Seasonal Levels of Essential Metals in Fresh and Fried Marine Shrimp and Fishes from Lagos Lagoon, Nigeria

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ABSTRACT

Transition metals are essential for health, forming integral components of proteins involved in all aspects of biological function. However, in excess these metals are potentially toxic, and to maintain metal homeostasis organisms must tightly coordinate metal acquisition and excretion. The diet is the main source for essential metals, but in aquatic organisms an alternative uptake route is available from the water. The levels of Zinc, Iron and Manganese accumulation in marine fish, shrimp and water were investigated in this study to cover the two major seasons in Nigeria. Water and samples of fish and shrimps were pooled weekly for five weeks between November and December 2007 during the dry season and repeated in April 2008 during the rainy season and analyzed using standard methods. The results obtained showed that the levels of bioconcentration of Zinc, Iron and Manganese in shrimp and fish were significantly higher than the levels of accumulation in water. The result also revealed temporal differences, with higher bioconcentration values observed during the rainy season. The highest bioconcentration of trace metal detected was Zinc, in fried fish (15.7 mg/l) and fried shrimp (11.1 mg/l). However, the value of Zinc is lower than the FAO recommended limits (30 mg/kg), although its relatively high level suggests a high bio-availability of the heavy metals in the studied water body.

Keywords: Trace Metals, Lagos Lagoon, Marine Fish, Marine shrimp, Aquatic pollution

1. Introduction

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, urbanization, inadequate consideration of environmental impact analysis of developmental projects and the rush towards industrialization and urbanization without proper planning and management. Transition metals (i.e. copper, zinc, iron, cobalt, selenium, manganese) are essential for the health of most organisms, forming integral components of proteins involved in all aspects of biological function. However, in excess they are toxic, binding to inappropriate biologically sensitive molecules or forming dangerous free radicals. Consequently, there is a fine balance between metal deficiency and surplus and it is vital for organisms to maintain metal homeostasis via balancing absorption and excretion (Bury, Walker and Glover, 2002).

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., (1990) 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 (Forstner and Wittman, 1983). Fish can accumulate high concentrations of metals present in the water or in their food, thus increasing the concentration of toxic compounds found in the surrounding medium.

Zinc (Zn) provides a molecular mechanism by which growth hormone can bind to the prolactin receptor (Cunningham et al, 1990). However, like all essential elements, Zn can also be toxic. Small incremental changes in Zn intake can have significant effects on the absorption of Fe in some individuals (Yadrick et al, 1989). Iron (Fe), though an essential part of haemoglobin may cause conjunctivitis, choroiditis, and retinitis if it contacts and remains in the tissues. Manganese (Mn) is required for normal brain function. But exposure to high levels through inhalation or ingestion may cause adverse health effects. Fishes being one of the main aquatic organisms in the food chain may often accumulate large amounts of certain metals. Essentially, fishes assimilate these heavy 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. Baseline surveys of the concentration of heavy metals in selected fish species have been conducted on several coasts around the world (Rainbow and Phillips, 1993).

The metal contaminants in aquatic systems usually remain either in soluble or suspension form and finally tend to settle down to the bottom or are taken up by the organisms. The progressive and irreversible accumulation of these metals in various organs of marine creatures ultimately leads to metal-related diseases in the long run because of their toxicity, thereby endangering the aquatic biota and other organisms (Hart, 1982). This study was designed to investigate the levels of Fe, Mn and Zn in Lagos lagoon, Nigeria including their accumulation in-dwelling fish and shrimps. We also considered the public health implications by assessing the levels of these metals in fried fish and shrimps.

2. Materials and methods

2.1 Study area

Lagos State is one of the most populated state in Nigeria having about fifteen million people and located on the geographical grid reference of longitude 3°5E, Latitude 7°20°N. It is one of the eight states located in the coastal zone of Nigeria. Lekki lagoon lies between longitude 3°40’ and 4°30’ and between latitude 6°25’ and 6°39’ N (Ikusemiju, 1975). Lagos drainage system has six major canals which drains water from tertiary drainage systems and eventually empties into the Lagos lagoon. Samples were taken from a fishing village in Lekki-Epe, Lagos State

2.2 Sampling Protocol

Water sampling was done 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 species
(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.

2.3 Laboratory analysis

Digestion of samples was carried out based on the method described by (APHA, 1998) and (ASTM, 2001). Zinc, Iron and Manganese were determined using Atomic Absorption Spectrophotometer (AAS Philips Unicam 969). The Bioconcentration factors (BCF) of Zn, Fe and Mn were calculated, using the mean metal concentration in each tissue and the corresponding metal concentration in water as follows:

\[ BCF = \frac{C_{wf}}{C_w} \]

Where \( C_{wf} \) is the concentration of metal in a fish’s tissue due to uptake of the metal from the ambient water and \( C_w \) is the concentration of the metal in the water.

2.4 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 \( p \leq 0.05 \).

3. Results and discussions

The water was visibly polluted from domestic activities and non-point sources (Figure 1).

![Figure 1: Severe pollution of the Lagoon from point and non-point sources](image)

The shrimp sampled was Macrobrachium rosenbergii, while fish species sampled include Hemichromis spp, mullet (Mugilidae) and grunter (javelin fish). The shrimp were edible and fish samples collected 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 collection. Results of bioconcentration levels of Zn, Fe and Mn in marine fish and shrimp during the dry and rainy seasons are presented in Figures 2 and 3 respectively.

**Figure 2:** Bioconcentration levels of Zn, Fe and Mn in marine fish during dry and rainy seasons

**Figure 3:** Bioconcentration levels of Zn, Fe and Mn in marine Shrimp during dry and rainy seasons

Comparative bioconcentration factors of Zn, Fe and Mn in marine shrimp and fish during rainy and dry seasons are presented in Figures 4 and 5 respectively; while the comparative bioconcentration levels of zinc, iron and manganese in pooled samples of ready-to-eat fried
shrimp and fish is presented in Figure 6.

**Figure 4:** Comparative bioconcentration factors (BCF) of Trace metals in marine shrimp and fishes during rainy season

**Figure 5:** Comparative Bioconcentration factors (BCF) of Trace metals in marine shrimp and fishes during dry season
The level of significance of the observed differences in the concentration of the trace metals (Zn, Fe and Mn) in marine shrimp and fish both within seasons and between seasons using student t-test is presented as table 1.

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

<table>
<thead>
<tr>
<th></th>
<th>Shrimp (Rainy season)</th>
<th>Fish (dry season)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zn</td>
<td>0.98</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>0.79</td>
</tr>
<tr>
<td>Fe</td>
<td>0.20</td>
<td>0.015*</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.002*</td>
</tr>
<tr>
<td>Mn</td>
<td>0.41</td>
<td>0.002*</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>0.34</td>
</tr>
</tbody>
</table>

* t-test is regarded as significant at a value of p≤ 0.05
In this study, both fish and shrimp are able to bioaccumulate the three heavy metals studied in their tissues (Figs. 2-7). This may be because of improper discharge of wastes from various human activities in the study area especially from industrial, oil sectors and municipal discharges, (Kakulu and Osibanjo 1992). Iron was found in high concentrations in both fish and shrimps (Figs. 2-5). This finding demonstrates an evidence of bioconcentration of Fe by fish and shrimp. Excess waterborne iron may be toxic to fish, due to the formation of iron ‘flocs’ on the gills, resulting in gill clogging and respiratory perturbations (Dalzell and MacFarlane, 1999).

Zinc bioconcentration in fish and shrimp was relatively high although lower than the FAO recommended limit of 30 mg/kg. Generally, Zn is efficiently regulated by wildlife and tissue concentrations are not reliable indicators of exposure (Beyer and Storm, 1995). However, Eisler (1993) reported that elevated concentrations of waterborne Zn has adverse effects on growth, survival, behavior, and reproduction of sensitive fishes, with early life stages being the most sensitive. The predominance of Zn in both wet and dry season may suggest anthropogenic influence possibly from municipal sources. Also, it has been reported that excessive Zn affects the hepatic distribution of other trace metals in fish (Tchounwou et al, 1996). This, no doubt, would affect tissue metal concentrations as well as certain physiological processes. Zinc generates toxicity to fish by interfering with calcium homeostasis (Hogstrand and Wood, 1996).

Manganese is essential for bone structure, in reproduction and for the normal functioning of the nervous system. The observed higher bioconcentrations of heavy metals during the wet seasons may be attributed to increased land based run off to the water body and increased water current and wave action which may largely disturb the sediment, with the concomitant resurfacing of previously leached metallic ions into the sediment. Other factors include nature of sediment scavenged, type of food, and nature of run-off and or water quality.

There was a consistently higher concentration of these heavy metals in rainy season compared with dry season for both the water and tissues of fishes and shrimps. This may be attributable to changes in biological activity associated with increased in food availability resulting from higher and longer days and also due to increased productivity which induces a rise in the metabolite concentration in seawater which in turn increases the possibility of organic complexation of metals and subsequent changes in metal bio-availability. The relatively higher concentration of the metals in tissue of fish against that of the water suggests bioconcentration. The possible reason for this may be due to the organism’s absorption efficiency, feeding pattern, bioavailability or partitioning of compounds into lipids (Phillips, 1995). The metal concentrations observed in the tissues of shrimp in this study are similar to observations reported in previous studies in the Niger Delta (Olaifa and Ayodele, 2004, Ideriah et al, 2006). It is also evident from this study that fish and shrimp can be used as sentinels for metal pollution monitoring programme.

4. References