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BIOCHEMICAL CHARACTERISTICS AND ACCUMULATION OF HEAVY METALS IN FISHES, WATER AND SEDIMENTS OF THE RIVER BURIGANGA AND SHITALAKHYA OF BANGLADESH

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ABSTRACT

Heavy metals viz., Pb, Cd, Cu, Cr, Zn and Ni in particular of water, soil and available fish species from these two rivers are examined. The higher amount of heavy metals found in soils viz., Pb varied between 29.04 mg/kg and 64.78; Cd varied between 0.31 mg/kg and 5.01 mg/kg; Cu varied between 40.13 mg/kg and 111.10 mg/kg; Zn varied between 75.19 mg/kg and 333.76mg/kg ; Cr varied between 51.51 mg/kg and 118.14 mg/kg and Ni varied between 35.81 and 44.41 mg/kg over the whole year. A remarkable amount of Pb, Zn, Cr was recorded in the whole fish species collected from both rivers. In Buriganga, Pb varied between 4.32 mg/kg and 31.51 mg/kg and in Shitalakhya 11.44 mg/kg and 17.03 mg/kg. Zn values ranged 3.95 mg/kg to 51.50 mg/kg in Buriganga and 6.29 mg/kg to 62.02 mg/kg in Shitalakhya. The similar trend of Cr was recorded at Buriganga and Shitalakhya and it's ranged 7.83 mg/kg to 21.72 mg/kg. Cu and Ni were found under acceptable level. This finding indicates a major threat to human health in regard to consumption of fishes of those rivers. Dissolved oxygen (DO) content of the river Buriganga was found only 1.1 mg/l and 4.6 mg/l in Shitalakhya during winter. NH_3, BOD, COD and conductivity were recorded very higher values both in winter and summer period. The lower survival rate of fishes in these rivers may directly related to the lower level of oxygen content. In addition, the study made observation that the water of these two rivers inhabitable for aquatic organisms during winter and summer periods. While during monsoon period water of these rivers were found fairly unpolluted and which may allow aquatic organisms to live it in that period.

Keywords: Water quality, Heavy metals, Aquatic fauna, Human health.

Contribution/ Originality

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1. INTRODUCTION

The two major rivers Buriganga and Shitalakhya are flowing around the Dhaka city. Industrial waste, fertilizers, pesticides, garbage and sewage dumps, oil refineries, tanneries, oil from riverine transport, paper and pulp, ship building etc. whose effluents are discharged in these rivers. In addition, street litter, pet and yard waste, motor oil, paint travel through drains into rivers, and polluted the water. This has resulted in eutrophication and deterioration of water quality, affecting the biotope and, thus, their fishery. Water quality monitoring of these rivers has been done extensively by a number of workers/agencies. But no study of these rivers ever has been done regarding the impact of environmental degradation on fish & fisheries. Also, chemical data provide the measure of the concentration of pollutants responsible for degeneration.

Earlier, study reported that the dissolved oxygen (DO) in river Buriganga reaches critical level during certain periods of year [1] and they also reported that the quality of water was clearly showing downward trends. The river water contains 650 ppm dissolved solids with always-higher values of turbidity, color, CO_2 and BOD(biological oxygen demand than internationally recommended value for a river [2].

The steamers, launches, boats etc. that ply in the rivers pollutes the water by their fuel, waste materials etc. Rahman, et al. [3] and also marked out that the industrial wastes, unhygienic sewage and domestic wastes are also responsible for the pollution of Buriganga river. The other study made observation that the river water was alkaline; pH 7 to 7.8 and $CaCO_3$ content 0.81 to 1.21 gm/L. They also reported that total nitrogen and phosphates were found to be quantitatively low [4].

However, along the bank of the Shitalakhya, the authority of the Environmental Pollution Control (EPC, 1980a.) noted a total of 46 industrial units. EPC [5] reported that the jute mills and cotton mills discharged solids wastes of cotton and jute into the river with some toxic chemicals, which have definite deleterious effect on the aquatic fauna. The highly objectionable ammonia (NH_3) was discharged through leakage from the Urea Fertilizer Factory of Ghorashal plant. EPC [6] recorded 200 ppm of NH_3 from Shitalakhya with mortality of young fish. Thus, from fisheries point of view the present study was conducted for the first time, envisages to evaluate the impact of pollution on different aquatic communities in these two highly polluted rivers and their tributaries.

2. MATERIALS AND METHODS

This study was conducted in the river Buriganga and Shitalakhya in three different season's *viz*., monsoon, winter and other in summer period. In each river four sampling stations were selected

for the sample collection. During the period of study some of pollution free zones (with no major industries, upstream) have been selected as reference zone to compare the result eg. Raniganj, 24^0 04.034'N/90^0 37.898'E on the river Shitalakhya. The sampling stations were considered to the most polluted areas *viz*., Mirpur bridge, 23^0 47.111' N/ 90^0 20.206'E Kamrangirchar, 23^0 43.065'N/ 90^0 24.505'E, Jinjira, 23^0 42.450'N/90^0 24.344'E and Fatullah, 23^0 38.190' N/90^0 28.244E on the river Buriganga and in the river Shitalakhya *viz*., Ghorashal bridge, 23^0 56.279' N/90^0 37.063'E, Katchpur bridge, 23^0 42.024' N/90^0 30.094'E Kerosene ghat, 23^0 36.546' N/90^0 30.434'E in Narayanganj .

Some of physico-chemical parameters pH DO, NH_3, Alkalinity, hardness and conductivity of water in particular was analyzed on the site immediately after sample collection by using HACH Kit FF-2 and rests of the samples were analysed in the laboratory of the Riverine Station (RS**).** Soil samples were collected by using Ekman dredge from the different parts of the river. Immediately after collection the samples were preserved in polythene bag and then properly numbered. Finally samples were brought in the laboratory and dried in room temperature, powdered and sieved and preserved until analysis. Available fish samples were collected during the period of study to determine the accumulation of heavy metals. The digestion of the fish samples were done in the laboratory of Riverine station, Chandpur Major cat ions, heavy metals of water, soil and fishes were analyzed from the SRDI, Comilla; BUET, Dhaka and Environmental Monitoring Control Lab of Ministry of Shipping. The data was analysed by following [7] for water samples [8] for sediment samples and Piper [9], for fish tissue samples. Heavy metals of soil, water and fish samples were analysed by using atomic absorption spectrophotometer (model Shimadzu A6800).

3. RESULTS AND DISCUSSION

The different sampling sites of the river Buriganga and Shitalakhhya are shown in Fig 1**.** A very little amount of dissolved oxygen (DO) was found in winter in the river Buriganga (1.1mg/l) and in the Shitalakhya (4.6 mg/l). In summer it varied between 3.8 and 5.4 mg/l in these two rivers. Only in monsoon the dissolved oxygen content was found acceptable level (6.8 to7.9 mg/l) in both of the river (Fig 2 & 3). The value of pH was found suitable between 7.8 and 8.4 at river Buriganga and Shitalakhya during monsoon and summer. In winter period pH value was under acceptable level and it varied between 1.1 and 4.6. No NH_3 was also recorded in winter at Buriganga and Shitalakhya. During monsoon and summer NH_3 ranged varied 0.8 to 1.3 mg/l. Total alkalinity was detected within a range of 44.6 mg/l to 215.6 mg/l. The hardness varied from 46.2 mg/l to 85.1 mg/l during monsoon and summer at Buriganga and Shitalakhya. The alkalinity values indicated that river water was productive and hardness showed that water was hard type.

The values of bio-chemical oxygen demand (BOD) were higher in summer (4.8mg/l) following monsoon 3.5 and winter 2.5mg/l at Buriganga. In shitalakhya, highest values recorded during summer 6.5mg/l following winter 3.5mg/l and monsoon 2.8mg/l. BOD was found above acceptable level (<6.0 mg/l) during summer at Shitalakhya. The chemical oxygen demand (COD) values were remarkably higher than acceptable level (<40.0 mg/l) during winter and summer and its ranged varied 51.2 to 95.3 mgO_2/l. The values were found only under acceptable during monsoon and its varied 30 to 33.8 mgO_2/l. (Fig 1 & 2).The highest value of conductivity was

recorded during winter 768.3 mS/cm at Buriganga followed by Shitalakhya 408.5 mS/cm. The rest of the season conductivity varied between 124 to 287 mS/cm (Fig 2 & 3).

The heavy metals of river water during different seasons were summarized in Table 1. No Pb was found in monsoon period but in summer same amount of lead (Pb) was (0.18mg/kg) estimated in both of the rivers. In addition, a little amount of Pb (0.05mg/kg) was also recorded in river Buriganga. Cadmium (Cd) was recorded 0.1 mg/kg in both of the rivers during winter and no Cd was recorded in monsoon and summer period. No copper (Cu) was found in monsoon in both rivers and more or less similar trend was recorded during winter and summer and it's ranged 0.04 to 0.06 mg/kg in Buriganga and Shitalkhya. The highest value of zinc (Zn) was found summer (2.11 mg/kg) during summer in shitalakhya followed by river Buriganga (0.64mg/kg). Other than monsoon in Shitalakhya similar amount of Zn (0.04 mg/kg) was found in the rest of the period. The highest amount of chromium (Cr) was recorded 0.16mg/kg during monsoon in Shitalakhya followed by river Buriganga 0.11 mg/kg during winter. No Cr was recorded during monsoon and summer period in two rivers but in Shitalakhya during winter it was 0.08 mg/kg. No nickel (Ni) was found during winter and summer in Buriganga and highest Zn was found during monsoon (0.08mg/kg) in river Buriganga. In river Shitalakhya, the values of Ni varied between 0.01 and 0.04 mg/kg during the period of study. In summer period, lead was found above acceptable (0.16 mg/l) level in Buriganga and Shitalakhya.river. Cd was above acceptable (0.01 mg/l) level in Buriganga and Shitalakhya during winter. Cu was above acceptable (0.05 to 0.06 mg/l) level in Buriganga and Shitalakhya during winter and summer period. Cr was above acceptable (0.08 to 0.16 mg/l) level in Buriganga during winter and Shitalakhya during monsoon and winter period. Ni was found below acceptable level during winter and summer period and only in monsoon period it reached at above acceptable level. The similar findings were reported in Gomti river, where concentration of heavy metals *viz*., Cd, Cr, Cu, Fe, Pb, Mn, Ni, and Zn higher in sediment samples than that of water. The study indicates that some physico-chemical parameters *viz*., pH, TS, TDS, TSS, DO, BOD, COD, hardness may have direct or indirect influence on the incidence, transport and speciation of the heavy metals [10].

The outfall water from the different industries connected directly to the rivers were examined. The value of NH_3, COD and conductivity were found remarkably high (Table 5). The study made observation that the outfalls of different industries and urban areas were the main cause of river pollution. The heavy metals of water from three different outlets were presented in Table 6. The amount of Zn (16.99 mg/l) was found very high in the outlet from paper mills followed by outlet of Fatulla textile mills (6.98) and Mitford drain (1.18). It is assuming that that due to usages of Cr in the tannery, textile and paper mills that effluent Cr in particular directly discharged through the drain into the river. Pb was found above acceptable level in all of three outlet water. Other heavy metals were found below the acceptable level.

The most of the rivers soils were found acidic in nature with a few exceptions. Soil pH ranged from 5.93 to 7.43 (Table 2). The highest organic matter (6.66%) was found during summer at Shitalakhya followed by 3.47%, 2.39% and 1.58% during summer, winter and monsoon respectively at Buriganga. Organic carbon ranged 0.92 to 2.01 % in river Buriganga and 0.46 to

0.82 %. In the river Shitalakhya, total nitrogen content of soils of most rivers was very low and ranged between 0.090 to 0.10%. Available phosphorus ranged from 9.5 to 31.8 mg/kg **(Table 2).**

Heavy metals of soil *viz*., Pb, Cd, Cu, Zn, Ni and Cr in particular were determined (Table 3). The study made observation that heavy metals showed very high values than optimum level. In monsoon period highest Pb was recorded in Buriganga (64.78 mg/kg) followed by summer (44.09mg/kg) and monsoon (29.04mg/kg). The more or less similar values were found in the river Shitalakhya and it's varied between 23.69 and 28.36 mg/kg. The Cd was recorded more or less constant in the river Buriganga and it's ranged between 0.88 and 0.68mg/kg. In the river Shitalakhya the highest values was found in monsoon (5.01mg/kg) and lowest in summer 0.31mg/kg. The similar trend of Cu values was observed in the river Shitalakhya and Zn and Cr were remarkably higher in these rivers (Table 3). In winter and summer period drastically deteriorate the soil of the river Buriganga. Pb, Cu and Zn in particular were recorded in very high values (Table 3). Also the similar trend of Ni and Cr was recorded during the period of winter and summer period.

A number of researchers made similar observation that Gomti River which receives industrial as well as domestic wastes from various drains of Lucknow city contains high level of Cd, Cr, Cu, Ni, Pb, and Zn in water and sediment in rainy season compared to summer and winter. Because in rainy season runoff from open contaminated sites, agricultural field and industries, directly comes into the river without any treatment [11]. In both the cases, the concentration of Zn was maximum (0.091 /ml in water and 182.13 µg/g in sediment) and the concentration of Cd (0.001 µg/ml in water and 17.26 microg/g in sediment) was minimum. Higher concentration of metal in water and sediment during rainy season could be due to the industrial/agricultural/domestic runoff coming into the river [11].

The accumulation of heavy metal in fish has been determined. The values of heavy metals available in fish muscle are shown in Table 4. In Buriganga, the highest amount of Pb was found winter (31.51mg/kg) followed by summer (24.4 mg/kg) and the lowest value in monsoon (4.32). In Shitalkhyathe heavy metals of fish sample ranged 17.03 to 11.03 during the period of study. No remarkable variation of Cd was found during monsoon and winter in Buriganga and monsoon in Shitalakhya. Cd was also found similar in Buriganga during summer and in Shitalkhya during winter and summer (Table 4). Cu was found in Burigana only in monsoon (2.86mg/kg) and Shitalkhya during winter (1.07mg/kg). The less similar amount of Zn was found in Buriganga during winter and in Shitalakhya during monsoon and summer and it's ranged between 51.50 and 62.02 mg/kg. The highest values of Cr was found in the river Shitalkhya during summer (21.72 mg/kg) followed by winter (13.70mg/kg) and monsoon (9.39mg/kg) (Table 4). No Ni was found in the river Buriganga during monsoon and winter and in Shitalakhya during summer. The study made observation that most of the fishes accumulate heavy metals than that of acceptable level. Thus this finding reveals a major threat to human health in regard to consumption of fishes of those rivers.Fish availability at monsoon may be due to high oxygen content and the high population density of he fish at the monsoon may be due to migration of fish from catchments area. More

fishes of that period are perhaps for the migration upstream from the downstream and for relatively low BOD value (Fig 2 & 3).

Low fish population or their absence during winter and summer period may be due to pollution by the sewage effluents and substantial reduction in fish food organisms. Thus the fish is affected indirectly when its habitual food organisms are destroyed. [12].

The study made observation that Fish fauna was poor and was dominated by the uneconomic varieties in the studied rivers. The main fishes are recorded *Glosoogobius giuris, Mystus spp., Amblypharyngodon mola, Mastacembalus spp.* and gora chingri etc. The same uneconomic species *viz., Glossogobius giuris, Channa gachua, Puntius spp. Amblypharyngodon microlepis* and *Chela atpa* were found available at the River Subarnarekha(Bihar) under same environmental conditions. In addition, it is also reported that nearby river Hatia, Tatsilvai and Muri no specimens were found during the period of investigation [3]. It is reported that the levels of Hg and Cd were highest in the vicinity of a chlor-alkali plant while the highest concentration of lead was near a metallic pipe factory of Izmit Bay, Turkey. The amounts of heavy metals found in the shoreline sediment samples were similar to those found in fish species from the bay [10]. Other observation from the the river Aba also reported that fishes *viz., Lates niloticus* and *Oriochronis niloticus* in particular contains appreciable amounts of heavy metals *viz*, ZN and Mn and which is alarming for human health hazards while consume it. The high level of hevy metals may associate with the direct dumping of industrial wastes to this river [7].

The present findings also supported by the previous results made by different scientists that Cu, Ni and Pb were found very high levels in the sediments than water. In the case of fish samples analysis (Cyprinion *macrostomus* and *Garra rufa*) contain high concentration of these heavy metals and high concentrations of heavy metals may be directly related to the contamination of the Tigris River by Ergani Copper Plant and the geochemical structure of this region [6]. The present findings were found more or less similar compared with earlier investigation made by different study by the several researchers.

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Table-1. Heavy metals of water in the river Buriganga and Shitalakhya during the period of study

Rivers/ season	Heavy metals (mg/kg)					
	Pb (mean±SD)	**Cd (mean±SD**	**Cu (mean±SD)**	**Zn (mean±SD)**	**Cr (mean±SD**	**Ni (mean±SD)**
Buriganga						
Monsoon	(0.00±0.00)	(0.00±0.00	(0.00±0.00	(0.04±0.03)	(0.00±0.00	(0.08±0.02)
Winter	(0.05±0.03)	(0.01±0.003)	(0.04±0.02)	(0.04±0.03)	(0.11±0.08)	(0.00±0.00)
Summer	(0.16±0.03	(0.00±0.00)	(0.05±0.03)	(0.64±0.95)	(0.00±0.00)	(0.00±0.00)
Shitalakhya						
Monsoon	(0.00±0.00)	(0.00±0.00	(0.00±0.00	(0.00±0.00	(0.16±0.06)	(0.04±0.02)
Winter	(0.00±0.00)	(0.01±0.003)	(0.06±0.02)	(0.04±0.04)	(0.08±0.02)	(0.01±0.00)
Summer	(0.16±0.07)	(0.00±0.00)	(0.06±0.01)	(2.11±1.86)	(0.00±0.00)	(0.02±0.00)

Table-2. Soil characteristics of the river Buriganga and Shitalakhya

Rivers/Season	Soil parameters				
	PH	**Organic matter (%)**	**Organic carbon (%)**	**Total nitrogen (%)**	**Phosphorus, P (mg/kg)**
Buriganga					
Monsoon	(5.93±0.52)	(1.58±0.29)	(0.92±0.17)	(0.10±0.04)	(9.5±3.7)
Winter	(6.69±0.36	(2.39±0.96)	(1.39±0.56)	(0.17±0.06)	(44.0±8.2)
Summer	(6.56±0.31)	(3.47±2.11)	(2.01±1.22)	(0.20±0.18)	(24.5±22.5)
Shitalakhya					
Monsoon	(7.31±0.43)	(0.79±0.27)	(0.46±0.16)	(0.08±0.05)	(13.8±7.8)
Winter	(7.43±0.15)	(0.88±0.47)	(0.66±0.34)	(0.09±0.02)	(31.8±10.4)
Summer	(6.66±0.49)	(6.66±0.49)	(0.82±0.41)	(0.08±0.04)	(19.5±8.7)

Table-3. Heavy metals of soil in during the period of study

Rivers/ season	Heavy metals (mg/kg)					
	Pb (mean±SD)	Cd (mean±SD)	Cu (mean±SD)	Zn (mean±SD)	Cr (mean±SD)	Ni (mean±SD)
Buriganga						
Monsoon	29.04±23.20	0.88±0.69	63.98±12.91	129.62±56.05	118.14±67.46	40.30±13.13
Winter	64.78±42.63	0.68±0.07	110.10±101.51	333.76±393.76	72.04±50.12	44.41±10.41
Summer	44.09±54.49	0.73±0.39	108.39±140.51	711.51±1143.89	51.51±20.10	38.39±14.98
Shitalakhya						
Monsoon	28.36±8.49	5.01±5.99	46.78±11.03	75.19±6.47	63.22±37.92	39.22±4.83
Winter	22.48±9.47	0.85±0.94	50.02±2.54	76.69±11.79	100.86±64.28	38.28±4.91
Summer	23.69±10.97	0.31±0.20	40.13±8.57	100.66±15.82	70.4±0.00	35.81±2.79

Table-4. Heavy metals of sample fishes of the river Buriganga and Shitalakhya

Rivers/season	Heavy metals (mg/kg)					
	Pb (mean±SD)	Cd (mean±SD	Cu (mean±SD)	Zn mean±SD)	Cr (mean±SD)	Ni (mean±SD)
Buriganga						
Monsoon	4.32	0.91	2.86	3.95	7.83	0.00
Winter	31.51	0.68	0.00	51.50	9.98	0.00
Summer	24.40	1.65	0.00	4.42	13.70	1.09
Shitalakhya						
Monsoon	17.03	0.77	0.00	62.02	9.39	1.94
Winter	12.96	1.42	1.07	6.29	13.70	2.30
Summer	11.44	1.42	0.00	55.06	21.72	0.00

- Small Fish- Puti, Bele, Tengra, Mola, Guchi baim, Gutum, Chanda and gora chingri

Table-5. Water quality of some outlets falling into the rivers around Dhaka city, Bangladesh during winter period

River/outlet	Area/place	Ammonia (mg/l)	*COD (mg O_2/l)	Conductivity (mS/cm)
Buriganga	Mitford area drain	26.5	392.0	890.0
Buriganga	Hazaribag sluice Gate	16.5	282.0	584.0
Buriganga	Kamrangirchar sluice	31.5	182.0	474.0
Shitalakhya	Ghorashal paper mill	1.6	925.0	788.0
Shitalakhya	Ghorashal fertilizer factory	24.0	34.0	584.0

***COD** = chemical oxygen demand.

Table-6. Heavy metals of some outlets falling into the rivers around Dhaka city, Bangladesh during winter period

River	Outlet	Heavy metals (mg/l)					
		Pb	Cd	Cu	Zn	Cr	Ni
Buriganga	Drain near Mitford area	0.17	0.004	0	1.18	0	**0**
Buriganga	Fatulla textile mill	0.19	0.0007	0.06	6.98	**0**	0.002
Buriganga	Fatulla paper mill	0.17	0	0.05	16.99	0	0

BDL= Below detection level

Fig-3. Different sampling spots/stations in the river Buriganga and Shitalakhya

Fig-2. Water quality characteristics of the river Buriganga during the period of study

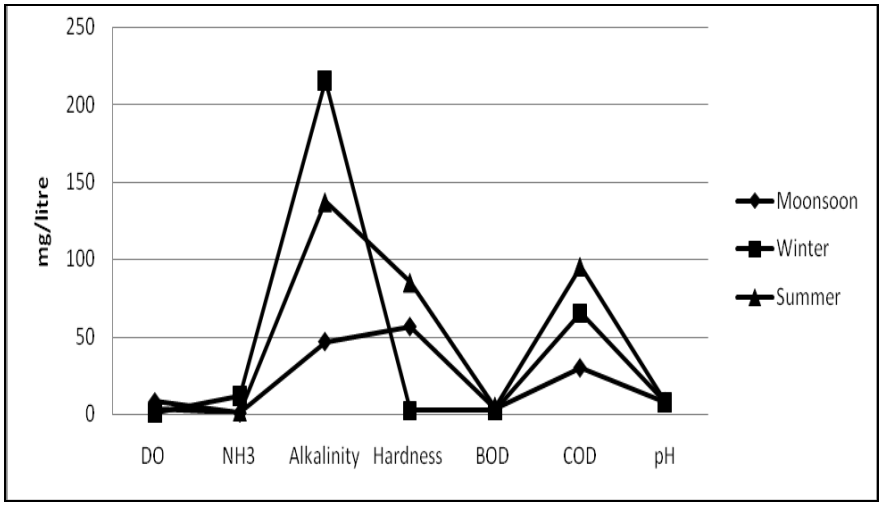

Fig-3. Water quality characteristics of the river river Shitalakhya during the period of study