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CONCENTRATIONS OF ZINC, COPPER, LEAD AND CADMIUM IN EDIBLE FIN FISHES OF COASTAL WEST BENGAL, INDIA

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ABSTRACT

The present paper aims to assess the concentrations of Zn, Cu, Pb and Cd in the muscle of commercially important fin fishes namely *Tenualosa ilisha*, *Liza parsia*, *Liza tade* and *Pampus argenteus*. The fin fish species accumulated metals as per the order *Liza tade* > *Liza parsia* > *Tenualosa ilisha* > *Pampus argenteus.* The metals accumulated as per the order Zn > Cu > Pb > Cd irrespective of the species and sampling stations. The spatial variation of bioaccumulation followed the order station 1 > station 2 > station 3 > station 4, which may be related to different degree of contamination in different locations. The accumulated heavy metals in the selected fishes collected from stations 1, 2 and 3 were found to be higher than the recommended maximum level (allowed in food) as prescribed by the World Health Organization (WHO, 1989) and FAO (1992) for fishes. However, in fishes sampled from station 4, the levels of heavy metals were lower than the recommended maximum values of FAO (1992).

INTRODUCTION

The River Ganga emerges from a glacier at Gangotri, about 7010 m above mean sea level in the Himalayas and flows down to the Bay of Bengal covering a distance of 2525 km. In this length, Ganga passes along 29 class-I cities (population over 1,00,000), 23 class-II cities (population between 50,000-1,00,000) and 48 towns having less than 50,000 population. About 50% of Indian population lives in the Ganga basin, and there are about 100 urban settlements with a total population of about 120 million on its banks. The delta region of the River Ganga may be said to start from Farakka in West Bengal. The river divides into two arms about 40 km south-east below Farakka at Khejurtala village in Murshidabad district. The right arm of the river (which was the original course of Ganga) continues to flow south in West Bengal in the name of the Bhagirathi (called Hooghly in its downstream stretch) which crosses 500 km to the sea (Bay of Bengal).

The Gangetic delta, at the apex of Bay of Bengal is recognized as one of the most diversified and productive ecosystems of the Tropics. The deltaic lobe is unique for its wilderness, mangrove gene pool and tiger habitat. However due to intense industrial activities in the upstream zone, and several anthropogenic factors, the western part of the deltaic complex is exposed to pollution from domestic sewage and industrial effluents leading to serious impacts on biota (Mitra and Choudhury, 1992). The presence of Haldia port-cum-industrial complex in the downstream region of the River Ganga (also known as the Hooghly River) has accelerated the pollution issue with a much greater dimension (Mitra, 1998). The organic and inorganic wastes released from these industries and urban units contain substantial concentrations of heavy metals. In this context it is interesting to note that the maritime state of West Bengal generates maximum urban wastes (27.97%) compared to other states other through which the River Ganga has traversed (Table 1). The central part of the delta (encompassing the surroundings of Matla River) is relatively less stressful in terms of industrial discharge. Due to siltation of the Bidyadhari channel, the area does not receive any water supply from the Hooghly River in the western sector and is therefore tide-fed in nature receiving the tidal flux from the Bay of Bengal (average salinity = ~32 psu). 85 percent of the people in the state of West Bengal (India) consume fishes that are caught from the Gangetic delta region. The present paper aims to highlight the concentrations of selective heavy metals (Zn, Cu, Pb and Cd) in the muscle tissue of four common fin fish species namely *Tenualosa ilisha*, *Liza parsia*, *Liza tade* and *Pampus argenteus* from four stations in the coastal West Bengal.

Table 1: Urban wastes (%) in the selected stations of the Ganga basin

State	Total population	Total (%)
Uttarakhand	8,489,349	25.66
Uttar Pradesh	166,197,921	20.78
Bihar	82,998,509	10.46
West Bengal	80,176,197	27.97
Total	337,861976	20.07

Source: CPCB (2009)

MATERIALS AND METHODS

Sampling stations

Four sampling stations were selected in coastal West Bengal namely Nayachar, Namkhana, Jharkhali and Shankarpur (Table 2).

Table 2: Sampling stations with coordinates and salient features

Station	Sampling coordinates	Salient features
Nayachar island (Stn.1)	21° 45′ 24" N 88° 15′ 24" E	It is located in the upstream of Hooghly estuary in the western sector of lower Gangetic delta and faces the Haldia port-cum-industrial complex that houses a variety of industrial units.
Namkhana (Stn.2)	21°45'48.54"N, 88°13'52.55"E	The present station is located in the downstream of Hooghly estuary. Fish landing, repairing and conditioning of fishing vessel and trawlers are the major activities in this station due to which heavy metals are leached in the ambient media.
Shankarpur (Stn.3)	$21^0$36'50"N $87^0$29'40" E .	The station is located 14 km east of Digha in West Bengal. It is also a major fishing harbour where mainly the marine and estuarine fishes are landed. The harbour can accommodate large number of fishing vessels and

		trawlers which are conditioned at regular intervals with antifouling paints. The antifouling paints are sources of Zn, Cu and Pb
Jharkhali (Stn.4)	$22^0$05'52.82" $88^0$41' 47.25"	Jharkhali, an island in the central Indian Sundarbans, is situated between two mighty rivers, Matla (on the west) and Bidya (on the east). The region is exposed to minimum anthropogenic and industrial impacts owing to its location adjacent to Reserve Forest.

Sampling of Specimen

Four commonly edible fin fish species namely *Tenualosa ilisha*, *Liza parsia*, *Liza tade* and *Pampus argenteus* were collected during high tide condition from the selected stations during a rapid EIA study from 15^{th} November to 30^{th} November, 2014. 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 (to avoid any error due to size difference) for analyzing the metal level in the muscle.

Analysis

Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) is now - a - day accepted as a fast, reliable means of multi-elemental analysis for a wide variety of sample types (Date and Gray, 1988). A Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer was used for the present analysis. 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 Crousty microwave oven of 2450 MHz frequency magnetron and 1100 Watt maximum power Polytetrafluoroethylene (PTFE) reactor of 115 ml volume, 1 cm wall thickness with hermetic screw caps, were used for the digestion of the collected biological samples. 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 glasswares were soaked in 10% (v/v) nitric acid for 24 h and washed with deionised water prior to use.

The analyses were carried out on composite samples of 10 specimens of each species having uniform size. This is a measure to reduce possible variations in metal concentrations due to size and age. 20 mg composite sample from each species of finfish were weighed and successively treated with 4 ml aqua regia, 1.5 mL HF and 3 ml H_2O_2 in a hermetically sealed PIFE reactor, inside a microwave oven, at power levels between 330-550 Watt, for 12 min to obtain a clear solution. The use of microwave-assisted digestion appears to be very relevant for sample dissolution, especially because it is very fast (Nadkarni, 1984; Matusiewicz and Sturgeon, 1989; De la Guardia, 1990). After digestion, 4 ml H_2BO_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. Taking distilled water in place of biological samples and following all the treatment steps described above the blank process was prepared. The final volume was made up to 50 ml. Finally, the selected fin fish samples and blank solutions were analyzed by ICP-MS. All analyses were done in triplicate and the results were expressed with standard deviation.

RESULTS

The results of analyses reveal spatial and species-wise variations of heavy metal level. In the selected fin fish species, the concentrations of Zn, Cu, Pb and Cd ranged from 53.02 ±0.68 (in *Pampus argenteus* at Jharkhali) – 193.44 ±1.59 (in *Liza tade* at Nayachar island), 47.23 ±0.19 (in *Pampus argenteus* at Jharkhali) –184.65 ±0.96 (in *Liza tade* at Nayachar island), BDL (in *Tenualosa ilisha* and *Pampus argenteus* at Jharkhali) –11.40 ±0.47 (in *Liza tade* at Nayachar island) and BDL (in *Tenualosa ilisha* and *Pampus argenteus* at Jharkhali) – 9.86 ±0.32 (in *Liza tade* at Nayachar island) respectively (Tables 4-7). The accumulation of heavy metals followed the order Zn>Cu>Pb>Cd and the station-wise metal concentration was Nayachar island (Stn.1) > Namkhana (Stn.2) > Shankarpur (Stn.3) > Jharkhali (Stn.4). The selected heavy metals in fin fish muscle were much higher(except in samples collected from station 4) than permissible limits for human consumption as recommended by Food Agricultural Organization (1992).

DISCUSSION

Heavy metals are non-biodegradable (in nature) and after their release in the water bodies, they can be absorbed on sediments particles or accumulated in aquatic organisms

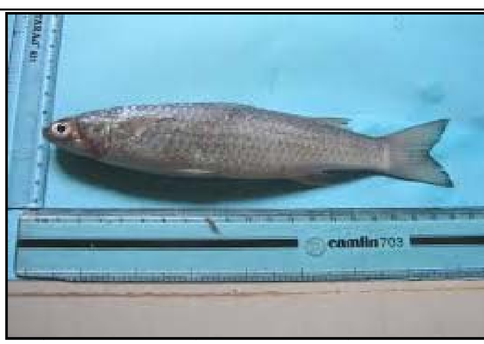
(Kotze et al., 1999), especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards (Jezierska and Witeska, 2001). Fish species mostly absorb heavy metals from its feeding diets, sediments and surrounding waters resulting to their accumulation in reasonable amounts (McCarthy and Shugart, 1990). Microhabitat utilization, feeding habits, age, sex and fish species also determine the accumulation pattern of heavy metals (Kotze et al., 1999). Bioaccumulation of heavy metals in fin fish is species-dependent and therefore feeding habits and life style are important criteria to be considered (Chen and Chen, 1999). The food and feeding habit of the selected fin fish species is highlighted in Table 3. *Liza tade* feeds both from the ambient water body and the surrounding mud/sediment compartment and are detritivorous in nature and hence exhibits highest level of metal accumulation. *Liza parsia* feeds mostly from the ambient aquatic phase and accumulates the 2nd highest level of metal in their body tissues. *Tenualosa ilisha* is a migratory fish and gets exposed to variable environment during migration. *Pampus argenteus* is found quite away from the estuarine/near-shore region and is a major component of demersal fisheries. With their habitat far away from the near-shore region, *Pampus argenteus* is least exposed to pollution levels that are maximum near the shore.

The significant spatial variation of heavy metals (as reflected through ANOVA in Table 8) may be attributed to the type and degree of anthropogenic pressure in and around our selected sampling stations. Nayachar island (Stn. 1), located opposite to Haldia port-cum-industrial complex is exposed to maximum level of heavy metals as pointed out by earlier researchers, (Mitra and Choudhury, 1992; Mitra, 1998; Mitra et al., 2011; Mitra et al., 2012; Mitra, 2013). The highest accumulation of heavy metals in fish tissues collected from this sampling station is thus a reflection of the heavy metal status in the ambient media. Stations 2 and 3 have the busiest fish landing stations in the State of West Bengal where the main activities are repairing and conditioning fishing vessels and trawlers. Antifouling paints used for these purposes generate Zn, Cu and Pb in the ambient media due to which considerable accumulation of heavy metals is observed in the fish muscles collected from these stations (Namkhana and Shankarpur). The lowest level of heavy metals in the fish sampled from station 4 is due to the location of the station almost adjacent to the Reserve Forest, where anthropogenic activities are strictly restricted by the Department of Forest, Govt. of West Bengal, India. Hence, this station may be designated as the control zone.

The core findings from the study are listed below:

- Pronounced spatial variations of heavy metals is attributed to degree of contamination of the ambient media in and around the selected sampling sites (Table 8)
- Stations 1, 2 and 3 are highly vulnerable in context to heavy metal concentrations in the fish tissues. Enforcement of the existing laws should be strictly implemented to treat the effluent released from the point sources in and around these three stations
- Regular monitoring of the aquatic phase and sediment compartment is needed by authorized bodies like Central Pollution Control Board, State Pollution Control Board, and Department of Environment

Table 3: Selected fin fishes with their food and feeding habits

Species	Food and feeding habit
 *Liza tade*	Primarily herbivore and have preference for green algae and diatoms. They also feed on zooplankton like copepods, polychaetes along with detritus and debris (Kottelat et al., 1993; Allen, 1991). It is capable of adapting to freshwater
 *Liza parsia*	Primarily herbivores and have preference for blue green algae, green algae, diatoms and decaying matter

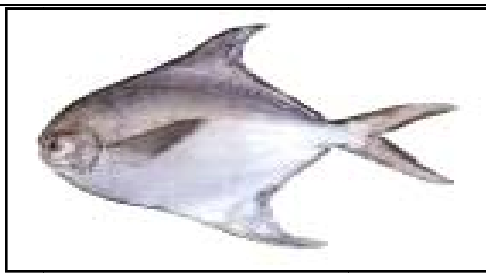
 *Tenualosa ilisha*	*T. ilisha* is basically a plankton feeder, but feeds at the bottom during spawning season and it prefers diatoms as food item (Hora and Nair 1940)
 *Pampus argenteus*	It is an inshore species, usually seen in shoals over the muddy bottoms associated with other demersal fishes. Studies along the east coast indicated the importance of small crustaceans, algae and semi-digested pulp in their diet (Kuthalingam, 1963; Rao, 1964; Pati, 1978).

Table 4: Zn concentrations (in ppm dry wt.) in finfish muscles

Species	Nayachar island (Stn. 1)	Namkhana (Stn. 2)	Shankarpur (Stn. 3)	Jharkhali (Stn. 4)
Liza tade	193.44±1.59	182.12±1.45	162.34±1.32	85.01±1.23
Liza parsia	185.23±1.35	176.12±1.21	153.56±1.11	71.45±1.09
Tenualosa ilisha	174.34±1.30	161.78±1.21	146.45±1.13	64.67±1.02
Pampus argenteus	165.55±0.92	155.84±0.83	133.12±0.73	53.02±0.68

WHO (1989) level for Zn in food 100 ppm ;
FAO (1992)level for Zn in fish 30 – 100 ppm

Table 5: Cu concentrations (in ppm dry wt.) in finfish muscles

Species	Nayachar island (Stn.1)	Namkhana (Stn.2)	Shankarpur (Stn.3)	Jharkhali (Stn.4)
Liza tade	184.65±0.96	172.34±0.86	166.87±76	73.16±0.65
Liza parsia	173.76±0.54	161.23±0.43	154.65±0.32	61.23±0.26
Tenualosa ilisha	166.69±0.43	157.13±0.34	142.18±0.23	53.21±0.16
Pampus argenteus	154.45±0.33	143.21±0.21	134.78±0.15	47.23±0.19

WHO (1989) level for Cu in food 30 ppm
FAO (1992)level for Cu in fish 10 – 100 ppm

Table 6: Pb concentrations (in ppm dry wt.) in finfish muscles

Species	Nayachar island (Stn. 1)	Namkhana (Stn. 2)	Shankarpur (Stn. 3)	Jharkhali (Stn. 4)
Liza tade	11.40±0.47	9.85±0.43	7.39±0.41	2.67±0.42
Liza parsia	10.05±0.46	8.45±0.44	6.23±0.45	1.34±0.43
Tenualosa ilisha	9.67±0.45	7.27±0.43	5.14±0.42	BDL
Pampus argenteus	8.12±0.44	6.78±0.42	4.31±0.41	BDL
WHO (1989) level for Pb in food 2 ppm				
FAO (1992)level for Pb in fish 0.5 – 6.0 ppm				

Table 7: Cd concentrations (in ppm dry wt.) in finfish muscles

Species	Nayachar island (Stn.1)	Namkhana (Stn.2)	Shankarpur (Stn.3)	Jharkhali (Stn.4)
Liza tade	9.86±0.32	8.23±0.25	7.33±0.20	1.83±0.16
Liza parsia	7.12±0.31	6.89±0.26	5.89±0.13	1.01±0.11
Tenualosa ilisha	6.97±0.30	5.99±0.21	5.94±0.11	BDL
Pampus argenteus	5.76±0.25	5.68±0.19	5.59±0.10	BDL
WHO (1989) level for Cd in food 1 ppm				
FAO (1992) level for Cd in fish 0.05 – 5.5 ppm				

Table 8: ANOVA showing variations of heavy metal concentrations between fin fish species and selected stations during November 2014

Variables	Fcal	Fcrit
Zn		
Between Species	166.769	3.8625
Between Stations	2726.83	3.8625
Cu		
Between Species	130.983	3.8625
Between Stations	2209.682	3.8625
Pb		
Between Species	88.001	3.8625
Between Stations	746.756	3.8625
Cd		
Between Species	19.506	3.8625
Between Stations	149.237	3.8625

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