Original Research Article

BIOACCUMULATION OF HEAVY METALS IN MACROINVERTEBRATES FROM OJO RIVER, LAGOS, NIGERIA.

ABSTRACT

Aim: To provide information regarding the concentrations of various heavy metals in the tissues of crab (*Potamon fluviatile*), prawn (*Macrobrachium rosenbergii*) and crayfish (*Metanephrops australiensis*) obtained from the Ojo river of Lagos State, Nigeria.
Study design: Commercially sold marine crustacean samples (crab, prawn and crayfish) obtained from the Ojo river of Lagos, Nigeria, were assessed for the presence of heavy metals, and also the potential health risks for local consumers**.**
Place and duration of study: Ojo river, located close to Ojo local government secretariat, Ojo, Lagos State, Nigeria.
Methodology: Live samples of macroinvertebrates such as *Metanephrops australiensis*, *Potamon fluviatile* and *Macrobrachium rosenbergii* were purchased from the fishermen at the riverside in Ojo and immediately transferred to the laboratory. The samples were oven-dried, grounded into a fine powder, subjected to sample digestion and finally, atomic absorption spectrophotometer (AAS) was used to determine the concentration of heavy metals present in each sample.
Results: The result indicated variations in the metal body load among species. All the metals were below the FAO/WHO permissible limit for food consumption except for Cd in crayfish which was slightly beyond the set limit. The highest concentration examined were found in crayfish, followed by crab and prawn. Zinc (Zn) and iron (Fe) were associated by their relatively high concentration in the tissues of the marine organisms, while lead Pb) which was the least concentrated in the tissues was found to be absent in the tissues of both crab and prawn.
Conclusion: The human health risk evaluation for the marine organisms indicated that they are safe for consumption. However, the potential health risk from consuming seafood exposed to these metals should not be ignored.

Keywords: heavy metals, crab, prawn, crayfish, crustacean, Ojo river, Lagos, FAO/WHO

1. INTRODUCTION

Aquatic ecosystems are water-based environments which allow for possible interactions between biotic and abiotic components. These ecosystems are usually divided into two types: the “freshwater ecosystem” and the “marine ecosystem” [1] as cited in [2]. The freshwater ecosystem occupies less than 1% of the Earth’s surface and comprises rivers, lakes, streams, ponds, reservoirs, groundwater, andwetlands. The marine ecosystem is the largest water ecosystem occupying over 70% of the Earth’s surface. This ecosystem is subdivided into the ocean, estuaries (brackish water), salt marshes, coral reefs, mangroves and algal colonies [2, 3].

Marine organisms are known as popular food sources to the inhabitants of the coastal region. Known to possess a high amount of protein and reduced quantity of saturated fats, marine organisms also offer other range of health benefits. However, these benefits could be compromised as a result of contaminants present in the marine ecosystem at levels beyond the tolerance of these organisms [4-6].

Contaminants in the marine ecosystem often remain in either soluble or suspension forms which tend to settle at the bottom of the sea, while some are taken up by organisms in the benthic region of the marine ecosystem. The inland waters exhibit more significant toxic effects arising from the indiscriminate deposition of waste as a result of their relatively small nature compared to the oceans and the seas. This justifies the heavily felt impact of waste deposition in the rivers, streams, lakes and wetlands [7]. It was argued that about 80% of the pollutants from freshwater are directed into the marine environment [8]. This explains the reason for the noticeably high level of pollutants in the ocean and low concentrations in many freshwaters.

Heavy metals are chemical elements capable of polluting the marine ecosystem. These metals are a group of metals and metalloids (including their compounds) that are of significant toxicity to the environment or ecotoxic. Heavy metals like manganese, iron, cobalt, copper, zinc and molybdenum are elements essential to the growth and changes in the life cycle of any organism, however, these metals are toxic at high concentrations. While metals like mercury, lead and cadmium are toxic even at low concentrations [6, 7, 9].

The main contributor of heavy metals to the surrounding environment especially the marine ecosystem is anthropogenic. This includes an increase in agricultural practices, urbanization, industrial development, industrial effluents, communal sewage, smelting, fuel combustion, mining, etc. inadequate consideration for environmental impact, among other factors [9-11].

The presence of heavy metals in the marine ecosystem poses a serious health problem to both the marine organisms and the consumers of these marine organisms in the long run [6, 12]. Heavy metals have prolonged half-lives; hence they do not degrade easily and they often bioaccumulate in living tissues through metabolic and bioabsorption processes [10]. This may result in marine organisms exhibiting symptoms of toxicity. The toxicity effects of these metals rarely manifest immediately after the exposure of toxins to the environment or the organisms, the symptoms become apparent mostly after a few years of exposure [9].

The exposure time of an organism in the marine ecosystem to a toxin has a significant effect on the level of bioaccumulation in such an organism. Irrespective of how short the exposure period might be, a significant amount of the metal may have been deposited in such an organism [9, 10]. Other factors accounting for the accumulation of heavy metals in the tissue of aquatic organisms are salinity, pH, life cycle, size and age, temperature, hardness, ecological needs, capture season and feeding habits of such organisms [10].

Marine organisms such as fish, periwinkle, crab, and oyster have been implicated as accumulators of trace metals and other heavy metals [10, 13, 14]. Hence, the metal body loads of aquatic biota are often measured and used to identify the associated ecological risks and potential sub-lethal effects. The coastal sediments are host sites for pollutant metals, coupled with the devastating effect of certain toxic metals on human health, metal pollution is potentially one of the most serious forms of aquatic pollution. Benthic organisms (e.g., macroinvertebrates such as crustaceans, molluscs etc.) are likely to be most directly affected by sediment metal concentrations because the benthos is the major repository of the particulate materials that wash into the aquatic systems [6, 14, 15]. Therefore, understanding the distribution and bioaccumulation of heavy metals in macroinvertebrates in coastal regions is crucial for scientists and government regulatory agencies [6].

The use of aquatic invertebrates is common when selecting a bioindicator. The aquatic macroinvertebrates are a popular choice for bioindicators as they are easy to sample, relatively easy to identify with the naked eye, have limited mobility, relatively quick recolonization times, frequently live for more than a year, and are an excellent indicator of integrating ecological condition [16]. Hence, macroinvertebrates are the specimens of choice in this study.

Compared to other coastal areas, the major and most affordable source of animal protein available to the local people (living along the coastline of the Ojo river) is fish and other sea foods such as prawns, crayfish, shrimps, crabs, oyster, periwinkle etc. obtained from the river, which therefore makes the maintenance of the health of the river and its resources inevitable. Most crustaceans are edible, and they serve as a healthy alternative to fish in the diets of some of the locals. They also serve as a means of livelihood for those involved in its harvesting and marketing. However, there is limited information regarding the metal contents and or the bioaccumulation potential of edible macroinvertebrates from the Ojo division of Lagos, Nigeria, particularly the Ojo River, hence the need for this study.

This study aims to provide information regarding the concentrations of various heavy metals in the tissues of crab (*Potamon fluviatile*), prawn (*Macrobrachium rosenbergii*) and crayfish (*Metanephrops australiensis*) obtained from the Ojo river of Lagos State, Nigeria.

2. MATERIAL AND METHODS

2.1. Sample collection

Live samples of macroinvertebrates such as *Metanephrops australiensis*, *Potamon fluviatile* and *Macrobrachium rosenbergii* were purchased from the fishermen at the riverside in Ojo. The Ojo river is brackish, and it is located in the Ojo Local Government Area of Lagos State, Nigeria which is between latitude 40, 58' to 32.578''N and longitude 80, 20' to 30.124''E, and a surface area of about 264km. The crab, prawn and crayfish bought were kept in plastic containers and transported immediately to the laboratory for analysis.

2.2. Sample treatment

In the laboratory, the samples were placed in clean acid-washed porcelain crucibles and oven-dried at 105°C for 24 hours in a drying oven. The dried samples were later ground into a fine powder form. The samples were kept till further analysis [17].

2.3. Sample digestion

Five grams of ground powder samples were weighed and transferred to a clean crucible, which was labelled according to the sample number and the dry-ashing process was carried out in a muffle furnace by a stepwise increase of the temperature up to 550°C and then left to ash at this temperature for 6 hours. The samples were removed from the furnace and allowed to cool. The ash was made wet with water and 2.5 ml of concentrated HNO_3 was added. The crucible was covered with a watch glass and placed on a hot plate. The digestion was performed at a temperature of 90 to 95°C for 1 hour. The ash was dissolved in 5 ml of 9.25% HCl and digested again on a hot plate until the white fumes ceased and the sample volume reduced to 2 ml. After cooling, 20 ml of distilled water was added and filtered using Whatman filter No.41. The filtered sample was then diluted up to the mark of 50 ml standard volumetric flask, and stored in a polyethylene container until analysis. All samples were prepared identically in triplicates. Blanks were prepared to check for background contamination by the reagents used [17, 18].

2.4. Preparation of standards and analysis of samples

Working standard solutions of copper (Cu), iron (Fe), zinc (Zn), chromium (Cr), lead (Pb), cadmium (Cd) and manganese (Mn) were prepared from the stock standard solutions containing 1000 ppm of the element in 2N HNO_3. The instrument was calibrated with a calibration blank and three series of calibration standard solutions, and measurements of elements were performed using the atomic absorption spectrophotometer (AAS) (Model: ELICO SL-194) [17].

3. RESULTS AND DISCUSSION

Seafood contains all of the essential amino acids and thus are complete protein sources for humans. Other nutrients inherent in seafood are vitamins, essential minerals with relatively low calories and fat contents. Seafood like fish, crustaceans, and molluscs are the primary source of animal protein for the inhabitants of coastal areas [19]. However, because these marine organisms can absorb chemical contaminants from the environment into their living tissues, the nutritional value and consumer health risk from seafood must be taken into consideration.Tables 1 and 2 below show the average concentration of heavy metals in crayfish, prawn and crab obtained from the Ojo river and their comparison with the FAO/WHO standards. Crayfish contained more heavy metals than prawns and crabs (Figure 1), lead was only detected in crayfish (Figure 2).

Table 1. Mean concentration of heavy metals (Mean±SD, mg/kgdryweight) in macroinvertebrates

ND-Not detected

From the result shown in Figure 1, heavy metals in the macroinvertebrates vary in concentrations. Crayfish decreased in the following order: Fe > Zn > Cu > Cr > Mn > Cd > Pb, prawn decreased in the following order Zn > Fe > Mn > Cd > Cu > Cr > Pb, while crab decreased in this order; Zn > Fe > Cd > Cu > Cr > Mn > Pb. The phenomenon that different metals are accumulated at varying concentrations in different species in the environment was observed in this study. This phenomenon was also reported by Ekpo *et al*., (2014) who assessed heavy metal concentrations in water, sediments, crab and periwinkle from the Uta Ewa Creek of Ikot Abasi, Akwa Ibom State, Nigeria [20]. The difference in the levels of accumulation of heavy metals in the different species examined in this study could be primarily attributed to the differences in the physiological role of each species. The regulatory ability of individual specie, behaviour and feeding habits are other factors that could have influenced the accumulation of metals in the different species [20].

Samples	**Metals (mg/kg)**						
	Lead (Pb)	Copper (Cu)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Iron (Fe)	Manganese (Mn)
Crayfish (*Metanephrops australinsis*)	0.142±0.010	8.190±0.100	11.310±0.160	1.820±0.006	0.510±0.006	11.800±0.100	1.220±0.003
Crab (*Potamon fluvidale*)	ND	0.035±0.003	3.728±0.170	0.033±0.002	0.085±0.005	1.099±0.144	0.013±0.007
Prawn (*Macrobrachium rosenbergii*)	ND	0.022±0.002	1.850±0.150	0.015±0.002	0.032±0.003	1.620±0.099	0.660±0.003

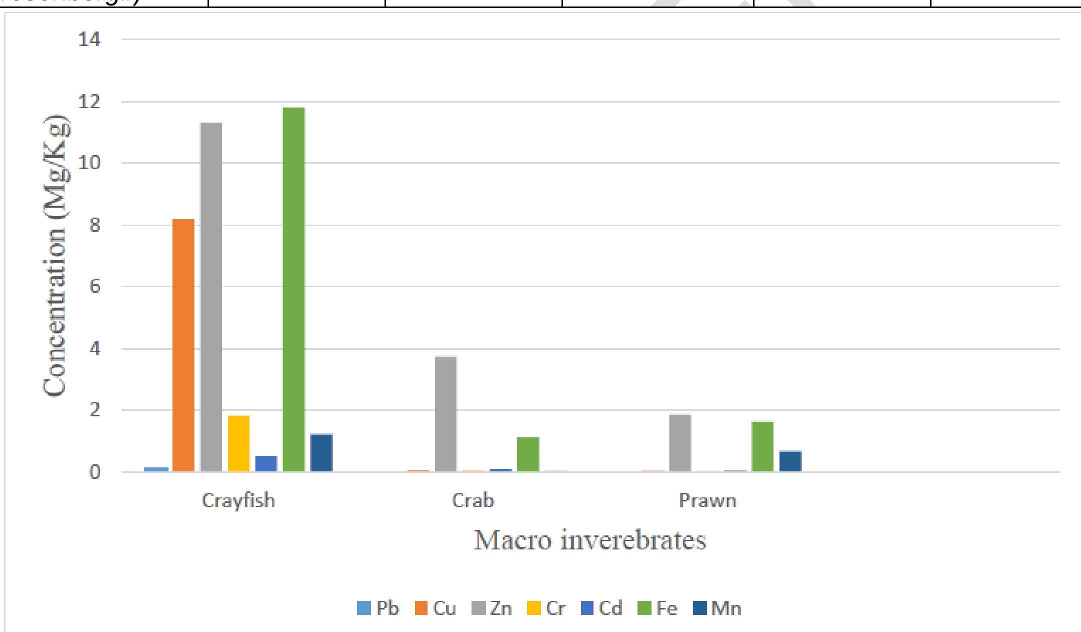

Figure 1. Heavy metal concentration in crayfish, crab and prawn from Ojo river

The mean concentrations of heavy metals assessed in this study were mostly below the permissible limit set by FAO/WHO except for the case of cadmium (Cd) in crayfish (Table 2). Cadmium concentration beyond the FAO/WHO permissible limit for food may inhibit metabolic enzymes when consumed over a long period [17]. Also, the mean concentration of lead (Pb) present in crayfish was below the permissible limit but was absent in both the crab and prawn assessed in this study (Table 2). This was similar to the report by Olowu *et al.*, (2010), who reported the same manner of accumulation in crab and prawn samples where lead (Pb) was found to be absent in both the crab and the prawn samples. The absence of lead may be attributed to the lack of heavy industrial activities around the sample site [17].

The metal body loads of the macroinvertebrates decreased in the following order: crayfish> crabs> prawns (Figure 2), this may be due to the functional differences in the body of the macroinvertebrates, and this variation could also be an indication of the degree to which individual species absorb particulate matter from the surrounding water and sediments while feeding. Crayfish and crabs are bottom feeders and are generally expected to absorb more metals than surface feeders like prawns. This is in agreement with an earlier report made by Olowu *et al.*,(2010), who assessed the level of heavy metals in crabs and prawns in the Ojo river, Lagos, Nigeria using atomic absorption spectrophotometer [17].

Table 2. Mean concentration of heavy metals (Mean ± SD, mgkg^{-1} dry weight) in macroinvertebrate samples compared with FAO/WHO permissible limit.

Metals	**Macroinvertebrate samples**			**FAO/WHO**Permissible limit
	Crayfish (*Metanephrops australiensis*)	Crab (*Potamon fluviatile*)	Prawn (*Macrobrachium rosenbergii*)	
Copper (Cu)	8.190±0.100	0.035±0.003	0.022±0.002	73.3 [21]
Iron (Fe)	11.800±0.100	1.099±0.144	1.620±0.099	425.5 [21]
Zinc (Zn)	11.310±0.160	3.728±0.170	1.850±0.150	99.4 [21]
Chromium (Cr)	1.820±0.006	0.033±0.002	0.015±0.002	2.3 [21]
Lead (Pb)	0.142±0.010	ND	ND	0.3 [21]
Cadmium (Cd)	0.510±0.006	0.085±0.005	0.032±0.003	0.2 [21]
Manganese (Mn)	1.220±0.003	0.013±0.007	0.660±0.003	0.4 [21]

**ND-Not detected*

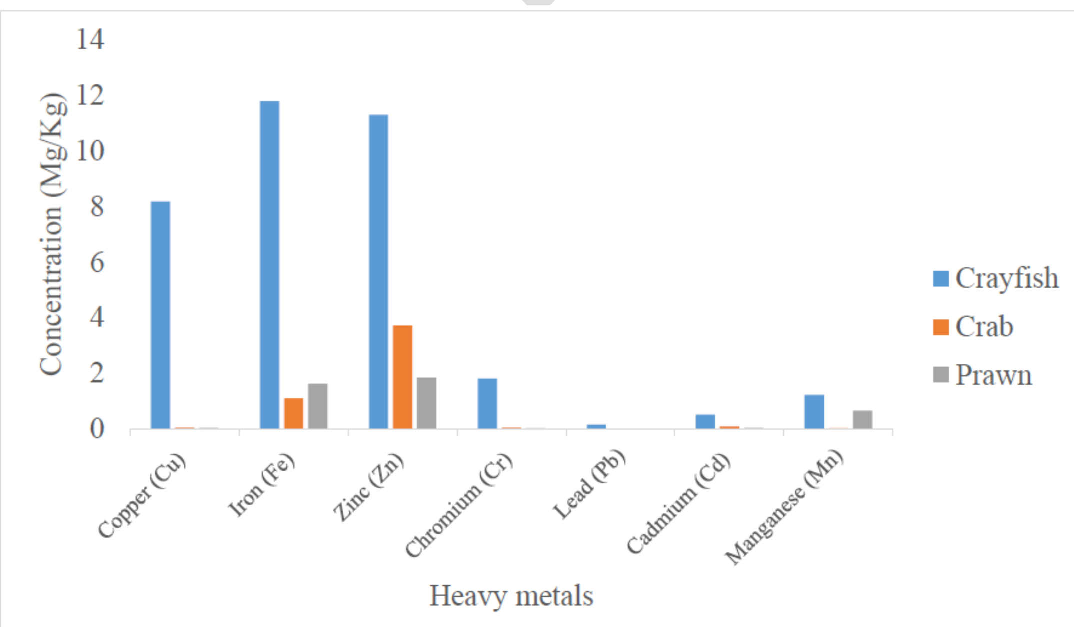

Figure 2: The mean concentration of heavy metal within crayfish, crab and prawn

Several factors could predicate metal accumulation in marine organisms. These factors could be a result of living habits, feeding strategies, metabolic activities, and living environments in which these organisms are found [19]. The absence of lead in the crab and prawn could be related to activities around the location of the river [17]. Ojo local government area consist mostly of farmlands, residential houses and warehouses for furniture supplies. There are few or no industrial activities around the study location.

4. CONCLUSION

In summary, from the evaluation of the results obtained in this study, the macroinvertebrates examined from the Ojo river possess heavy metals at a range within the permissible limits set by the FAO/WHO for consumption. Hence, these macroinvertebrates could be considered safe for consumption, but there is a need for continuous monitoring of these macroinvertebrates especially crayfish to prevent bioaccumulation of toxic metals over an extended consumption period. It is recommended that more sensitization be done to the public on the dangers of aquatic pollution and further assessments be done at regular intervals to keep monitoring the metal body loads of the aquatic biota.

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