Human health risk assessment of metal contamination through consumption of *Sesarmaangolense* and *Macrobrachiummacrobrachion* from Benin River, Nigeria

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ABSTRACT

Human health risk assessment of heavy metal contamination through consumption of shrimps (Macrobrachiummacrobrachion) and crabs (Sesarmaangolense) from Benin River (Southern Nigeria) was studied. Assessment of heavy metal concentrations was conducted in surface water, sediment and whole tissues of fauna using Atomic Absorption Spectrophotometer. Mean heavy metal concentrations for Cu, Cd, V,Pb and Ni in surface water were 0.04, 0.01, 0.02, 0.02, 0.06 mg/L while in sediment, concentrations were 0.08, 0.02, 0.04, 0.06, 0.12 mg/kg. Mean bioaccumulationlevels of heavy metals inshrimp were 3.43, 1.12, 1.79, 1.30, and 6.17 mg/kg respectively while in crab Cu, Cd, V, Pb and Ni had mean values of 2.26, 0.74, 1.92, 0.86 and 4.05 mg/kg. Target hazard quotients (THQs) for Cu, Cd, V,Pb and Ni in shrimp were 0.2720, 0.3520, 0.5626, 0.1135, 0.0970, and incrab, THQs were 0.0178, 0.2326,0.6034, 0.0751, 0.0636.The total THQ (TTHQ) which measures the aggregated risk due to heavy metal uptake via the ingestion of M. macrobrachion and S.angolense were 1.1521 and 0.9925 respectively. TTHQ values in M. macrobrachion were greater than 1, indicating risk to human health from consumption of M. macrobrachion. TTHQ in S.angolense was less than unity, suggesting that the consumption of the crab is unlikely to cause any adverse health effects to consumers.

Keywords: Shrimp; Crab; Hazard; Aquatic; Bioaccumulation

1.0 INTRODUCTION

Heavy metal pollution is a worldwide environmental problem (Wang et al. (2010).Aquatic systems may be contaminated with heavy metals released from industrial and agricultural activities (Ezemonye and Enuneku 2012).Heavy metals are easily transported and accumulated in the environment. They arrive in aquatic ecosystem as dissolved and solid wastes from domestic, industrial and agricultural run offs. (Megateli (2009).Rivers are used as a source of drinking water for humans and considered as a sink for waste. Undoubtedly, a riverine aquatic environment suffers the consequences of domestic and industrial activities occurring in its watershed (Taweel*et al*., 2013). In Nigeria, environmental management practices are inefficient due to poor infrastructure and lack of environmental protection awareness (Ihedioha and Okoye 2012).

In the aquatic environment, heavy metals are easily taken up by aquatic organisms where they are strongly bound with sulfhydryl groups of proteins and accumulate in their tissues. The accumulation of heavy metals in the tissues of organisms can result in chronic illness and cause potential damage to the population (Amirah*et al*., 2013). Heavy metal intake by aquatic organisms in a polluted aquatic environment is dependent on ecological requirements, metabolism and other factors such as salinity, water pollution level, food and sediment. All heavy metals are potentially harmful to most organisms at some level of exposure and absorption (Yilmaz, 2003).

Human exposure to toxic metals has become a major health risk (Yabe *et al.* 2013). Seafood consumption has been reported as an important route of human exposure to a variety of chemical contaminants (Usero*et al* 2003). Heavy metals deserve special attention as they represent a group of highly toxic substances accumulating in the tissues of aquatic organisms and being conveyed through the food chain to human.

Several methods have been proposed for the assessment of the potential health risks from chemical exposure. Current non-cancer risk assessment methods are typically based on the use of target hazard quotient (THQ). THQ is a ratio between the estimated dose of a contaminant and the reference dose below which there will not be any appreciable risk (US EPA 2000). If the ratio is greater than 1, there may be concern for potential health. This method of risk estimation has been used by Wang *et al*., (2005) and Amirah*et al*., (2013) and has been shown to be valid and useful.

2.0 MATERIALS AND METHODS

2.1 Study site

The study area was selected due to rapid growth and development. It comprises residential, commercial, oil and gas industry, small and medium enterprises (SME) industry and logging.

The Benin River (figure 1) is located in the coastal belt of Southern Nigeria at theWestern boundary of the upper Delta and the lowlands. This River drains the major rivers Ethiope, Ossiamo, Osse and Siluko into the Atlantic Ocean. It is approximately 93 km long withaverage width of 3.0 and 1.4 km in its downstream andupstream section, respectively. It is an important channel for small ships and other watercrafts like speed boat, yacht and canoe. Three distinct longitudinal zones can be recognized in this river; the upper freshwater zone, the middle transitional zone with salinity fluctuations and the lower coastal zone which is predominately saline. The predominant vegetations at the shed include *Pandanus candelabrum; Elaeisguineensis; Nymphaea lotus; Salvinianymphellula; Echinochloapyramidalis; Pistiastratiotes; Azollaafricana.*

Samples of water for characterization of heavy metal concentrations were obtained from three stations designated along stretch of Benin River at Koko town, north central part of Delta State (Latitudes $05^0$59'43.6" – $05^0$59'35.7"N; Longitude $005^0$28'06.7"- $005^0$25'56.2"E). Samples of *M.macrobrachion* were collected within these designated stations. Along this stretch is located bitumen blending plant belonging to Total Nig. Ltd, facilities of Optima petroleum company and watercraft maintenance workshop.

2.2 Field sampling

The sampling period spanned from January, 2013 to June, 2013.Water samples for heavy metal determination were collected in acid washed polyethylene bottles at three different locations within the sampled stretch. The bottles were rinsed thoroughly with deionised water after washing with dilute nitric acid (HNO_3). In the field the bottles were rinsed several times with the river water and 1 litre sample was then collected at about 50 cm below the water surface. The water samples were acidified with concentrated nitric acid for preservation.

Samples of sediment for characterization of heavy metal concentrations were obtained by the aid of Eckmans grab.

Specimens of *M. macrobrachion* were collected at low tide regime using woven cylindrical traps with non-return valve. They were collected from a single fisherman in order to assure regularity in fishing methodsThe samples were put in pre-cleaned polythene bagsand preserved in ice chest at -4^{o}C and transferred immediately to the laboratory for analysis.

2.3 Sample preparation and metal analysis

In the laboratory prior to drying in an oven at 105℃, weights of *M. macrobrachium* and *S. angolense* samples were measured with the aid of electronic balance. Two grams of dried homogenised sample of each tissue was digested in 15 ml hydrochloric acid, 5ml nitric acid, and 5ml perchloric acid (3:1:1) solution and heated in a digester until brown fumes were expelled, tissues dissolved completely and a colourless solution obtained. The flask and its contents were allowed to cool and thereafter the digested sample was made up to 50ml with distilled water (Raghuramulu*et al.* 2003.Surface water, sediment, crab and fish samples were analysed for Cu, Cd, V, Pb and Ni using Atomic Absorption Spectrometry PG 550.

2.4 Quality control analysis

The equipment (AAS) was first calibrated using certified reference standard (SRM 1570) of the National Institute of Standards and Technology for the respective heavy metals to obtain calibration curve with the equation R^2=99.7. Reagent blank was run at intervals of every five samples analysis to eliminate equipment drift. All samples were analyzed in duplicates for reproducibility accurate checks and precision.

2.5 Target Hazard Quotient

The method for the determination of THQ was provided in the United States EPA Region III Risk based concentration table (US EPA 1989). The dose calculations were carried out using standard assumptions from an integrated United States EPA risk analysis.

Assumptions for the health risk calculations are;

1. Ingested dose is equal to the absorbed pollutant dose (USEPA 1989).
2. Cooking has no effect on the pollutants (Cooper *et al*., 1991).
3. The average body weight of a Nigerian is assumed to be 70 kg
4. Average lifetime of a Nigerian is 52 years.

THQ is determined by the following equation

$$THQ = \frac{Efr \times EDtot \times FIR \times C}{RfDo \times BWa \times ATn} \times 10^{-3}$$

Where EFr is exposure frequency (365 days/year); EDtot is the exposure duration 52 years, average lifetime); FIR is the food ingestion rate (g/day); C is the heavy metal concentration in crab/shrimp (µg/g);

RfDo is the oral reference dose (mg/kg/day). BWa is the average adult body weight (70 kg) and ATn is the averaging exposure time for non carcinogens (365 days/year × number of exposure years assuming 52 years).
Since exposure to two or more pollutants may result in additive and/or interactive effects, total THQ in this study is treated as the arithmetic sum of the individual metal THQ values, derived by the method of Chien*et al.* (2002).

2.6 Statistical Analysis
Inter station comparisons were carried out to test for significant differences in the concentration of the heavy metals in the sediment samples using parametric analysis of variance (ANOVA). If significant value ($P<0.05$) were obtained in the ANOVA, Duncan multiple range test was performed to determine the location of significant differences.

3.0 RESULTS
Various heavy metals characterized in the surface water samples are summarized in table 1. With the exception of Cd and Pb, the concentrations of the heavy metals showed no significant difference ($p>0.05$) among the three designated stations water samples were collected. At average, the concentrations of heavy metal in the surface water samples were Cu: 0.04 mg/l; Cd: 0.01 mg/l; V: 0.02 mg/l;Pb: 0.02 mg/l and Ni: 0.06 mg/l. Furthermore the concentrations of these heavy metals followed the decreasing order of Ni > Cu >Pb = V > Cd (fig. 2).
Spatial variation in heavy metal concentrations of sediment samples is shown in table 2. Recorded concentrations of most analyzed elements were far below the lower limit of FEPA standards. Except for Cd and Ni, other heavy metal concentrations differed insignificantly ($p>0.05$) among the stations. Cadmium was the least accumulated heavy metal at stations 1 and 3 with average concentrations of 0.00 and 0.03 mg/kg respectively. Across the stations, Nickel was the most accumulated metal with an average concentration of 0.11, 0.11 and 0.14 mg/kg at stations 1, 2 and 3 respectively.
Mean heavy metal concentrations in the sediment samples obtained from the three designated stations of Benin River are shown in figure 3.
Table 3 shows the summary of the various heavy metals concentrations in the whole tissue of *M. macrobrachion.* From the table it can be observed that iron and cadmium respectively were the most and least accumulated of heavy metals in the whole tissue of *M. macrobrachion*.
The heavy metal concentrations in the whole tissue of crab obtained from sampled area is as summarized in table 4. The trend of the metals accumulation was Fe> Zn>Mn> Ni> Cr> Cu>Pb> Cd (Table 4).
The oral reference doses for the heavy metals andthe target hazard quotients (THQs) of studied metals through the consumption of shrimps and crabs for residents are shown in table 5.

4.0 DISCUSSION
Various analysed heavy metals were bioaccumulated in the whole tissue of *M.Macrobrachion.*. The order of the magnitude of these heavy metals in the whole tissue of *M.macrobrachion*and *S. angolense*were Ni> Cu>V>Pb> Cd. Cd was the least accumulated heavy metal in both *M macrobrachium* and *S. angolense*.
The range of concentrations of Cu (1.05-4.19mg/kg) in crab and(2.18-4.91 mg/kg)in shrimp recorded in this study is lower than that (860-1620 mg/kg) reported by Anetekhai*et al.* (2007) in a related species *M. vollenhovenii*in Ologe Lagoon, Lagos, Nigeria.
This difference might be due to greater metal load in Ologe Lagoon because of the presence of Agbara Industrial Estate, which discharges its waste into the lagoon (Kusemiju*et al.*, 2001).

Furthermore the ranges of concentrations of Cd (0.34-1.37) and Pb (0.40-1.59) for crab; and Cd (0.71-1.60 mg/kg) andPb (0.82-1.86 mg/kg) for shrimp recorded in this study were high when compared to Cd (0.01 – 0.08 mg/kg) andPb (0.03 - 0.06 mg/kg) documented by Omoigberale and Ikponmwosa-Eweka (2010). These differences are attributable to the prevailing anthropogenic activities going on at these aquatic ecosystems which differed spatially although within the same ecozone. These differences can also be attributed to the chemical composition of bedrock of these rivers.The high Lead concentration in the tissue of this shrimp as recorded in this study may have resulted from wastes generated by industries on its watershed and activities of motorized water craft which dominate the means of transportation therein. Edema and Egborge (1999) documented a similar result in the tissue of *Macrobrachiumvollenhovenii* from Warri River (an aquatic ecosystem with similar anthropogenic activities as in Benin River).

Rantetampang and Mallongi (2013) reported that lead concentrations in water column, sediment, bivalve, pelagic and benthic fishes of Santani Lake, Papua, Indonesia ranged from 0.13 to 1.87mg/l, 1.24 to 3.84mg/kg dw, 0.43 to 2.76 mg/kg ww, 0.27 to 2.78 mg/kg ww and 1.39 to 3.55 mg/kg ww respectively.

The relatively high levels of Cu in *M. macrobrachion*and *S. angolense*can be attributed partly to its function in the respiratory pigment haemocyanin (Van den Broek, 1979) and metalloenzymes (De Silva and Anderson, 1995). Aquatic organisms are known to be selective in metal accumulation due to toxicity effects. According to Hopkin (1989), Decapods regulate their net assimilation of metals, which require 0.07 mg/kg of Zn and 0.08 mg/kg of Cu to activate the enzymes and respiratory proteins.

Levels of heavy metals in aquatic biota are of particular interest because of the potential risk to humans who consume them. Concentrations of Pb and Cd are of health importance in this study. The concentration of these metals in the crab exceeded the FAO/WHO permissible limit for items to be consumed by man (Table 4).

The effects of heavy metals in the environment depend to a large extent on whether they occur in forms that can be taken up by plants or animals. Crabs are bottom feeders and are generally expected to concentrate more metals than surface feeders like prawn which is in agreement with earlier reports.

The results obtained in this study showed that Sesarmid crab *S.angolense* accumulated in varied concentrations the various metals analyzed. Cd and Pb concentrations in the tissue of this crab species is of concern because *Sesarmaangolense* is both a source of income and nutrition for populations within and outside this area. Consumption of food contaminated by these metals can serve asmain source of heavy metal intake inpeople not occupationally exposed. *Sesarmaangolense* from Benin River in Southern Nigeria is unsafe for consumption. This calls for an urgent action against any activity that brings about the release of Pb and Cd into this environment.

The THQ values for shrimp and crab were both in the order V>Cd>Pb>Ni>Cu. The highest THQ values were for Vanadium with the values 0.6034 and 0.5626 for crab and shrimp respectively.The least THQ values were for Cu with values 0.0270 and 0.0178 for shrimp and crab respectively. Vanadium was the major risk contributor while Cu was the least for both organisms studied. The THQ of each metal studied from this research is less than 1 which shows that people will not experience significant health risk from the consumption of individual metals through contaminated shrimp or crab from the river.

CONCLUSION

The shrimp (*M. macrobrachion*)and crab (*S. angolense*)bioaccumulated heavy metals.Ni had the highest mean bioaccumulation of 6.17 and 4.05 mg/kg in the shrimp and crab respectively for the stations studied. Cd was the least accumulated heavy metal in both *M macrobrachium* and *S. angolense*.

THQ of each metal studied from this research is less than 1 which shows that people will not experience significant health risk from the consumption of individual metals through contaminated shrimp or crab from the river. However, results from the study showed that TTHQ values in *M. macrobrachion* were greater than 1, indicating risk to human health from consumption of *M. macrobrachion.* TTHQ in*S. angolense* was less than unity, suggesting that the consumption of the crab by residents is unlikely to cause any adverse health effects to consumers.

REFERENCES

Amirah, M.N., Afiza, A.S., Faizal , W.I.W., Nurliyana, M.H., Laili, S. (2013). Human health risk assessment of metal contamination through consumption of fish.*J. Environ. Polut. Hum. Hlth*, 1(1): 1-5.

Anetekhai, M. A., Akin-Oriola, G. A., Aderinola, O. J. and Akintola, S. L. (2007). Trace metal concentration in *Macrobrachiumvollenhovenii*from Ologe Lagoon, Lagos, Nigeria. *J. Afrotrop. Zool., Special Issue*, 25-29.

Chien, L.C., Hung, T.C., Choang, K.Y., Yeh, C.Y., Meng, P.J., Shieh, M.J., Han, B.C (2002). Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. *Sci. Total Environ*, 285: 177-185.

Cooper , C.B., Doyle, M.E., Kipp, K. (1991). Risk of consumption of contaminated seafood, the Quincy Bay case study.*Environ. Hlth. Perspect*. 90: 133-140.

De Silva, S.S. and Anderson, T.A. (1995): Fish nutrition in Aquaculture. 1st ed. London.Chapman & Hall.

Edema, U. and Egborge, A. B. M. (1999). Heavy metal content of *Macrobrachim*sp. (Crustacea: Palaemonidae) from Warri River, Nigeria. *Trop. J. Environ. Sci. Hlth*2(1), 65-70.

Ezemonye, L.I., Enuneku, A.A. (2012). Hepatic bioaccumulationm of cadmium in the crowned bullfrog, Hoplobatrachusoccipitalis and flat backed toad, *Bufomaculatus.Int. J. AquatSci*, 3(1): 15-22.

FAO (Food and Agriculture Organization) (1983).Compilation of legal limits for hazardous substances in fish and fishery products, FAO Fishery Circular No. 464, pp. 5–100.

FAO/WHO (1989).Evaluation of certain food additives and the contaminants mercury, lead and cadmium, WHO Technical Report, Series No. 505.

FEPA (1991).Guidelines and Standards for Environmental Pollution Control in Nigeria.Federal Environmental Protection Agency (FEPA) Nigeria.

Ihedioha, J.N., Okoye, C.O. (2012). Cadmium and lead levels in muscle and edible offal of cow reared in Nigeria. *Bull. Env.Contam.Toxicol*., 88: 422-427.

Kusemiju, V., Fadiya, A. A. Aderinola, O. J. and Akintola, S. L. (2001).Comparative analysis of heavy metals in water, sediments and tissues of *Lumbricusviolaceus*from Agbara and Iba streams.*Nig. J. Res. Rev. Sci*., 2, 114-117.

Megateli, S., Semsari, S., Couderchet, M. (2009).Toxicity of heavy metals (Cd, Cu and Zn) by *Lemma gibba.Ecotoxicol. Environ Saf.* 72: 1774-1780.

Rantetampang, A.L., Mallongi, A (2013). Lead contamination and its potential risks due to seafood consumption from Sentani Lake, Papua, Indonesia. *Int.J.Sci Res Publ*. 3(10): 1-6.

Taweel, A., Shuhalmi-Othman, M., Ahmad., A.K. (2013). Assessment of heavy metals in tilapia fish (oreochromisniloticus) from Langat River and Engineering lake in Bangi, Malaysia and evaluation of health risk from tilapia consumption. *Ecotoxicol. Environ. Saf.* 93: 45-51.

USEPA (1986).Quality Criteria for Water.EPA-440/5-86-001, Office of Water Regulations Standards, Washington DC, USA.

US EPA (1989).Risk assessment guidance for superfund. In: Human Health Evaluation Manual (Part A), Interim Final, vol 1. Office of Emergency and Remedial Response, US Environmental Protection Agency, Washington DC.

US EPA (2000). Risk based concentration table. Philadelphia PA: United States Environmental Protection Agency, Washington DC.

Usero, J., Izquierdo, C., Morillo, J., Gracia, I. (2003). Heavy metals in fish (*Solea vulgaris*, *Anguilla Anguilla* and *Liza aurata*) from salt marshes on the southern atlantic coast of Spain. *Environ. Int.* 29: 949-956.

Van de Brock, W. L. F. (1979). Seasonal levels of chlorinated hydrocarbons and heavy metals in fish and brown shrimps from the Medway Estuary Kent. *Environ. Pollut*. 19: 21-28.

Wang, X.L., Sato, T., Xing, B.S., Tao, S (2005).Health risk of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish.*Sci. Tot. Environ.* 350: 28-37.

Wang, J., Shang, C., Xia, T. (2010).Environmental risk assessment of heavy metals in Bohai Sea, North China.*Proc. Environ. Sci.* 2: 1632-1642.

Yabe, J., Nakayama S.M.M., Ikenaka, Y., Muzandu, K., Choongo, K., Mainda, G., Kabeta, M., Ishizuka, M., Umemura, T. (2013).Metal distribution in tissues of free ranging chickens near a lead-zinc mine in Kabwe, Zambia.*Environ. Toxicol.Chem.*32(1): 189-192.

Yilmaz, A.B. (2003). Levels of some heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in the tissue of *Mugilcephalus* and *Trachurusmediterraneus* from Iskenderun Bay, Turkey.*Environ. Res.* 92: 277-281.

FIGURES AND TABLES

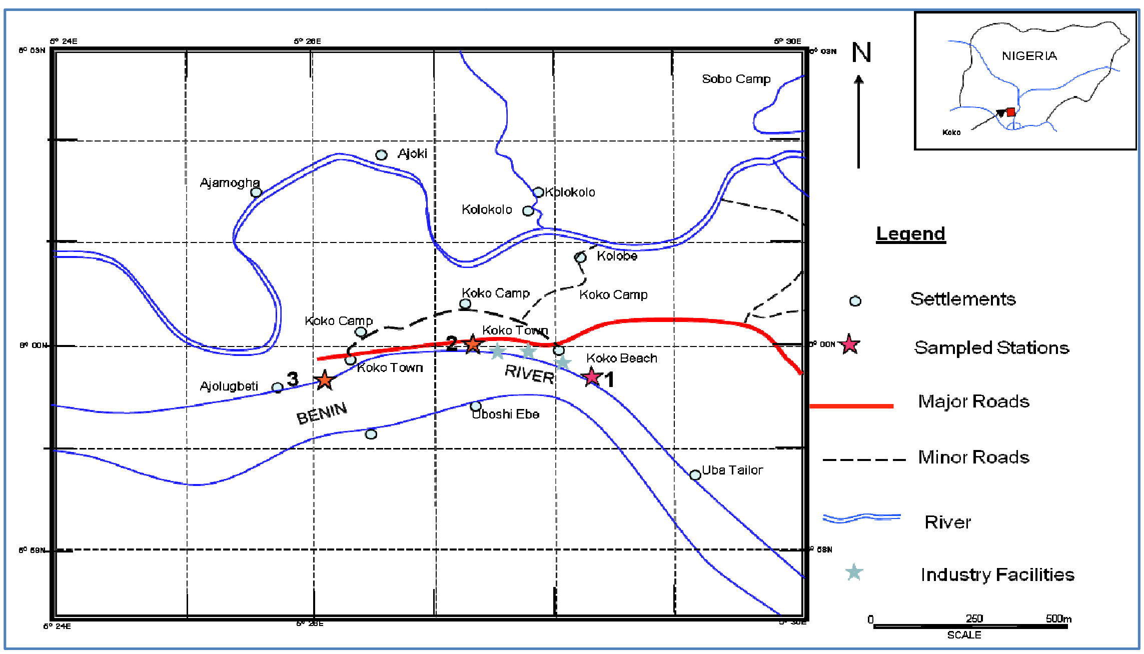

Figure 1: Map showing Sampled Stations

Table 1: Spatial variation in heavy metal concentrations ofsuface water samples.

Parameters	Station 1	Station 2	Station 3	Average	FEPA Permissible Limits
	X̄±SD	X̄±SD	X̄±SD		
Copper	0.03±0.01	0.04±0.01	0.04±0.01	0.04±0.01	0.10
Cadmium	0.00±0.00*	0.02±0.00	0.01±0.01	0.01±0.01	0.01
Vanadium	0.02±0.00	0.02±0.01	0.02±0.01	0.02±0.01	0.01
Lead	0.00±0.00*	0.03±0.01	0.03±0.01	0.02±0.02	0.05
Nickel	0.05±0.01	0.06±0.02	0.07±0.02	0.06±0.02	0.05

Heavy metal concentrations in the water were measured in mg/l; (*) - Significantly different ($p<0.05$).

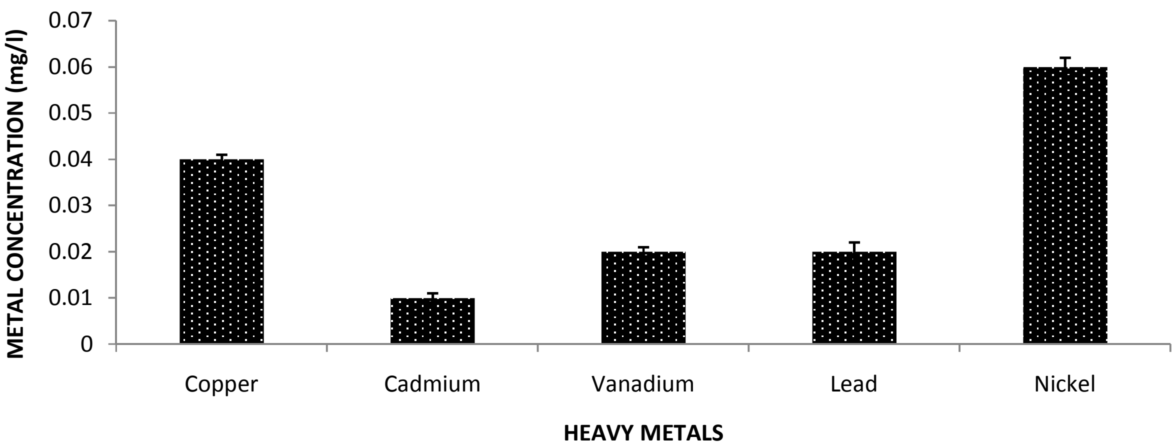

Figure 2: Mean heavy metal concentrations in the surface water samples from the three designated stations in Benin River.

Table 2: Spatial variation in heavy metal concentrations of sediment samples.

Heavy Metal	STATION 1 X̄±SD	STATION 2 X̄±SD	STATION 3 X̄±SD	p-Value	Average	FEPA Limits
Copper	0.06±0.01	0.08±0.01	0.08±0.02	p>0.05	0.08±0.02	36-190
Cadmium	0.00±0.00 [c]	0.03±0.00 [a]	0.03±0.01 [b]	P<0.01	0.02±0.02	0.8-12
Vanadium	0.04±0.01	0.04±0.00	0.04±0.01	p>0.05	0.04±0.01	
Lead	0.05±0.01	0.06±0.00	0.06±0.01	p>0.05	0.06±0.01	85-530
Nickel	0.11±0.01 [b]	0.11±0.01 [b]	0.14±0.03 [a]	p<0.05	0.12±0.02	35-210

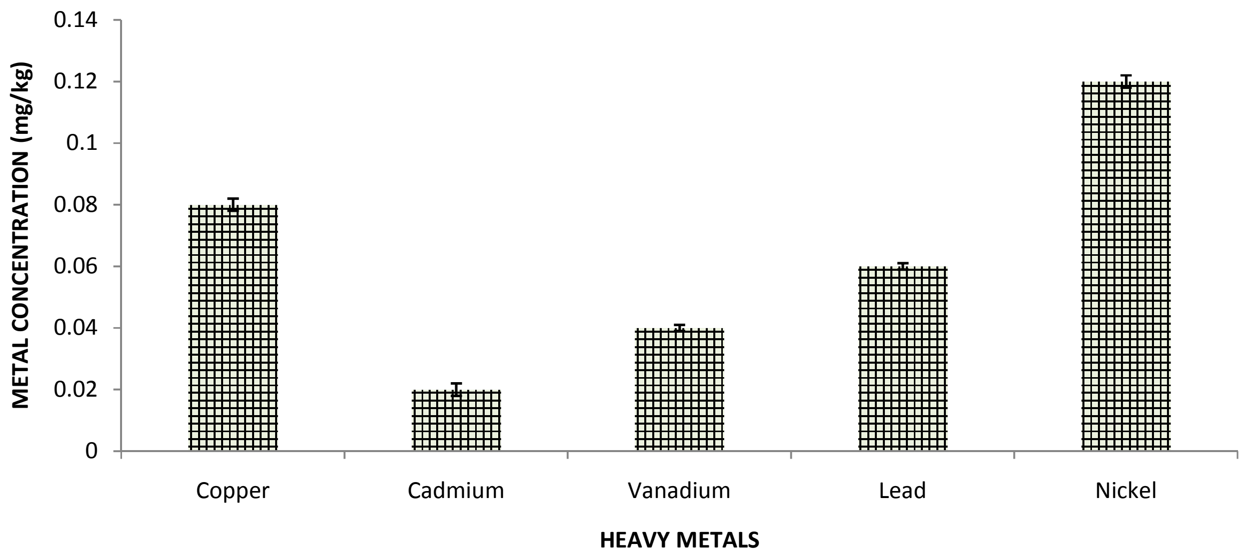

Figure 3: Mean heavy metal concentrations in sediment samples from the three designated stations in Benin River.

Table 3: Heavy metal concentrations in the whole tissue of *M. macrobrachion.*

Heavy metals	Bioaccumulation X̅±SD	Min- Max	FAO, 1983	WHO/FAO 1989
Cu	3.43±1.07	2.18-4.91	30	30
Cd	1.12±0.35	0.71-1.60	0.5	0.5
V	1.79±0.56	1.13-2.55	-	-
Pb	1.30±0.41	0.82-1.86	0.5	0.5
Ni	6.17±1.92	3.91-8.81	-	-

Mean heavy metal concentrations in *M. macrobrachion*were measured in mg/kg.

Table 5: THQs of the studied heavy metals in shrimp and crab

Element	Concentration In shrimp	Concentration in crab	RfDo	THQ (Shrimp)	THQ (Crab)
Cu	3.43	2.26	0.04	0.0270	0.0178
Cd	1.12	0.74	0.001	0.3520	0.2326
V	1.79	1.92	0.001	0.5626	0.6034
Pb	1.30	0.86	0.0036	0.1135	0.0751
Ni	6.17	4.05	0.02	0.0970	0.0636
			TTHQ	1.1521	0.9925

Table 4: Heavy metal concentrations in the whole tissue of *S. angolense.*

	Bioaccumulation			
	$\overline{x}$±SD	Range	FAO, 1983	WHO/FAO, 1989
Cu	2.26±1.15	1.05-4.19	30	30
Cd	0.74±0.38	0.34-1.37	-	0.5
V	1.92±0.98	0.89-3.56	-	-
Pb	0.86±0.44	0.40-1.59	0.5	0.5
Ni	4.05±2.07	1.88-7.52	-	-

Mean heavy metal concentrations in *Sesarmaangolense*were measured in mg/kg.