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SEASONAL VARIATION OF HEAVY METAL CONCENTRATIONS IN *GLOSSOGOBIUS GIURIS* FROM THE SUNDARBANS MANGROVE SWAMPS OF BANGLADESH

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Abstract: The concentration of Cu, Zn, Fe, Pb, Cd, Cr and Ni were determined in *Glossogobius giuris*, a bottom feeder Gobi fish, from the rivers and estuaries of the Sundarbans mangrove forest in the South West coastal region of Bangladesh. The concentration of Cu, Zn, Fe, Pb, Cd, Cr and Ni was found to vary seasonally from 0.523-5.64, 5.17-23.2, 12.68-119.79, 0.139-4.94, 0.023-0.279, 0.086-2.83 and 0.58-5.3 $\mu g\ g^{-1}$ the dried fish muscle respectively. Fe was the most abundant metal found in the muscle, while cadmium was present at a lower level. The concentrations of all the metals studied were below the permitted levels recommended for human consumption except the Ni. The causes of higher Ni values have been discussed.

Key words: Heavy metal, *Glossogobius giuris*, bioaccumulation, Sundarbans, Mangrove forest, Bangladesh

Introduction

The continual development of agricultural, industrial and urban activities has been resulted in a number of environmental problems. Heavy metal concentration in aquatic environment is a critical concern, due to toxicity of metal and their accumulation in aquatic habitats. Organisms can uptake the metals directly or with food particles from water body. These metals are then bound to different parts of the body and may cause harmful effects (Hossain, 1996). The urban and industrial activities in the coastal areas of Bangladesh causes significant amount of pollutants (including heavy metals) in to the Bay of Bengal. The tidal current causes the quick transport and dispersion of pollutants (Khan *et al.,* 1998). Fish is one of the main foodstuffs of Bangladesh. Fish are rich in essential minerals and vitamins and low in saturated fats, making them an ideal food for human consumption (Sharif *et al.,* 1993a). The South-West region is famous for one of the largest fish production zones of Bangladesh. With rapid expansion in both population and industries a large amount industrial and agricultural pollutants containing heavy metals may be accumulated in the coastal region of the Bay of Bengal through numerous rivers of the subcontinent. Due largely to discharge of industrial effluents and wastes into sea, the concentration of some elements have become alarmingly high and are considered a serious health hazard to human and aquatic organism as well (Ahmed *et al.,* 2002). Fish are known to concentrate metals in their body tissues in varying proportions depending upon the species, condition, environment and their inhibitory processes. Therefore, fish are often used as indicators of marine pollution (Sharif *et al.,* 1993b). Since fish forms an important source of protein food for man, they can become the indirect source of metal accumulation in human body leading sometime to toxic effects. Among various fish

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species, bottom living benthos-feeding fishes are highly susceptible to bioaccumulation of some heavy metals that accumulate in the bottom sediment.

The Sundarbans, the largest single tract of mangrove forest (6,000 km^2 in size) in the world, is a dynamic, fragile and complex ecosystem. There are rivers and canals across the forest like a net with their innumerable branches. The Sundarbans is a transitional zone between freshwater supplied from the rivers and marine water from the open sea. Thus, the Sundarbans provides a seasonal habitat for freshwater species, marine water species, as well as species, which pass through the Sundarbans during breeding or spawning migrating (Hussain and Acharya, 1994).

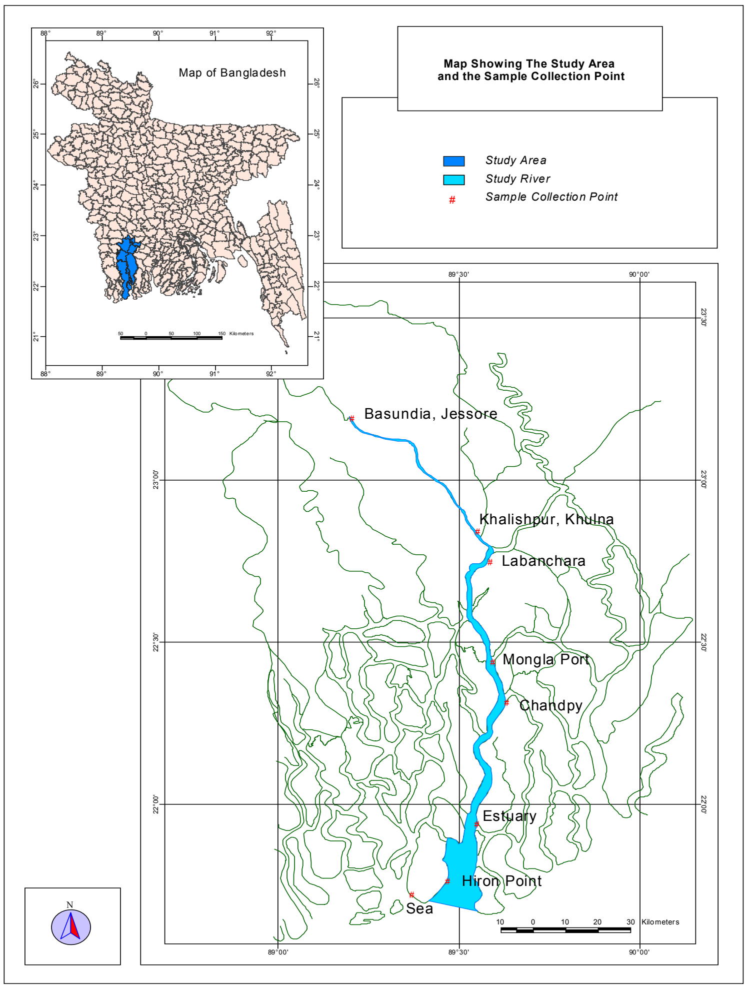

Fig. 1. Location map of study area and sampling sites.

Information on heavy metal concentration in aquatic environment are very limited in Bangladesh. Studies yet to be carried out to reveal the rate of bio-accumulation and bio-magnification of heavy metals in aquatic organisms in Bangladesh. However, a few study (Sharif *et al.,* 1991; 1993a; 1993b) have been carried out to measure the concentration of some trace metals in some selected fish from different aquatic ecosystems and the Bay of Bengal (Ahmed *et al*., 2002, 2003; Datta and Subramanian, 1998; Khan *et al*., 1996, 1998; Rao *et al*., 1985; Chowdhury, 1994; Biswas, 1998; Subramanian *et al*., 1988; Haque *et al*., 2004, 2005 and Talukdar, 1995). Therefore, present study was designed to measure the concentration of some heavy metals in the bottom feeder fish *Glossogobius giuris*, locally known as *Bailla maach,* from the Sundarbans mangrove swamps of Bangladesh.

Materials and Methods

Sampling sites: Seven sampling stations were selected in the Southwest region of Bangladesh covering the Bhairab-Rupsha-Passur river system where the industrial zone is established in recent past. Five sampling stations were established the rivers Bhairab, Rupsha and Passur and the other two at the estuary of Hironpoint and the Bay of Bengal. The estuary at Hironpoint is located inside the Sundarbans and is formed by the confluence of the complex river systems. The names of the seven stations are Basundia, Khalishpur, Labanchara, Mongla Port, Chandpai, Hironpoint and the Bay of Bengal. The location map showing the sampling stations are given in Fig. 1.

Sample collection, storage and analysis: Specimens of the Gobby fish (*G. giuris*) covering various sizes were caught by using commercial fishing nets. Fish samples were colleted during three different periods 15-31 October, 2000; 15-28 February, 2001; and 15-30 June 2001 covering in rainy, winter and summer season respectively. The fishes were washed thoroughly with fresh water immediately after catching in order to remove mud or other fouling substances and put them in clean polythene bag and preserved in ice during transportation. After transportation to the laboratory, the fish was allowed to attain room temperature. The non-edible parts i.e., internal organs, head, bone, skin and tails were removed with the help of a steam cleaned stainless steel knife. The required portion (muscle) of the fish was then washed with distilled water and cut in small pieces (2-3 cm) using the cleaned knife over a clean polyethylene sheet. The sample was then air dried to remove excess water and weighed. The sample was transferred to a clean petridish and dried in an air oven at 60 ^{o}C for 72 h. The dried samples were grinded in glass mortar; sieved through 1mm mesh and stored in airtight plastic vials inside a desiccator until transfer for analysis. The dried fish samples were digested with H_2SO_4-HNO_3-H_2O_2 mixture following standard procedure (Hanson, 1973). The digested content was diluted with deionized water and filtered quantitatively in to a 50 ml volumetric flask. The digested samples were then analyzed by using air acetylene flame with combination, as well as single element hollow cathode lamps into an atomic absorption spectrophotometer (Shimadzu, AAS-6800) in the laboratory of AERE, Savar Dhaka. The sample was injected by an automatic sampler and the absorbance and concentration data were automatically printed out and displayed.

Results

Copper (Cu): The concentration of Cu in *G. giuris* during rainy season was ranged from 0.523 to 1.96 µg g^{-1}. The height value (1.96 µg g^{-1}) was found at Basundia and the lowest value (0.523 µg g^{-1}) was found at Hironpoint stations. During winter season, the highest value (5.6412 µg g^{-1}) was in Bhairab river at Basundia and the lowest value (1.0534 µg g^{-1}) was in the Bay of Bengal. For summer season, the highest value (2.2370 µg g^{-1}) was in the Rupsha river at Labanchara and the lowest value (0.5832 µg g^{-1}) was in the Bay of Bengal (Table 1). The maximum mean concentration (3.10±1.8 µg g^{-1}) was found in the Rupsha river at Labanchara and the minimum mean concentration (0.756±2 µg g^{-1}) was found in the Bay of Bengal (Table 2).

Zinc (Zn): During rainy season, the concentration of Zn in *G. giuris* was varied from 5.4585 to 19.0465 µg g^{-1}. The highest value (19.0465 µg g^{-1}) was found at Hironpoint and the lowest value (5.4585 µg g^{-1}) at Mongla port stations. During winter season, the highest value (23.1971 µg g^{-1}) was Passur river at Mongla port and the lowest value (6.4509 µg g^{-1}) was in the Bhairab river at Khalishpur. In summer season, the highest value (12.4274 µg g^{-1}) was found in the Passur river at Mongla port and the lowest value (5.1657 µg g^{-1}) was in the Hironpoint (Table 1). The maximum mean concentration (13.69±7.2 µg g^{-1}) was found in the Passur river, Mongla port and the minimum mean concentration (7.65±0.8 µg g^{-1}) was in the Bhairab river at Khalishpur. The mean concentration of Zn was also higher in the Bay of Bengal with a value of 12.09±3.7 µg g^{-1} (Table 2).

Iron (Fe): During rainy season, the concentration of Fe in *G. giuris* was varied from 26.37 to 81.89 µg g^{-1}. The highest value (81.89 µg g^{-1}) was observed in the Passur river at Mongla port and the lowest value (26.37 µg g^{-1}) was found in the Bay of Bengal. For winter season, the highest value (119.79 µg g^{-1}) was measured in the Passur river at Chandpai and the lowest value (19.95 µg g^{-1}) was found in the Bhairab river at Basundia. During summer season, the highest (49.29 µg g^{-1}) and the lowest (12.68 µg g^{-1}) were observed in the Passur river at Mongla port and in the Bhairab river at Basundia respectively (Table 1). The maximum mean concentration (71.34±19.1 µg g^{-1}) was found in the Passur river at Mongla port and the minimum mean concentration (26.84±1.0 µg g^{-1}) was measured in the Rupsha river at Labanchara. The mean concentration of Fe was also higher in the Passur river at Chandpai (67.51±45.2 µg g^{-1}) (Table 2).

Lead (Pb): During rainy season the concentration of Pb in *G. giuris* were varied from 2.0021 to 4.9442 µg g^{-1}. The highest (4.9442 µg g^{-1}) was at Khalishpur and the lowest (2.0021 µg g^{-1}) value of Pb was at Labanchara respectively. Measured for winter season, the highest value (4.2597 µg g^{-1}) was measured in Bhairab river at Basundia and the lowest value (0.1396 µg g^{-1}) was measured at Hironpoint. During summer season the highest value (2.9901µg g^{-1}) was in the Bay of Bengal and the lowest value (0.4508 µg g^{-1}) was in the Bhairab river at Basundia (Table 1). The maximum mean concentration of Pb (3.30±1.4 µg g^{-1}) and the minimum (1.64±0.9 µg g^{-1}) were observed in the Bhairab river at Khalishpur and in the Passur river at Chandpai respectively (Table 2).

Cadmium (Cd): The concentration of Cd in *G. giuris* during rainy season was ranged from 0.1021 to 0.2795 µg g^{-1}. The highest value (0.2795 µg g^{-1}) was found in the Bay of Bengal and the lowest value (0.1021 µg g^{-1}) was in the Bhairab river at Basundia. For winter season, the highest value (0.2406 µg g^{-1}) was observed in the Rupsha river at Labanchara and the lowest value (0.0468 µg g^{-1}) was in the Passur river at Chandpai. During summer season, the highest value (0.2398µg g^{-1}) was found in the Bay of Bengal and the lowest value (0.0233 µg g^{-1}) was in the Passur river at Chandpai (Table 1). The maximum mean concentration (0.230±0.05 µg g^{-1}) was in the Bay of Bengal and the minimum mean concentration (0.066±0.05 µg g^{-1}) was in the Chandpai. The mean concentration of Cd was also higher at Hironpoint (0.219±0.06 µg g^{-1}) (Table 2).

Chromium (Cr): During rainy season the concentration of Cr in *G. giuris* could not be detected at any stations because the detection limit for Cr was 0.01µg L^{-1}. For winter season, the highest value (2.8294 µg g^{-1}) was found in the Passur river at Chandpai and lowest value (0.1341 µg g^{-1}) was at Hironpoint. During summer season, the highest value (2.0826 µg g^{-1}) was at Hironpoint and the lowest value (0.0855 µg g^{-1}) was found in the Bay of Bengal (Table 1). The maximum mean concentration (1.80±0.6 µg g^{-1}) was measured at Mongla port and the minimum mean concentration (0.822±0.5 µg g^{-1}) was at Labanchara. The mean concentration of Cr was also higher at Chandpai (1.69±1.6 µg g^{-1}) (Table 2).

Table 1. Concentration (µg g^{-1}dry wt.) of heavy metals in *Glossogobius giuris* (*Bailla*) fish from the rivers, estuary and sea off the Sundarbans mangrove swamps of Bangladesh.

Location	Season	Cu µg g^{-1}	Zn µg g^{-1}	Fe µg g^{-1}	Pb µg g^{-1}	Cd µg g^{-1}	Cr µg g^{-1}	Ni µg g^{-1}
Basundia, Jessore Bhairab River	Rainy	1.9640	9.3548	64.30	4.6717	0.1021	BDL	0.5823
	Winter	5.6412	7.1529	19.95	4.2597	0.1320	1.6278	0.8731
	Summer	0.8066	7.9598	12.68	0.4508	0.0406	0.8959	2.3624
Khalishpur, Khulna Bhairab River	Rainy	1.5237	8.4889	27.36	4.9442	0.1526	BDL	0.7676
	Winter	4.6281	6.4509	50.86	2.2920	0.2093	2.2003	1.3369
	Summer	1.4829	8.0204	48.43	2.6765	0.0429	0.6863	2.8685
Labanchara, Khulna Rupsha River	Rainy	1.7925	5.9461	28.00	2.0021	0.1632	BDL	1.0058
	Winter	5.2731	7.5422	25.86	2.0220	0.2406	1.2358	1.2467
	Summer	2.2370	10.2207	26.66	2.0826	0.0604	0.4082	3.2521
Mongla port, Khulna Passur River	Rainy	0.8838	5.4585	81.89	3.1436	0.1668	BDL	2.1029
	Winter	2.8698	23.1971	82.85	1.4670	0.1616	2.2849	1.7945
	Summer	1.2862	12.4274	49.29	2.0953	0.0719	1.3154	3.3219
Chandpy, Khulna Passur River	Rainy	1.9600	13.4999	42.75	2.7819	0.1286	BDL	3.2969
	Winter	3.5373	12.0306	119.79	1.0126	0.0468	2.8294	4.4927
	Summer	1.3351	10.3351	39.98	1.1135	0.0233	0.5622	4.6841
Hironpoint, Khulna Passure Estuary	Rainy	0.5228	19.0465	27.73	3.9579	0.2745	BDL	5.1890
	Winter	1.6144	8.2037	44.96	0.1396	0.1554	0.1341	2.4547
	Summer	0.5956	5.1657	39.34	2.9119	0.2299	2.0826	4.1650
Bay of Bengal, North-west tip of the Bay of Bengal of Bangladesh coast	Rainy	0.6314	17.2918	26.37	3.8825	0.2795	BDL	5.3287
	Winter	1.0534	10.4926	75.91	0.9450	0.1716	2.0456	2.7606
	Summer	0.5832	8.4253	40.01	2.9901	0.2398	0.0855	4.9475

Nickel (Ni): During rainy season, the concentration of Ni in *G. giuris* at the seven sampling stations ranged from 0.5823 to 5.3287 µg g^{-1} and the highest value (5.3287 µg g^{-1}) was found in the Bay of Bengal and the lowest value (0.5823 µg g^{-1}) was at Basundia. In winter season, the highest value (4.4927 µg g^{-1}) was observed in the Passur river at Chandpai and the lowest value (0.8731 µg g^{-1}) was Basundia. For summer season, the highest value (4.9475 µg g^{-1}) was measured in the Bay of Bengal and the lowest value (2.3624 µg g^{-1}) was at Basundia (Table 1). The maximum (4.35±1.3 µg g^{-1}) mean concentration and the minimum (1.27±0.9 µg g^{-1}) of Ni were measured in the Bay of Bengal and in the Bhairab river at Basundia respectively (Table 2).

Table 2. Concentration (mean ± S.D.) of Cu, Zn, Fe, Pb, Cd, Cr and Ni (µg g^{-1} dry wt.) in the *Glossogobius giuris* (*Bailla*) fish from different sampling stations of the Sundarbans mangrove swamps of Bangladesh.

Location	Cu	Zn	Fe	Pb	Cd	Cr	Ni
Basundia, Jessore, Bhairab River	2.80±2.5	8.16±0.9	32.31±27.9	3.13±2.3	0.092±.04	1.26±0.5	1.27±0.9
Khalishpur, Khulna, Bhairab River	2.54±1.8	7.65±0.8	42.22±12.9	3.30±1.4	0.135±.08	1.44±1.0	1.66±1.0
Labanchara, Khulna, Rupsha River	3.10±1.8	7.90±1.7	26.84±1.0	2.04±0.04	0.155±.09	0.822±0.5	1.83±1.2
Mongla port, Khulna, Passur River	1.68 ±1.0	13.69±7.2	71.34±19.1	2.24±0.8	0.133±.05	1.80±0.6	2.41±0.8
Chandpai, Khulna, Passur River	2.28 ±1.1	11.96±1.2	67.51±45.2	1.64±0.9	0.066±.05	1.69±1.6	4.16±0.7
Hironpoint, Khulna, Passure estuary	0.911 ±.6	10.81±5.9	37.34±8.7	2.34±1.9	0.219±.06	1.11±1.3	3.94±1.3
Bay of Bengal, North-west tip of the Bay of Bengal of Bangladesh coast	0.756 ±.2	12.09±3.7	47.43±25.5	2.61±1.5	0.230±.05	1.07±1.3	4.35±1.3

Discussion

Copper (Cu): The highest concentration of Cu was observed in the Rupsha river at Labanchara, which might be due to ship breaking, and repairing activities of Khulna ship yard and industrial effluents. The expected limit of Cu for human consumption with respect to ANHMRC 1987 (Anon, 1987; Sharif, *et al.,* 1993a) was 10.0 µg g^{-1} wet wt. (dry wt. 50 µg g^{-1} nearly). The recommended maximum concentration of Cu in fish flesh with respect to MFFSC, UK (Anon, 1956) was 20 µg g^{-1} wet wt. (dry wt. 80-100 µg g^{-1} almost). The mean concentration of Cu in the muscle tissue of the Goby fish (*G. giuris*) varies markedly at different locations along the studied waterway (Table 2). The maximum values were clustering around the industrial outfalls (Basundia to Labanchara in Khulna-Jessore districts). The sea and the estuarine stations showed the lowest Cu value in the fish studied. Since *G. giuris* is a bottom feeder having a limited migration habit, the observed concentrations could be related to the concentration of Cu in the sediment.

Zinc (Zn): The highest concentration of Zn was observed in the Passur river at Mongla port, which might be due to the cement industries, shipping and ship breaking activities of Mongla port and domestic wastes. The expected limit of Zn for human consumption with respect to ANHMRC 1987 (Anon, 1987; Sharif, 1993a) was 150.0 µg g^{-1} wet wt. (in dry wt. 750.0 µg g^{-1} around). The recommended maximum concentration of Zn in fish flesh with respect to MFFSC, UK (Anon, 1953) was 50 µg g^{-1} wet wt (in dry wt. 200-250 µg g^{-1} approximately).

Iron (Fe): The higher concentrations of Fe were observed in the Passur river at Mongla port and Chandpai which might be due to the discharge of metal rust (Iron) and various types of refuse and disposable materials from the scrapped ships, industries, tankers, mechanized boats and shipping and ship breaking activities at Mongla port.

Lead (Pb): The highest concentration of Pb was observed in the Bhairab river at Khalishpur, which might be due to oil tankers, oil refinery, mechanized boats, jute mills, textile mills, boat and barge building and repairing activities of Khalishpur. The expected limit of Pb for human consumption with respect to ANHMRC 1987 (Anon, 1987; Sharif *et al.,* 1993a) was 1.5 µg g^{-1} wet wt. (in dry wt. 7.5 µg g^{-1} almost). The recommended maximum concentration of Pb in fish flesh with respect to GBP (Anon, 1979) was 2 µg g^{-1} wet wt. (dry wt. 10 µg g^{-1} almost). The maximum values for Pb in the muscle tissue of *G. giuris* were measured from Basundia and Khalishpur, which could be attributed to the influence of local industrial and domestic discharges.

Cadmium (Cd): The maximum values of Cd were observed in the Bay of Bengal and at Hironpoint, which might be due to river run-off from upstream rivers and from neighboring countries. The expected limit of Cd for human consumption with respect to ANHMRC 1987 (Sharif *et al.,* 1993a) was 0.2 µg g^{-1} wet wt. (dry wt. 1.0 µg g^{-1} just about). The expected concentration of Cd in fish flesh with respect to MAFF-UK (Franklin, 1987) was 0.2 µg g^{-1} wet wt. (dry wt. 1.0 µg g^{-1} approximately).

Chromium (Cr): The higher concentrations of Cr were observed in the Passur river, Mongla port and Chandpai, which might be due to the industries, shipping and ship breaking activities at Mongla port.

Nickel (Ni): The maximum value of Ni was observed in the Bay of Bengal Sea, which might be due to river run-off from up stream environment and from neighboring countries. In most of the stations higher concentration of Ni was found during summer season and the mean concentrations were increased upstream to downstream which indicated that it might be come from neighboring country, India. The expected limit of Ni for human consumption with respect to ANHMRC 1987 (Sharif *et al.,* 1993a) was 1.0 µg g^{-1} wet wt. (dry wt.5.0 µg g^{-1} just about). The concentration of Ni in *G. giuris* seems to be increasing with the salinity of river water. *G. giuris* is considered as tasty fish all over Bangladesh and grows both in fresh and brackish waters.

The trace metals in *G. giuris* from other major aquatic systems of Bangladesh are compared in Table 3.

Table 3. Comparison of trace metal concentrations found in *Glossogobius giuris* from different river systems in Bangladesh. All values are expressed in mg kg^{-1} of dried fish muscle.

Element	Aquatic system / location	Concentration (mg kg^{-1})	Source	Present study
Cu	Dhaleswari River, Dhaka	5.17 - 7.48	Ahamad *et al*., 2002	0.523 - 5.642
	Buriganga River, Dhaka	4.46 - 6.07	Islam *et al*., 2002	
	Shitalakhya River, Dhaka	5.19 - 6.03	Bhowmik *et al*., 2002	
	Bangshi River, Dhaka	2.17 - 9.01	Rahman *et al*., 2003	
Zn	Bangshi River, Dhaka	129.7 - 189.1	Rahman *et al*., 2003	5.17 - 23.21
Pb	Dhaleswari River, Dhaka	4.25 - 8.17	Ahamad *et al*., 2002	0.1396 - 4.9442
	Buriganga River, Dhaka	8.71 - 11.45	Islam *et al*., 2002	
	Shitalakhya River, Dhaka	7.17 - 9.21	Bhowmik *et al*., 2002	
	Bangshi River, Dhaka	1.31 - 5.17	Rahman *et al*., 2003	
Cd	Dhaleswari River, Dhaka	0.61 - 0.71	Ahamad *et al*., 2002	0.0233 - 0.2795
	Buriganga River, Dhaka	0.81 - 0.96	Islam *et al*., 2002	
	Shitalakhya River, Dhaka	0.81 - 1.07	Bhowmik *et al*., 2002	
	Bangshi River, Dhaka	0.041 - 0.116	Rahman *et al*., 2003	
Cr	Shitalakhya River, Dhaka	3.13 - 3.37	Bhowmik *et al*., 2002	0.0855 - 2.8294
	Dhaleswari River, Dhaka	7.15 - 11.92	Ahamad *et al*., 2002	
	Buriganga River, Dhaka	6.07 - 7.05	Islam *et al*., 2002	
Ni	Bangshi River, Dhaka	1.5 - 3.98	Rahman *et al*., 2003	0.5823 - 5.3287
	Dhaleswari River, Dhaka	4.75 - 10.17	Ahamad *et al*., 2002	
	Buriganga River, Dhaka	8.65 - 11.21	Islam *et al*., 2002	
	Shitalakhya River, Dhaka	10.53 - 11.32	Bhowmik *et al*., 2002	

The concentration values of various trace metals found for *G. giuris* grown in the Bhairab-Rupsha-Passur river system are in general lower than those reported for other rivers mentioned in Table 3. It may be noted that the rivers listed in Table-3 are fed with freshwater and are known to be highly polluted with industrial and urban discharges. Moreover, these rivers are rather closed systems with little or no tidal variations. These rivers become active during rainy season and overflows because of torrential upstream discharges. On the other hand, the current aquatic systems in the present study is regulated by tidal variations round the year and constitute variable freshwater-seawater interactions. So, the observed variations may be ascribed to either the geographical location of the aquatic systems or to the quality of water that the species inhabits in.

In the present study, the concentration of Ni in fish tissue was found higher in the sea and estuarine areas than the recommended values of ANHMRC (Anon, 1987) but the concentration of Cu, Zn, Pb, and Cd was much lower than the recommended values. Thus, the Ni concentration in the Goby fish living in the sea and estuarine areas is harmful for human consumption. While the concentration of other heavy metals are not harmful for human consumption. The causes of higher Cd and Ni concentration in the Sea and in the Passur estuary at Hironpoint could be attributed as follows-

i) The numerous rivers of GBM and their tributaries that criss-cross Bangladesh carry pollutants from the whole drainage area, including upstream areas in India, Nepal, Bhutan and China.

ii) The natural geomorphological features of Sundarbans mangrove ecosystem usually prevent the mixing of shallow freshwater run off with high saline sea water of the Bay of Bengal.

Conclusion

High concentration of Nickel has been found in the muscles of *Glossogobius giuris* from Bay of Bengal and in the Passur estuary at Hironpoint. Fish samples from other stations contained heavy metal levels below the standard level. It is clearly evident from the results that the Sundarbans mangrove ecosystem is increasingly polluted with the Ni metal. However, the source of Ni metal in the Sundarbans mangrove ecosystem is yet to be identified.

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