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HEAVY METAL CONTAMINATION IN SURFACE WATER AND MACROBRACHIUM TISSUES ALONG EAGLE ISLAND, NIGER DELTA, NIGERIA

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ABSTRACT

This study evaluated the level of selected heavy metals in the surface water and macrobrachium along Eagle Island, Bonny Estuary. Triplicate samples were collected from four locations for six months (May-October 2021). Samples were processed and analysed for heavy metals according to standards. The result showed that the concentration of heavy metals (chromium: Cr, lead: Pb, nickel: Ni and zinc: Zn) in water from the four studied locations had similar mean values of 0.001±0.00. Meanwhile, there was a significant variation in the level of heavy metals in macrobrachium in all the locations. The mean Cr value of 0.15±0.46 mg/kg, 0.001±0.00 mg/kg, 0.01±0.00 mg/kg and 0.03±0.05 mg/kg was observed. For Pb, 0.09±0.00 mg/kg, 2.15±0.03 mg/kg, 0.05±0.00 mg/kg and 0.003±0.00 mg/kg were recorded. For Ni, 0.23±0.01 mg/kg, 0.01±0.00 mg/kg, 0.08±0.00 mg/kg and 0.00±0.00 mg/kg were obtained. For Zn, 2.11±0.01 mg/kg, 2.06±0.00 mg/kg, 0.46±0.30 mg/kg and 0.00±0.00 mg/kg were recorded, respectively, from Eagle Island - UST Bar gate, Mgboshimili, Ogbogolo and Rumueme. The concentration of heavy metals in water fell below WHO and FEPA limits for drinking water. In contrast, some heavy metal levels in macrobrachium from Eagle Island exceeded the regulatory limits set by WHO. The observed increase in these heavy metals may be due to oil bunkering activities within the creeks. Thus, the level of some heavy metals in macrobrachium from water bodies (Station I and II) pose a concern as it may cause some health risks and implications for man, who is the final consumer.

KEYWORDS: concentration, creek, oil, pollutants, shrimps.

INTRODUCTION

Water is a universal solvent that dissolves various organic and inorganic chemical and environmental pollutants. Among the inorganic-organic of river water, heavy metals are seen as the most important form of pollution in the aquatic environment due to their toxicity and accumulation by aquatic organisms (Madhuri *et al*., 2012). The elements can cause serious histological alterations in the tissues of marine organisms such as fish and shrimps (Ahmed *et al*., 2014).

Fishes and other aquatic animals living in polluted waters tend to accumulate heavy metals on several factors such as metal concentration, duration of exposure, means of metal uptake, and environmental intrinsic factors such as fish age, feeding rate and habitat (Caeiro *et al*., 2005). The productivity of a given body of water is determined by its physical, chemical, and biological properties. The environmental properties of water need to be conducive for aquaculture and especially for fish to grow well.

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However, an ideal water condition is necessary for the survival of fish since the entire life process of fish is wholly dependent on the quality of its habitat (Mustapha, 2008).

In the Niger Delta region, heavy metal levels have increased over the past decade due to domestic, industrial, mining and agricultural practices (Kaoud, 2015); wastes released from these various activities are discharged into the marine environment, which results in extensive ecological differences, due to their level of toxicity persistence and accumulative behaviour in the organism that dwell in the marine ecosystem (Indrajit *et al*., 2011). Among environmental contaminants, metals are of particular concern due to their toxic effect and bioaccumulation ability in marine environments (Censis *et al*., 2016).

Several studies have been carried out on the concentration of heavy metals from various water systems in Rivers State, particularly river Iwofe (Akankali and Davies, 2020), Azuabie Creek (Akankali and Davies, 2021; Daka *et al*., 2008), New Calabar River (Nwineewi *et al*., 2019). Hence, this study seeks to investigate the levels of heavy metals in surface water and macrobrachium along Eagle Island, Bonny Estuary.

MATERIALS AND METHODS

Description of the study area

The study was conducted along Eagle Island, Bonny Estuary, in Port Harcourt, Rivers State (Figure 1). It lies within latitudes 4° 47’ 10.2” to 4° 47’ 21.8” N and longitudes 6° 53’ 33.55” to 6° 58’ 31.3” E. The climatic condition is tropical, with two distinct seasons: wet (March - October) and dry season (November - February). The vegetation is characterised by red mangrove (*Rhizophora racemore*), white mangrove (*Avicennia africana*), black mangrove (*Laguncularia racemose*) and other plants such as fern: *Achrostichum aureum* and grass: *Paspalum varginatum* (Ngah *et al*., 2017). Anthropogenic activities such as fishing, dredging, oil bunkering, construction and maintenance of speed boats and discharge of domestic waste are ongoing in this region. Three sampling stations were chosen along the study area, as indicated in Figure 1.

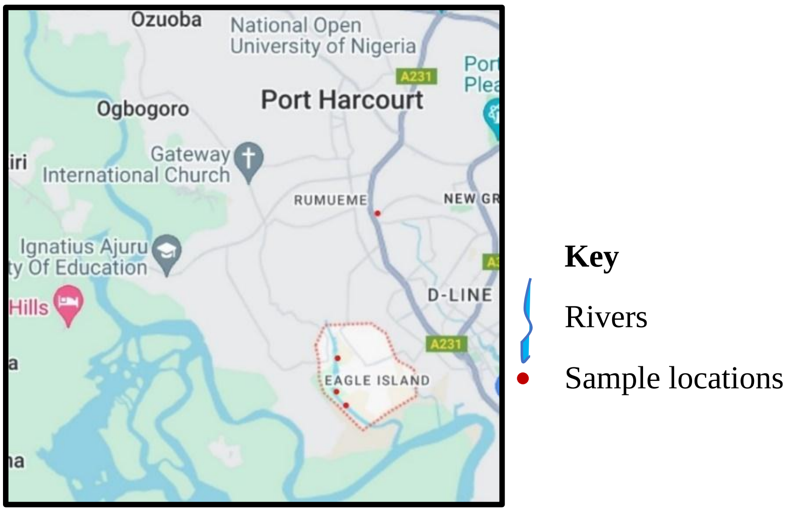

Figure 1. Map of the study area showing sampling stations

Sample collection

Triplicate samples of water and macrobrachium were collected from three stations (upstream, downstream, and middle stream) on Eagle Island (UST Bar gate, Mgboshimili, Ogbogolo), and a control sample was collected from Rumueme. Sampling was carried out in six months (May – October 2021). Water samples were collected in clean 2-litre capacity plastic bottles at 20 cm depth beneath the water surface according to the standard method (APHA, 2005). Prior to their use, the bottles were washed and rinsed with deionised water. Samples of *macrobrachium* spp. were cut using a barrier trap (non-return valve) and stored in a well-labelled plastic container before taking to the laboratory.

Sample preparation and analysis

In the laboratory, water samples were acidified with nitric acid (HNO_3) and preserved following standard methods for heavy metal analysis as described in APHA 3110, using the flame Atomic Absorption Spectrophotometer (AAS, Buck Scientific Model-210). The *macrobrachium* spp. Samples were digested using nitric acid, and then an atomic absorption spectrometer was first calibrated (using the standard solution) for the different metals of interest: zinc, chromium, lead, and nickel.

Statistical analysis

Analysis of variance was employed to analyse the data using SPSS software version 20.0. The data were expressed as mean ± standard error of the mean. The level of significance was set at $p \leq 0.05$.

RESULT AND DISCUSSION

The results obtained from this study are presented in Table 1 – Table 3, while the graphical representation of variations of each heavy metal concentration is shown in Figure 2 – Figure 9.

Table 1. Comparison of mean levels of heavy metal analysed in the surface water of Eagle Island

Parameters			Stations			
(mg/L)	I	II	III	IV	WHO(2011)	FEPA(2007)
Cr	0.001±0.00	0.001±0.00	0.001±0.00	0.00±0.00	0.05	<1.00
Pb	0.001±0.00	0.001±0.00	0.001±0.00	0.00±0.00	0.01	<1.00
Ni	0.001±0.00	0.001±0.00	0.001±0.00	0.00±0.00	0.02	<1.00
Zn	0.001±0.00	0.001±0.00	0.001±0.00	0.00±0.00	3.00	<1.00

Table 1. shows the heavy metal concentrations in water samples along Eagle Island. The heavy metals (Cr, Pb, Ni, Zn) investigated were relatively low and had mean values of 0.001 ± 0.00 mg/L in all the stations throughout the period of study. Thus, there was no significant variation ($p>0.05$) among the levels of heavy metals in the water samples from the various sampling stations (Station 1, Station 2, Station 3, Station 4). The absence of variation suggests that the difference in anthropogenic activities going in the creek at different locations does not alter the heavy metal concentration in the water.

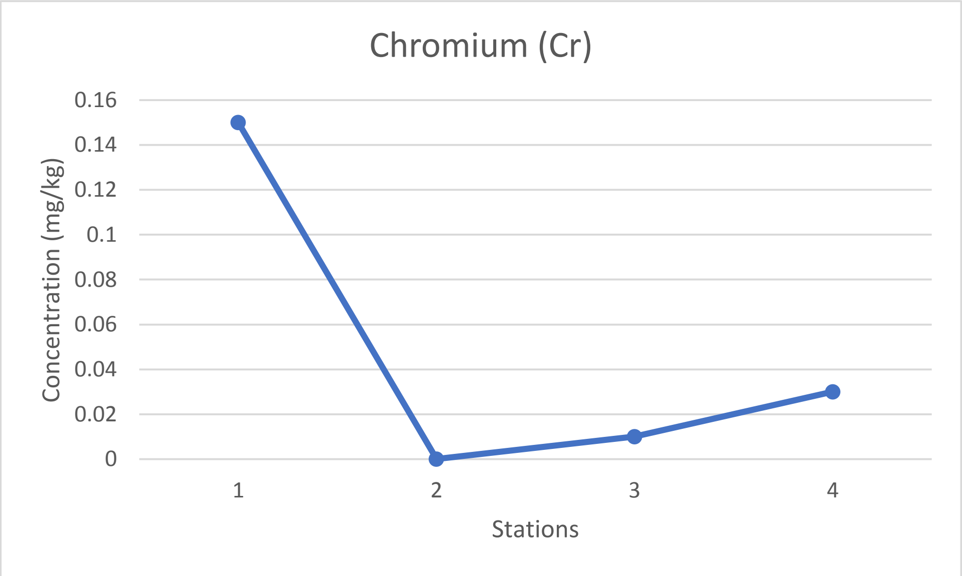

Figure 2. Mean variations in Cr (mg/L) during the study period.

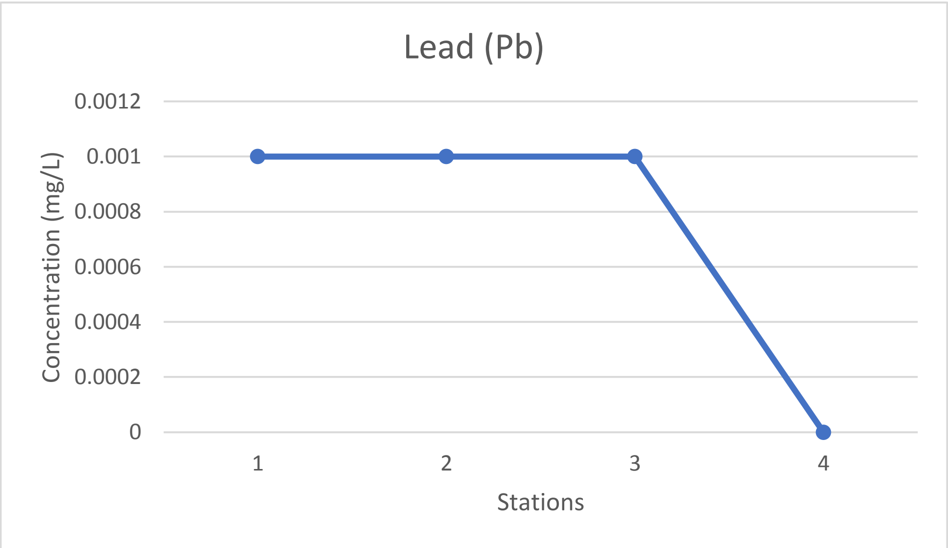

Figure 3. Mean variations in Pb (mg/L) during the study period.

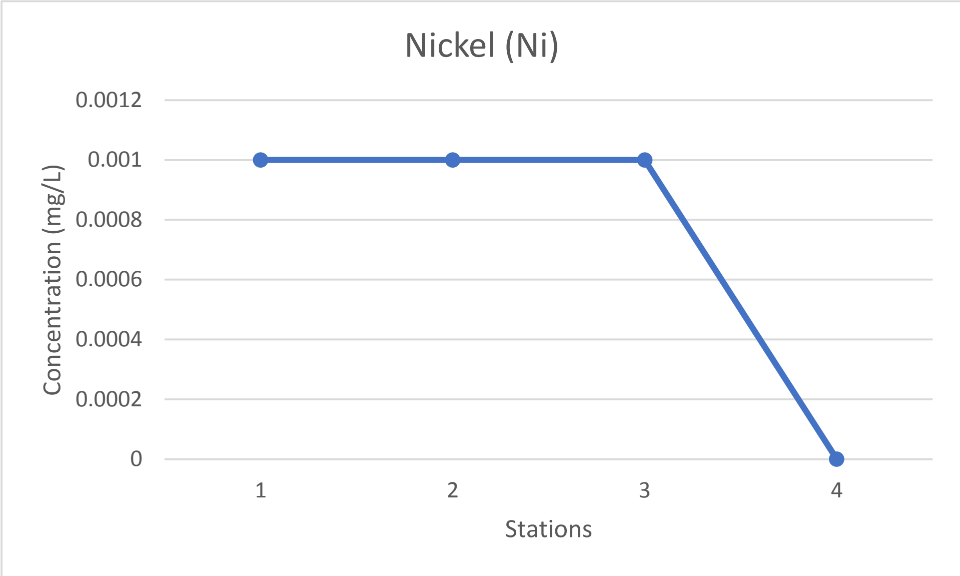

Figure 4. Mean variations in Ni (mg/L) during the study period.

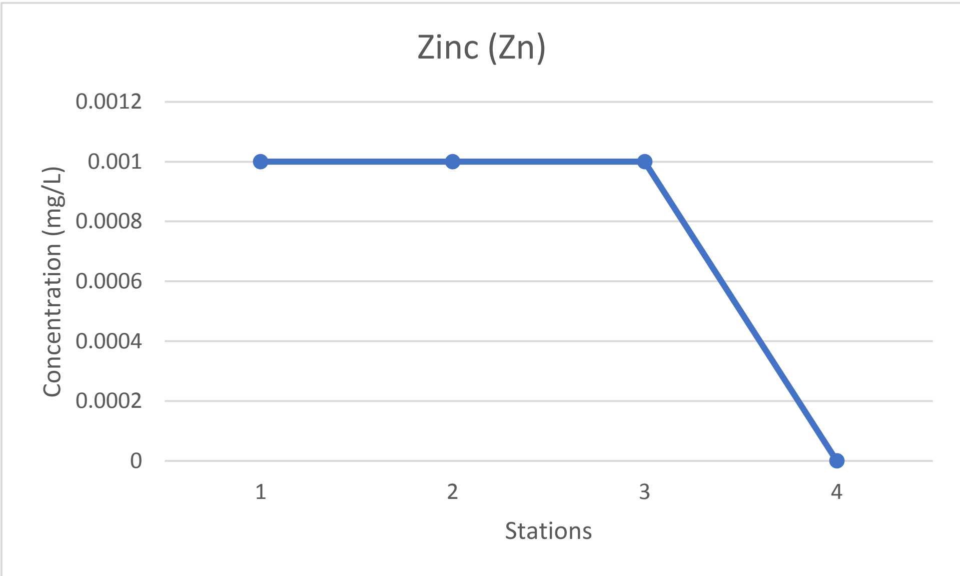

Figure 5. Mean variations in Zn (mg/L) during the study period.

Generally, the concentration of heavy metals in the surface water from the study area is below the level specified for drinking water by the Federal Environmental Protection Agency (FEPA, 2007) and the World Health Organization (WHO, 2011).

Table 2. Comparison of mean levels of heavy metal analysed in macrobrachium samples from Eagle Island

Parameters			**Stations**			
(mg/kg)	**I**	**II**	**III**	**IV**	**WHO(2011)**	**FEPA(2007)**
Cr	0.15±0.46	0.001±0.00	0.01±0.00	0.03±0.05	0.05	<1.00
Pb	0.09±0.00	2.15±0.03	0.05±0.00	0.003±0.00	0.01	<1.00
Ni	0.23±0.01	0.01±0.00	0.08±0.00	0.00±0.00	0.02	<1.00
Zn	2.11±0.01	2.06±0.00	0.46±0.30	0.00±0.00	3.00	<1.00

Table 2 presents the levels of some heavy metals in shrimp tissue along Eagle Island. The heavy metal levels were in the order Pb>Zn>Ni>Cr. The concentration of heavy metals in macrobrachium from the study location shows similarity among the different stations. This could result from similar activities occurring in surface water along the study location.

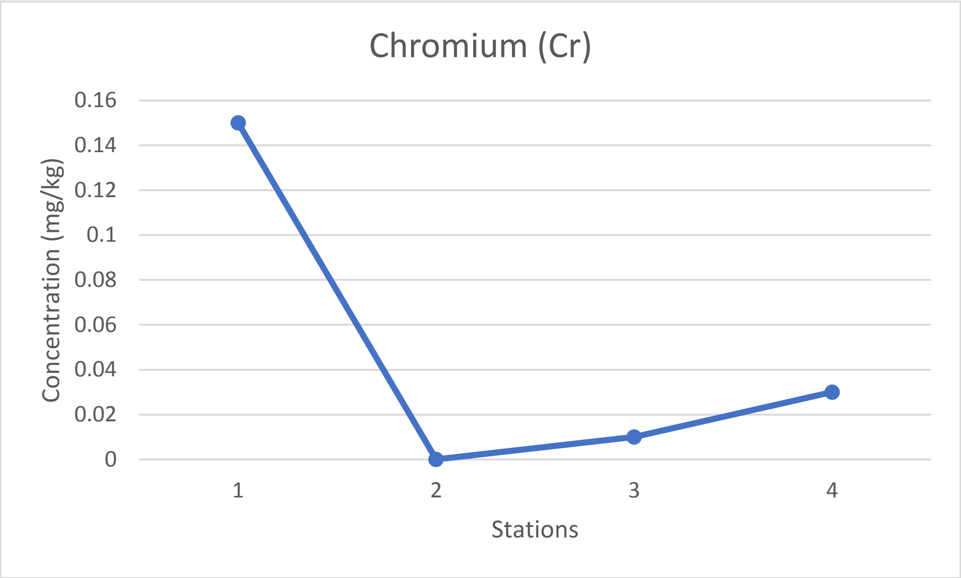

Figure 6. Mean variations in Cr (mg/kg) during the study period.

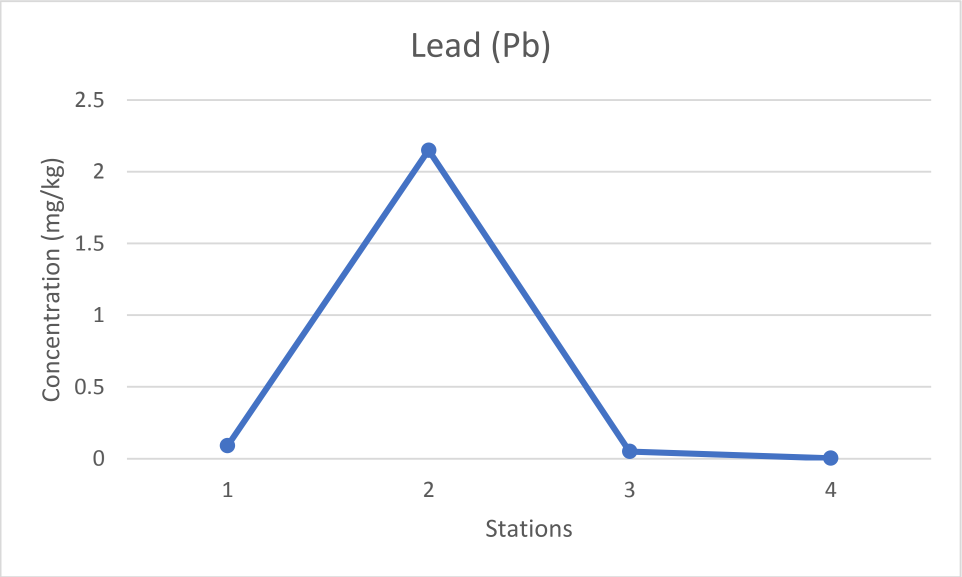

Figure 7. Mean variations in Pb (mg/kg) during the study period.

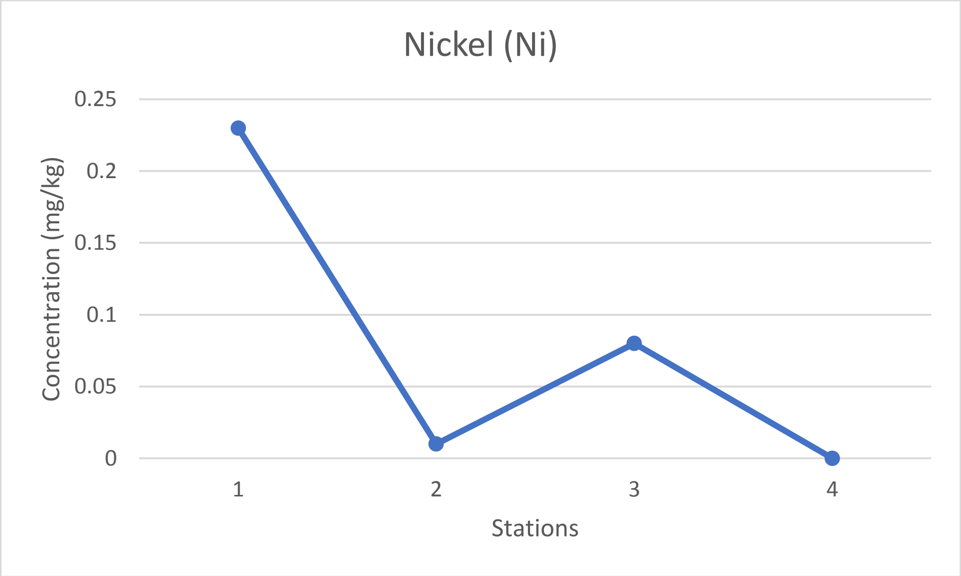

Figure 8. Mean variations in Ni (mg/kg) during the study period.

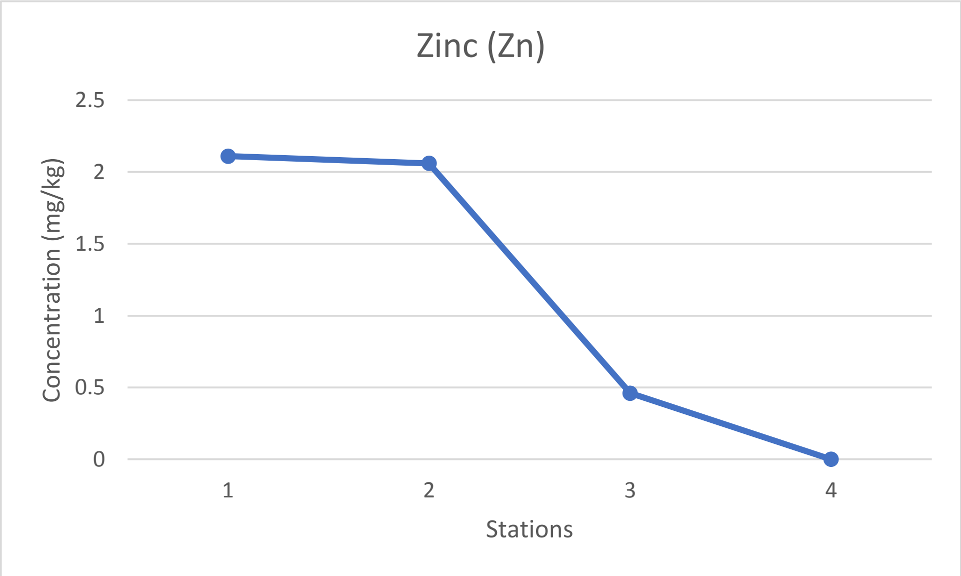

Figure 9. Mean variations in Zn (mg/kg) during the study period.

However, among the metals studied, Pb exhibited the highest mean concentration in the tissues of macrobrachium, with Station 2 recording the highest value at 2.15±0.03 mg/kg. This was followed by Station 1, which recorded a concentration of 0.09±0.00 mg/kg, higher than that observed at other stations. The observed mean (2.15±0.03 mg/kg) from location 2 indicates that it is the most impacted station and also shows a significant variation among locations; concentrations higher than this (9.18±7.18 mg/kg) had earlier been reported by Adedeji and Okocha (2011) in Epe Lagoon, but notwithstanding it is higher than 0.001±0.00 mg/kg by Akankali and Davies (2020) in Iwofe Creek. Zinc (Zn) also had higher metal concentrations in locations 1 and 2. The reason may be associated with the anthropogenic activities within the locations. Nevertheless, the observed mean of 2.06±0.00 mg/kg is low when compared to the concentration of 52.88±4.01 mg/kg reported by Adedeji and Okocha (2011) from Epe Lagoon, Lagos but relatively higher than the 0.64±0.045 µg/g in Ojo rivers Lagos by Olowu and Ayo (2010). Thus, this could result from contaminant loading in the study environment. The observed highest mean of chromium (0.001±0.00 mg/kg) from Station 1 is low compared to the findings of Olowu (2010), who reported 4.06±7.0 µg/g. Nickel's highest value (0.23±0.01 mg/kg) obtained from Station 1 is comparable to the range 0.105 - 0.210 mg/kg reported by Akankali and Davies (2020).

Thus, while the heavy metal concentration in the surface water studied is below the WHO (2011) acceptable tolerable limit for aquatic biota Cr (0.05), Pb (0.01), Ni (0.02), and Zn (3.0) and does not pose any threat to the river for now, the levels of some heavy metals, such as Cr, Pb, and Ni in macrobrachium (shrimps) tissue call for concern and monitoring.

Table 3. Comparison of heavy metal concentration in water and macrobrachium from Eagle Island

Parameters Stations	Cr	Pb	Ni	Zn
W1	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
S1	0.15±0.46	0.09±0.00	0.23±0.01	2.11±0.01
W2	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
S2	0.001±0.00	2.15±0.03	0.01±0.00	2.06±0.00
W3	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
S3	0.01±0.46	0.05±0.00	0.08±0.00	0.46±0.30
W4	0.01±0.00	0.00±0.00	0.00±0.00	0.00±0.00
S4	0.03±0.05	0.03±0.05	0.00±0.00	0.00±0.00

Key: W= water; S= shrimp (macrobrachium); 1, 2, 3, 4 = sample locations

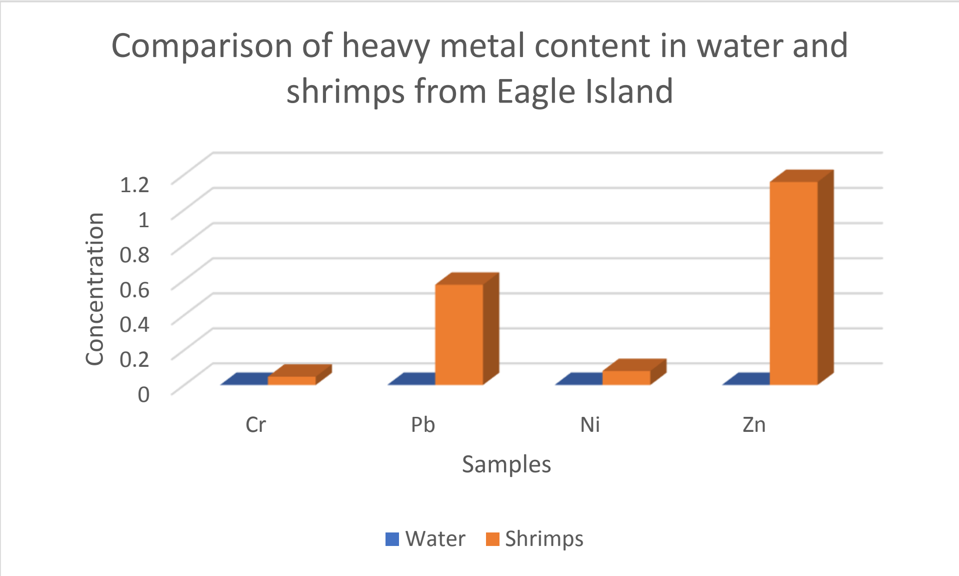

Figure 10. Comparison of heavy metal content in water and macrobrachium from Eagle Island

From Table 3 above, it was shown that Pb obtained higher values in macrobrachium than in water in all the locations, as well as that of Zn and Ni, which were also higher in macrobrachium except in location 4. Chromium obtained a higher value in macrobrachium in location 1, as shown in Table 3. The level of heavy metal concentration observed in macrobrachium, which was more than the level observed in water, could be attributed to the discharged heavy metal components, which are effectively dispersed and incorporated in the body tissue of the organism.

CONCLUSION

For all the metals investigated (Cr, Pb, Ni, & Zn), the levels in surface water were below the recommended limits for aquatic life water quality. In contrast, the levels of some heavy metals in macrobrachium (shrimps) tissue (Cr, Pb, and Ni) were higher than those of regulatory bodies. However, the river may be safe for human consumption and may not pose any serious concern for now. Hence, the levels of heavy metal in macrobrachium obtained from this water body call for concern as it may pose risks to human health, which is the final consumer of this aquatic organism.

RECOMMENDATION

Constant environmental monitoring programmes and research of this nature should be carried out routinely to assess the status of different heavy metals in the marine environment and provide baseline data for risk assessment purposes.

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Conflict of interest

The authors declare that there are no conflicts in the submission and publication of this article.

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