Human health risk assessment of heavy metal accumulation through fish consumption, from Machilipatnam Coast, Andhra Pradesh, India

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The progress of aquaculture, agriculture and industrial development activities has led to the increased pollutants emission into the coastal ecosystem. Heavy metals are one of the most common pollutants in the coastal area. This observation deals with the human health risk assessment of metal accumulation through the consumption of marine fish Liza macrolepis. The concentration of zinc (Zn), lead (Pb), nickel (Ni), copper (Cu), mercury (Hg) and cadmium (Cd) were investigated in muscle and liver of the fish in this coast. The study explains the heavy metal concentration in the fish and leads to health risk assessment in the human beings. The average measured concentrations (mg/kg) in the edible organs of fish were follows: Zn concentration was 34.6 and 38.2 that of Pb was 14.2 and 15.5, that of Ni was 10.4 and 11.8; that of Cu was 33.2 and 34.2; that of Hg 2.1 and 2.9 that of Cd were 0.8 and 0.9 in the muscle and liver respectively. The average “Target Hazard Quotient” (THQ) value of Zn goes to 17.9; Pb was 7.3; Ni was 5.3; Cu was 17.2; Hg was 1.08; and Cd was 0.4 recorded in the study area in food fish L. macrolepis.

Key words: Heavy metals, health risk, Liza macrolepis, Target hazard quotient (THQ).

INTRODUCTION

The rapid development of industrial activities has resulted in heavy metal pollution, which is a significant health hazard to human beings through food chain. Heavy metals may enter into the ecosystems from different natural and anthropogenic sources, including domestic waste water, application of pesticides and inorganic fertilizers, shipping and harbor activities, and also geological weathering of earth crust (Yilmaz, 2009). According to World Health Organization (WHO, 1991). Metal occurs less than 1% of the earth’s crust, with trace amount generally found in the environment and when these concentrations exceed a stipulated limit, they may toxic to the surrounding environment. The last three decades were witness to several reports on the toxicity of heavy metals in human beings, due to the contamination in the fish and fishery organisms (Anim et al., 2011; Mohamad and Osman, 2014). The accumulation of heavy metals in the aquatic environment has direct consequence to man and to the ecosystem. The impact of increasing concentration of such metal in the environment is further enhanced by their poor degradability, which results in bioaccumulation and transport along successive links of the food chain (Ciesielski et al., 2010).

Among the aquatic fauna, fish is the most susceptible to heavy metal toxicants (Nwaedozie, 1998). It is well known that fish are good indicators of chemical pollution and as a result they long been used to monitor metal pollution in coastal and marine environment. Adverse anthropogenic activities on the coastal environment include aquaculture operations, burning of fossil fuels and geologic weathering.
contribute to the heavy metals in the water bodies (Erdogrul and Erbilir, 2007). Lee and Cundy (2001) reported that human activities such as dredging and reclamation in coastal environment can remobilize the heavy metals from sediment to water.

Fishes lie at the top of the aquatic food chain and may concentrate large amounts of metals from the water. Fish take heavy metals from the surrounding water through their gills which are the primary route for the uptake of water borne pollutants and contaminated them in their tissues (Allen and Wilson, 1991; Kalay et al., 1999). The food of the fish is another source of these pollutants. Krishna Kumar et al. (1990) have studied the heavy metal concentration in marine zooplankton and invertebrates. All forms heavy metals in aquatic ecosystems may be taken by marine organisms and ultimately enter aquatic food chains and accumulate in various concentrations in organisms tissues (Tuzen, 2009). The study would provide a base line data related to the heavy metal pollution stress in the Machilipatnam coastal area and could help in designing strategies aimed at the management of the control of the metal pollution and associated with health risk.

MATERIALS AND METHODS

Fish samples (Liza macrolepis) are collected from fish landing centre, at Machilipatnam (Lat: N 16° 11' 3.768" and Long: E 81° 8' 5.7588") of Bay of Bengali coast, and transported to the laboratory in ice boxes and stored at -10°C until subjected for future analysis. The fishes were dissected and care was taken to avoid external contaminated to the samples. Rust free stainless steel kit was sterilized to dissect the fishes. None edible parts (Fins, scales, intestine) removed and parts like muscle and liver was chopped in to small pieces before air drying and then dried on an oven at 60°C until constant weight was obtained. The dried samples were powdered with pestle and mortar. The resulting fine powder was stored until chemical analysis. The samples (triplicate) were analyzed to each metal (Zn, Pb, Ni, Cu, Hg, and Cd) and was detected in ash samples of fish muscle recoded in mg/kg according to APHA (1998) using an Atomic Absorption Spectrophotometer (GBC Avantie model, Australia). Statistical analyses were performed using SPSS 12.0 software for windows. Mean and standard deviation (±) of heavy metal concentrations in mg/kg dry weight of fish muscle and liver were calculated.

Health risk assessment

Health risk assessment was calculated only for fish muscle. The liver was eliminated according to common house hold practices in this area.

Estimated daily intake (EDI):

\[
EDI = \frac{EF \times ED \times FR \times CF \times CM}{W_{AB} \times TA} \times 10^{-3}
\]

\(EF\) = The exposure frequency 365 days/year.
\(ED\) = The exposure duration, equivalent to average life time (65 years).
\(FR\) = The fresh food ingestion rate (g/person/day) which is considered to be India 55 g/person/day (Mitra et al., 2012).
\(CF\) = The conversion factor (= 0.208) (The content of fresh weight (fw) to dry weight (dw) considering 79% of moisture content).
\(CM\) = The heavy metal concentration in food stuffs (mg/kg dw).
\(W_{AB}\) = Average body weight (bw) (average body weight to be 60kg).
\(TA\) = Is the average exposure of time for non carcinogens (It is equal to \(E_F \times E_D\) as used by in many previous studies (Wang et al., 2005).

Target hazard quotient

\[
THQ = \frac{EDI}{RFD}
\]

RFD: Oral reference dose (mg/kg bw/day).

“THQ” below 1 means the exposed population is unlikely to experience obviously adverse effects, whereas “THQ” above means that there is a chance of non-carcinogenic effects, with an increasing probability as the value increases.

RESULTS AND DISCUSSIONS

The average concentration of heavy metals (Zn, Pb, Ni, Cu, Hg and Cd) determined in fish muscle and liver are given Table 1. The highest concentration of the metal in liver and muscle tissue of was recorded in Zn, followed by Cu, Pb, Ni, Hg and Cd. Higher concentration metals was recorded in the liver compare with muscle tissues. Zn is essential element and is an important component of the human body. Further, zinc is an essential nutrient for almost all plants. For this reason, algae growing in streams and lakes can absorb a large part of the zinc dissolved in water. In addition to its nutritive effect, zinc is also toxic to most forms of plants when present in amounts exceeding certain limits. In the present study shows that the average concentration of fish muscle goes to 34.6 mg/kg and fish liver goes to 38.2 mg/kg of zinc and it contain within the permissible limits of WHO (2010) standards. Lead is a heavy metal that occurs in nature mainly lead sulphide. This metal is extremely insoluble and is readily absorbed by organic matter, especially under reducing conditions. Buckley and Hargrave (1989) reported that the lead
sources of environmental contamination are from mining, smelting and reprocessing operation and as a combustion product of lead additives in gasoline. Lead has also been used in a variety of paints and is a common constituent in municipal and industrial wastes. Lead was causes mental retardation among children and also hyper tension in pregnant women (Beevens et al., 1976). Lead poisoning causes by symptoms of intestinal cramps, anemic condition and fatigue (Umar et al., 2001). Lead is highly toxic to aquatic organisms, especially fish (Rompala et al., 1984). The biological effects of sub lethal concentrations of lead included delayed embryonic development, suppressed reproduction and inhibition of growth, increased mucus formation, neurological problems, enzyme inhalation and kidney dysfunction (Leland and Kawabara, 1985). The level of average lead in muscle and liver goes to 14.2 and 15.2 mg/kg respectively. According to WHO (1985), the maximum accepted limit was 2 mg/kg for food fish. The present study indicated that the concentration of lead levels was higher than permissible limits.

Nickel plays important role in the biology of organisms and plants also. In the present study nickel was observed at an average of 10.4 mg/kg in case of fish muscle, and 11.8 mg/kg (body weight) in case of liver. Our present study shows that the average concentration was higher than WHO (1985) and FAO (1989) standards. Copper is an essential metal of number of enzymes, and also higher levels of copper leads to toxic effects on biota. Excessive intake of this metal results in its accumulating in the liver. Sources of contamination in natural sediments are often related to mining wastes, industrial metal manufacturing and processing, corrosion products or as a result of excessive use of antifouling paints in marine areas. Copper is also often association with sewage sludge, where it is most likely complexes with a variety of organic compounds. In the present study the results shows that the average concentration of copper in fish muscle goes to 33.2 mg/kg (body weight) in case of muscle where as liver goes to 34.2 mg/kg, which is higher than the permissible limits set by WHO (1985).

Mercury is highly dangerous as it readily bio accumulates in the aquatic organisms. Methyl-Hg the most toxic form of mercury is a known neurotoxin. Consumption of Hg contaminated fish on regular basis therefore has been recognized to cause of severe health problems. Mercury concentration of above permissible levels in fish muscle can be associated with emaciation, decreasing in coordination, losing appetite_ and mortality in fish (Eisler, 1987). Mercury pollution in aquatic ecosystems has received great attention since the discovery of mercury as the cause of Minamata disease in Japan in the 1950’s. Mercury poisoning in the adult brain is characterized by damage of discrete visual cortex areas and neuronal loss in the cerebellum granule layer (Vettori et al., 2003). Further, mercury poisoning during the early stages of nervous system development may cause catastrophic consequences for infants who exhibit widespread neural impairment (Harada, 1995). In the present study mercury average concentration was 2.1 mg/kg in muscle tissue and 2.9 mg/kg in the liver which was higher than permissible levels of WHO (1985). Cadmium is toxic element which shows their carcinogenic effect on aquatic biota and humans. It is widely distributed at low levels in the environment and is not an essential element for humans, animals and plants. In the present study Cd shows 0.8 mg/kg in case of muscle and liver 0.9 mg/kg. According WHO(1989), the pregnant women and breast feeding woman are likely to be at much greater risk due to the vulnerability of embryos and infants exceeding due to the permissible limits of Cd.

Heavy metals are one of the more serious pollutants in our natural environment due to their toxicity. The efficiency of metal up take from polluted water may different ecological need, metabolism and contaminated level, food and sediment as well as other environmental factors such as temperature, salinity and interacting gent (Rauf et al., 2009). When the organisms are exposed to high level metal in an aquatic environment, they can absorb the available metals directly from the environment via the gills or

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Heavy Metals</th>
<th>Liza macrolepis (No. Specimens-30)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Muscle (Means ± SD)</td>
</tr>
<tr>
<td>1.</td>
<td>Zinc (Zn)</td>
<td>34.6±1.4</td>
</tr>
<tr>
<td>2.</td>
<td>Lead (Pb)</td>
<td>14.2±1.3</td>
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<tr>
<td>3.</td>
<td>Nickel (Ni)</td>
<td>10.4±1.4</td>
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<tr>
<td>4.</td>
<td>Copper (Cu)</td>
<td>33.2±1.7</td>
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<tr>
<td>5.</td>
<td>Mercury (Hg)</td>
<td>2.1±0.56</td>
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<tr>
<td>6.</td>
<td>Cadmium (Cd)</td>
<td>0.8±0.19</td>
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<thead>
<tr>
<th>Heavy Metals</th>
<th>S. No.</th>
<th>Table 1. Average heavy metals concentration (mg/kg dry weight) in liver and muscle of Liza macrolepis collected from Machilipatnam coast, Andhra Pradesh, India</th>
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</thead>
</table>
|              |        | Abbreviations: S.No.: Serial Number; SD: Standard deviation \n
Abbreviations: S.No. : Serial Number; SD: Standard deviation
Table 2. THQ values of muscle in *Liza macrolepis* collected from Machilipatnam coast, Andhra Pradesh, India.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Heavy Metals</th>
<th><em>Liza macrolepis</em> (No. Specimens-30)</th>
<th>Muscle THQ ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Zinc (Zn)</td>
<td>17.9±1.0</td>
<td></td>
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<tr>
<td>2.</td>
<td>Lead (Pb)</td>
<td>7.3±0.8</td>
<td></td>
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<tr>
<td>3.</td>
<td>Nickel (Ni)</td>
<td>5.3±0.8</td>
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<tr>
<td>4.</td>
<td>Copper (Cu)</td>
<td>17.2±1.2</td>
<td></td>
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<tr>
<td>5.</td>
<td>Mercury (Hg)</td>
<td>1.8±0.45</td>
<td></td>
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<tr>
<td>6.</td>
<td>Cadmium (Cd)</td>
<td>0.4±0.12</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: S.No: Serial Number; THQ: Target Hazard Quotient; SD: Standard deviation

The increasing demand of food safety has accelerated researching regarding the risk associated with consumption contaminated by heavy metal (Mansour et al., 2009). In the present study our results clearly showed that the all observed metals are higher than that of results reported by Li et al. (2014) and Mohamad and Osman (2014).

The estimated Target Hazard Quotient of the observed heavy metals through consumption of fish was given in Table 2. The average “THQ” values for individual heavy metal are above 1, except cadmium. Ambedkar and Maniyan (2011) concluded that the heavy metal concentration were above the maximum levels recommended by regulatory agencies and depending on daily intake by consumers, might represent a risk for human health. Li et al.(2014) reported that highest total “THQ” value poses relatively higher potential health risks of human beings, particularly for the people residing in the areas with serious metal pollution.

Finally, we conclude that long term continuous monitoring is essential of metal pollution in Machilipatnam coast. The “THQ” values of the all the studied metals in fish samples were above 1 except Cd. It is suggesting that the concentration of the metals in fish muscle from Machilipatnam coast pose to health hazards to the consumers.

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