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Full Length Research Paper

Comparative study of persistent toxic metal levels in land crab (*cardiosoma armatum)* and lagoon crab (*callinectes amnicola)* in Lagos Lagoon

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The comparative study of persistent toxic metal levels of two species of crab *Cardiosoma armatum* and *Callinectes amnicola* were studied from June 2009 to October 2009. This work provides information on the concentration of Cd, Zn, Ni, Fe and Pb in the limb, shell, flesh and gills of the two species of crab, their environment - water and sediments, and also analysis with a view to assessing accumulation of metals in the organisms. Metal concentration was determined following wet digestion and analyzed using Atomic Absorption Spectrophotometer (AAS). The concentrations observed in crab samples were lower than the WHO permissible level of 2.00µg/g for Lead (Pb) and Cadmium (Cd) in foods. The mean values obtained fell in the ranges: Fe (0.041-0.219µg/g); Zn (0.647-1.774µg/g); Cd (0.093-0.635µg/g); Ni (0.261-0.825µg/g); Pb (0.160-0.261µg/g) for *Callinectes amnicola* and Fe (0.071-0.313µg/g); Zn (0.807-1.731µg/g); Cd (0.022-0.663µg/g); Ni (0.181-1.279µg/g); Pb (0.151-0.501µg/g) for *Cardiosoma armatum*. Although, the levels were lower than the permissible levels, it was observed that *Cardiosoma armatum* and *Callinectes amnicola* accumulated more than the environment. There was no significant difference in the distribution of metals between the two crabs at 95% confidence level. This is indicative of bioaccumulation of the persistent toxic metals in the organism.

Keywords: Comparative, *Cardiosoma armatum; Callinectes amnicola*; persistent toxic metals; bioaccumulation.

INTRODUCTION

Coastal belts are highly populated and urbanized with industries. Marine food such as fish, prawn, crab and mussel are delicacies and form an important staple part of daily food. The tendency of heavy metals to get accumulated in marine animals is of scientific interest in heavy metal chemistry (Kumar and Hema, 2005). Anthropogenic pollutants are sources of persistent toxic metal contaminants in the Ocean (Lakshmanan *et al*., 2009). Industrial activities such as mining, electroplating, tanning, metallurgical operation, emissions from vehicular traffic gas exhausts, Crude Oil and Hydrocarbon exploration and exploitation, energy and fuel production, downwash from power lines, intensive agriculture and sludge dumping, and manufacturing have led to the release of persistent toxic metals into the environment (Samara, 2006; Alo and Olanipekun, 2006)). These metals may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Ashray 2005; Vosyliene and Jankaite, 2006). Human health, agricultural development and the ecosystems are all at risk unless water and land systems are effectively managed (Kehinde *et al*., 2009; Rao *et al*., 2002).

The bioavailability of trace metals is the key factor determining tissue metal levels in the marine biota (Kumar and Heme, 2005). Persistent toxic metals bioaccumulate in living organisms reaching levels that cause toxicological effects (Samara 2006). Unlike the organic pollutants which are biodegradable toxic metals like Ni (II) Cr (VI) are not biodegradable

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Figure. 1: Map Of The Lagos Lagoon And Its Environ

(Rotterdamsewag, 2006). Nickel has been reported to cause pulmonary fibrosis and inhibit many enzymatic functions (Liphadzi and Kirkham, 2005). The accumulation of these metals often result in skeletal problems, brain and kidney damage, depression, hair and vision loss (Adeyeye 1994; Williams *et al*., 2004).

In fish, concentrations of most metals are usually related to the age and size measurements of bioaccumulation of Iron, Manganese, Zinc, Copper, Nickel, and Lead by *Pseudocrenilabus philander* from a mine-polluted impoundment revealed that there was an inverse relationship between metal concentration and body mass of fish (De Wet *et al*., 1994). Although considerable work has been carried out on persistent toxic along the Lagos Lagoon, there is a paucity of information in the comparison of metal uptake of land crab *(Cardiosoma armatum)* and lagoon crab *(Callinectes amnicola)*. Crabs are aquatic organisms and its chemical composition may be greatly influenced by the environment, especially with increase cases of environmental concern which include cadmium, lead, zinc, mercury, arsenic and chromium (Forstner and Wittman 1993; Seddek *et al.*, 1996.

Land Crab (*Cardiosoma armatum*)

Land crab is a common name for multiple species of true crabs adapted for terrestrial existence. They belong to the Family Gecarcinidae. They are associated with water at one period or the other in their life cycle especially during reproduction. Their soft body is usually covered by a thick carapace or shell which is lined with a thick membrane richly supplied with blood vessels (Microsoft Encarta, 2009). The adult life of the land crab is spent away from salt water while the young ones need water for their survival. Land crabs reach sexual maturity in approximately 4 years. Peak reproductive activity occurs during full moons in summer. After mating, an adult female lays her eggs but carries the egg mass beneath her body for approximately 2 weeks prior to migrating to the ocean and releasing the eggs into shallow inshore waters. A female may produce 300,000 - 700,000 eggs per spawn, but very few larvae survive to become small crabs. The larvae are eaten by fish and other aquatic animals. Run-off water from river/streams affects their existence as they are commonly found in mangrove area. Also, Land crabs are vegetarian and occasionally feed on large insects (Mark *et al.*, 2003).

Lagoon Crab (*Callinectes amnicola*)

These species of crab belongs to the Family Portunidae. It is well distributed in almost all fresh water, near the shore, rivers, brackish and marine environment, most of which are likely to be polluted by effluents from domestic, industrial wastes or pathogenic activities (Ayejuyo *et al.*, 2008). Lawal-Are and Kusemiju (2000) described its size composition, growth pattern and feeding habits in Badagry Lagoon. Solarin and Kusemiju (2003) gave an appraisal of the gender participation in the crab fishery in Lagos Lagoon while (Lawal-Are, 2009) documented the heavy metal concentration in the crab in Lagos Lagoon.

The Study Area

The Nigerian coastal area is dominated by extensive stretches of sandy beaches (barrier islands), lagoons, estuaries and beaches, creeks and a deltaric complex of swamps and salt tolerant mangrove forests (Ibe, 1988; Onyema, 2007; Dublin-Green and Tobor, 1992)

The coastal area of south-western Nigeria, more specifically is a meandering network of lagoons that angle approximately 45^o to the prevailing south-westerlies wind coastline (Hill and Webb, 1958; Ibe, 1988; Chukwu, 2002). The Lagos Lagoon complex (Figure 1) stretches for 257km from Benin Republic to the west of Niger Delta to the east and consists of nine lagoons namely: Yewa,

Table 1: GPS of Sampling Points

SAMPLING POINTS	COORDINATES ON LAND	COORDINATES ON WATER	DESCRIPTION OF AREA AROUND THE POINTS
1	6°31′ 46.88″N 3°23′ 57.38″E	6°31′ 46.94″N 3°24′ 00.24″E	Mangrove area that have been sand-filled around Araromi area
2	6°31′ 46.21″N 3°23′ 57.08″E	6°31′ 45.37″N 3°24′ 00.28″E	Shore based populated area
3	6°31′ 45.47″N 3°23′ 57.20″E	6°31′ 44.35″N 3°24′ 00.28″E	Poor sewage systems and generation of domestic waste
4	6°31′ 44.70"N 3°31′ 57.35″E	6°31′ 43.33″N 3°24′ 00.17″E	Shore based for fishing activities
5	6°31′ 44.70″N 3°23′ 58.37″E	6°31′ 42.31″N 3°23′ 59.90"E	Sand mining activities, high level of domestic waste introduction
6	6°31′ 43.00″N 3°23′ 58.39″E	6°31′ 41.06″N 3°23′ 59.97″E	Lagos Lagoon shallow zone
7	6°31′ 42.26″N 3°23′ 58.77″E	6°31′ 40.10″N 3°24′ 00.06″E	Former wet land fill to build human habitation around Ilaje road area
8	6°31′ 41.11″N 3°23′ 58.61″E	6°31′ 39.68″N 3°24′ 00.31″E	Shallow part of the Lagos Lagoon shoreline at Ilaje road area
9	6°31′ 40.44″N 3°23′ 58.61″E	6°31′ 39.10″N 3°24′ 00.53″E	Reparine area proximate to the Lagos Lagoon shoreline at Ilaje road area
10	6°31′ 40.09″N 3°23′ 58.64″E	6°31′ 39.10″N 3°24′ 00.87″E	Higher population area with poor urban planning

Ologe, Badagry, Iyagbe, Lagos, Kuramo, Epe, Lekki, and Mahin Lagoons from the west to the east (FAO, 1969; Nwankwo, 2003).

The Lagos Lagoon has a surface area of 208km^2 (FAO, 1969). It is shallow, open and experiences environmental gradients linked to rainfall patterns (Nwankwo *et al.*, 2003). Epe Lagoon is connected to the Lagos Lagoon to the west and the Lekki Lagoon to the east. The Lagos Lagoon is the largest of the four lagoon systems of the Gulf of Guinea (Webb, 1958). The tidal range is small only about 0.6 -1.2m. the Lagos Lagoon forms part of an intricate system of water ways; the interconnecting creek are also very shallows and are sites of active silting and mud deposition. (Onyema, 2009). Two factors influence the biological, physical and chemical characteristics of the Lagos Lagoon according to (Nwankwo, 1998) and they are fresh water discharge from rivers and tidal seawater incursion.

MATERIALS AND METHODS

Collection of Samples

Crab samples were purchased from fishermen at the bank of Ebute – Araromi River of the Lagos Lagoon in Bariga, Lagos State. The GPS of the sites are given in Table 1. The crab samples were collected over a period of 5 months at 2 weeks interval between June and October, 2009 during rainy season. Samples were collected forth nightly for the study of levels of pollution from persistent toxic metals in the specified environment. 20 different samples were collected for the species of crab – *Callinectes amnicola* (Figure 2) and *Cardiosoma armatum* (Figure 3); in sampling the environment – Sediment and Water were also collected for analyses. The samples were kept in polythene bags and taken into the laboratory where they were refrigerated and analyzed.

Treatment of Samples

Thawed crab samples were dissected into four parts, namely: flesh, limb, gills, and shell (carapace). Each of this part was subjected to digestion to ensure removal of all organics and materials that could be in form of impurity interfering with the actual metal to be analyzed. For the purpose of this analysis, wet digestion was employed.

Digestion and Analyses of Metals

10 grams of each part of the crab and sediment were weighed into a 250ml conical flask. 10ml of nitric acid was added and boiled on a hot plate in a fume cupboard until a white fume was observed on top of the conical

Figure 2a. Dorsal view of *Callinectes amnicola*

Figure 2b. Ventral view of *Callinectes amnicola*

Figure 3a. Dorsal view of *Cardiosoma armatum*

Figure 3b. Ventral view of *Cardiosoma armatum*

flask indicating all organics and any other impurities were burnt off. The solution is made up to 50ml mark with distilled water. The presence of some selected trace metals [Lead (Pb), cadmium (Cd), Nickel (Ni), Zinc (Zn) and Iron (Fe)] was determined using Atomic Absorption Spectrophotometer (AAS), model Buick Scientific 210 GVP following wet digestion with Nitric acid (Kakulu *et al.*, 1987). For water samples, 90ml of the sample was taken and boiled with 10ml of the acid (Nitric acid) in a 250ml conical flask to evaporate all impurities. The samples were then analysed for heavy metal using same method of the AAS. For recovery studies, samples were spiked with various concentrations of the standard solutions of the metals (FAO, 1983; Kakulu *et al.,* 1987)

RESULTS AND DISCUSSION

The result of the analyses shows the concentration of metals present in different parts (limb, gills, shell and flesh) of the two species of crab – *Cardiosoma armatum* and *Callinectes amnicola* and the environment – sediments and water for the period between June and October, 2009 (Table 2). The highest concentration of 0.767µg/g was observed in the flesh of *Callinectes amnicola* in the month of October, 2009 and the lowest concentration of 0.010µg/g was obtained in the flesh of the same species. *Cardiosoma armatum* shows higher concentration of Fe in the month of October, 2009 with a concentration of 0.826µg/g. It was observed that Fe was not detected in *Cardiosoma armatum* in the second and sixth collection in the month of June and August respectively. But the fifth collection in the month of August shows the lowest concentration obtained to be 0.002µg/g. The mean of the distribution shows that Fe is higher in parts of *Cardiosoma armatum* than in *Callinectes amnicola* except in the flesh. It was observed that, there was no significant difference in the accumulation of the metals at 95% confidence level in spite of the difference observed in the concentration of metal in both species.

Zn showed a concentration of 2.009µg/g for *Callinectes amnicola* in the month of September, 2009 in the seventh collection and the lowest concentration of 0.235µg/g. The highest level of metal obtained for *Cardiosoma armatum* was 1.945µg/g and the lowest level is 0.058µg/g in the month of June, 2009. It was observed that *Cardiosoma armatum* accumulated more of the metal than *Callinectes amnicola* by comparing their mean concentrations. Although, a simple paired t-test and f-test did not show a significant difference at 95% confidence level. Cd, Pb and Ni are some of the poisonous persistent toxic metals known. It was observed that the two species of crab shows more accumulation of Cd than Pb. The highest level obtained for Cd was 0.995µg/g in the month of July,

Table 2. Mean Concentration of Metals in Crab Samples

Callinectes amnicola						
		Iron	***Zinc***	***Cadmium***	***Nickel***	***Lead***
Limb	*(µg/g)*	0.2080	1.7740	0.6350	0.7770	0.1900
Gills	*(µg/g)*	0.0410	0.8360	0.5850	0.2620	0.1600
Shell	*(µg/g)*	0.2190	0.6470	0.3610	0.2610	0.1620
Flesh	*(µg/g)*	0.1760	1.1630	0.0930	0.8250	0.2610
Cardiosoma armatum						
Limb	*(µg/g)*	0.2640	1.7310	0.6630	0.6840	0.5010
Gills	*(µg/g)*	0.0710	0.8070	0.0220	0.8240	0.1770
Shell	*(µg/g)*	0.3130	1.2350	0.3160	1.2790	0.2200
Flesh	*(µg/g)*	0.1410	0.8320	0.0730	0.1810	0.1510
Sediment	*(µg/g)*	0.5720	1.3270	0.5480	1.0370	0.4120
Water	*(mg/l)*	0.1510	0.7000	0.0160	0.1440	0.1570

Table 3. Comparison of mean concentrations of parts of the two species of crab

	t-test	**f-test**
Limb	0.5000	0.8000
Gills	0.9860	0.7001
Shell	0.1640	0.0715
Flesh	0.1250	0.4589

Sampling period (n) = 10
Degree of freedom = 9
95% Confidence level = 2.262

2009 in the fourth collection for *Callinectes amnicola* and 0.989µg/g for *Cardiosoma armatum* in the first collection in the month of June. The highest level obtained for Pb is 0.762µg/g in the first collection for Callinectes *amnicola* and 0.985µg/g for *Cardiosoma armatum* in the month of June, 2009 in the second collection. The levels obtained were lower than the WHO 2.00µg/g permissible level for Lead and Cadmium in foods. A simple paired t-test and f-test showed that, there was no significant difference at 95% confidence level for the two species of crab. Nickel was observed to be very high in the month of June in the first collection in the flesh of *Callinectes amnicola* with 4.449µg/g. Although, there was difference in the bioaccumulation, it was observed that at 95% confidence level there was no significant difference between the mean of the two species. Also, the level observed for the level of Ni was lower than the WHO 2.00µg/g permissible level for Pb and Cd in foods. Below is the table for the mean concentration of the analysis for the period between June and October, 2009.

This study showed the buildup of metals in the sediment, water and crabs – *Cardiosoma armatum* and *Callinectes amnicola* of Lagos Lagoon. Persistent toxic metals were present in all the parts of the crab.

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 (1983), Kakulu *et al.,* (1987) and Federal Environmental Protection Agency - FEPA (1991), the WHO recommended quantities of persistent toxic metals are: Cd-2.00µg/g; Pb-2.00µg/g; Zn-1000µg/g.

The result is in conformity with the observation of (Lawal-Are, 2001) that, the trace metal concentrations were much lower in the crabs during the wet season. This must have resulted from the very high dilution of the lagoon water from the heavy rains that occur from June to November each year.

Although, the levels obtained were lower than the permissible levels, it was observed that *Cardiosoma armatum* and *Callinectes amnicola* accumulated more of the metals than that of the environment - water and sediments. Furthermore, it was observed that more of the metals were found in the sediments than in water. Reasons could have been that the sediments served as a sink for accumulation of pollutants and as a result more of the metals were found in *Cardiosoma armatum* than *Callinectes amnicola*. All these are indicative of bioaccumulation of the persistent toxic metals though lower than the permissible levels. Hsiao-Chien *et al*

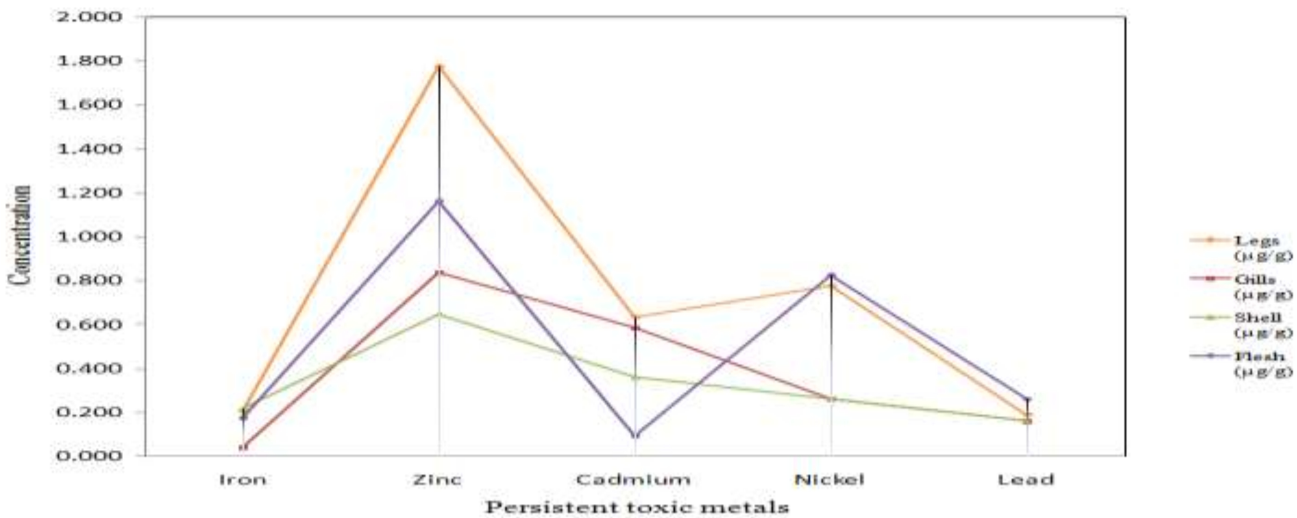

Figure 4. Mean concentration of metals (Fe, Zn, Cd, Ni, Pb) in *Callinectes amnicola* from Lagos Lagoon (June – October, 2009)

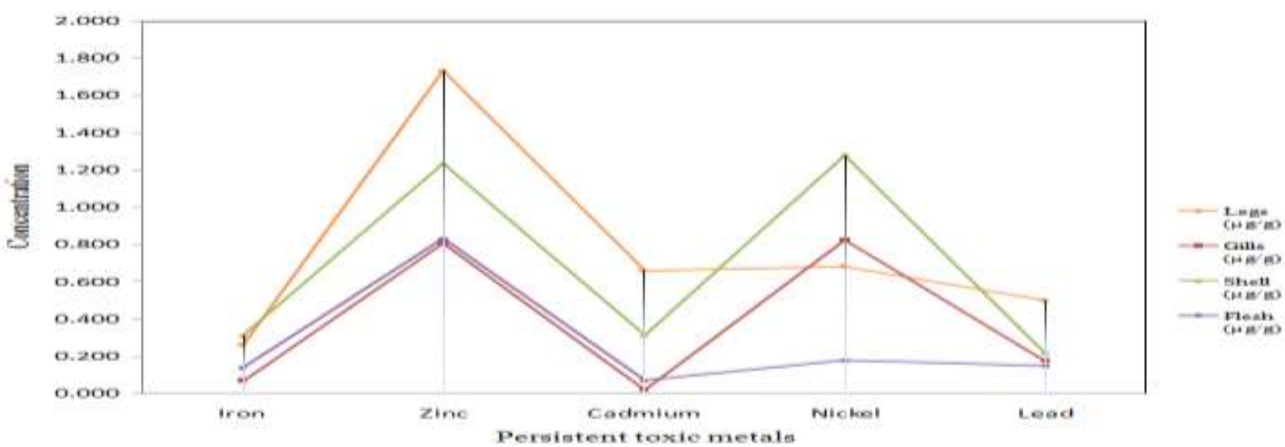

Figure 5. Mean concentration of metals (Fe, Zn, Cd, Ni, Pb) in *Cardiosoma armatum* from Lagos Lagoon (June – October, 2009)

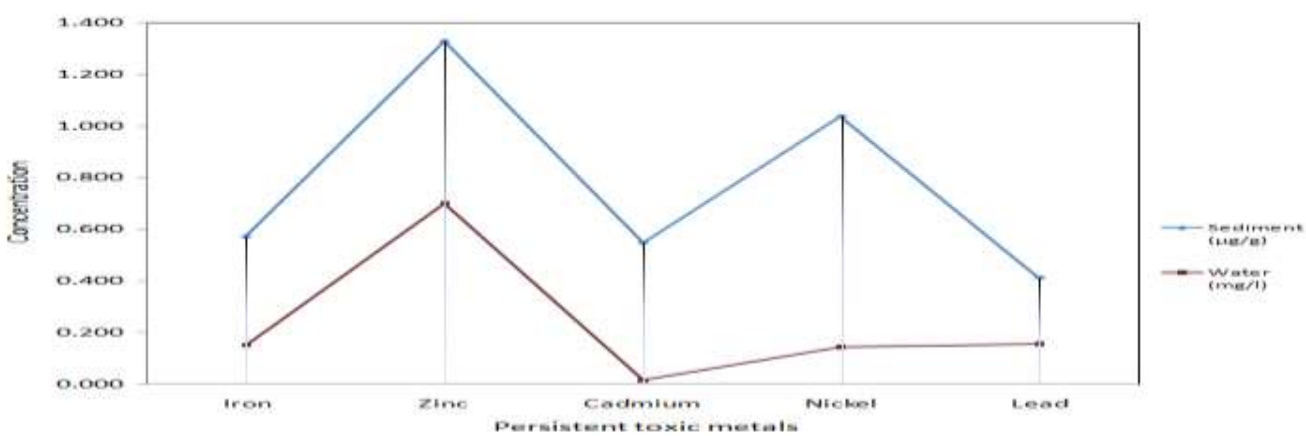

Figure 6. Mean concentration of metals (Fe, Zn, Cd, Ni, Pb) in water and sediments from Lagos Lagoon (June – October, 2009)

(2008) in their research revealed that crab is a potential biomonitor of Pb and Ni pollution in aquatic ecosystems. Therefore, it can be deduced that crabs as one of the aquatic biota bioaccumulates and serves as bioindicator of persistent toxic metals or contaminants in aquatic environments. Williams *et al* (2007) have 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 in 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 (Sagen and PusCo 1991; Adeyeye 1994; Udoh *et al.*,1999; Ayejuyo *et al.*, 2003; Adekoya *et al.,* 2006).

This result documented the comparison of Persistent toxic metals in *Callinectes amnicola* and *Cardiosoma armatum* and serves as an indicator of trace metal contents in the crabs from Lagos Lagoon. The levels obtained were within the maximum permissible limit set by WHO 2.00µg/g in foods for Pb and Cd. By the results obtained, the crabs from the study site are still safe for human consumption.

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