Concentration of Heavy Metals in Fish Juveniles of Gangetic Delta of West Bengal, India

Abhijit Mitra, Kunal Mondal and Kakoli Banerjee

Department of Marine Science, University of Calcutta, 35 B.C. Road, Kolkata – 700 019, West Bengal, India

Abstract. Ten years (1999 – 2008) of observations in the Gangetic delta region in northwestern Bay of Bengal clearly indicate that the heavy metal concentrations in the commercially important fish juvenile tissue have increased in the western sector (in the Hugli estuary), whereas in the central part of the deltaic complex the picture has reversed (in the Matla estuary). Increased dilution due to Himalayan glacier melting along with rapid rate of industrialization and urbanization in the western part of Gangetic delta may be attributed for such spatial variation of heavy metals level in the juvenile fish tissue. In both the sectors, heavy metals accumulated in the juvenile fish muscles in the order Zn > Cu > Pb.

Key words: Gangetic delta, Fish juveniles, Heavy metals, Fish muscles

INTRODUCTION

Ever increasing industrialization is causing environmental pollution and the effluents from chemical industries are contaminating air, water and soil everyday[8,9]. Sea is the most exposed area of contamination as majority of the industrial and urban wastes are discharged along the coastal areas. Heavy metals such as copper, zinc and lead are normal constituents of marine and estuarine environments, but when additional quantities are introduced through industrial wastes or sewage, they enter the biogeochemical cycle and pose adverse impact on the biotic community. Due to their toxic nature, these chemical constituents interfere with the ecology of a particular environment and on entering into the food chain they cause potential health hazards, mainly to human beings. It was reported by several workers that the discharge of heavy metals into the sea through rivers and streams results in the accumulation of pollutants in the marine environment especially within fishes[11]. Fish and fishery products can be used for monitoring potential risk to humans because these are directly consumed by a large population[11]. Bioaccumulation patterns of metals in fish muscle can be utilized as effective indicators of environmental metal contamination. However, different opinion also exists in context to use of fish as potential indicators of conservative pollutants. According to many researchers, fishes by virtue of their mobile nature are not fair indicator of aquatic contamination, but their regular consumption by human beings makes it absolutely necessary to monitor their different organs, particularly the muscles. This study is important not only from the safety point of view of human health, but also from the quality point of view as many of the fish species selected in the present study have high export value.

The Gangetic delta at the apex of Bay of Bengal recognized as the most diversified and productive ecosystem among all the maritime states of India faces pollution in the western sector from domestic sewage and urban and industrial effluents leading to serious impacts on biota. These organic and inorganic wastes containing heavy metals mainly originate from the city of Kolkata, Howrah and the newly developing Haldia port-cum-industrial complex. The most abundant heavy metals in the estuarine complex are Zn, Cu and Pb. The present paper aims to highlight the level of these heavy metals in juveniles of five commercially important species of finfish collected from the aquatic subsystem of Hugli (in the western part of the Gangetic delta complex) and Matla (in the central part of deltaic complex) estuary over a period of 10 years (1999 – 2008).

MATERIALS AND METHODS

Description of the Study Site: The Hugli is the westernmost estuary of the Gangetic delta that spans almost the entire coast of the maritime state of West Bengal. Multifarious industries are situated on the banks of the Hugli River, namely, paper, textiles, chemicals, pharmaceuticals, plastics, shellac, food, leather, jute, pesticides etc[12]. A considerable quantity of toxic and hazardous substance is being released into this important aquatic system through these industrial effluents along with huge organic load emanating from
agricultural and aquacultural activities and several non-point sources. The central sector, on the other hand is free from such industrial and anthropogenic influences, and dissolved heavy metals originate in the Matla River mainly from antifouling paints used for conditioning fishing vessels and trawlers.

Yearly samples (1999 to 2008) were collected from the sampling stations viz. Nayachar (stn. 1) and Canning (stn. 2) in these two sectors (Fig. 1) during April (pre-monsoon month in the present geographical locale) to analyze tissue metals in commercially important fish juveniles.

**Sampling of Specimen:** Juveniles of five species of finfish, namely *Thryssa hamiltonii*, *Tenuola islisha*, *Liza parisia*, *Liza tade* and *Stolephorus commersonii* were collected with fine meshed net during high tide condition from the selected stations for a period of 10 years during April of every year between 1999 and 2008 as this is the breeding season of most of the estuarine fishes in the present geographical locale. The fish juveniles were stored in a container, preserved in crushed ice, and brought to the laboratory for further analysis. Finally, the fish juveniles were identified with the expertise of the Zoological Survey of India (Calcutta).

**Analysis of Heavy Metals:** Inductively coupled plasma – mass spectrometry (ICP-MS) is now-a-days accepted as a fast, reliable means of multi-elemental analysis for a wide variety of sample types[2]. A Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer was used for the present study. A standard torch for this instrument was used with an outer argon gas flow rate of 15 L/min and an intermediate gas flow of 0.9 L/min. The applied power was 1.0 kW. The ion settings were standard settings recommended, when a conventional nebulizer/spray is used with a liquid sample uptake rate of 1.0 mL/min. A Moulinex Super Crouty microwave oven of 2450 MHz frequency magnetron and 1100 W maximum power Polytetrafluoroethylene (PTFE) reactor of 115 ml volume, 1 cm wall thickness with hermetic screw caps, were used for the digestion of the muscle samples of fish juveniles. All reagents used were of high purity available and of analytical reagent grade. High purity water was obtained with a Barnstead Nanopure II water-purification system. All glassware was soaked in 10% (v/v) nitric acid for 24 h and washed with deionised water prior to use.

20 mg muscle samples from each species of fish juveniles were weighed and successively treated with 4 ml aqua regia, 1.5 ml HF and 3ml H$_2$O$_2$ in a hermetically sealed PTFE reactor, inside a microwave oven, at power levels between 330-550 W, for 12 min to obtain a clear solution. After digestion, 4 ml H$_2$BO$_3$ was added and kept in a hot water bath for 10 min, diluted with distilled water to make up the volume to 50 ml. The process blank was prepared by taking distilled water in place of muscle samples and following all the treatment steps described above. The final volume was made up to 50 ml. Finally, the samples (treated muscles of fish juveniles) and process blank solutions were analyzed by ICP-MS.

**RESULTS AND DISCUSSION**

**Results:** In many parts of the world, especially in coastal areas and on smaller islands, fish is a major part of food, which supplies all essential elements required for life processes in a balanced manner[7]. Hence, estimation of heavy metal accumulation is of utmost importance in this sector of biotic community. In the present programme highest concentration of Zn was observed in all the species of fish juveniles followed by Cu and Pb (Fig. 2 to 7). The species wise variation was not uniform for all the metals. In general, Zn accumulated as per the order *Liza tade* > *Liza parisia* > *Tenuola islisha* > *Thryssa hamiltonii* > *Stolephorus commersonii* with few exceptions in 2001, 2002, 2005 and 2006 in the samples of Matla estuary. Cu accumulated as per the order *Liza tade* > *Thryssa hamiltonii* > *Liza parisia* > *Tenuola islisha* > *Stolephorus commersonii* with exception in the year 2001 in the sample of Hugli estuary. Pb accumulated as per the order *Thryssa hamiltonii* > *Liza tade* > *Liza parisia* > *Tenuola islisha* > *Stolephorus commersonii* in both the estuaries.

**Discussion:** A number of studies have shown that various factors such as season, length and weight, physical and chemical status of water can play a role in the tissue accumulation of metals. The present study exhibited significant spatial variations of metal level in the fish juveniles between the western and central sectors, which may be due to different salinity profile and trend. The western part of the Gangetic delta is connected to Himalayan glacier through Bhagirathi River. Researchers pointed out that the glaciers in the Himalayan range are melting at the rate of 23 m/yr[4,5,6]. This along with Farraka discharge has resulted in gradual freshening of the system[9], which has role in elevation of dissolved metal level in the system. The presence of chain of factories and industries along the bank of Hugli estuary is another major cause of increased metal level in the aquatic phase of Hugli estuary that have been reflected in the juvenile fish tissue. The central sector on contrary is deprived from freshwater supply of Ganga-Bhagirathi system, and the Matla River is now tide fed with an increasing trend of salinity[9]. This results in the precipitation of dissolved metals on the sediment showing low metal level in the tissue of fish juveniles thriving in the system. The
Fig. 1: Location of sampling site at the Hugli and Matla estuarine stretch

Fig. 2: Zn concentrations in fish juveniles collected from Hugli estuary (A= Thryssa hamiltonii, B= Tenualosa ilisha, C= Liza parsia, D= Liza tade, E= Stolephorus commersonii)
Fig. 3: Zn concentrations in fish juveniles collected from Matla estuary (A= Thryssa hamiltonii, B= Tenualosa ilisha, C= Liza parsia, D= Liza tade, E= Stolephorus commersonii)

Fig. 4: Cu concentrations in fish juveniles collected from Hugli estuary (A= Thryssa hamiltonii, B= Tenualosa ilisha, C= Liza parsia, D= Liza tade, E= Stolephorus commersonii)

Fig. 5: Cu concentrations in fish juveniles collected from Matla estuary (A= Thryssa hamiltonii, B= Tenualosa ilisha, C= Liza parsia, D= Liza tade, E= Stolephorus commersonii)
absence of factories and industries around Matla estuary is another cause for low concentration of metal within the tissue of fish juveniles.

Of the three metals analysed in the present study, Zn and Cu are essential elements while Pb is a non-essential element for most of the living organisms. Zn being an essential element for normal growth and metabolism of animals, exhibited highest accumulation in the fish muscles when compared with the other two metals. Cu, the other essential metal also exhibited greater concentration when compared with the non-essential metal (Pb). Accumulation of metals in different species is the function of their respective membrane permeability and enzyme system, which is highly species specific and this cause may be attributed to variation in metal level in different fish tissues.

The main sources of Zn in the present geographical locale are the galvanization units, paint manufacturing units and pharmaceutical processes. The main sources of Cu in the coastal waters are antifouling paints\(^1\), particular type of algicides used in different aquaculture farms, paint manufacturing units, pipe line corrosion and oil sludges (32 to 120 ppm). Ship bottom paint has been found to produce very high concentration of Cu in sea water and sediment in harbours of Great Britain and southern California\(^1,\)\(^3\). The most toxic of these heavy metals is Pb, which finds its way in coastal waters through the discharge of industrial waste waters, such as from painting, dyeing, battery manufacturing units and oil refineries etc. Antifouling paints used to prevent growth of marine organisms at the bottom of the boats and trawlers also contain lead as an important component. These paints are designed to constantly leach toxic metals into the water to kill organisms that may attach to bottom of the boats which ultimately is transported to the sediment and aquatic compartments. Lead also enters the oceans and coastal waters both from terrestrial sources and atmosphere and the atmospheric input of lead aerosols can be substantial. The sampling station Nayachar Island is exposed to all these activities being proximal to the highly urbanized city of Kolkata,
Howrah and the newly emerging Haldia port - cum - industrial complex. The high concentration of Cu in the fish muscles of Nayachar Island (s.tn.1) in the Hugli estuarine stretch may be related to intense industrialization around the zone (Annexure I). The present study is important not only from the human health point of view, but it also presents a time – integrated baseline data bank on heavy metal level in fish juveniles which are consumed by members of higher trophic level in the mangrove dominated Gangetic delta.

REFERENCES


ANNEXURE 1

- **INDIAN OIL CORPORATION LTD (IOCL)**, refinery (capacity is 6 million metric tonnes per annum (MMTPA), other activities is Blended LPG;
- **HALDIA PETROCHEMICAL LIMITED (HPL)**, the plant and capacity are listed in Table 1 below:

<table>
<thead>
<tr>
<th>Manufacturing units</th>
<th>Capacity (KTA)</th>
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<tbody>
<tr>
<td>Naphtha Cracker Unit</td>
<td>520</td>
</tr>
<tr>
<td>Linear Low Density Polyethylene</td>
<td>260</td>
</tr>
<tr>
<td>High Density Polyethylene</td>
<td>300</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>300</td>
</tr>
<tr>
<td>Benzene Extraction Unit</td>
<td>85</td>
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<tr>
<td>Butadiene Extraction Unit</td>
<td>82</td>
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<tr>
<td>Pyrolysis Gasoline Hydrogenation Unit</td>
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<td>LPG</td>
<td>143</td>
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<tr>
<td>Cyclopentane</td>
<td>20</td>
</tr>
<tr>
<td>MS Euro III</td>
<td>294</td>
</tr>
</tbody>
</table>

KTA = Kilo Tonnes per Annum

- MCC PTA India Corp Pvt. Ltd., Purified Terephthalic Acid (PTA) plant at Haldia, India. The plant capacity is 940,000 mt/year;
- SOUTH ASIAN PETROCHEM, The plant capacity is 140 KTA;
- SHAW WALLACE and Co. Ltd., Major activities are Technical Acephate, MIT, Dimethionate Technical;
- TATA CHEMICALS Ltd., Fertilizer with capacity 1.2 millions tonnes per annum;
- KE TECHNICAL Pvt. Ltd., Major activities are Industrial Synthetic Textile;
- PRAXAIR INDIA PRIVATE LIMITED, Major activities are atmosphere and specialty gas with plant capacity 1,800 tonnes of oxygen and 1,250 tonnes of nitrogen per day;
- EXIDE INDUSTRIES Ltd., Activities and products are Batteries, Sturt Light Ignition, Submarine Cell;
- ELECTROSTEEL CASTING Ltd., the activities are manufacture high quality ductile iron pipes and fittings and provide turnkey contract execution for pipeline projects;
- HOOGHLY METCOKE AND POWER COMPANY Ltd., Activities are metallurgical production with capacity 1.6 million tonne of high quality metallurgical coke per annum;
- TATA POWER COMPANY Ltd., Power Plant with capacity 2 X 45 MW;
- ALCAMAR OIL AND FATS Ltd., Product is refined vegetable oil;
- MP GLYCHEM INDUSTRIES Ltd., main activities is to extract oils from all oil seed by solvent Extraction Process with capacity vegetable oil refining capacity of 600 TPD (tonnes/day);
- RUCHI SOYA INDUSTRIES Ltd., major activities are Vanaspati Acid Oil and Refined Oil with the largest solvent extraction capacity (4,000 tonnes/day) and a refining capacity of 3,450 tonnes/day;
- MANAKSIA Ltd, Major activities are aluminium and steel products;
- STEEL CITY PRECISION TECHNO Pvt. Ltd., Major activity is cold storage services.