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METALLIC BIOACCUMULATION IN *SESARMA HUZARDII* (DECAPODA: SESARMIDAE) FROM TWO ESTUARINE CREEKS UNDER DIFFERENT ANTHROPOGENIC INFLUENCES

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Abstract

Heavy metals are of particular concern due to their toxicity and bio-accumulation ability in benthic organisms like aquatic crabs. This study analysed heavy metal concentrations in sediment and in species of mangrove crab, *Sesarma huzardii*, from Abule-Agege and Abule-Eledu Creeks by Atomic Absorption Spectrophotometry. The physico-chemical parameters (temperature, transparency, pH, conductivity, salinity and dissolved oxygen) of both creeks were not significantly different ($P > 0.05$). However, significantly higher concentrations of copper (5.08±0.08 mg kg^{-1}), iron (75.36±0.13 mg kg^{-1}) and zinc (14.5±0.11 mg kg^{-1}) were recorded in the sediment of Abule Agege Creek. All examined heavy metals were found in crab samples in varying and sometimes very low but measurable concentrations (except for nickel in Abule-Agege Creek). Bio-sediment accumulation factor (BSAF) of chromium (0.50) was the same in *S. huzardii* collected from both creeks. At the same time, the BSAFs of all other heavy metals were significantly different. The mangrove Crab, *S. huzardii* can be used for environmental monitoring largely because of its heavy metal bioaccumulation potential as a benthic organism.

Introduction

Mangrove ecosystems are found along tropical and subtropical coastlines all over the world, and they serve as nurseries for a range of marine vertebrate and invertebrate species (SANNI et al. 2020). The species of the mangrove crab (Sesarmidae) are amphibious and can be found around intertidal areas with moist/wet muddier regions of the mangrove. They live beneath drift and high tide mark in the estuaries and lagoons. Although these species does not really constitute a food item for the coastal

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communities, they however play a major ecological role in the mangrove ecosystem where they help to clean up the mangrove areas by its feeding habits on the fallen leaves (Onadeko et al. 2015, Moruf and Ojetayo 2017). The species, *Sesarma huzardii* cohabiting with other mangrove crabs such as *Goniopsis pelli* and *Uca tangeri* have been found in swamps of the Lagos Lagoon, distributed up to the tidal limit in the lagoon (Moruf and Lawal-Are 2018, Lawal-Are et al. 2019a, Moruf 2020).

Over the years, several studies have emphasized the enormous threats posed to ecological receptors within the Lagos Lagoon and the adjacent creeks (Usese et al. 2018, Lawal-Are et al. 2021). About 2000 medium and large-scale industries in Lagos State discharge untreated effluents directly or indirectly into the Lagos Lagoon (Uaboi-Egbenni et al. 2010). The Ogun River carries wastes from the hinterland and discharges into the Lagoon. The effluents from Agbara Industrial Estate also drain into Lagos Lagoon through discharge into Ologe Lagoon, which is linked to Lagos Lagoon through Badagry creek (Uaboi-Egbenni et al. 2010). These contaminants have detrimental effects by accumulating in bottom sediments of the mangrove environment and altering its natural status (Bakshi et al. 2018, Moruf et al. 2021).

Aquatic organisms bioaccumulate contaminants such as heavy metals in minute amounts over time, and then get concentrated higher up the food chain (biomagnification). Accumulation of heavy metals begins when the organisms are faced with high concentrations in the surrounding medium; according to Moruf and Akinjogunla (2019), body levels of non-essential metals such as cadmium and lead were not found to be regulated by crustaceans. With respect to Lagos Lagoon, information exists on the occurrence of heavy metals in the muscle tissue and shells of gastropod molluscs (Moruf and Akinjogunla 2018), levels of oxidative stress markers in the mangrove oyster (Usese et al. 2019), and crab responses to environmental stressors (Lawal-Are et al. 2019b). However, comparative data are scarce on heavy metal accumulation in the tissues of mangrove crabs from different creeks adjacent to the Lagos Lagoon. Therefore, this study aimed to investigate and compare metal bioaccumulation in the visceral of the mangrove crab, *S. huzardii* from two estuarine creeks, Abule-Agege and Abule-Eledu, adjacent to the Lagos Lagoon in Lagos, Nigeria.

Materials and Methods

Study site

Two sites with different levels of anthropogenic influences were selected on the coast of Lagos: Abule-Agege and Abule-Eledu Creeks. They form part of the many sluggish tidal creeks that drain into the Lagos Lagoon. Five different study sites (600 m^2 each) located along each creek were surveyed (Figure 1). Each sample location was georeferenced with a Magellan Sport Track global positioning system (GPS) with accuracy of a metre. Abule–Agege Creek is located on Latitude 6°30′53″N and Longitude 3°24′44″E while Abule-Eledu Creek is located on Latitude 6°31′20″N and longitude 3°23′95″E. The creeks are shallow (≤ 1m) and meander through a mangrove swamp inundated at high tide and partially exposed at low tide (Emmanuel and Ogunwenmo 2010, Moruf et al. 2018). The sources of pollution to the sampling stations include solid waste, household waste and refuse dumping.

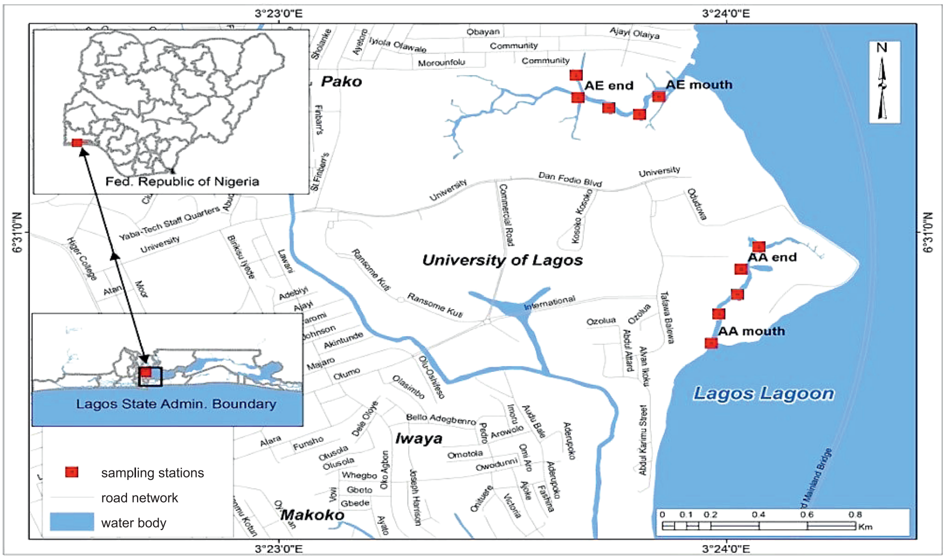

Fig. 1. Map showing the study area (red dots indicating the study site)

Collection of samples

A monthly collection of samples was carried out from January to June 2019. Water and surface sediment (at a depth of 2 cm) were collected using bottles with glass stoppers (250 ml reagent bottles and 1,500 ml polypropylene plastic containers) and 0.05 m^2 Eckman Grab, respectively. Five representative water and sediment samples from each of the five sampling sites from both creeks were taken. A total of 158 adult specimens of *S. huzardii* (80 from AA Creek and 78 from AE Creek) were hand-picked using protective rubber gloves. All samples were transported in a cooling box to the laboratory immediately after collection. The examined crab samples ranged in carapace length between 1.8 cm and 5.5 cm, while weight was between 4.8 g and 34.4 g.

Water quality analysis

Water samples were analyzed for physico-chemical parameters using the methods recommended by APHA (2005). The temperature was measured in-situ using a mercury-in-glass thermometer, and readings were taken to the nearest 0.1°C. In addition, salinity, pH, dissolved oxygen, and conductivity were measured using a refractometer (Model No: RHS-10), pH meter (Model: HI 2210), Lutron DO meter (Model: DO 5519), and conductivity meter (Model: EC 215), respectively.

Heavy metal analysis

Tiny stones were carefully removed from each bulk sediment sample and oven dried to constant weight at 105ºC. Each of the dried bulk samples was crushed separately with a clean pestle and mortar to homogenize it. Approximately 5 g of sediment was weighed into a crucible and heated to carefully burn the sample. A muffle furnace was used to heat the residue at 550ºC for complete oxidizing of carbon content (about 1 h). A few drops of Aqua-regia were used to dissolve the residues, followed by dilution with water. The resulting mixture was then filtered, rinsed thoroughly, and the filtrate was made up to the 100 ml mark in a standard (volumetric) flask. The resulting solution from the digestion was then analyzed with Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst 200 using air-acetylene flame.

The muscle tissue of the crab samples was oven dried to constant weight at 105°C. The dried samples from each station were ground into a fine powder with a pestle and mortar, placed in bottles, and labeled. One gram of homogenized sample was digested with 8 mL HNO_3 and 2 mL H_2O_2 using a four-step digestion program in a microwave digestion system (MARSXpress, CEM, USA), performed according to the procedure of Turkmen and Ciminli (2007). After calibration, samples were analyzed for chromium, copper, iron, lead, nickel, manganese, and zinc by atomic absorption spectrophotometer.

Bio-sediment accumulation factor (BSAF), which is the ratio of the metal concentration in crab tissue to the metal concentrations in sediment (DEFOREST et al. 2007) was also calculated as:

$$\text{BSAF} = \frac{heavy\ metal\ concentration\ in\ crab}{heavy\ metal\ convcentration\ in\ sediment}$$

Data analysis

Normality of data was tested using the Kolmogorove-Smirnov Test ($\alpha = 0.05$). Homogeneity of variance was tested using Levine's test. Differences between mean concentrations in samples from the two different sampling locations were tested using *T*-test ($\alpha = 0.05$). Statistical analyses were performed with Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 12.0.1.

Results

Physico-chemical variables of two estuarine creeks

The data obtained for physico-chemical parameters at Abule-Agege and Abule-Eledu Creeks from January to June 2019 are represented in Table 1. There was slight variability in the mean parameter values obtained at the study zones. More so, all the investigated parameters were not statistically significant ($p > 0.05$) between both creeks. Abule-Agege Creek was higher in mean values of air temperature (29.90±0.01°C), water temperature (29.00±0.30°C), transparency (34.10±4.50 cm), conductivity (12470.68±112.10 µs cm^{-1}), salinity (8.60±7.10 ppt) and dissolved oxygen (2.90±0.01 mg L^{-1}). At Abule-Eledu Creek, the pH values (at 25°C) revealed that the water was slightly alkaline, with a range of 7.03–8.30. The mean value of dissolved oxygen was generally low, with a range varying between 3.60 mg L^{-1} and 4.20 mg L^{-1} across zones.

Table 1
Mean (±SE) and range (in bracket) of physico-chemical parameters of two estuarine creeks in Lagos, Nigeria

Parameter	Abule-Agege Creek	Abule-Eledu Creek	*P*-value ($P < 0.05$)*
Air temperature [°C]	29.90±0.01 (27.22–31.20)	29.12±0.09 (27.10–30.08)	0.30
Water temperature [°C]	29.00±0.30 (27.60–28.20)	28.40±0.01 (26.10–27.03)	0.24
Transparency [cm]	34.10±4.50 (28.98–39.80)	33.90±5.20 (27.90–36.50)	0.92
pH at 25°C	7.80±0.50 (7.10–8.50)	7.90±0.01 (7.03–8.30)	0.32
Conductivity [μS cm^{-1}]	12470.68±112.10 (2141.10–2400.20)	11087.52±101.80 (1234.20–0540.30)	0.32
Salinity [ppt, at 25°C]	8.60±7.10 (5.90–13.70)	7.60±5.30 (5.10–13.20)	0.34
Dissolved oxygen [mg L^{-1}]	4.0±0.01 (3.70–4.20)	3.90±0.05 (3.60–4.05)	0.25

Heavy metal concentration in sediment of two estuarine creeks

Table 2 shows the concentration of heavy metals (chromium, copper, iron, lead, nickel, manganese and zinc) in sediment samples collected from the intertidal zone of Abule-Agege and Abule-Eledu Creeks.

Table 2
Concentration of heavy metals (mean±SE) in sediment samples from two estuarine creeks in Nigeria

Heavy metals [mg kg^{-1}]	Abule-Agege Creek	Abule-Eledu Creek	*P*-value ($P < 0.05$)*
Chromium	0.04±0.01	0.06±0.03	0.18
Copper	5.08±0.08	1.41±0.05	0.04*
Iron	75.36±0.13	36.58±0.11	0.01*
Lead	0.03±0.01	0.01±0.01	0.09
Nickel	0.01±0.05	0.02±0.02	0.00*
Manganese	1.64±0.01	0.67±0.05	0.08
Zinc	14.5±0.11	7.8±0.15	0.03*

Higher concentrations [mg kg^{-1}] of copper (5.08±0.08), iron (75.36±0.13), lead (0.03±0.01), manganese (1.64±0.01) and zinc (14.5±0.11) were found at Abule-Agege Creek while higher mean values of chromium (0.06±0.03) and nickel (0.02±0.02) was observed at Abule-Eledu Creek. The significantly higher concentration of copper, iron, and zinc at Abule-Agege Creek implies that anthropogenic contribution to the heavy metal loads was clearly noticed in sediments.

Heavy metal concentration in visceral samples of *Sesarma huzarddii*

Table 3 shows the concentrations of heavy metals [mg kg^{-1}] in the visceral of the mangrove crab (*S. huzardii*) collected from Abule-Agege and Abule-Eledu Creeks. With the exception of chromium (0.02±0.05 mg kg^{-1}), non-significant ($p > 0.05$) higher mean values of heavy metals were found in *S. huzardii* collected from Abule-Agege Creek, for copper (3.27±0.08 mg kg^{-1}), lead (0.02±0.01 mg kg^{-1}), manganese (0.84±0.01 mg kg^{-1}) and zinc (5.06±0.18 mg kg^{-1}). Nickel was not detected in the crab samples from Abule-Agege Creek, but the mean value of 0.01±0.05 mg kg^{-1} was measured in the crab samples from Abule-Eledu Creek. However, a significantly higher concentration of iron (36.46±0.16 mg kg^{-1}) was detected in crab samples from Abule-Agege Creek.

Table 3

Concentration of heavy metals (mean±SE) in visceral samples of *Sesarma huzardii* from two estuarine creeks in Nigeria

Heavy metals [mg kg^{-1}]	Abule-Agege Creek	Abule-Eledu Creek	*P*-value ($P < 0.05$)*
Chromium	0.02±0.05	0.03±0.03	0.21
Copper	3.27±0.08	1.33±0.05	0.07
Iron	36.46±0.16	10.41±0.09	0.00*
Lead	0.02±0.01	0.01±0.01	0.12
Nickel	ND	0.01±0.05	0.00*
Manganese	0.84±0.01	0.5±0.01	0.07
Zinc	5.06±0.18	4.07±0.15	0.13

ND – not detected

Bio-sediment accumulation factor of heavy metals in *S. huzardii*

The bio-sediment accumulation factor (BSAF) of heavy metals in *S. huzardii* can be seen in Figure 2. Except for nickel (in Abule-Agege Creek), all examined heavy metals were observed to bio-accumulate in measurable concentrations in sampled crabs across the creeks. Confirming the clue from the standard deviation error bars (no overlapping), *t*-test was used to draw a conclusion. BSAF of chromium (0.50) was found to be the same in *S. huzardii* from both creeks, while the BSAFs of all other heavy metals were significantly different (P < 0.05). Except for BSAF of iron, all other BSAFs were higher in crabs collected from Abule-Eledu Creek.

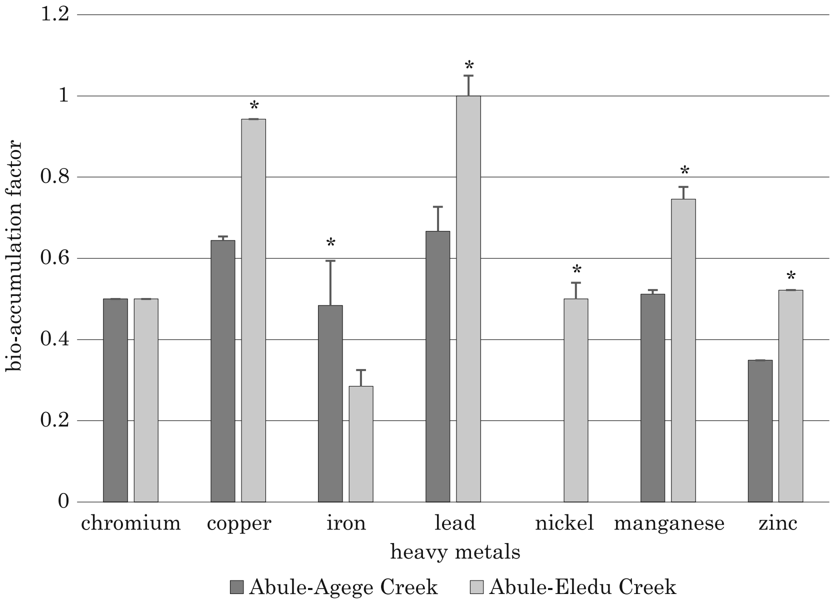

Fig. 2. Bio-sediment accumulation factor of *Sesarma huzardii* from two estuarine creeks

Discussion

The variations among the investigated physico-chemical parameters of both creeks were not statistically significant (P > 0.05). However, most of the investigated parameters were slightly higher in Abule-Agege Creek. The temperature range was within the tropical climate range of < 40ºC for coastal waters as stated by FMENV (2001). The decrease or increase in water temperature depends mainly on the climatic conditions sampling times, sunshine hours and affected by specific characteristics of water environment such as turbidity, wind force, plant cover and humidity (Ahmed et al. 2017, Lawal-Are et al. 2021). A similar observation was reported by Adejumobi et al. (2019) for Makoko Creek in Lagos, Nigeria. Water temperature is easily influenced by turbidity, vegetation cover, run-off, inflows, and heat exchange with the air (Oboh and Agbala 2017).

In this study, high transparency values confirm the known phenomenon that transparency and rainfall are inversely related to the region, as stated by LAWAL-ARE et al. (2019c). Furthermore, the creeks exhibited the usual alkaline properties and correspond with EMMANUEL and OGUNWENMO (2010), who reported pH values ranging between 7.30 and 9.20. This alkaline pH may be due to the buffering effects of the seawater. Conductivity and salinity have been previously reported as associated factors in the tidal creeks of Lagos Lagoon (ONYEMA et al. 2010). These parameters are similar in this study for both creeks. To a large extent, these variations in conductivity and salinity could be attributed to the effect of tidal seawater incursion and freshwater input from adjoining creeks and land as expected during the dry season (ONYEMA et al. 2010). According to LAWAL-ARE et al. (2010), salinity is an environmental barrier in the distribution of crabs. The lower values of dissolved oxygen recorded at Abule-Eledu Creek could be attributable to the consumption of the dissolved oxygen by aerobic microorganisms which biodegrade the organic wastes. Similar observations were reported by NKWOJI (2016) at Iddo, Ogudu and Agboiyi Creeks of Lagos Lagoon.

Heavy metals are of particular concern due to their toxicity and ability to be bio-accumulated in benthic organisms (MORUF and DUROJAIYE 2020). Sediment has been known to be the major depository of metals, holding more than 99 percent of the total amount of metal present in the aquatic system (ADERINOLA et al. 2009). The result from this present study revealed measurable concentrations of heavy metal in the sediment of Abule-Eledu Creek. At the same time, nickel was not detected in the sediment of Abule-Agege Creek. Higher concentrations of all the heavy metals (except chromium) were recorded in the sediment of Abule-Agege Creek than in the sediment of Abule-Eledu Creek, which in turn reflected on the bioaccumulation level in the mangrove crabs. Amongst all the metals analyzed, iron was observed to have the highest value. This was in agreement with the study of ONWUTEAKA et al. (2015), where the level of iron was the highest metal contamination in both water and sediment of the brackish water creek system of the Niger Delta. UABOI-EGBENNI et al. (2010) also reported iron with the highest heavy metal concentrations in Lagos Lagoon.

The present study examined heavy metals accumulated in the sampled crab, *S. huzardii,* to varying degrees. Lead > copper > manganese > chromium > iron > zinc > nickel were the heavy metal bio-accumulation patterns discovered in crabs from Abule-Agege Creek, in decreasing order. Heavy metal bioaccumulation patterns in crabs from Abule-Eledu Creek, on the other hand, followed a decreasing order of lead > copper > manganese > zinc > nickel/chromium > iron. This pattern is similar to that reported by Moruf and Akinjogunla (2019) on heavy metal accumulation in *Farfantepenaeus notialis* from two interconnecting brackish/freshwater lagoons in Lagos, Nigeria.

The heavy metals' bio-sediment accumulation factors (BSAF) showed that the crab visceral accumulated all the investigated heavy metals (except nickel in Abule-Agege Creek) in varying concentrations with lead as the highest, while iron was recorded as the lowest accumulated heavy metals in Abule-Eledu Creek. The BSAFs of the heavy metals (except chromium) were significantly different in crabs collected from both creeks. The heavy metal concentrations in the mangrove crab, *S. huzardii* may be attributed to the bio-magnification of metals in the biota. In contrast, the higher concentrations of metals in sediment may be attributed to metal-contaminated phytoplanktons that die and are deposited in the sediment.

Conclusion

The physico-chemical parameters estimated in this study did not significantly ($P > 0.05$) change across both Abule-Agege and Abule-Eledu Creeks, suggesting similar regional geological zone. It was found that the concentration of copper, iron and zinc were significantly ($P < 0.05$) higher in the sediment of Abule-Agege Creek than that of Abule-Eledu Creek. Except for nickel in Abule-Agege Creek, all examined heavy metals were observed to bio-accumulate in measurable concentrations in sampled crabs across the creeks. The mangrove crab, *Sesarma huzardii* can be used for environmental monitoring, largely because of its heavy metal bioaccumulation potential as a benthic organism.

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