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Research article

Accumulation of trace elements in sediment and fish species of Paira River, Bangladesh

Md. Saiful Islam[1,2,]* and Md. Habibullah-Al-Mamun[2,3]

[1] Department of Soil Science, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh
[2] Environment and Information Sciences, Yokohama National University, 79-7 Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa, 240-8501, Japan
[3] Department of Fisheries, University of Dhaka, Dhaka-1000, Bangladesh

*** Correspondence:** Email: Islam-md.saiful-nj@ynu.jp; Tel: +8801717372057.

Abstract: Sediments and tissues of eleven fish species (*Channa punctata*, *Cyprinus carpio*, *Heteropneustes fossilis*, *Colisa fasciata*, *Channa striata*, *Notopterus notopterus*, *Tenualosa ilisha* and *Corica soborna*) were analyzed for (chromium (Cr), nickel (Ni), copper (Cu), arsenic (As), cadmium (Cd) and lead (Pb)). The abundance of trace elements in sediments were Cr > Ni > Cu > Pb > As > Cd and in fish species were Cu > Ni > Cr > Pb > As > Cd. The range of mean element concentration in fish species were Cr (0.44–0.97), Ni (0.45–1.1), Cu (0.91–1.5), As (0.18–0.37), Cd (0.016–0.20) and Pb (0.47–0.92 mg/kg wet weight (ww)). The concentrations of Ni, Cd and Pb in some fish species exceeded the international permissible standards suggesting that these species are not safe for human consumption. The biota-sediment accumulation factor for the studied elements in *C. soborna* and *T. ilisha* were slightly higher than the other species indicated that these species can be used as a potential bio-indicator for the contamination study of trace elements.

Keywords: trace elements; sediment; fish species; BSAF; Bangladesh

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1. Introduction

Trace elements are widespread environmental pollutants generated from natural and anthropogenic activities [1,2]. The sources such as industrial effluents, agricultural runoffs, transport, burning of fossil fuels, animal and human excretions and geologic weathering and domestic waste contribute to the accumulation of trace elements in the water bodies [3,4]. Trace elements such as chromium, nickel, copper, arsenic, cadmium and lead are regarded as serious aquatic pollutants because of their toxicity, bioaccumulation and persistence in the environment [5–7]. During the last decade, urban and industrial developments have aggravated some serious concerns about the aquatic environment. It has been well documented that surface sediment may act as a sink for various pollutants and pose risks to water through biogeochemical exchanges with overlying water layer [8].

Trace elements pollution in the environment have become a wide concern owing to their ever increasing contamination of soil, sediment, water and food in many regions of the world and particularly in some developing countries like Bangladesh [9,10]. Trace elements are a threat to the supply water but also they pose risks to humans through consumption of aquatic products [11]. In the last few decades, trace elements have been widely studied for their toxic effects [6,12] and accumulation in organisms [5,13,14]. Therefore, studies on bioaccumulation of toxic elements in fish species are important in determining the tolerance limits of trace elements in fish species, effects on fish and bio-magnification through food chain [15]. Fish is an important part of human diet as well as a good indicator of environmental contamination by trace elements. Fish has been considered as the top of the aquatic food chain [16,17]; therefore, they normally can accumulate trace elements from food, water and sediments. The accumulated trace elements in fish can counteract their beneficial effects; several adverse effects to human health have been known [18]. This may include serious threats like renal failure, liver damage, cardiovascular diseases and even death [19]. Little is known about the association of biota-sediment contaminants to the aquatic organisms [20]. Therefore, study on biota-sediment accumulation factor of trace elements is very important to assess accumulation of trace elements in different fish species.

In the world, Bangladesh is one of the largest deltas formed by the Ganges, Brahmaputra and Meghna and spreading over five countries namely, China, Bhutan, Nepal, India and Bangladesh [4]. In Bangladesh, everyday huge amount of untreated industrial wastes is being discharged into the open water bodies. Besides, a considerable amount of trace elements enriched suspended solids is coming down from neighboring country like India through the Teesta and the Brahmaputra Rivers [4] and have been accumulated in the riverine environment. Consequently, it poses severe threats to fish and other aquatic biota. The Paira River is only the active section with intensive district traffic and supplies water for the people living adjacent the river. The sediments of Paira River are traditionally dredged and used as an amending material for agricultural soil. As well, the river aquatic products, such as fish is used for local food consumption. In contrast, over exploitation, mismanagement and improperly treated industrial effluents in Paira River brings a great challenge for the ecosystem balance [10,21]. Consequently, the study river has been raised public attention due to its extreme pollution. To date, no scientific study regarding biota-sediment accumulation of trace elements has been conducted so far in the study area. Therefore, the objectives of this study are- to monitor the levels of trace elements in sediments and fish species and to assess the biota-sediment accumulation factor of trace elements of Paira River, Bangladesh.

2. Materials and methods

2.1. Study area and sampling

This study focused on the Paira River located at the southern part in Bangladesh. The area of Patuakhali district is about 3204.58 km^2, total population of this district is about 1,444,340 persons and population density is 450.7/km^2 [21]. The study river makes a junction between the Patuakhali district and Dhaka City through river transportation. The study area is located between latitudes 22º20′50.04″ and 22º27′04.23″ N and longitudes 90º22′50.81″ and 90º26′47.44″ E. The sampling was conducted during February-March and August−September, 2012. Forty eight sediments and eighty samples of eight different fish species i.e., *Channa punctata*, *Cyprinus carpio*, *Heteropneustes fossilis*, *Colisa fasciata*, *Channa striata*, *Notopterus notopterus*, *Tenualosa ilisha* and *Corica soborna* were collected using standard protocol [22] from eight stations (P1, P2, P3, P4, P5, P6, P7 and P8) of Paira River (Figure 1). The Paira River receives domestic raw sewage, household waste, and industrial waste from surrounding habitation. The study river has been considered as the main flow of polluted water from the peripheral rivers of the capital Dhaka City, Bangladesh to the Bay of Bengal. Fish species were collected using nylon net by the help of fishermen at almost the same locations where the sediments were collected. After collection, fish samples were carefully washed immediately with distilled water and the edible part of fish (muscles tissues) were cut into small pieces and then oven dried at 70–80 °C to attain constant weight. The river bed sediment samples were taken at a depth of 0 to 5 cm using a portable Ekman grab sampler. The upper 2 cm of each sample was taken from the center of the catcher with an acid-washed plastic spatula to avoid any contamination from the metallic parts of the sampler. The dried fish and sediment samples were crumbled and pulverized with a porcelain mortar and pestle and sieved through 2 mm nylon sieve and stored in airtight clean zip lock bag in freezer condition at 8 °C up to chemical analysis was carried out. The processed samples were brought to the Yokohama National University, Japan, for chemical analysis.

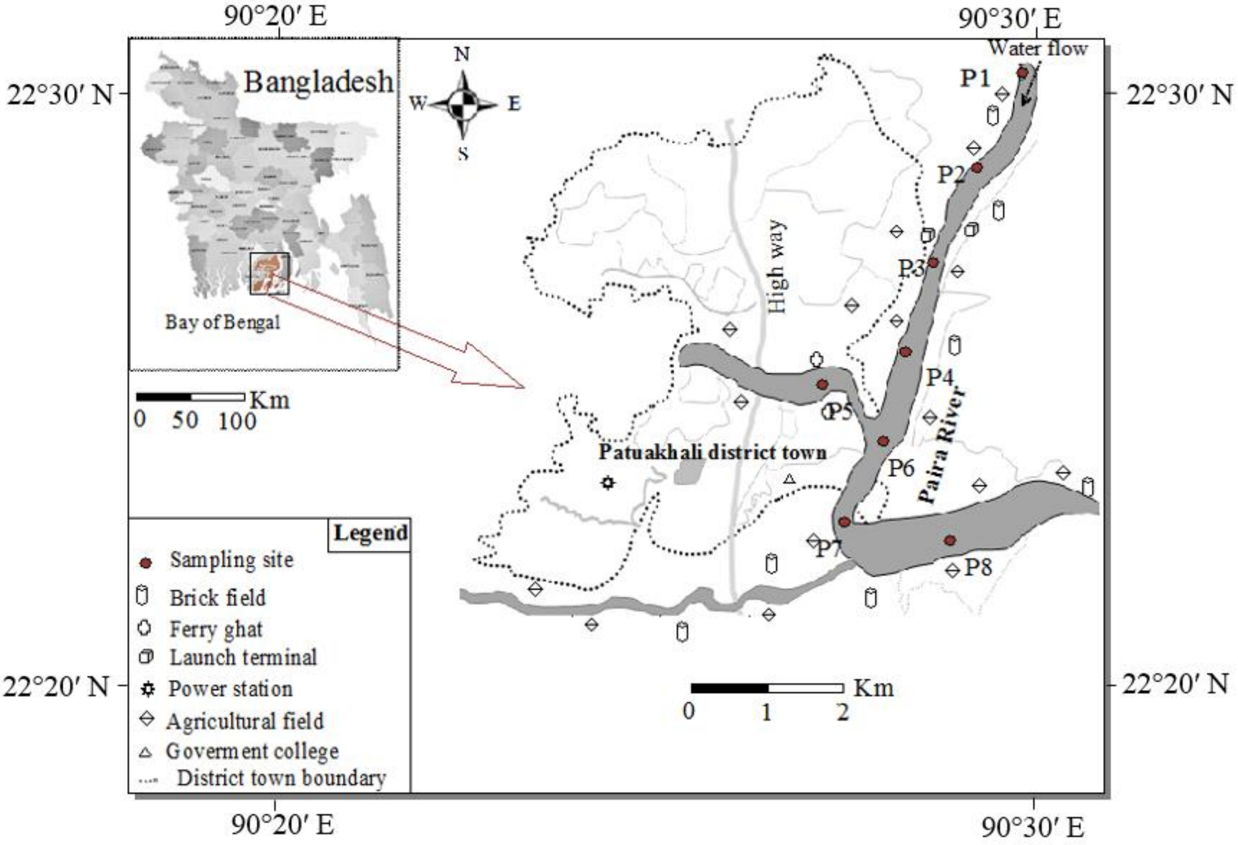

Figure 1. Map of the study area of Paira River in Bangladesh.

2.2. Analytical procedure

All reagents used were Merck, analytical grade (AR) and Milli-Q (Elix UV5 and MilliQ, Millipore, USA) water was used for solution preparation. For trace elements analysis, 0.5 g of sediment and 0.5 g of the dried fish samples were digested with 6 mL 69% HNO_3 and 2 mL 30% H_2O_2 (Wako Chemical Co, Tokyo, Japan) in a microwave digestion system (Berghof speedwave®, Eningen, Germany). The digested samples of sediment and fish were filtered through Whatman no. 42 filter paper and the filtrates were diluted to 50 mL with Milli-Q water. All samples were stored at ambient temperature before analysis. For trace elements, samples were analyzed using inductively coupled plasma mass spectrometer (ICP-MS) and detailed operation procedure of ICP-MS was stated in Table S1. The detection limits of ICP-MS for the studied metals were 0.7, 0.6, 0.8, 0.4, 0.06 and 0.09 ng/kg for Cr, Ni, Cu, As, Cd and Pb, respectively. Blank samples were analyzed after eight samples and all analyses were replicated three times. The precision and analytical accuracy were checked by analysis of standard reference material, NMIJ CRM 7303—Lake Sediment and DORM-2—dogfish muscle from the National Research Council, Canada). The measured values for reference materials are reported in Table S2.

2.3. Physicochemical properties of sediment

The pH of sediments was measured in 1:2.5 of sediment to water ratio. The suspension was allowed to stand overnight prior to pH determination. The pH was measured using a pH meter with the calibration of pH 4.0, pH 7.0 and pH 9.0 standards. For electrical conductivity (EC) determination, 5.0 g of sediment was taken in 50 mL polypropylene tubes. Then, 30 mL of distilled water was added to the tube and was shaken for 5 minutes. After that, EC was measured using a portable EC meter (Horiba D-52). Percent nitrogen and organic carbon content of sediments were measured using an elemental analyzer (model type: Vario EL III, Elenemtar, Germany). For total nitrogen (TN) and total organic carbon (TOC) determination, sediments were weighed in tin or silver vessels and loaded in the integrated carousel. In a fully automatic process, the transfer of samples through the ball valve into the combustion tube. Each sample was individually flushed with carrier gas to remove atmospheric nitrogen, resulting in a zero blank sampling process. The catalytic combustion was carried out at a permanent temperature of up to 1200 °C. The element concentration from the detector signal, and the sample weight on the basis of stored calibration curves were measured.

2.4. Bioaccumulation of trace elements in fish species

Trace elements in sediments and fish species from the studied river were used for calculating biota-sediment accumulation factor (BSAF). The BSAF is an index of the ability of fish species to accumulate a particular element with respect to its concentration in sediment. It was calculated by the following equation [23].

$$BSAF = \frac{C_{fish}}{C_{sediment}} \quad (1)$$

Where, C_{fish} is the concentration of trace elements in fish species (mg/kg dw) and $C_{sediment}$ is the concentration of trace elements in sediment (mg/kg dw).

2.5. Statistical analysis

The data were statistically analysed using the statistical package, SPSS 16.0 (SPSS, USA). The means and standard deviations of trace elements in sediment and fish species were calculated. A multivariate method in terms of principal component analysis (PCA) was used to obtain the detailed information of the data-set and gain insight into the distribution of trace elements by detecting similarities or differences in samples.

3. Results and discussion

3.1. Physicochemical parameters and trace elements in sediment

Physicochemical properties of sediments are presented in Table 1. The pH of the sediments was slightly acidic for all the sites except P1 and P8 which showed slight alkalinity. The composition of the organic carbon in the riverine sediments was ranged from 1.0 to 1.9. The highest value of % C was observed at P6 sites which might be attributed to the high amount of drainage water from Patuakhali district urban area. The high rate of organic growth together with the organic detritus introduced by the drainage system can be considered the main source of organic carbon [24]. Total nitrogen content was in the range of 0.12–0.20 % and was found to be high in P4 and P6 sites (Table 1). The concentrations of trace elements in sediments are presented in Table 2. The distributions of trace elements in sediments were not uniform among the sites which might be due to differences in sources of trace elements and complex reactions such as adsorption, flocculation and redox condition in sediments [24,25]. The concentrations of trace elements at P7 and P8 sites were much higher than others sites indicated that downstream river activities and urbanization drove trace elements contamination in surface sediment [26,27]. The urban activities (industrial discharges, municipal waste water, household garbage, and urban runoff) of Patuakhali district are the main reasons of higher metal input at P7 and P8 sites. Higher contaminations of trace elements in Yuandang Lagoon due to the municipal sewage discharge or other unknown pollution sources from Xiamen City were observed by Yan et al. [28] which are in line with the findings of the present study.

Table 1. Physicochemical properties in sediments of Paira River, Bangladesh.

Sites	pH	EC (µS/cm)	% N	% C	C/N ratio
P1	7.8	34	0.16	1.5	9.7
P2	7.0	23	0.15	1.7	11
P3	6.6	28	0.13	1.2	9.0
P4	6.9	34	0.20	1.4	7.1
P5	6.3	25	0.12	1.0	8.5
P6	6.4	33	0.18	1.9	11
P7	6.2	18	0.13	1.7	14
P8	7.4	24	0.12	1.0	8.7

The average concentration of trace elements in sediments were in the decreasing order of Cr > Ni > Cu > Pb > As > Cd. Among the sites, the average concentration of Cr was 45 mg/kg, where the highest Cr was observed in sediment collected from site P7 (67 mg/kg) (Table 2). The mean concentration of Ni was 34 mg/kg and the highest was observed at P7 site (61 mg/kg). The average concentration of Cu was 30 mg/kg, where an elevated level of Cu was found at sites P7 and P8 (Table 2). Higher level of Cu indicates its higher input in the sites (P7 and P8), which is originated from anthropogenic activities such as vehicle and coal combustion emissions [26], car lubricants [29], and natural activities such as metal contents of rocks and parent materials, processes of soil formation [27,30]. Among the sites, the highest As was observed at P8 site (27 mg/kg) followed by P7 site (19 mg/kg). Recently, the anthropogenic activities such as treatment of agricultural land with arsenical pesticides [29], treating of wood using chromated copper arsenate, burning of coal in thermal plants power stations, and sediment excavation that alters the hydraulic regime and/or arsenic source material increased the rate of discharge into freshwater habitat [21,31]. The mean concentration of Cd in sediment was 0.71 mg/kg with the mean range of 0.38–1.2 mg/kg (Table 2). Average concentration of Pb was 25 mg/kg where an elevated level of Pb was found at sites P7 (49 mg/kg) (Table 2). The elevated level of Pb in sediments at P7 site can be due to the effect from point and non-point sources; such as leaded gasoline, municipal runoffs and atmospheric deposition, chemical manufacturing and steel works in urban area of Patuakhali district [4,21,32].

Table 2. Concentrations of trace elements (mg/kg) in sediments of Paira River, Bangladesh (mean ± SD).

Trace elements	Sampling sites							
	P1	P2	P3	P4	P5	P6	P7	P8
Cr	37 ± 11	44 ± 16	38 ± 21	26 ± 2.7	58 ± 5.6	27 ± 10	67 ± 27	65 ± 21
Ni	23 ± 11	26 ± 10	42 ± 6.9	25 ± 11	24 ± 11	26 ± 2.3	61 ± 6.1	48 ± 6.9
Cu	17 ± 2.4	17 ± 7.7	42 ± 11	13 ± 3.2	20 ± 4.5	25 ± 6.2	50 ± 2.3	53 ± 13
As	4.0 ± 1.6	5.8 ± 2.3	13 ± 4.0	12 ± 3.9	5.0 ± 2.5	6.0 ± 2.0	19 ± 3.0	27 ± 2.3
Cd	0.52 ± 0.34	0.41 ± 0.20	0.88 ± 0.34	0.45 ± 0.21	0.69 ± 0.22	0.38 ± 0.30	1.2 ± 0.73	1.1 ± 0.61
Pb	13 ± 3.2	19 ± 2.6	38 ± 6.2	14 ± 3.0	12 ± 3.7	19 ± 5.3	49 ± 11	38 ± 5.0

3.2. Trace elements in fish species

Significant changes in pH, redox potential, salinity, particulate matter or microbial activity could increase the mobility and transport of trace elements in aquatic media and possibly increase their bioavailability in biota [25]. The concentrations of six trace elements i.e., Cr, Ni, Cu, As, Cd, Pb in eight different fish species are listed in Table 3. As a whole, the mean concentrations of trace elements in fish species showed the descending order of Cu > Ni > Cr > Pb > As > Cd. The concentration of trace elements varied considerably among the fish species. However, as a whole, the concentration of studied trace elements among the fish species were the following descending order of *N. notopterus* > *H. fossilis* > *C. carpio* > *C. striata* > *T. ilisha* > *C. soborna* > *C. punctate* > *C. fasciata*. Bottom dwelling fishes are found to exhibit higher concentration of trace elements than pelagic fishes [33]. The mean concentration of Cr in fish species was 0.70 mg/kg, where the mean concentration ranged from 0.44 to 1.1 (mg/kg) (Table 3). The mean concentration of Ni was 0.82 (mg/kg), where the highest Ni was observed in *N. notopterus* (1.1 mg/kg). The Ni concentration in four fish species was higher than the maximum allowable concentration (MAC) in fish (0.8 mg/kg) [34], indicated that Ni might pose risk to human if consume these fish species.

Table 3. Concentration of trace elements [mg/kg, fresh weight (fw)] in fish species of Paira River, Bangladesh (Replication = 3).

Local name	Scientific name		Cr	Ni	Cu	As	Cd	Pb
Taki	*Channa punctata*	Mean ± SD	0.74 ± 0.13	0.49 ± 0.27	1.2 ± 0.42	0.18 ± 0.018	0.019 ± 0.011	0.47 ± 0.25
		Range	0.61–0.95	0.27–0.96	0.43–1.6	0.16–0.22	0.008–0.039	0.22–1.1
Koi	*Cyprinus carpio*	Mean ± SD	0.78 ± 0.28	1.0 ± 0.13	1.3 ± 0.75	0.25 ± 0.049	0.025 ± 0.004	0.81 ± 0.17
		Range	0.46–1.2	0.84–1.2	0.42–2.1	0.18–0.29	0.020–0.031	0.48–1.1
Shing	*Heteropneustes fossilis*	Mean ± SD	0.97 ± 0.26	1.0 ± 0.20	0.91 ± 0.59	0.27 ± 0.059	0.016 ± 0.012	0.92 ± 0.32
		Range	0.62–1.4	0.78–1.4	0.12–1.9	0.20–0.39	0.009–0.040	0.57–1.6
Kholisha	*Colisa fasciata*	Mean ± SD	0.70 ± 0.33	0.59 ± 0.36	1.1 ± 0.51	0.18 ± 0.022	0.019 ± 0.011	0.52 ± 0.30
		Range	0.30–1.5	0.15–1.0	0.29–1.8	0.13–0.20	0.007–0.036	0.25–1.0
Shoil	*Channa striata*	Mean ± SD	0.69 ± 0.17	0.91 ± 0.30	0.97 ± 0.72	0.25 ± 0.060	0.020 ± 0.010	0.78 ± 0.27
		Range	0.45–0.99	0.37–1.2	0.17–2.2	0.13–0.31	0.009–0.032	0.38–1.0
Foli	*Notopterus notopterus*	Mean ± SD	1.1 ± 0.31	1.1 ± 0.21	1.2 ± 0.53	0.25 ± 0.057	0.022 ± 0.017	0.82 ± 0.36
		Range	0.53–1.3	0.53–1.4	0.42–2.2	0.16–0.32	0.009–0.051	0.41–1.4
Hilsha	*Tenualosa ilisha*	Mean ± SD	0.48 ± 0.22	0.54 ± 0.44	1.1 ± 0.57	0.51 ± 0.18	0.17 ± 0.19	0.51 ± 0.47
		Range	0.21–0.84	0.048–1.1	0.066–2.0	0.28–0.83	0.001–0.60	0.035–1.2
Kachki	*Corica soborna*	Mean ± SD	0.44 ± 0.34	0.45 ± 0.42	1.5 ± 0.54	0.37 ± 0.26	0.20 ± 0.20	0.58 ± 0.42
		Range	0.037–1.0	0.039–1.0	0.86–2.5	0.036–0.84	0.005–0.50	0.036–1.3
Detection limit for ICP-MS Analysis (ng/kg)			0.7	0.6	0.8	0.4	0.06	0.09
Maximum Allowable Concentration (MAC)			1.0	0.8	4.5	1.0	0.1	0.5

The mean concentration of Cu was observed 1.2 (mg/kg) with the mean ranged from 0.91 to 1.5 (mg/kg) (Table 3). Arsenic is widespread in the environment due to both anthropogenic and natural sources. The highest concentration of As was observed in *T. ilisha* (0.51 mg/kg) followed by the species *C. soborna* (0.37 mg/kg). In fish samples, the mean concentrations of Cd ranged from 0.016 mg/kg (*H. fossilis*) to 0.20 mg/kg (*C. soborna*) (Table 3). The average concentrations of Cd in the fish species (*T. ilisha* and *C. soborna*) were higher than MAC (0.10 mg/kg) (Table 3) indicated that these two species might pose health hazards due to the consumption from the studied river. In the investigated fish species the mean concentration of Pb ranged from 0.47 mg/kg (*C. punctata*) to 0.92 mg/kg (*H. fossilis*). Lead concentrations in most fish species were higher than the safe limit of 0.5 mg/kg set by WHO [34], indicating these species were contaminated by Pb and might pose risks to human.

Principal component analysis (PCA) was employed to assume the hypothetical sources of trace elements following standard procedure [35,36], which enables clustering of variables into different groups, such variables belongs to one group are highly correlated with each other [37]. Principal component analysis was performed on the dimensionless standardized form of data set and presented in Figure 2. Varimax rotation was used to maximize the sum of the variance of the factor coefficients. Multivariate principal component analysis (PCA) of trace elements in the samples explaining about 91% (sediment) and 73% (fish) cumulative variance of the data (Figure 2). In PCA analysis, first three principal components were computed and the variance explained by them was 67.7%, 14.9% and 8.5% for sediment and 31.6%, 24.2% and 16.9% for fish, respectively (Figure 2). Overall, PCA revealed three major groups of the elements for both sediment and fish. One group comprised of Cr for sediment and Cu and As for fish, which were predominantly contributed by lithogenic sources [38]. Second group showed Cd for both sediment and fish which was contributed by the industrial emissions in the sampling sites. Third group revealed the loadings of Ni, Cu, As and Pb for sediment and Cr, Pb and Ni for fish indicated that these were mostly contributed by the anthropogenic activities.

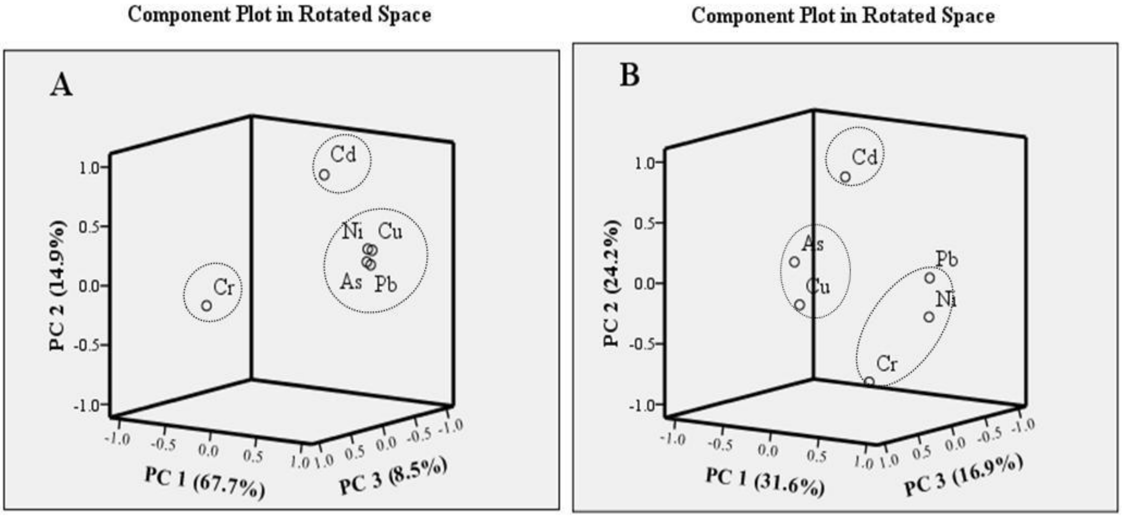

Figure 2. Principal component analysis (PCA) of trace elements in sediment (A) and fish (B) of Paira River, Bangladesh. PCA analysis showed three groups of the studied metals in sediment and fish.

Table 4. Biota-sediment accumulation factors (BSAFs) of trace elements in fish species collected from Paira River, Bangladesh.

Local name	Scientific name		Cr	Ni	Cu	As	Cd	Pb
Taki	*Channa punctata*	Mean ± SD	0.068 ± 0.030	0.059 ± 0.024	0.188 ± 0.126	0.083 ± 0.049	0.102 ± 0.086	0.076 ± 0.031
Koi	*Cyprinus carpio*	Mean ± SD	0.067 ± 0.045	0.121 ± 0.051	0.217 ± 0.168	0.118 ± 0.086	0.155 ± 0.070	0.152 ± 0.092
Shing	*Heteropneustes fossilis*	Mean ± SD	0.085 ± 0.044	0.130 ± 0.052	0.162 ± 0.106	0.131 ± 0.085	0.122 ± 0.127	0.165 ± 0.079
Kholisha	*Colisa fasciata*	Mean ± SD	0.050 ± 0.017	0.078 ± 0.060	0.165 ± 0.061	0.084 ± 0.057	0.127 ± 0.098	0.106 ± 0.077
Shoil	*Channa striata*	Mean ± SD	0.060 ± 0.033	0.110 ± 0.048	0.147 ± 0.092	0.119 ± 0.085	0.130 ± 0.106	0.137 ± 0.078
Foli	*Notopterus notopterus*	Mean ± SD	0.096 ± 0.056	0.131 ± 0.049	0.168 ± 0.095	0.121 ± 0.092	0.158 ± 0.167	0.151 ± 0.104
Hilsha	*Tenualosa ilisha*	Mean ± SD	0.043 ± 0.028	0.076 ± 0.058	0.181 ± 0.164	0.265 ± 0.232	1.01 ± 0.851	0.101 ± 0.100
Kachki	*Corica soborna*	Mean ± SD	0.044 ± 0.045	0.061 ± 0.054	0.206 ± 0.126	0.150 ± 0.152	1.46 ± 1.51	0.115 ± 0.068

Table 5. Correlation of trace elements between sediments and fish species of Paira River, Bangladesh.

Trace elements	Sediment *C. punctata*	Sediment *C. carpio*	Sediment *H. fossilis*	Sediment *C. fasciata*	Sediment *C. striata*	Sediment *N. notopterus*	Sediment *T. ilisha*	Sediment *C. soborna*
Cr	−0.153	−0.378	−0.340	0.539	−0.080	−0.422	−0.284	−0.282
Ni	0.292	−0.751*	−0.079	−0.358	0.111	0.399	0.018	−0.050
Cu	0.136	0.273	−0.053	0.797*	0.538	0.446	0.228	0.029
As	−0.170	−0.539	−0.278	−0.459	−0.388	−0.644	−0.280	0.398
Cd	−0.032	0.294	−0.532	−0.075	−0.664	−0.525	0.669	0.130
Pb	0.583	0.141	0.319	−0.004	0.608	0.458	0.620	0.538

*Correlation is significant at 0.05 level (2-tailed).

3.3. Bioaccumulation of trace elements in fish species

Trace elements from sediments can be accumulated in fish tissues [30]. Bioaccumulation of trace elements in fish species is not only dependent on the element exposure and its environment, but also different physiological and biochemical activities through which a specific organism deals with trace elements [39]. Hence, different organisms accumulate trace elements from the environment depending on their filtration rate, ingestion rate, gut fluid quality, as well as the detoxification strategies they adopt (e.g., storage in non-toxic form or elimination) [40]. Table 4 clearly showed large variations in BSAF among different fish species and trace elements. Among the studied elements, the ranking order of mean BSAF values were Cd > Cu > As > Pb > Ni > Cr. Among the selected six trace elements Cd showed the highest value of BSAF suggesting higher rate of accumulation in fish species. At some sites, levels of trace elements might be high although accumulation is lower than expected due to the complexation of trace elements [4].

The BSAF for the studied elements in *C. soborna* and *T. ilisha* were slightly higher than the values obtained for other fish species (Table 4). This can be explained by the sediment ingesting as well as bottom feeding behavior of *C. soborna* and *T. ilisha* which may lead to the much greater BSAF in this study [41]. Therefore, the fish species investigated in this study, *C. soborna* and *T. ilisha* can be used as a potential bio-indicator for the contamination of trace elements in the riverine environment. The present study revealed that slightly higher accumulations of trace elements were observed in two species (*C. soborna* and *T. ilisha*). From the literature survey, it was noticed that these species are bottom feeder and therefore, sediments could be the major sources of trace elements in these fish species [7,41,42]. The BSAF of individual element among the fish species and sampling sites were not in similar pattern due to the environment specific phenomenon. It was considered that ingested sediments which found in the digestive tract of fish as an acid ambient, which accelerated the higher amount of trace elements concentration than it was expected. Significant correlation was observed between sediment and *C. carpio* for Ni, whereas sediment and *C. fasciata* showed significant correlation for Cu (Table 5).

4. Conclusions

The purpose of this study was to assess levels of six trace elements (Cr, Cu, As, Cd, Pb and Ni) in both surface sediment and fish samples from the Paira River situated at the southern part of Bangladesh. The results indicated that concentrations of trace elements were low in fish samples, and the highest concentrations were recorded at sites P7 and P8 due to wastewater discharges from Patuakhali district urban area. Some fish species from the study river were also contaminated by the relevant trace elements especially Ni, Cd and Pb, which could be a potential health concern to the local residents. Principal component analysis (PCA) revealed that trace elements were mostly contributed by the anthropogenic activities. Biota sediment accumulation factor (BSAF) of trace elements in *C. soborna* and *T. ilisha* were slightly higher than other species, which might be due to their mode of feeding behavior and these two species could be used as potential bio-indicator for trace elements pollution. Furthermore, in addition to metal studies, other bioaccumulative organic contaminants such as dioxins/furans, chlorinated pesticides, and polychlorinated biphenyls (PCBs) being of health concern should be evaluated in fish species from this urban river.

Conflict of interest

The authors declare there is no conflict of interest.

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