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HEAVY METAL BIOACCUMULATION IN *CALLINECTES AMNICOLA* AND *FARFANTEPENAEUS NOTIALIS* FROM THREE SELECTED TROPICAL WATER BODIES IN LAGOS, NIGERIA.

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ABSTRACT

The bioaccumulation of heavy metals in organisms is as a result of pollutants discharge generated by anthropogenic and natural activities which has become a tremendous concern in developing nations. The levels of cadmium, copper, chromium, lead, zinc and nickel in the tissue of *Callinectes amnicola* and *Farfantepenaeus notialis* collected from Igbese River, Makoko and Lekki Lagoon were evaluated for a period of eight months. Heavy metals analysis was done using Atomic Absorption Spectrophotometer. The mean concentration values of heavy metals in the tissues of lagoon crab recorded are-Cr (0.14, 0.71 and 0.19 mg/l), Cu (2.17, 1.27, 1.51 mg/l), Pb (0.47, 0.26, 0.15 mg/l), Zn (0.04, 1.05, 0.63 mg/l), Ni (0.33, 0.30, 0.19 mg/l) in Igbese River, Makoko site and Lekki Lagoon respectively. While metal concentration in tissue of shrimps observed are-Cr (0.28, 0.18 and 0.14) mg/l, Cu (1.21, 1.03, 0.56) mg/l, Pb (0.26, 0.19, 0.13) mg/l, Zn (0.74, 1.11, 0.36) mg/l, Ni (0.28, 0.27, 0.15) mg/l across Igbese river, Makoko site and Lekki lagoon respectively. There was a significant difference ($P<0.05$) observed in Cr and Pb of the lagoon crab. The bioaccumulation factor was found highest in the pink shrimp at Makoko with an increasing order of Pb > Ni > Zn > Cr > Cu > Cd. The bioaccumulation factor (BAF) of the metal from sediments to tissues of lagoon crabs and shrimps observed highest accumulation in comparison with water to tissues. The observed metals with higher BAF values were Pb (0.81, 1.82 and 1.60) in lagoon crabs and Pb (1.46, 2.68 and 2.00) in shrimps and Zn (1.23, 1.01 and 1.32) in lagoon crabs and Zn (1.73, 0.95 and 2.31) in shrimp's bioaccumulated from sediment across Igbese river, Makoko site and Lekki Lagoon respectively. While the least BAF metal was Cu with values of 0.03, 0.12 and 0.03 in lagoon crabs and 0.06, 0.15 and 0.09 in shrimp's bioaccumulated from water across Igbese river, Makoko site and Lekki Lagoon respectively. The results revealed that heavy metals concentrations in the lagoon crab and pink shrimp were below the threshold levels associated with toxicological effects and regulatory permissible limits.

Key words: Bioaccumulation, C*allinectes amnicola*, Heavy metals, Lagoons*, Farfantepenaeus notialis*,

INTRODUCTION

Coastal environments are highly populated and urbanized with industries. Marine foods are essential delicacies and form an important staple food for daily living of every human being. The ability of heavy metals been accumulated in marine animals is of great scientific interest as far as the knowledge of heavy metal is concerned (Kumar and Hema, 2007). Anthropogenic pollutants are sources of persistent toxic metal contaminants in the ocean (Lakshmanan *et al*., 2009). Increasing industrial activities in recent decades have regularly introduced heavy and toxic metals, as well as use of fertilizers or pesticides in many ecosystems (Adoki and Orugbani, 2007). At the same time, significant amounts of municipal and agricultural wastes are discharged into the environment. These pollutants enter atmospheric and hydrological circulation and are finally deposited on river beds, swamps and in the marine environment, thus leading to a sink of contamination (Herbert *et al.,* 2006).

Aquatic invertebrates take up and accumulate trace heavy metals which have the potential to cause toxic effects. Decapod crustaceans have the ability to metabolically regulate essential metals like zinc, copper and manganese (Rainbow, 1995) and in contrast tend to be effective as bioaccumulators of non-essential metals such as lead and cadmium, reflecting environmental levels and serve as bio-indicators of these metals (Rainbow *et al.,* 1990). Monitoring the concentration of heavy metals in water, sediment and aquatic fauna is important because the knowledge of these, especially in the sediment gives vital information regarding their sources, distribution and degree of pollution (Adefemi *et al.,* 2004; Oyakhilome *et al.,* 2012).

Crustaceans, especially members of the order Decapoda (shrimp, crabs and lobsters) are ecologically and economically important. This interest has prompted scientific studies in many areas, including reproduction. Furthermore, the presence of metal pollutants in fresh water has been found to disturb the delicate balance of the aquatic ecosystem. Thus manifesting in the fish physiology as fish tends to concentrate some metals in their body tissues (Aiyesanmi, 2006).

The fate of heavy metals introduced by human activities into aquatic ecosystems has recently become the subject of wide spread concern, since beyond the tolerable limits they become toxic (Pocock *et al.,* 1994; Koller *et al.,* 2004). Determination of harmful and toxic substances in water sediments and biota, gives direct information on the significance of pollution in the aquatic environment (Hugget *et al.,* 1973). The pollution of sediments, water resources and biota by heavy metals is of major concern especially in many industrialized countries because of their toxicity, persistence and bio-accumulative nature (Ikem *et al.,* 2003).

Therefore, this paper seeks to provide information on the concentrations of lead (Pb), Chromium (Cr), copper (Cu), nickel (Ni), cadmium (Cd) and zinc (Zn) in the tissues of Lagoon crabs and Pink shrimps, water and sediments found in the Igbese River, Makoko site along the Lagos Lagoon and Lekki Lagoon of Lagos State of Nigeria.

MATERIALS AND METHODS

Brief description of study sites

Station 1 (Igbese River): It is located at Ikorodu area of Lagos State with GPS coordinates of 6^0 45' 37.03"N and 3^0 32'14.65"E. It is a freshwater body which empties into the Lagos Lagoon via the Ogun River.

Station 2 (Makoko): It is located at Makoko area with GPS coordinates of $6^0$47'36"N and $3^0$27'29"E. The Makoko site lies within the Lagos Lagoon and it receives freshwater from Lekki Lagoon via Epe Lagoon in the North-east and discharges from Majidun, Agboyi and Ogudu creeks as well as Ogun River in the North-west (Soyinka, 2008; Lawal-Are and Nwankwo, 2011).

Station 3 (Lekki Lagoon): The Lekki Lagoon is one of the largest lagoons in West Africa, covering an area of nearly 247 km^2 and it supports a major fishery. The lagoon is located between Lagos and Ogun States of Nigeria and it lies between longitude 4° 00' and 4° 15' E and between latitude 6° 25' and 6° 37' N. According to Kusemiju (1973), the lagoon has a surface area of about 247 km^2 and it is mostly shallow, (3.0m average depth) the maximum depth being 6.4m. Lekki Lagoon is a freshwater environment fed by the River Oni in the North eastern part and by Rivers Oshun and Saga in the north western parts of the lagoon. It opens into the sea via the Lagos Lagoon and Lagos harbor.

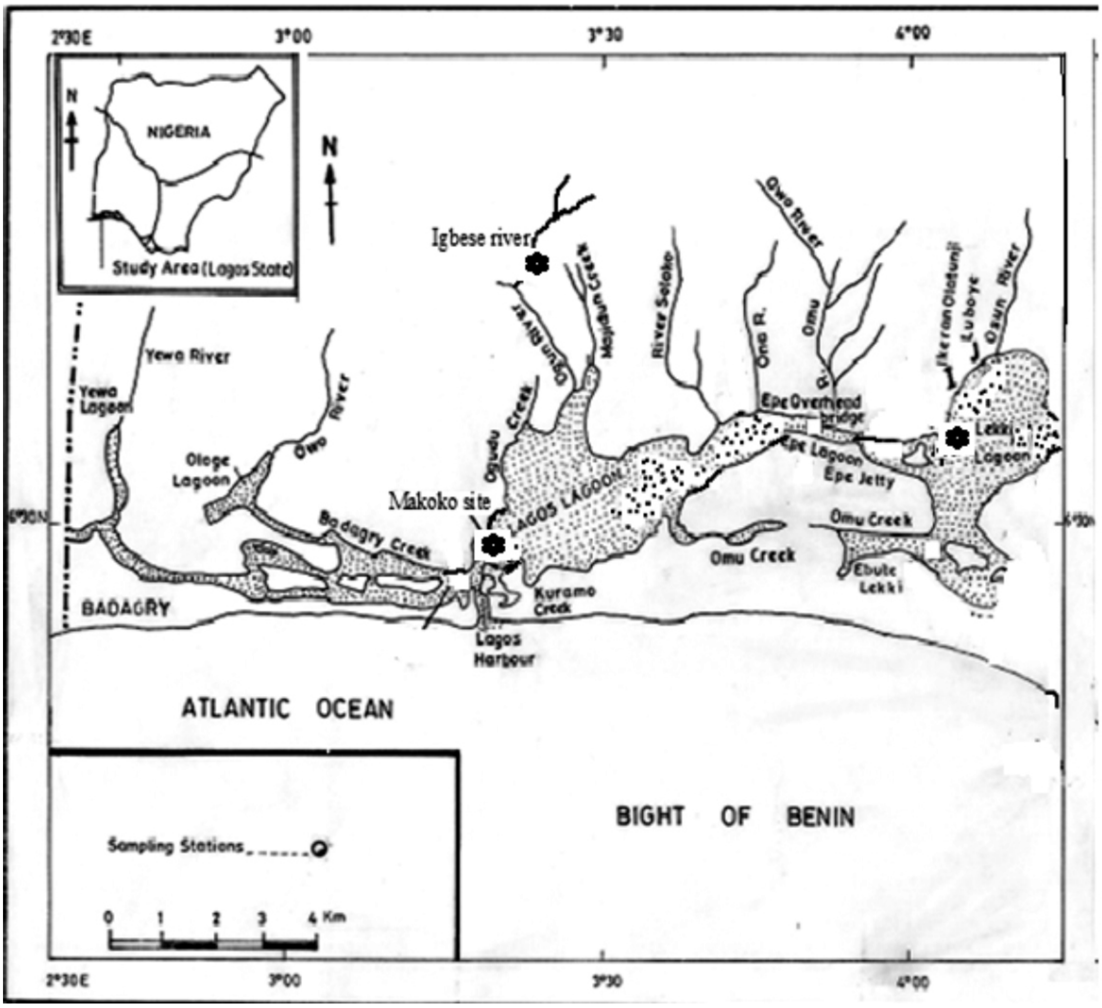

Figure 1: The three sampling stations (Igbese River, Makoko site and Lekki Lagoon) indicated with ✹

SAMPLES COLLECTION

Water, Sediment, Crabs and Shrimps samples were collected for a period of eight (8) months from the three (3) stations which include: the Makoko area along the Lagos Lagoon, Igbese River situated at Ikorodu area of Lagos and Lekki Lagoon.

Collection of Water samples

Water samples were collected with sampling bottles from each of the three stations, stored in an ice chest and transported to the laboratory for the determination of the heavy metals.

Collection of Sediment samples

Sediment sampling was performed with Van-veen grab from the bottom at all stations. After sampling, the samples were packed in plastic bags, preserved in an ice chest and transported to the laboratory for analysis.

Collection of Specimens

Samples of Lagoon crabs (*Callinectes amnicola*) and Pink shrimps (*Farfantepenaeus notialis*) were collected weekly for a period of eight months, from March to October, 2013. The shrimps were purchased from Shrimpers using wooden boats or canoes powered by small outboard engines while the crab was also collected from each of the stations. Samples were transferred to the laboratory in an ice chest and stored in a deep freezer for further analysis. Each crab was properly cleaned by rinsing with distilled water to remove debris, planktons and other external adherent and then they were dissected for the collection of the tissues.

DETERMINATION OF HEAVY METALS

Determination of Metals in Water

Sample pre-treatment: 100 ml of thoroughly well mixed water sample was transferred into a beaker and 5 ml concentrated nitric acid was added. The beaker was placed on a hot plate and evaporated to dryness. The beaker was then cooled and another 5 ml of concentrated nitric acid was added. Heating continued until a light coloured residue was observed. Then 1 ml concentrated nitric acid was added and warmed slightly to dissolve the residue. The walls of the beaker were then washed with distilled water and the volume was adjusted to 50 ml. The samples were digested to determine the levels of cadmium, chromium, copper, lead, zinc and nickel present in them using Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst (Model No: Analyst 200).

Digestion of Sediment Samples

About 5 g of sediment samples was weighed into a clean porcelain crucible and heated over a hot plate to ignite as well as carefully burn the sample. The residue was then heated in a muffle furnace at 550 ºC until the carbon content (organic matter) was carefully and completely oxidized (about 1 h). The residues left was dissolved in a few drops of aqua-regia (3 parts concentrated HCl + 1 part concentrated HNO_3**)** and then diluted with distilled water. The resulting mixture was then filtered, rinsed very well and the filtrate made up the 100 ml mark in a standard (volumetric) flask according to APHA (1998) and FAO/SIDA (1986).

Determination of Metals in Sediments

The resulting solution from the digestion was then aspirated into the flame of the Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst 200 using air-acetylene flame for the metal analysis against standard metal solutions. Each metal was analyzed using the specific hollow cathode lamp at a specific wavelength (FAO/SIDA, 1986).

Determination of Metals in Lagoon Crab (*C. amnicola*) and Pink Shrimp (*F. notialis*)

After digestion of the shell (carapace) of crab and the tissue of Pink shrimp respectively, the resulting solution from the digestion was then aspirated into the flame of the Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst 200 using air-acetylene flame for the metal analysis against standard metal solutions. Each metal (cadmium, chromium, copper, lead, zinc and nickel) was analyzed using the specific hollow cathode lamp at a specific wavelength according to APHA, (1998); Radajevic and Bashkin, (1999) and Onyeonwu (2000).

Bioaccumulation factor (BAF)

Bioaccumulation factor (BAF) was calculated to determine the level of heavy metal accumulation in the tissue of the organism using the formula below:

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

Where BAF is the ratio of metal concentration in the crabs and shrimps tissue to its concentration in the sediment and water.

Statistical Analysis

One-way analysis of variance (ANOVA) and comparison of means by Duncan's New Multiple Range Test (DMRT) was used to test for significant differences in the level of heavy metals.

RESULTS AND DISCUSSION

The result of the analyses of the concentration of heavy metals present in the tissue of the Crab (*Callinectes amnicola*), Pink shrimp (*Farfantepenaeus notialis*), Sediments and Water of the three (3) sampling stations (Igbese River, Makoko area and Lekki Lagoon) for the period of eight (8) months is presented in table 1.

Table 1: Mean Concentration of Metals in the water, sediment, Lagoon Crab (*Callinectes amnicola*) and Pink Shrimp (*Farfantepenaeus notialis*) Samples collected from Igbese River, Makoko and Lekki Lagoons.

SAMPLE	WATER (Mean ± S.E) (mg/L)					
STATIONS	**Cd**	**Cr**	**Cu**	**Pb**	**Zn**	**Ni**
IGBESE	0.014 ± 0.01^{a}	0.189 ± 0.05^{a}	0.07 ± 0.03^{ab}	0.05 ± 0.03^{a}	0.16 ± 0.05^{a}	0.03 ± 0.04^{a}
MAKOKO	0.008 ± 0.005^{a}	0.075 ± 0.11^{a}	0.15 ± 0.03^{b}	0.14 ± 0.03^{a}	0.14 ± 0.04^{a}	0.04 ± 0.00^{b}
LEKKI	0.003 ± 0.00^{a}	0.173 ± 0.07^{a}	0.05 ± 0.03^{a}	0.08 ± 0.05^{a}	0.05 ± 0.03^{a}	0.02 ± 0.01^{a}
SEDIMENT (Mean ± S.E) (mg/kg)						
IGBESE	0.00 ± 0.00^{a}	0.17 ± 0.12^{a}	0.45 ± 0.08^{b}	0.38 ± 0.02^{ab}	1.28 ± 0.04^{b}	0.28 ± 0.03^{b}
MAKOKO	0.00 ± 0.00^{a}	0.16 ± 0.03^{a}	0.56 ± 0.13^{b}	0.51 ± 0.04^{b}	1.06 ± 0.03^{ab}	0.47 ± 0.05^{c}
LEKKI	0.00 ± 0.00^{a}	0.07 ± 0.04^{a}	0.17 ± 0.05^{a}	0.24 ± 0.07^{a}	0.83 ± 0.24^{a}	0.14 ± 0.04^{a}
LAGOON CRAB (Mean ± S.E) (mg/kg)						
IGBESE	0.00 ± 0.00^{a}	0.14 ± 0.02^{a}	2.17 ± 0.08^{b}	0.47 ± 0.10^{b}	1.04 ± 0.18^{a}	0.33 ± 0.03^{b}
MAKOKO	0.00 ± 0.00^{a}	0.71 ± 0.13^{b}	1.27 ± 0.03^{ab}	0.28 ±0.06^{ab}	1.05 ± 0.17^{a}	0.30 ± 0.02^{ab}
LEKKI	0.00 ± 0.00^{a}	0.19 ± 0.07^{a}	1.51 ± 0.46^{a}	0.15 ± 0.07^{a}	0.63 ± 0.24^{a}	0.20 ± 0.06^{a}
PINK SHRIMP (Mean ± S.E) (mg/kg)						
IGBESE	0.00 ± 0.00^{a}	0.28 ± 0.10^{a}	1.21 ± 0.03^{b}	0.26 ± 0.07^{a}	0.74 ± 0.13^{ab}	0.28 ± 0.03^{b}
MAKOKO	0.00 ± 0.00^{a}	0.18 ± 0.08^{a}	1.02 ± 0.14^{b}	0.19 ± 0.04^{a}	1.11 ± 0.16^{b}	0.27 ± 0.02^{b}
LEKKI	0.00 ± 0.00^{a}	0.14 ± 0.04^{a}	0.56 ± 0.19^{a}	0.13 ± 0.06^{a}	0.36 ± 0.13^{a}	0.15 ± 0.05^{a}

Means with the same superscript alphabet along the row are not significantly different ($P > 0.05$)

Bioaccumulation Factor of Heavy Metals

The result of the heavy metals bioaccumulated in the tissue of the Crab (*C. amnicola*) and Pink shrimp (*F. notialis*) is presented in figure 2.

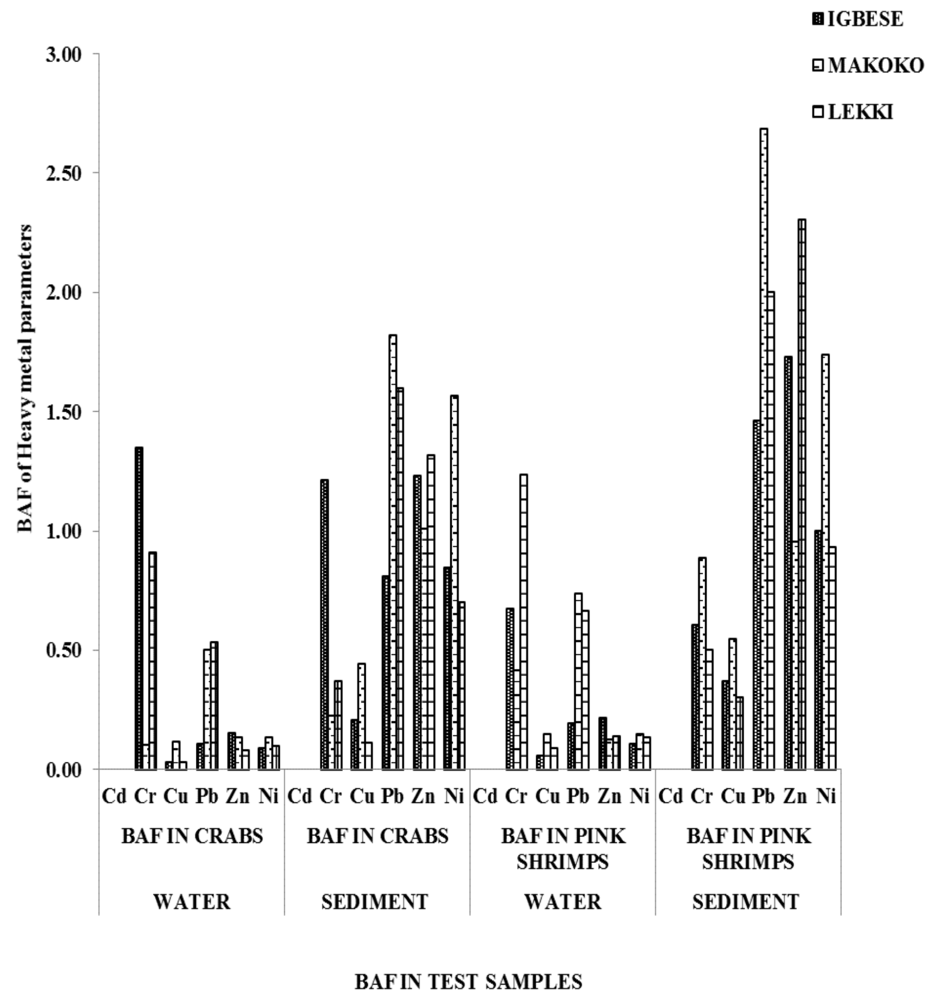

Figure 2: Bioaccumulation factor of heavy metals in the tissue of Lagoon crabs and Pink shrimps from the water and sediments in Igbese River, Makoko site and Lekki Lagoon.

This study showed that the heavy metal concentrations are more accumulated in the sediments and Pink shrimps, which showed a significant difference ($P < 0.05$) compared to Lagoon crabs and water. The concentrations of the trace metals were below the recommended permissible safe level for human consumption by World Health Organization and Food and Agricultural Organization. According to FAO (1986) and FEPA (1991), the WHO recommended quantities of persistent toxic metals in water are: Cd - 2.00μg/g; Pb - 2.00μg/g; Zn - 1000μg/g; Ni - 2.00μg/g while FEPA (1991) for water, the statutory limit or permissible requirements are (Cd, Cr, Cu, Pb, Zn and Ni) – (<1 mg/l). The heavy metal accumulated in the water at the entire sampling stations fell within the permissible limits of waste water and effluent discharge into the aquatic ecosystem. While at the Makoko site, Pb was high and exceeds the permissible limit in the Pink shrimps (*Farfantepenaeus notialis*) and found to be moderate in the Lagoon crabs. The Pink shrimp heavy metal bioaccumulated followed a decreasing order for Igbese River - Zn > Pb > Ni > Cr > Cu > Cd; Makoko site – Pb > Ni > Zn > Cr > Cu > Cd and Lekki lagoon- Zn > Pb > Ni > Cr > Cu > Cd. For the Lagoon crabs, Igbese River - Zn >Cr > Ni > Pb > Cu > Cd; Makoko site – Pb > Ni > Zn > Cu > Cr > Cd and Lekki lagoon- Pb > Zn > Ni > Cr > Cu > Cd. Zinc and lead bioaccumulated most and cadmium was least.

For Pink shrimps, there was a strongly positive correlation between Cr and Zn (Lekki lagoon) ($r = 0.780$) and Ni and Zn (Lekki lagoon) ($r = 0.716$). While the Lagoon crabs showed strongly positive correlation between Cu (Makoko site) and Cu (Lekki lagoon) ($r = 0.739$); Ni (Igbese River) and Ni (Makoko site) ($r = 0.751$); Cu (Igbese River) and Cu (Makoko site) ($r = 0.808$); Zn (Igbese River) and Zn Makoko site) ($r = 0.829$); which also indicated that there was a significant difference ($P<0.05$).

It can be deduced that crabs and shrimps as some of the aquatic biota bioaccumulates and serves as bio-indicator of persistent toxic metals or contaminants in aquatic environments. This study is in agreement with findings of Williams *et al.,* (2007) who reported higher concentration of trace metals in fine grain muddy sediments of Igbede and Ojo Rivers in Nigeria coast lines compared to the coarse and sandy deposits of Ojora coastlines. In another work, (Ayejuyo *et al.,* 2008) reported various levels of five metals in sediments of water arising from indiscriminate dumping of human and industrial wastes into Rivers freely flowing in and out of fish ponds. Interaction between the biota and their environment is becoming consistent and robust (Ayejuyo *et al.*, 2003; Adekoya *et al.,* 2006).

Probable Effect Concentrations (PEC) of sediment metal levels (Pb: 128, Cd: 5, Cr: 111, Cu: 149, Zn: 459 mg/kg) has been proposed by McDonald *et al.*, (2000). The results of the present study show that the levels of Cd, Cu, Cr, Pb and Zn were much below the proposed effect concentration of sediment levels. Above this level, metals may have adverse effects on sediment dwelling organisms. The present results showed that metal concentrations were low in the tissues of the shrimps and crabs despite the physiological roles in the metabolisms of the organisms.

In conclusion, the findings of this study indicated that the Pink shrimp and Lagoon crabs are still fit for human consumption since the heavy metals concentrations falls under the recommended permissible safe level for human consumption by World Health Organization and Food and Agricultural Organization. Therefore, as a measure to boost biomonitoring of the aquatic ecosystem, industrialists and other commercial users should take steps to reduce the aquatic pollution as these heavy metals are biomagnified in the tissues of human beings through the food chain.

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