Assessment Level of Heavy Metal in Prawns (Macrobrachium Macrobrachion) and Water from Epe Lagoon

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ABSTRACT

This study assessed the concentrations of Mn, Cu, Zn, Pb and Cd in whole prawn specimens and water samples from Epe Lagoon, Lagos State, using Techcomp AA 6000 atomic absorption spectrophotometer. The mean concentration of each heavy metal in prawn specimens and water samples and the bioconcentration factor were determined. The mean concentrations of the metals in prawn specimens were in the order of Mn; 69.36 ± 78.53mg/kg > Zn; 52.88 ± 4.01mg/kg > Cu; 54.82 ± 13.88mg/kg > Pb; 9.18 ± 7.18mg/kg > Cd; 0.83 ± 0.20mg/kg. The mean concentrations of Mn, Cu and Pb in prawn specimens were above the maximum limits recommended by WHO. While level of Zn was lower than the WHO and FAO limits, the level of Cd was similar to WHO and FAO limits. The mean concentrations of the metals in water samples were within the limits recommended by WHO and FEPA. The results suggest that Epe lagoon is contaminated with heavy metals and the consumption of prawns of the lagoon could pose health hazards to man. Consequently, continuous environmental pollution monitoring to check heavy metal hazards is hereby recommended.

Key words: Heavy metals, Macrobrachion, Bioconcentration, Lagoon

Introduction

Heavy metals are natural components of the earth’s crust and they can enter the water and food cycles through a variety of chemical and geochemical processes [21,12]. Advancement in technology as well as increase in population have led to environmental concerns relating from indiscriminate dumping of refuse and discharge of industrial effluents, petroleum waste water, and crude oil spills replete with most common heavy metals in our environment [23]. SCEP [19] reported that various activities by man in recent years have increased the quality and distribution of heavy metals in the atmosphere, land and water bodies. The fates of heavy metals introduced by human activities into aquatic ecosystems have recently become the subject of widespread concern, since beyond the tolerable limits they become toxic [17,10]. All heavy metals are potentially harmful to most organisms at some levels of exposure and absorption. At low concentrations, many heavy pesticides and fungicides, etc., may have been applied and industrial districts where there may have been waste deposits [7]. Water sediments and the biota are generally metal reservoirs in aquatic environments [22]. Various activities by man in recent years have increased the quantity and distribution of heavy metals in the atmosphere, land and water bodies. The extent of this widespread but diffused contamination has raised concern about their hazards on plants, animals and humans.

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metals including mercury, cadmium, lead, arsenic and copper inhibit photosynthesis and phytoplankton growth. Biney et al. [2] reported delayed embryonic development, malformation and reduced growth of adult fish, mussels and crustaceans under similar conditions.

The human health aspect linked to the consumption of heavy metal contaminated fish is of great concern. Man being at the top of many food chains is highly vulnerable as in the cases of Cd and Hg poisoning (Itai – itai and Rheumatic diseases) in the Jintsu River and Minamata, Japan [11, 20].

Determination of harmful and toxic substances in water sediments and biota, gives direct information on the significance of pollution in the aquatic environment [8]. We therefore thought it necessary to investigate the concentrations of Mn, Cu, Zn, Pb, and Cd in prawns and water from Epe lagoon of Lagos state, which is a receptacle of untreated industrial effluents.

Materials and Methods

Study Area

Epe lagoon lies between latitudes 03°05’ – 04°01’N and longitudes 005°30’ – 005°40’E. It has a surface area of more than 243km² and is sandwiched between two other lagoons, the Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish water) in the west. The lagoon is connected to the sea through the Lagos Harbour.

Sample Collection

Sampling was conducted on Epe Lagoon, Lagos in May, 2010. Water samples were collected from two points, with one point at the shore line (inshore site) and the other point at about 150m off the shoreline (offshore site). The water samples were collected at a 30cm depth in nitric acid pre rinsed 300ml plastic bottles and accurately labeled. A total of 15 live prawn specimens were purchased from the local market women at the water site. Three prawn specimens were purchased at random from 5 different market women. These specimens were all rinsed in the water body to remove debris, if any and wrapped in cellophane bags and labeled. The specimens were identified as *M. macrobrachion*. The collected water samples and prawn specimens were kept in ice during transportation for analysis.

Laboratory Analysis

The heavy metal analysis was done according to standard methods for heavy metal determination [13], using Techcomp AA 6000 Atomic Absorption Spectrophotometer. In the laboratory, both water and prawn specimens were transferred into the freezer to avoid deterioration pending analysis.

Prawn specimens

Frozen Prawn specimens were allowed to thaw gradually at room temperature. They were dehydrated to a constant weight using an oven at 60°C for 2days. Individual whole specimens were pulverized to a uniform particle size, 0.2g of pulverized weight were put in a 50ml digestion tube. 2.5ml of H₂SO₄/selenium mixture was added and placed in an aluminium block on a hot plate. This was heated at approximately 200°C until solution fumed. Each tube was removed from the hot plate and allowed to cool for 10 minutes. 1ml of 30% H₂O₂ was added to each tube. After reaction subsided, each tube was followed with an additional 2ml H₂O₂. Each tube was replaced on hot plate, heated to 330°C until clear (usually for 2hrs). The yellow tint of the solution disappeared as the digest is completed. The solution was poured into a centrifuge tube and made up to 30ml mark with distilled water. This was centrifuged at 3000 r.p.m. for 10mins. The supernatant was also decanted into sample vials for analysis.

Water Samples

25ml of each water sample was measured into a digestion tube and 20ml of nitric acid was added. It was digested at 160°C for 2hrs until there was a clear or colourless solution which was allowed to cool. The solution was poured into a centrifuge tube, made up to 30ml with distilled water and centrifuged at 3000 r.p.m. for 10mins. The supernatant was also decanted into sample vials for analysis. In both cases (specimen and water sample digestion), Reagent blanks were also prepared accordingly; to test the purity of the reagents. Metal concentration, for all extraction were determined by Techcomp AA 6000 Atomic Absorption spectrophotometer, using the respective lamps and wave lengths. Values of heavy metals were expressed in mg/kg for prawn specimens and mg/l for water samples.

Determination of Bioconcentration Factor (BCF)

According to Environmental Protection Agency guidelines, “the BCF is defined as the ratio of chemical concentration in the organism to that in surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces.”
The BCF was calculated thus:

\[
BCF = \frac{\text{Level of Substance (Heavy metal) in Prawn}}{\text{Level of Substance (Heavy metal) in water}}
\]

**Statistical Analysis**

Data collected were computed into means with standard deviation. For easy statistical analysis, metals not detected were assigned a value of zero.

**Results**

The mean concentrations of the analysed heavy metals, (Managenese (Mn), Copper (Cu), Zinc (Zn), Lead (Pb) and Cadmium (Cd)) in the sampled prawns is as presented in figure 1. Mn had the highest value while Cd had the lowest value. The mean concentrations of the analysed heavy metals (Mn, Cu, Zn, Pb and Cd) in the sampled water body are as presented in figure 2. All the metals except Cu were below detectable limit. For easy statistical analysis, the metals not detected were assigned a value of zero. The BCF of detected metal from the sampled water body is given in figure 3. Copper was the only detected metal. A comparison of the mean levels of the metals in prawn specimens and water body sampled during this study and other studies with WHO, FEPA and FAO standards is shown in Tables 1 and 2 respectively. The mean concentrations of Mn, Cu and Pb in prawn specimens were above the maximum limits recommended by WHO. While level of Zn was lower than the WHO and FAO limits, the level of Cd was similar to WHO and FAO limits (Table 1). This finding showed that the prawns (M. macrobrachion) from Epe lagoon is contaminated with heavy metals and therefore not safe for human consumption. It suggests bioaccumulation which is a process whereby an organism concentrates metals in its body from the surrounding medium or food, either by absorption or ingestion [1,5].

On the other hand, the result of the quantitative metal analysis of the water samples showed that none of the metals analysed was detected from water samples collected from the shore but Cu only was detected at about 150m offshore. This may be attributed to the point of collection (e.g proximity to pollution) of the water samples which could have possibly affected the detectability of the other metals. A similar finding was observed by Adedeji and Okocha, [1] (unpublished) in Asejire River in Oyo state in which none of the analysed metals was detected from the water samples collected at the shore but Cu and Zn only were detected about 150m offshore. For easy statistical analysis, the metals not detected were assigned a value of zero. The calculated mean concentrations of the metals (i.e. shore and off shore), were within the limits recommended by WHO and FEPA (Table 2). The observed low mean concentration of 0.05mg/l for Cu in water sample compared to its high mean concentration of 54.82mg/kg in prawn is supported by Obasohan et al 2006 who observed that the level of heavy metals in water were lower than levels for sediment and fish.

**Discussion**

The accumulation of toxic metals to hazardous levels in aquatic biota has become a problem of increasing concern [3,6,9,12]. Heavy metals end up in the aquatic environment by a number of routes, both natural and anthropogenic. Examples of anthropogenic sources are industry, mining, transport, municipal wastes, agriculture, dump leachates and geothermal development. Some of these activities spread metals into the atmosphere and are later deposited on land and water. Eleven metals are known to be essential for aquatic life. Of the metals analysed in this report, Mn, Cu and Zn are grouped in this class while Pb and Cd are non-essential. The result of this study showed that all the metals analysed in prawn specimens, Mn had the highest mean concentration while Cd had the lowest. It was in the order of Mn; 69.36 ± 78.53mg/kg > Zn; 52.88 ± 4.01mg/kg > Cu; 54.82 ± 13.88mg/kg > Pb; 9.18 ± 7.18mg/kg > Cd; 0.83 ± 0.20mg/kg. The mean concentrations of Mn, Cu and Pb in prawn specimens were above the maximum limits recommended by WHO. While level of Zn was lower than the WHO and FAO limits, the level of Cd was similar to WHO and FAO limits (Table 1). This finding showed that the prawns (M. macrobrachion) from Epe lagoon is contaminated with heavy metals and therefore not safe for human consumption. It suggests bioaccumulation which is a process whereby an organism concentrates metals in its body from the surrounding medium or food, either by absorption or ingestion [1,5].

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**Conclusion**

The results of this investigation showed that prawns from Epe lagoon were contaminated by the heavy metals. The finding is worrisome in view of the health implications for the population that depend on the lagoon for prawn requirements.

The results further showed that given the point of water sample collection (e.g proximity to pollution), some of the metals were not detected and this may not over rule their presence. Consequently, very close monitoring of heavy metal loads in Epe lagoon is recommended in view of the possible risks to health of consumers.
Fig. 1: Distribution of Heavy metals in prawn specimens from Epe lagoon.

Fig. 2: Distribution of Heavy metals in sampled water body from Epe lagoon.

Fig. 3: Bioconcentration factor of detected metal.

Table I: Comparison of the mean metal concentrations in prawn specimens with those of WHO and FAO

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Mn</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Cd</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epe Lagoon</td>
<td>69.36+78.53</td>
<td>54.82+13.88</td>
<td>52.88+4.01</td>
<td>9.18+3.40</td>
<td>0.83+0.21</td>
<td>This study</td>
</tr>
<tr>
<td>WHO (1989) (ug/g)</td>
<td>1</td>
<td>30</td>
<td>100</td>
<td>2</td>
<td>1</td>
<td>WHO (1989)</td>
</tr>
<tr>
<td>FAO maximum limits for prawn</td>
<td>-</td>
<td>10</td>
<td>1000</td>
<td>-</td>
<td>0.2</td>
<td>FAO</td>
</tr>
</tbody>
</table>

Results are presented for Epe-Lagoon as mean ± standard deviation

Table II: Comparison of the mean metal concentration in sampled water bodies with those of other rivers and WHO and FEPA standards

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Mn</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Cd</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epe Lagoon</td>
<td>0.00+0.00</td>
<td>0.05+0.07</td>
<td>0.00+0.00</td>
<td>0.00+0.00</td>
<td>0.00+0.00</td>
<td>This study</td>
</tr>
<tr>
<td>Ipohoa River</td>
<td>0.42</td>
<td>0.15</td>
<td>0.32</td>
<td>0.10</td>
<td>0.21</td>
<td>Okorokwo, 1992</td>
</tr>
<tr>
<td>River Niger</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.11</td>
<td>Okorokwo, 1992</td>
</tr>
<tr>
<td>Olumoro water bodies</td>
<td>0.07</td>
<td>0.07</td>
<td>2.01</td>
<td>0.04</td>
<td>0.10</td>
<td>Idodo-Umeh, 2002</td>
</tr>
<tr>
<td>WHO (1997)</td>
<td>0. 01</td>
<td>1.00</td>
<td>5.00</td>
<td>0.05</td>
<td>0.05</td>
<td>WHO (1997)</td>
</tr>
<tr>
<td>FEPA (2003)</td>
<td>0.05</td>
<td>&lt;1.00</td>
<td>20</td>
<td>&lt;1.00</td>
<td>&lt;1.00</td>
<td>FEPA (2003)</td>
</tr>
</tbody>
</table>

Results are presented for Epe Lagoon as mean ± standard deviation
References


