in Warri. *E. radiata* is a delicacy and loved by some coastal inhabitants of the Niger Delta such as the Urhobos, Ijaws and Itsekiris. Heavy metal concentration of *E. radiata* sold in McIver Market in Warri is investigated to ascertain the level of safety of the clam consumed in the area.

MATERIALS AND METHODS

Fifteen samples of fresh water clam, *E. radiata*, predominant in the Niger Delta region (Udoidiong and Akpan, 1991) with average length of 12cm each were purchased from McIver Market in Warri once every month. This market is the major market where fishermen who fish the shellfish from creeks like Ayakoromo, Obotobe, Gbekebor and Ogodobri in Burutu Local Government Area bring clams for sale to local dealers who sell to consumers (Figure 1). Sampling for the study was undertaken for a period of one year spanning Nov. 2008 to Oct. 2009. The clams were transported to the Fisheries Laboratory of the Delta State University Asaba campus, Asaba, for sample preparation.

The samples were washed, weighed and frozen prior to preparation and analysis. The soft tissues of the bivalves were extracted, weighed and dried in a laboratory oven for 3 days at a constant temperature of 60^0C (APHA, 1989). The dry samples were weighed and crushed or homogenized using a porcelain mortar and stored in an air tight container. Ten grams of the dried, homogenized samples were weighed into 250ml conical flask. Twenty milliliters of Perchloric acid ($HClO_4$) and twenty milliliters of Nitric acid (HNO_3) in a ratio of 1:1 were then added to the sample. The content was heated in a burner (digester) until the volume decreased to 5 ml with temperature not exceeding 160^{o}C. The residue was energized with 5 ml 20% Hydrochloric acid (HCl) and filtered using Whatman no.1 filter paper into 100ml volumetric flask and made up to the 100 ml mark with deionized water (APHA 1989; O'Leary & Breen, 1997). The digest was transferred to plastic bottles and later analyzed using the Atomic Absorption Spectrophotometer (AAS) at Nigeria Institute for Oil Palm Research (NIFOR). The occurrence and levels of Copper, Cadmium, Lead, Cobalt, Nickel, Manganese and Chromium in tissues of *E. radiata* were determined using an air acetyl flame. Hydride generation and cold vapor techniques (VGA 77) were used for Arsenic and Mercury.



Map drawn by Professor Francis Odemerho, Southern Illinois University, Edwardsville, USA

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FIGURE 1: MAP SHOWING McIver MARKET WHERE THE CLAMS WERE PURCHASED

Rainfall data was collected for the corresponding study period from Nigerian Meteorological Agency (NIMET) in Warri. Data obtained was analyzed using two way analysis of variance (ANOVA) at 95% confidence level. Regression plots were used to know the level of interaction of dry weight of the clams with amount of rainfall, to compare the interaction of the individual heavy metals with the mean dry weight of the clams and to know the relationship between heavy metal concentration in the clams and amount of rainfall.

RESULTS

E. radiata samples had higher monthly mean dry weight in the months of November, January and February with 77g, 64g and 97g weight respectively. Lowest monthly mean dry weights for *E. radiata* were observed in the months of May, June and August with 37g, 31g and 12g weight respectively (Table 1). A reduction in the amount of rainfall was observed in the month of September (118mm) showing a proportionate increase in mean dry weight (58g) of *E. radiata.* The same trend was observed in the months of December, January and March with rainfall values of 24mm, 13mm and 67mm respectively and with a proportionate increase in the mean dry weight of *E. radiata*. A negative regression (y=-4.9263+445.26) of rainfall against mean dry weight was observed (Figure 2).

Individual heavy metal differed significantly ($P<0.05$) in concentration. However, heavy metal concentrations did not vary significantly ($P>0.05$) by months. Heavy metal concentrations in tissues of *E. radiata* indicated that January and February had the highest concentration of heavy metals in the samples tested (Table 2). The mean concentration of heavy metals followed a sequence of: Iron > Nickel> Lead > Copper > Arsenic > Manganese > Chromium > Cadmium > mercury.

TABLE 1: Monthly Dry weights of *E. radiata* and Rainfall amounts

Months	Mean Dry Weight (g)	Rainfall amount (mm)*
November	77.330	73
December	50.667	24
January	64.000	13
February	97.333	86
March	50.000	67
April	51.333	138
May	36.667	209
June	30.667	383
July	40.000	407
August	12.000	415
September	58.000	118
October	49.330	369

*Source: NIMET, Warri (2008-2009)

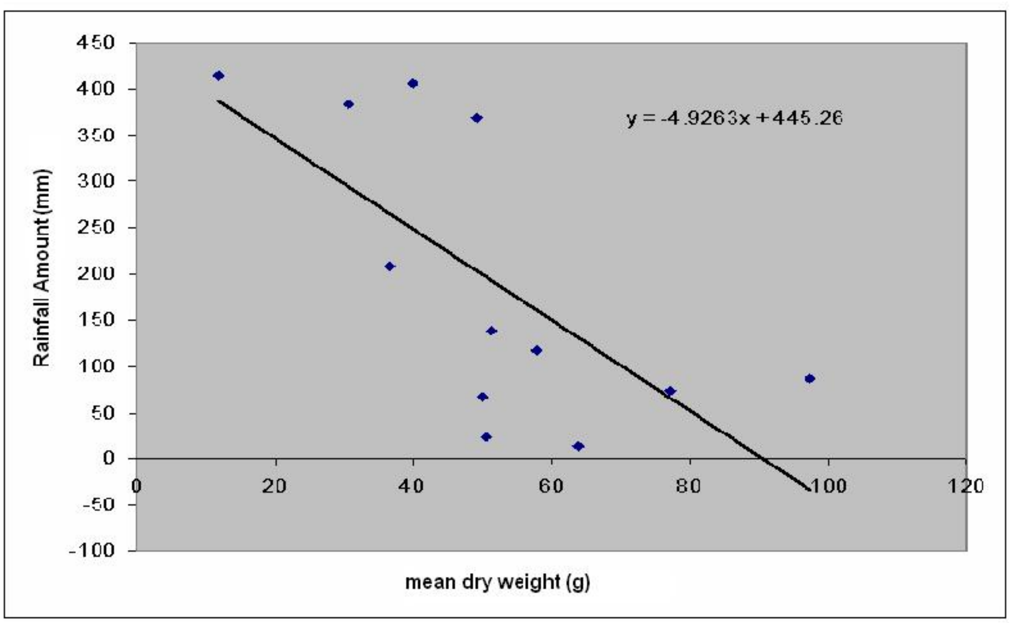

FIGURE 2: Regression plot of mean dry weight of *E. radiata* and rainfall amount

The concentration of mercury ranged from 0.154 mg/kg - 1.3mg/kg, lead from 1.38 mg/kg - 5.383mg/kg and Nickel from 0.224 mg/kg - 34.31mg/kg in tissues of *E. radiata*. Chromium, copper and manganese had values which ranged from 0.86 mg/kg - 3.775mg/kg, 3.25 mg/kg - 10.32mg/kg and 0.563 mg/kg - 4.149 mg/kg respectively. The other heavy metals analyzed were iron which ranged from 16.9 mg/kg – 49.77 mg/kg, arsenic ranging from 1.7 mg/kg – 3.51 mg/kg and cadmium which ranged from 0.915 mg/kg – 1.349 mg/kg. Iron had the highest concentration among the metals across the months. Its highest concentration were in the months of January, February and December with values of 47.77 mg/kg, 48.94 mg/kg and 41.21 mg/kg while its lowest concentrations were in the months of July and September with values of 16.9 mg/kg and 17.5 mg/kg respectively. Nickel was observed to be higher in concentration in the month of February with 34.31mg/kg and lowest in March with values 0.224 mg/kg. *E. radiata* had highest concentration of copper in July with 10.32 mg/kg and lowest values of 3.25 mg/kg each for the months of March and April. Chromium was highest in concentration in February (3.102 mg/kg) and August (3.675 mg/kg) while its lowest concentrations were in March (0.871 mg/kg) and April (0.86 mg/kg). Lead was highest in concentration in February with a value of 5.383 mg/kg and lowest in concentration in December with a value of 1.38 mg/kg. *E. radiata* had relatively low concentration of mercury during the study with the highest concentrations in the months of December (1.194 mg/kg) and January (1.457 mg/kg). The concentration of Manganese was highest in the months of August, July September and June having the following values: 4.149 mg/kg, 3.94 mg/kg, 3.784 mg/kg, and 3.52 mg/kg while it had its lowest value in the month of February (0.563 mg/kg). Arsenic was highest in concentration in *E. radiata* in September and lowest in January with the values of 3.209mg/kg and 1.7 mg/kg respectively. Cadmium in tissues of *E. radiata* was relatively uniform throughout the period of study but for the months of April with the highest concentration of 1.349 mg/kg and March with 0.911 mg/kg as the lowest concentration (table 2). Mercury, Nickel, Chromium, Copper, Manganese, Iron and Arsenic had levels below the world standard while Lead and Cadmium had concentrations exceeding the world limit (table 3). Mercury, lead, nickel, chromium and iron had increased concentrations in tissues of *E. radiata* as the mean dry weight increased with equations: $y=0.006x+0.1095$, $y=0.003x+3.1472$, $y=0.3167x-9.1963$, $y=0.3167x-9.1963$ and $y=0.3213x+9.1471$ respectively. This was not the case with copper which displayed a negative regression with the body weight which increased as the concentration of copper reduced ($y=-0.0418x+7.5747$). A negative regression was also observed for manganese, arsenic and cadmium which decreased in concentrations in tissues of *E. radiata* as the mean dry weight increased with equations: $y=-0.0381x+4.6656$, $y= -0.0151x+3.536$ and $y=-0.0016x+1.1186$ respectively (Table 4). Monthly mean heavy

TABLE 2: Monthly variation of heavy metals in *E. radiata* in relation to rainfall amount

Months/Heavy Metal Conc in mg/kg	*Hg*	*Pb*	*Ni*	*Cr*	*Cu*	*Mn*	*Fe*	*As*	*Cd*	*Mean*	*Rainfall**
November	0.818	2.184	9.019	3.351	4.221	2.206	20.150	2.099	0.953	5.000	72.500
December	1.194	1.380	9.134	3.102	4.217	2.317	41.210	1.935	0.921	7.268	23.800
January	1.300	1.457	10.090	3.049	4.208	2.425	49.770	1.700	0.917	8.324	13.000
February	0.200	5.383	34.310	3.775	4.206	0.563	48.940	2.550	1.052	11.220	86.100
March	0.167	4.172	0.224	0.871	3.250	2.035	18.690	3.400	0.911	3.747	66.900
April	0.174	4.071	0.781	0.860	3.250	2.098	18.500	3.190	1.349	3.808	138.200
May	0.165	3.900	0.870	2.033	4.905	3.340	18.590	3.200	1.340	4.260	209.200
June	0.153	3.710	2.080	2.469	9.728	3.520	17.890	3.009	0.934	4.833	383.400
July	0.155	2.190	2.085	2.904	10.320	3.940	16.900	3.010	0.915	4.713	407.100
August	0.163	3.830	4.052	3.675	5.430	4.149	21.750	3.510	1.151	5.301	414.500
September	0.154	3.214	2.758	2.900	7.135	3.784	17.500	3.209	1.017	4.630	117.500
October	0.371	4.113	9.731	3.213	4.236	2.117	18.250	2.275	1.005	5.035	368.800
MEAN (± S.E)	*Hg*	*Pb*	*Ni*	*Cr*	*Cu*	*Mn*	*Fe*	*As*	*Cd*	*Mean*	*Rainfall**

* Source: NIMET, Warri (2008-2009)

TABLE 3: Comparism between mean of heavy metal concentration of *E. radiata* studied and world standard

Metals	MEAN (mg/kg)	World Standard (mg/kg)
Hg	0.418	0.5
Pb	3.300*	1.5
Ni	7.095	80.0
Cr	2.684	13.0
Cu	5.426	20.0
Mn	2.708	50.0
Fe	25.678	300.0
As	2.757	86.0
Cd	1.039*	1.0

* Mean higher than world Standard (FAO/WHO, 1984)

metal concentrations when compared with monthly amounts of rainfall show that the months with the highest mean heavy metal concentration had the lowest total monthly amount of rainfall while the lowest mean concentration corresponded with the month with the highest rainfall amount. A regression of mean heavy metal concentration against rainfall amount gave a negative quadratic equation value of y=-26.644+343.12
(Figure 3).

TABLE 4: Regression parameters of mean dry weight versus heavy metal concentrations (mg/kg) in tissues of *E. radiata*

Mean dry weight	Metal	R	A	b	S.E (b)
	Hg	0.31	0.1095	0.0060	0.413
	Pb	0.05	3.1472	0.0030	1.751
12.00- 97.33	Ni	0.74	9.1963	0.3167	7.266
	Cr	0.20	2.2272	0.0089	1.297
	Cu	-0.39	7.5747	-0.0418	3.717
	Mn	-0.80	4.6656	-0.0381	1.951
	Fe	0.55	9.1471	0.3213	11.337
	As	-0.54	3.5360	-0.0151	1.493
	Cd	-0.21	1.1186	-0.0016	0.469

r = Correlation Coefficient; a = Intercept; b = Slope; S.E= Standard Error.

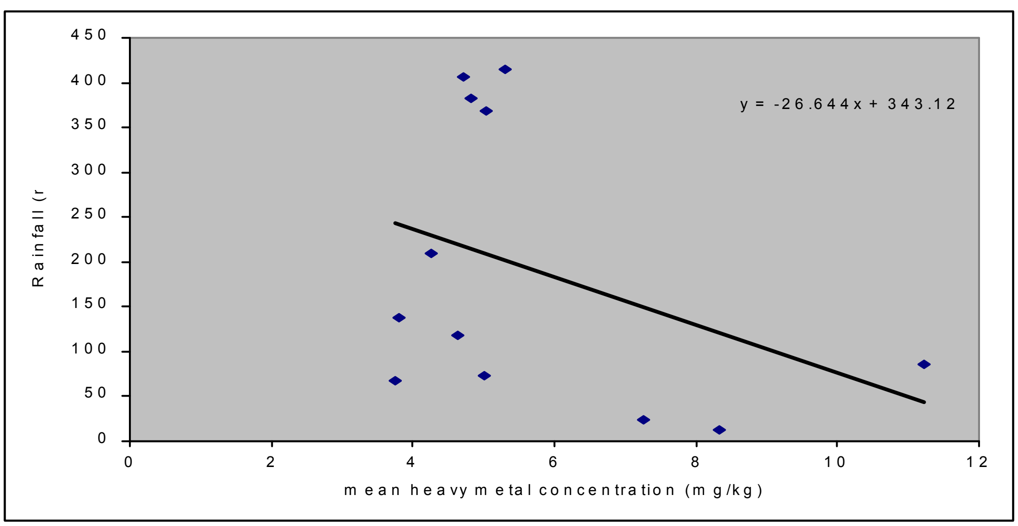

FIGURE 3: Monthly mean of *E. radiata* heavy metal concentration in relation to rainfall amount

DISCUSSIONS

The monthly mean dry weight of *E. radiata* was higher in the dry months of November, January and February while the mean dry weight was lower in the rainy months of May, June and August during the study. This indicates that the average dry weight of *E. radiata* reduced with increasing rainfall amounts. This negative relationship between average dry weight of *E. radiata* and rainfall can be attributed to the fact that the availability of the clams is reduced as the fishermen experience difficulties in harvesting the clams in the deeper waters of the rainy season than in the shallower waters of the dry season (Putnam, 2011). Also during the rains, the volume of water per surface area is increased and since *E. radiata* is sessile and a filter feeder, the amount of food per water volume is reduced, hence the clams will have to do more work filtering the water for food, burning more energy for less food (Durve, 2010). With reduced volume of water in the dry season, there is more food per volume of water. So, more food is available to the clam per intake of water in the dry season. Furthermore, according to the life cycle of *E. radiata* as in other tropical clams spawning starts in the rainy season (Velez *et al.,* 1985) and since a lot of energy is required in the reproductive process for the production of eggs and sperms (Schneider, 2004) as spawning usually occur more than once during the spawning season (Whetstone *et al.,* 2005), there is reduction in the body mass as a result of increased metabolism and activities that support reproduction. In the dry season, the reproductive process undergone in the rainy season is long completed and the young clams are approaching maturity, hence there is increase in the dry weight of the clams.

There were variations in the range of minimum and maximum values of the heavy metals across the months with nickel (0.224-34.31 mg/kg) having the highest variation and cadmium (0.915-1.349mg/kg) having the lowest variation. This shows that the metals vary in their levels of accumulation in *E. radiata* on a monthly basis. The variations observed could be due to varying degrees of water pollution around the areas where the clams were harvested for sale in the market. From earlier reports, Warri area and the Niger Delta at large have been reported to suffer varying degrees of heavy metal and hydrocarbon pollution as a result of dredging, crude oil exploration and other industrial activities of man (Agbozu *et al.,* 2007, Ohimain *et al.* 2008). Iron with a mean concentration of 25.68mg/kg, had the highest concentration in tissues of *E. radiata.* Though this was below the world standard set by WHO/FAO (1984), it was remarkably high and this may probably be due to the fact that iron occurs at high levels in Nigeria's soil and sediments (Asaolu and Olaofe, 2004). Variation in concentration among the heavy metals shows that December, January and February had the highest monthly variation. Lead and cadmium exceeded the set limits of heavy metal concentrations (WHO/FAO, 1984).

The variation that existed between the heavy metals and the dry weight of *E. radiata* can be attributed to the fact that the different metals have different rate of absorption in the tissues of *E. radiata* (Wang, 2001) and that metals have different sources of entery into the water body and consequently bioaccumulating in the clam (Agbozu and Ekweozor, 2001). Mercury, lead, nickel, chromium and iron which indicated positive regression means that as the weight of *E. radiata* increases there is a proportional increase in the amount of these heavy metals in the tissues of *E. radiata.* This indicates an increase in bioaccumulation over time and that *E. radiata* is not able to discharge or pass out the heavy metals from its body (Das *et al*., 2007). Copper, Manganese, Arsenic and Cadmium indicated negative regression and this shows that as the weight of *E. radiata* increases the amount of these heavy metals in the tissues of *E. radiata* is reduced. Bryan *et al.* (1980) had a similar observation for *Scrobicularia plana*, Amiard *et al.* (1986) for *Mytilus edulis* and Udoidiong and Akpan (1991) for *E. radiate* attributing these to gonadal development which led to dilution of heavy metals in tissues of shellfish. Heavy metal concentration in *E. radiata* reduced as rainfall increased. Variability of heavy metal concentrations in shellfish has been observed to be affected by environmental factors especially rainfall which leads to dilution of the water bodies, hence lowering the concentrations of metals in the clams (Kanakaraju *et al.,* 2008, Olomukoro and Azubuike, 2009). Also, in the rainy season more water is available to the clam for respiration and filter feeding which allows the clam to give off some of the accumulated heavy metals via diffusion (depuration).

This study has shown that *E. radiata* from McIver Market, during the period of study accumulated some heavy metals of which lead and cadmium had levels higher than the WHO/FAO recommended limits. There is a need for constant monitoring of shellfish sold in McIver market to ascertain their safety levels before consumption

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