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Marine Shrimp and Fish as Sentinels of Heavy Metal Pollution of Lagos Lagoon

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Abstract: Pollution and contamination of the aquatic environment in Nigeria is increasing in scope and magnitude. This could be attributed to the development of various types of industries and the over population, especially Lagos, the commercial and Industrial center of Nigeria. The levels of three heavy metals (copper, chromium and lead) in Lagos lagoon and their accumulation in resident fish and shrimp were therefore investigated in this study. Upstream and downstream water and sediment samples were weekly collected collected between November-December 2007 during dry season and repeated between April and May, 2008 during the rainy season. Samples of fresh and ready-to-eat fish and shrimps were also purchased during the same periods. Results obtained showed that levels of bioaccumulation of metals in the body tissue of the organism studied were significantly higher than the levels of accumulation in water. The result also demonstrated the seasonal differences, with higher values in the rainy season than in the dry season for the heavy metal studied. Chromium was not detected in ready-to-eat fried fish and shrimp, while lead had the lowest value of 1.5mg/l in fried fish and 2.9mg/l in fried shrimp. However, the high lead level observed portends grievous public health risk since the FAO limit for lead is 0.5mg/kg.

Key words: Marine Pollution · Heavy Metal · Bioconcentration

INTRODUCTION

Heavy metals accumulate on available surfaces such as plants and aquatic bodies or sediments; they can be magnified through the food chain, thereby posing health risk to humans who consume sea food from contaminated sources [1, 2]. Nigeria's watersheds are susceptible to both climatic destructive influences as well as anthropogenic environmental hazards. Lagos is one of the eight states located in the coastal zone of Nigeria [3]. Lagos state being one of the most populated states in Nigeria houses numerous industrial establishments and is noted to be the highest waste generating state. Lagos' drainage system has 6 major canals which drains water from tertiary drainage systems and eventually empties into the lagoon.

A large number of physical and chemical wastes find their way into the aquatic environment and the pollutants are absorbed by fine grained organic particles that end up in the bottom deposits. Konar *et al.* [4] noted that heavy metals are serious pollutants of the aquatic environment with deleterious effects on aquatic fauna. These metals are toxic to aquatic life at low concentration particularly in soft water environment. The metals may be accumulated from water to higher levels in fish tissue [5]. Copper (Cu), Chromium (Cr) and Lead (Pb) salt are usually found in agricultural and industrial liquid wastes [6] which are discharged into water resources.

Lead is an environmental pollutant known to cause damage to human health, affecting, especially the central nervous system, reproductive organs, the immune system and kidney [7]. Cu is an abundant trace metal, although essential at low levels, it is also potentially toxic to aquatic organisms. Mechanisms of toxicity and consequences of exposure vary depending on ionoregulatory status [8]. Cr enters the environment in several different forms. In fish, Cr may hamper fertilization success by directly acting on the fertilized egg to cause death of the embryo, or it may react with the sperm and egg individually to impede fertilization [9].

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Fishes being one of the main aquatic organisms in the food chain often accumulate large amounts of metals through ingestion of suspended particulates, food materials and/or by constant ion-exchange process of dissolved metals across lipophilic membranes like the gills/adsorption of dissolved metals on tissue and membrane surfaces [1] Among the list of organic and inorganic substances released into the aquatic ecosystem, heavy metals have received considerable attention due to their toxicity and potential bioaccumulations by many aquatic species [10]. This study was designed to investigate the levels of lead, copper and chromium in Lagos lagoon, Nigeria including their accumulation by in-dwelling fish and shrimps.

MATERIALS AND METHODS

Sampling Protocol: Water sampling was accomplished by means of fishermen boat cruises and a life raft. Upstream and downstream water and fish samples were collected between November-December 2007 during dry season and repeated in April, during rainy season. Available shrimp specie (*Macrobrachium rosenbergii*) and different species (Hemichromis, mullet and grunter) of edible fishes were purchased from local fishermen. The fishes were preserved in Coleman coolers containing ice packs and sent to the laboratory for subsequent analysis.

Laboratory Analysis: Digestion of samples was carried out based on the method described byAPHA [11] and ASTM [12] and Copper, lead and chromium concentrations were determined using Atomic Absorption Spectrophotometer (AAS Philips Unicam 969). The Bioconcentration factors (BCF) of copper, lead, zinc and chromium between the fish tissues and the ambient water (BFW) were calculated, using the mean metal concentration in each tissue and the corresponding metal concentration for water.

$$BCF = \frac{Cwf}{Cw}$$

Where Cwf *is* the concentration of heavy metal in a fish's tissue due to uptake of lead from the ambient water and Cw is the concentration of heavy metal in the water.

Statistical Analysis: The result of heavy metal concentration in water, shrimp and fish were recorded and computed using SPSS®. The results were presented in graphical format as means ± standard deviation (SD). Students't-test was used to determine the level of significance of the heavy metal concentration in shrimp and fish within and between seasons. Differences were regarded as significant at p= 0.05.

RESULTS AND DISCUSSION

Samples were obtained off a fishing village in Lekki-Epe (Figure 1). Shrimp (*Macrobrachium rosenbergii*) and different species (Hemichromis, mullet and grunter) of edible fishes were purchased from local fishermen (Figure 2). The shrimp and fish samples were apparently fresh and free from gross contamination. There was also no physical evidence of spoilage as many of them were alive at the point of purchase. Bioconcentration level of chromium, copper and lead in Lagos lagoon water samples during dry and rainy seasons is Figure 3. Comparative assessment of seasonal bioconcentration levels of chromium, copper and lead in marine shrimp and fish is presented in Figures 4 and 5, respectively. Bioconcentration of chromium, copper and lead in fish and shrimp from the sampled location may be adduced to improper discharge of wastes from various human activities in the study area especially from industrial, oil sectors and municipal discharges, [13]. The level of lead (0.47 and 1.34 mg/kg for fish and 1.15 and 1.95 mg/kg for shrimp during dry and rainy seasons respectively) recovered in both the fish and shrimp samples are higher than the FAO limit (0.5mg/kg) during the rainy seasons for fish and shrimp samples and during dry season for shrimp samples [14].

Seasonal bioconcentration factors of chromium, copper and lead in marine shrimp and fish are presented in Figures 6 and 7, respectively. The higher concentration of heavy metals in body tissue of Fish and Shrimp than in the water demonstrates evidence of bio-accumulation of heavy metals in body tissues probably through contact respiration and feeding. The results of comparative bioconcentration levels of chromium, copper and lead in pooled samples of ready-to-eat fried fish and shrimp are presented as Figure 8. The level of significance of the observed differences in the concentration of chromium, copper and lead in marine shrimp and fish both within seasons and between seasons using student t-test is presented as Table 1.

Fig. 1: A fishing community on Lagos Lagoon in Lekki-Epe

Fig. 2: Marine fish and Shrimp on display by retailers

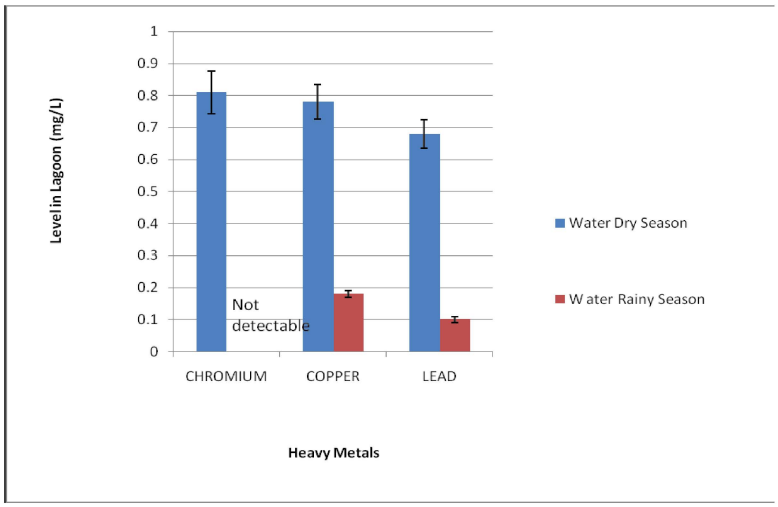

Fig. 3: Bioconcentration Level of Chromium, Copper and Lead in Lagos Lagoon Water Samples during dry and rainy seasons

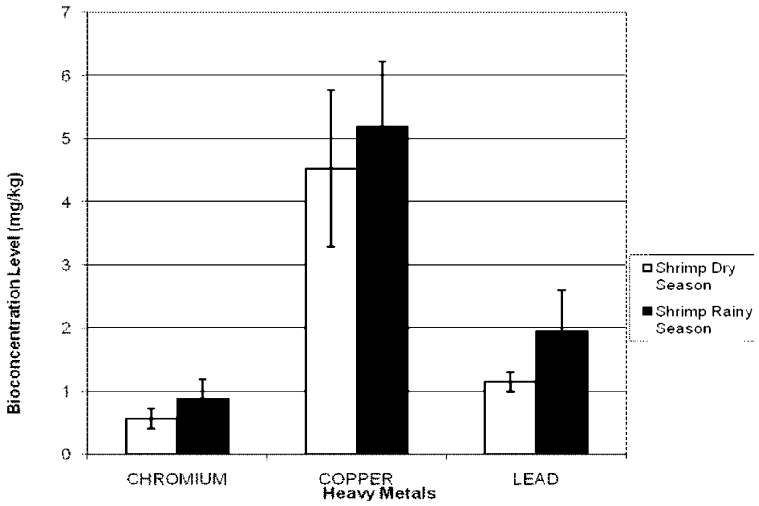

Fig. 4: Comparative bioconcentration levels of chromium, copper and lead in *Macrobrachium rosenbergii* from Lagos Lagoon during dry and rainy seasons

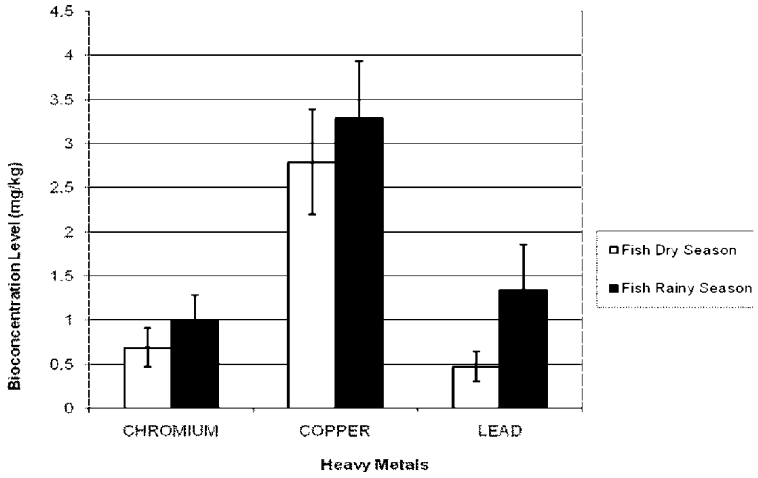

Fig. 5: Comparative bioconcentration levels of chromium, copper and lead in fish from Lagos Lagoon during dry and rainy seasons

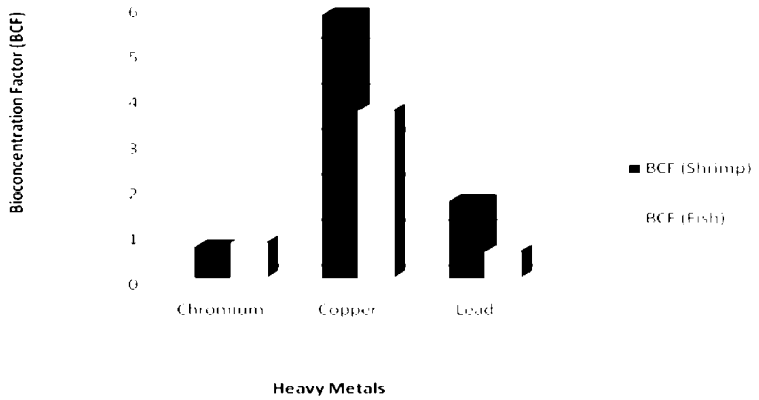

Fig. 6: Bioconcentration factors of chromium, copper, lead, in marine shrimp and fish during the dry season

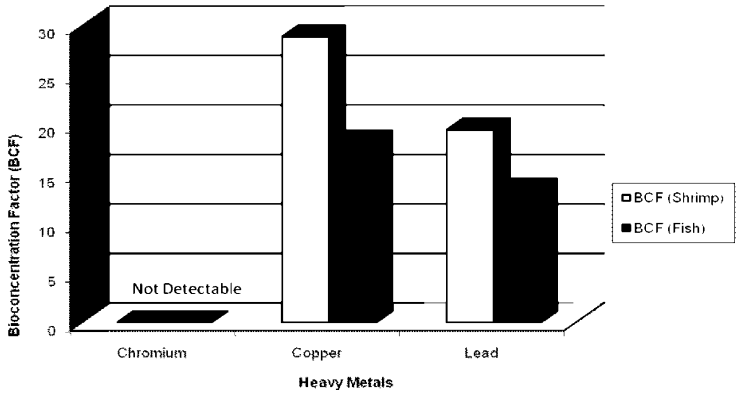

Fig. 7: Bioconcentration factors of copper and lead in marine shrimp and fish during the rainy season

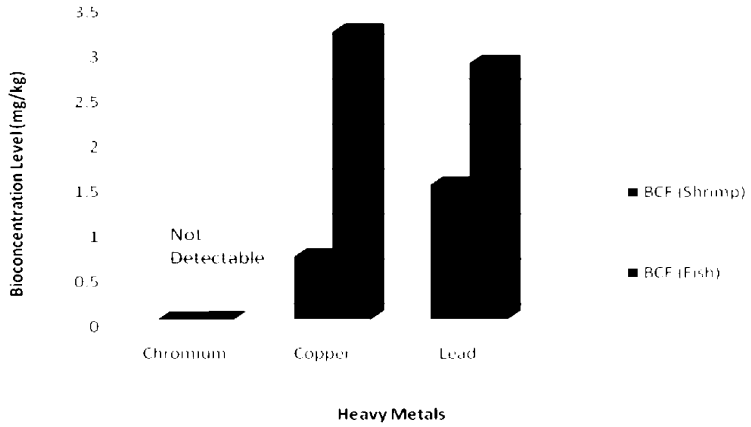

Fig. 8: Bioconcentration levels of copper and lead in pooled samples of ready-to-eat fried fish and shrimp

Table 1: Significance (p value) of differences in seasonal heavy metal concentration in marine shrimp and fish

		Shrimp (Rainy season)	Fish (dry season)
Cu	Shrimp (dry season)	0.42	0.04*
	Fish (Rainy season)	0.01*	0.03*
Pb	Shrimp (dry season)	0.09	0.0002*
	Fish (Rainy season)	0.19	0.04*
Cr	Shrimp (dry season)	0.13	0.38
	Fish (Rainy season)	0.61	0.12

* t-test is regarded as significant at p= 0.05

Cu is an essential element for vertebrates and commonly found in fish tissue. Moore and Ramamoorthy [15] suggested that even in polluted waters, fish muscle tissue concentrations seldom exceed 1g Cu/g. They also summarized that contaminated food is probably a more important source of copper than water. In the present study; Cu levels was 2.79 and 3.29mg/kg for fish and 4.53 and 5.2 mg/kg for shrimp during dry and rainy seasons, respectively. However, the values of Cu and Zn were lower than the FAO recommended limits (30mg/kg), while the relatively high level of Cu concentration in the organisms suggests a high bio-availability of the heavy metals in the studied water body. In ready-to-eat samples; chromium was not detectable. However, the difference in heavy metal bioconcentration levels in ready-to-eat fish and shrimp was not significant (p=0.43) at 95% confidence limit. However, the high lead level observed portends grievous public health risk since the FAO limit for lead is 0.5mg/kg.

In conclusion :Although the results have not explicitly shown a manifestation of toxic effects, the possibility of deleterious effects after a long period of consumption of sea foods with trace metals cannot be ruled out. The data obtained from this study could therefore serve as a fundamental source of information for future environmental impact assessment. It is necessary for industrial and effluent discharges to be monitored to ensure that critical limits are not exceeded.

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