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CONCENTRATIONS OF Zn, Cu and Pb IN THE MUSCLE OF TWO EDIBLE FINFISH SPECIES IN AND AROUND GANGETIC DELTA REGION

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ABSTRACT

We analysed concentrations of zinc, copper and lead in the muscle of two commercially important finfish species namely, *Liza parsia* and *Liza tade* in the western and central sectors of Gangetic delta region during 14th to 19th March, 2016 using Atomic Absorption Spectrophotometer. Metal accumulation followed the order Zn > Cu > Pb. Between the two species, the degree of metal accumulation was found to be in the order *Liza parsia* > *Liza tade,* which may be the result of difference in their food habit or degree of exposure to ambient media contaminated with heavy metals. Heavy metals in the edible parts of the investigated finfish species were compared with the permissible safety levels for human uses.

Keywords: Heavy metals, *Liza parsia*, *Liza tade,* Gangetic delta region, Atomic Absorption Spectrophotometer

INTRODUCTION

The sea and more particularly the aquatic system (*e.g.*, estuaries) are the ultimate repository of human's wastes. The highly dynamic nature of the marine environment allows for very rapid assimilation of these materials by process such as dilution, dispersal, oxidation, degradation or sequestration into sediments. However, the capacity for such assimilation is limited. Understanding this process of "absorption" by the oceans and thereby determining their "assimilative capacities" has been the main challenge of marine pollution research during the last few decades. There is little doubt that significant successes have been achieved in reducing the contamination of our natural waters. However the increasing number and total volume of marine discharge have in part affected these gains. This situation arises from the increasing individual demands for a higher standard of living.[1,27] The eastern, western and southern coasts of the peninsular India are ornamented by majestic rivers having extensive and highly productive estuarine areas. West Bengal, a maritime state in the north eastern part of the country, adjacent to Bangladesh, is indented at its southern part by numerous river openings. The important rivers from east to west are the Harinbhanga, Gosaba, Matla, Thakuran, Saptamukhi, Muriganga and Hugli, which ultimately terminate in the Bay of Bengal, but on the way encompass about 108 islands, criss-crossed and intersected by various creeks and delta distributaries. The chain of the factories and industries situated on the western bank of the Hugli estuary is a prominent cause behind the gradual transformation of this beautiful ecotone into stinking cesspools of the megapolis. The lower part of the estuary has multifarious industries such as paper, textiles, chemicals, pharmaceuticals, plastic, shellac, food, leather, jute, tyres and cycle rims.[2] Toxic effluents from these industries might scratch the magnificent network of life spun over a long evolutionary period of time in this biotope. Heavy metal contamination of the environment has been occurring for centuries but its extent has increased markedly in the last fifty years due to technological developments and increased consumer use of materials containing these metals. Increased circulation of hazardous heavy metals in soil, water and air has raised considerable concern for environmental protection and human health.[3-5] The pollution of aquatic ecosystems by trace metals is a significant problem[6-10], as trace metals constitute some of the most hazardous substances that can bio-accumulate.[11] Throughout the world, one key adverse environmental impact of trace metal contamination of the sediment and water column is the potential for transference of toxic metals into the food chain. Metals that are deposited in the aquatic environment may accumulate in the food chain and cause ecological damage while also posing a risk to human health.[12-14, 26, 28] *Liza parsia* and *Liza tade* are two major economically important fin fish in the lower Gangetic delta for their palatability. Hence, accumulation of heavy metals in the tissue of these fishes can cause harm to organisms in the higher trophic level of food chain including human. The present paper has attempted to scan these two finfish muscle tissue, in connection to bioaccumulation of zinc, copper and lead, collected from Nayachar Island, Sagar Island region, Gosaba and Satjelia Island in and around the Gangetic delta region stretch during 14 – 19th March, 2016.

MATERIALS AND METHODS

Selection of the sampling stations

Two sampling zones were selected each in the western and central sectors of Gangetic delta at the apex of the Bay of Bengal. The western sector of the deltaic lobe receives the snowmelt water of mighty Himalayan glaciers after being regulated through several barrages on the way. The central sector on the other hand, is fully deprived from such supply due to heavy siltation and clogging of the Bidyadhari channel in the late 15th century. The western sector also receives wastes and effluents of complex nature from multifarious industries concentrated mainly in the upstream zone. On this background four sampling stations (two each in western and central sectors) were selected (Table 1) to analyze the concentrations of heavy metals in the muscles of common edible fishes collected during 14th to 19th March, 2016.

Table -1

Sampling stations with coordinates and salient features

Station	Coordinates	Salient Features
Nayachar Island (Stn.1)	88° 15′ 24" E 21° 45′ 24" N	It is located in the Hooghly estuary and faces the Haldia port-cum-industrial complex, that houses a variety of industrial units
Sagar Island (Stn.2)	88° 01′ 47" E 21° 39′ 04" N	Situated at the confluence of the River Hooghly and the Bay of Bengal on the western sector of Gangetic delta region.
Gosaba (Stn. 3)	88° 39′ 46" E 22° 15′ 45" N	Located in the Matla Riverine stretch in the central sector of Gangetic delta region.
Satjelia Island (Stn. 4)	88° 50′ 43" E 22° 11′ 52" N	Located in the central sector of Gangetic delta region. Noted for its wilderness and mangrove diversity; selected as our control zone.

Sampling of Specimen

Two species of finfish, namely *Liza parsia* and *Liza tade* were collected during high tide condition from the selected stations during 14th to 19th March, 2016. The collected samples were stored in a container, preserved in crushed ice, and brought to the laboratory for further analysis. Similar sized specimens of each species were sorted out for analyzing the metal level in the muscle.

Analysis of physico-chemical variables of surface water

- **Temperature:** Measured by direct dipping a 0^0C-100^0C mercury thermometer during high tide period, preferably around 12:00 noon.
- **Salinity:** The surface water salinity was recorded by means of an optical refractometer (Atago, Japan), and cross-checked in laboratory by employing Mohr- Kundson method (after Strickland and Parsons, 1968).[15]
- **pH:** On spot measurement was done by using a portable pH meter (sensitivity = ± 0.02).
- **Dissolved oxygen (DO):** Measured by DO meter in the field and subsequently cross-checked in the laboratory by Winkler's method.[16]

Heavy metal analysis in fin fish tissue

1 gm of oven dried tissue of fin fish sample was digested with nitric acid and blank was prepared without the sample (specimen). The digested samples along with the blank were aspirated in Atomic Absorption Spectrophotometer (AAS) [Model Perkin Elmer Type 2380] and concentrations of the selected metals (Zn, Cu and Pb) were expressed in ppm (µg/gm dry wt. basis).

RESULTS

Surface water temperature ranged from 32.0°C (in Nayachar island) to 32.3°C (in Sagar island) (Figure 1). Surface water salinity was found to range from 2.95 psu (in Nayachar island) to 9.10 psu (in Satjelia) (Figure 2). Surface water pH ranged from 7.75 (in Nayachar island) to 8.05 (in Satjelia) (Figure 3) whereas, dissolved oxygen level in surface water was found to range from 4.99 ppm (in Nayachar island) to 5.98 ppm (in Satjelia) (Figure 4). In case of *Liza parsia,* the concentration of Zn was found to range from 34.66 ppm dry wt. (in Satjelia) to 102.78 ppm dry wt. (in Nayachar island). In the same species, concentration of Cu ranged from 19.50 ppm dry wt. (in Satjelia) to 70.11 ppm dry wt. (in Nayachar island) whereas, concentration of Pb ranged from 8.43 ppm dry wt. (in Nayachar island) to 13.00 ppm dry wt. (in Satjelia). In case of *Liza tade,* the concentration of Zn was found to range from 24.89 ppm dry wt. (in Satjelia) to 96.41 ppm dry wt. (in Nayachar island). In the same species, concentration of Cu was found to range from 15.90 ppm dry wt.(in Satjelia) to 52.60 ppm dry wt. (in Nayachar island) whereas, concentration of Pb ranged from 6.00 ppm dry wt. (in Nayachar island) to 11.23 ppm dry wt.(in Satjelia) (Figure 5, 6 and 7). In station 1 all the values for heavy metals (except Zn in *L. tade)* are much higher than the recommended levels of WHO (1989) for food.[17] In station 2, the values of Cu and Pb are higher whereas, in case of station 3 and station 4, the values of Pb are much higher than the permissible level in both the species of finfish (Table 2). Reports on metal concentration in *L. parsia* and *L. tade* under natural conditions for coastal waters of India are limited and the present data therefore can serve as a baseline figure for the species particularly in the Gangetic delta region.[18-19]

Table 2

Heavy metal concentrations (in ppm dry wt.) in finfish (Liza parsia and Liza tade) muscles

Heavy metal	**Finfish species**	**Stn. 1**	**Stn. 2**	**Stn. 3**	**Stn. 4**	**WHO (1989) level in food**
Zn	*Liza parsia*	102.78	80.16	56.12	34.66	100
	Liza tade	96.41	72.33	49.87	24.89	
Cu	*Liza parsia*	70.11	49.99	28.46	19.5	30
	Liza tade	52.6	42	25.26	15.9	
Pb	*Liza parsia*	13	11.64	9.21	8.43	0.05
	Liza tade	11.23	10.44	7.4	6	

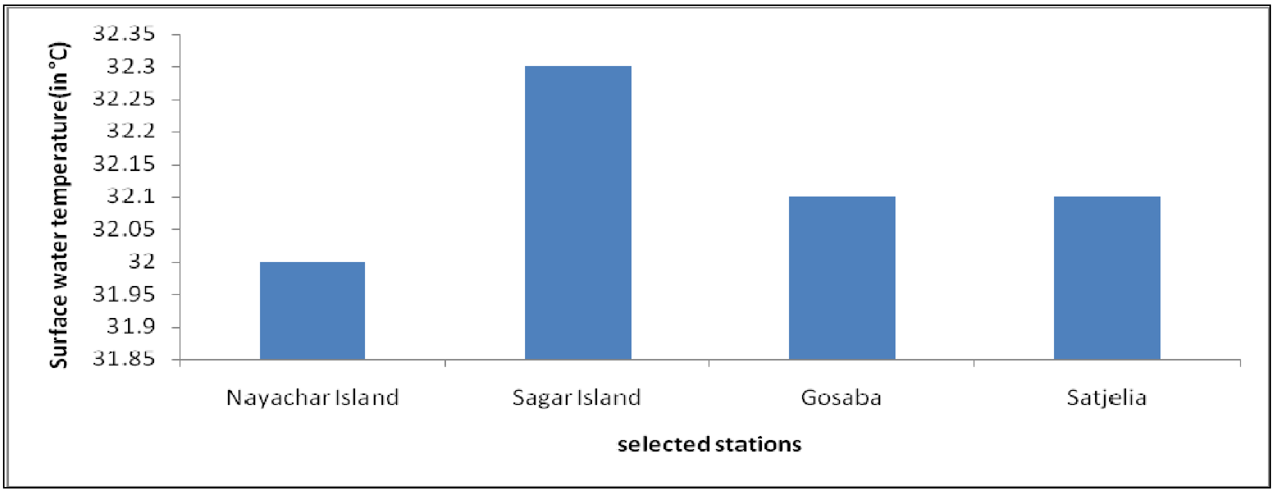

Figure 1: ***Variations of surface water temperature in selected stations***

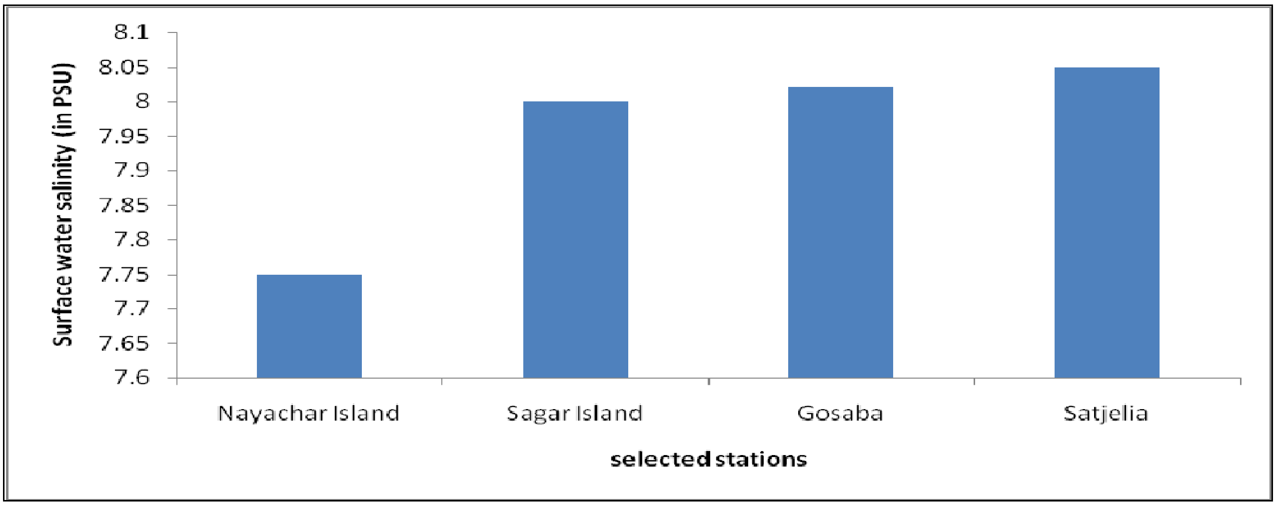

Figure 2: ***Variations of surface water salinity in selected stations***

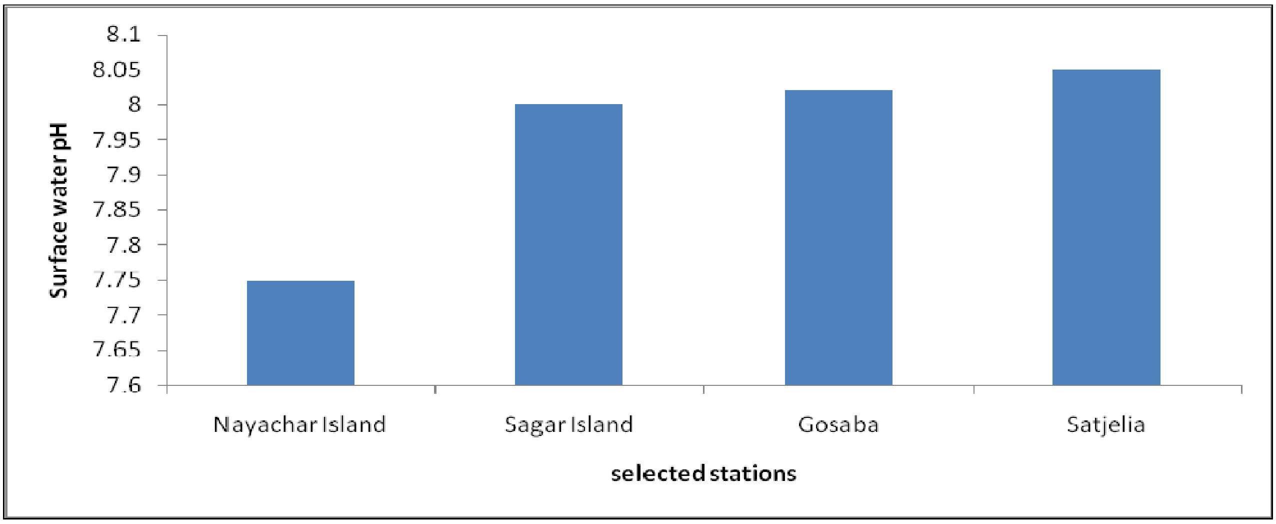

Figure 3: ***Variations of surface water pH in selected stations***

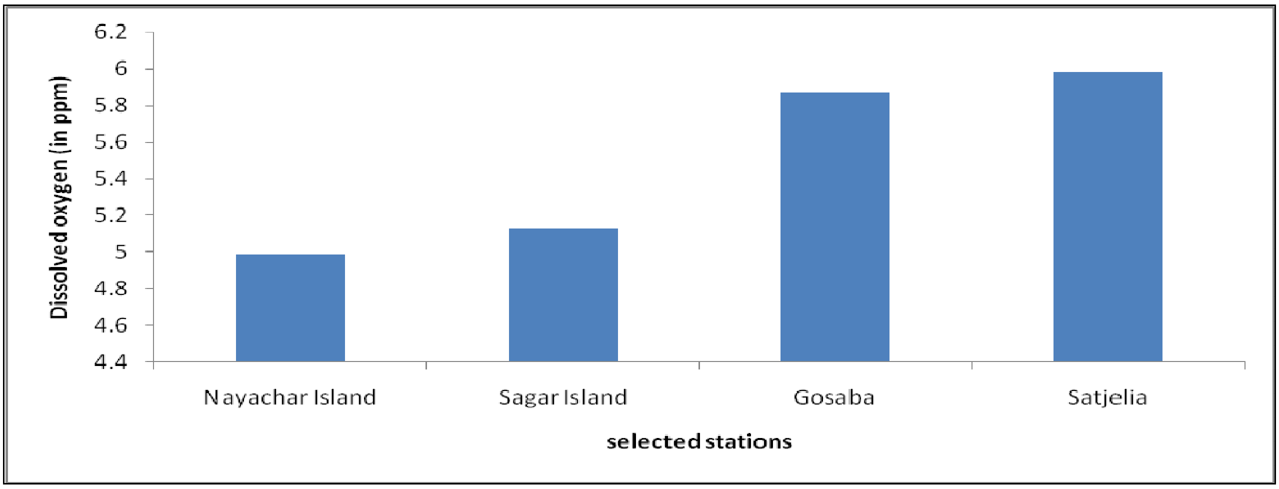

Figure 4: ***Variations of dissolved oxygen level in surface water in selected stations***

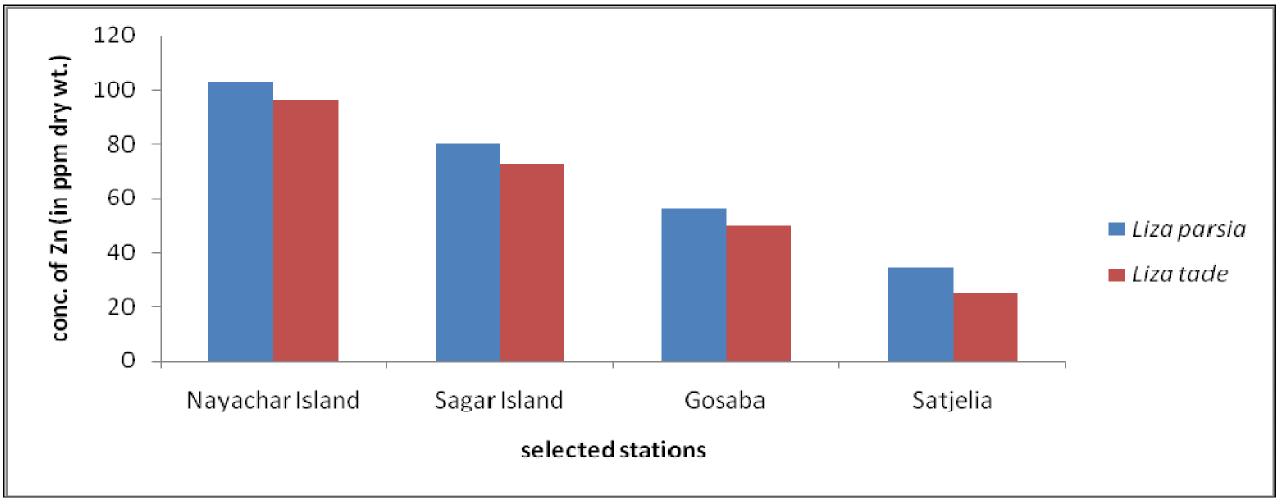

Figure 5: ***Variations of Zn in finfish muscle in selected stations***

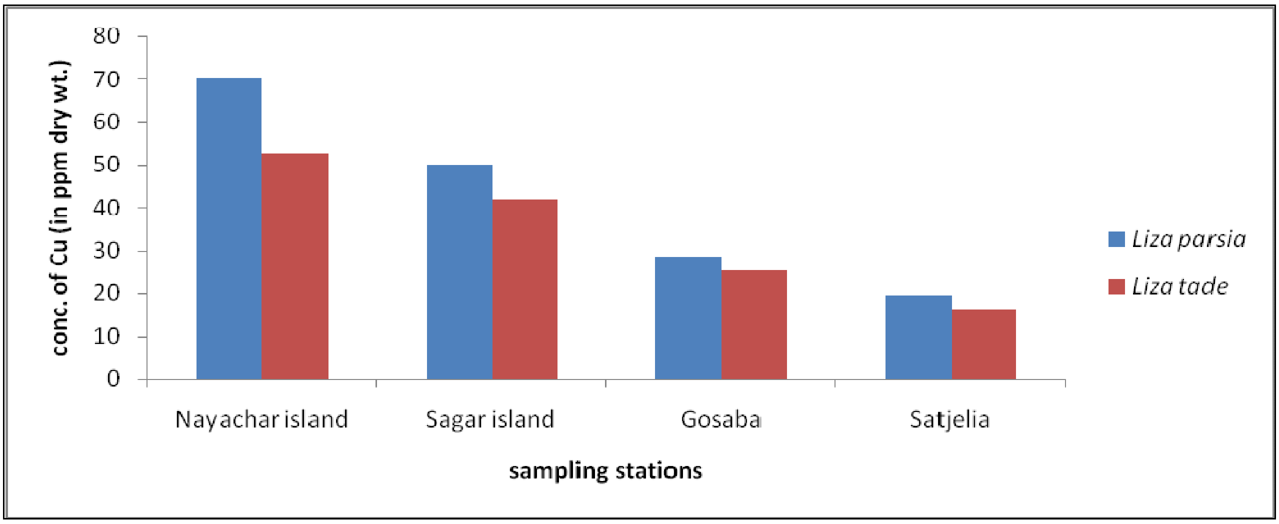

Figure 6: ***Variations of Cu in finfish muscle in selected stations***

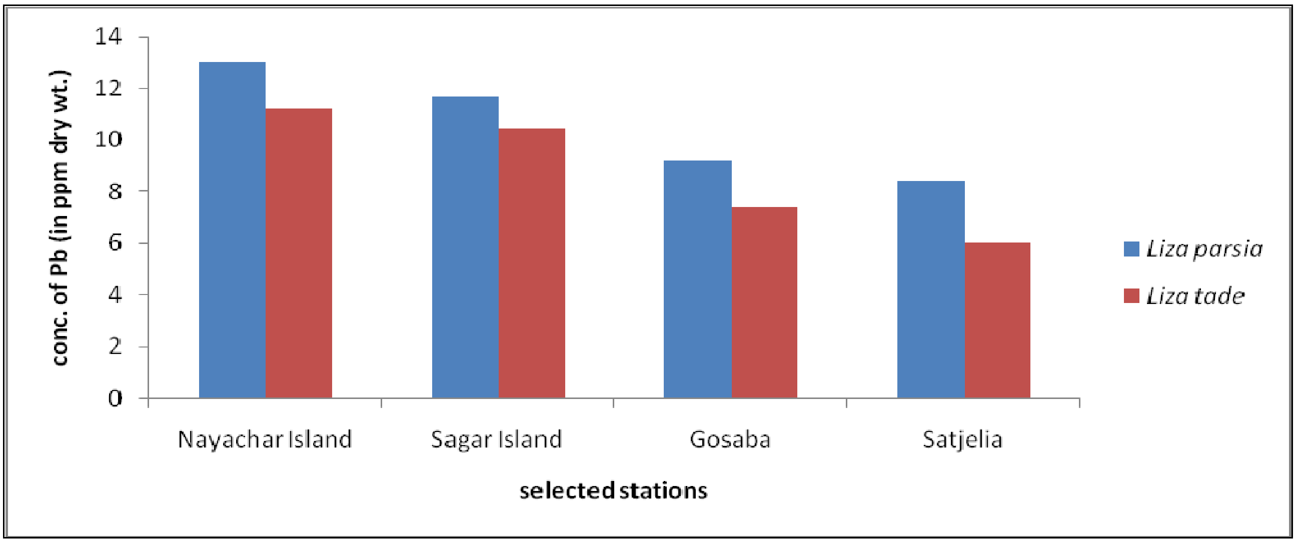

Figure 7: ***Variations of Pb in finfish muscle in selected stations***

DISCUSSION

Metals generally enter the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining wastes.[20] From an environmental point of view, coastal zones can be considered as the geographic space of interaction between terrestrial and marine ecosystems that is of great importance for the survival of a large variety of plants, animals and marine species.[21] Adverse anthropogenic effects on the coastal environment include eutrophication, heavy metals, organic and microbial pollution and oil spills.[22] The discharge of these wastes without adequate treatment often contaminate the estuarine water with heavy metals, many of which bioaccumulate in the tissues of resident organisms like fishes, oysters, crabs, shrimps, seaweeds *etc*. In many parts of the world, especially in coastal areas and on smaller islands, shellfish is a major part of food, which supplies all essential elements required for life processes in a balanced manner.[23] In developing countries like India, the demand for protein is accelerating at a rapid rate. The annual per capita fish consumption in India is only 4 kg against the recommended 31 kg by the Nutritional Advisory Committee on human nutrition.[24] Aquaculture has become a peak industry in the present millennium, which involves seafood farming with shrimp, cuttle fish, squid, lobster and such culinary delights actually "cultivated" in water tanks under scientifically controlled conditions.[25] Hence, estimation of heavy metal accumulation is of utmost importance in this sector of biotic community. Of the three metals studied in the present work, 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. The main sources of Zn in the present geographical locale are the galvanization units, paint manufacturing units and pharmaceutical processes, which are mainly concentrated in the Haldia industrial sector. Hence highest concentrations of Zn were documented in the fish muscles around station 1, whose western bank faces Haldia. Cu, the other essential metal also exhibited greater concentration when compared with the non-essential metal (Pb). The main sources of Cu in the coastal waters are antifouling paints, particular type of algaecides used in different aquaculture farms, paint manufacturing units, pipe line corrosion and oil sludges (32 to 120 ppm). In the present geographical locale, the major source of Cu is the antifouling paints used for conditioning fishing vessels and trawlers apart from industrial discharges. This is the reason why Cu was detected in the fish samples of station 3 and 4, where there is no existence of industries. The complete siltation of the Bidyadhari River also does not permit the industrial effluents released in the Hooghly estuary to mix with the estuaries in the central sector of the deltaic complex. The most toxic of the heavy metals is Pb, which finds its way in coastal waters through the discharge of industrial wastewaters, 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. Station 1 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. Station 2 falls in the navigational route of the ships and tankers for Haldia port, and also in the Hooghly channel, through which the wastes of the upstream region find way to Bay of Bengal. Hence fishes sampled from this station also exhibited considerable concentrations of heavy metals. Station 3 is in central sector of Gangetic delta region, where the pollution related activities are less compared to stations 1 and 2. The only source of pollution here is the leaching of metals from the antifouling paints used for conditioning fishing vessels and trawlers. Station 4 is within the vicinity of dense mangrove zone with minimum anthropogenic and industrial activities and hence the metal levels are less in the fishes sampled from the zone. The present study is important not only from the human health point of view, but it also presents a comparative account of heavy metals in edible fishes from two different sectors of Gangetic delta that are physico-chemically different. The high concentrations of heavy metals in fishes sampled from the aquatic subsystem around Nayachar Island (station 1) is a cause of concern, and requires regular monitoring of water quality around the point sources present near the vicinity of the island. Irrespective of species the pattern of concentration of different metals was comparable. In the present programme highest concentration of Zn was observed in all the species of shellfish followed by Cu and Pb. The pattern of metal concentration in this study was found in the order of Zn > Cu> Pb. The species wise variation was uniform for all the metals. Zn, Cu and Pb accumulated as per the order *Liza parsia* > *Liza tade*, which may be due to different food habit or period of exposure. The metal levels in biological samples depend on the ambient water chemistry. Therefore the common hydrological parameters (like surface water temperature, salinity, pH and dissolved oxygen) were also analysed during high tide condition. However, such one-time analysis cannot predict the inter-relationship between tissue metals and hydrological parameters. A more detailed and long term analysis may generate sound scientific findings.

CONCLUSION

Coastal pollution has been increasing significantly over the recent years and found expanding environmental problems in many developing countries. The discharges of industrial wastes have resulted in high metal concentrations in the local marine environment. The present study is important not only from the human health point of view, but it also presents a comparative account of heavy metals in edible fin fishes from two different sectors of Gangetic delta region (western and central sectors) that are physico-chemically different. The high concentrations of heavy metals in fin fishes sampled from Nayachar Island (Station 1) is a cause of concern, and requires regular monitoring of water quality around the point sources present opposite to the western bank of the island. Concentrations much above the recommended level (as per WHO) for toxic Pb in all the 3 other stations is also a cause of major concern for human health point of view. Strict enforcement of existing laws should be done in order to curb the situation.

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