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Metal pollution in water and sediment of the Buriganga River, Bangladesh: an ecological risk perspective

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ABSTRACT

Both industrial and domestic wastewater are drained into the Buriganga River, Dhaka, Bangladesh. In order to screen metal pollutant levels and to assess ecological risks, this study was conducted on water and sediment samples from the Buriganga River. A total of 13 metals in water and sediment samples were determined by atomic absorption spectroscopy. For sediment samples, the geo-accumulation index (I_{geo}), contamination factor (CF), potential ecological risk index, and pollution load index (PLI) were calculated. The I_{geo} increased in order of Ag > Pb > Cu > Zn > Hg > Cd > Cr > Co > Ni > As > Se > Sb > Be > Tl in both summer and winter seasons. The CFs identified major contaminating (moderate to very high) metals to be Ag, Pb, Cu, Zn, Hg, and Cd. Hg and Cd posed the highest ecological risk in the study area, and 86% of samples showed moderate (95–190) to considerable (190–380) ecological risk index. PLI attributed ~71% of the sampling site are polluted (PLI > 1) in both seasons. For water samples, degree of contamination (C_d), heavy metal evaluation index (HEI), heavy metal pollution index (HPI), and Nemerow index (NI) were calculated. C_d showed ~86% of the water samples have low to high degree of contamination, while HEI reflects 28% of the samples were highly polluted and HPI indicated 86% of samples were low to highly polluted. In addition, NI revealed that the river water is severely polluted by metals.

Keywords: Priority metals; Mercury; Ecological risk; Geo-accumulation index; Pollution

1. Introduction

The US Environmental Protection Agency (USEPA) has defined 129 toxic chemicals as priority pollutants. Among them, 13 are metals, 26 are pesticides, 11 are acid extractable organic compounds, and 46 are extractable organic compounds. The priority metals are arsenic (As), selenium (Se), cadmium (Cd), chromium (Cr(III and VI)), copper (Cu), lead (Pb), antimony (Sb), silver (Ag), thallium (Tl), zinc (Zn), beryllium (Be), and mercury (Hg). The priority pollutants are a subset of "toxic pollutants," as defined in the Clean Water Act (USA) [1]. Due to the ubiquity of these

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pollutants in wastewater, they are given high priority in the development of water quality criteria and effluent limitation guidelines. Trace amounts of metals are common in water, and are normally unharmful to health. In fact, low levels of metals are essential to sustain life. Calcium, magnesium, potassium, and sodium must be present to maintain normal body functions. Low levels of cobalt, copper, iron, manganese, molybdenum, selenium, and zinc are needed as catalysts for enzymatic activities. However, high levels of essential metals, or toxic metals, such as aluminum (Al), As, Be, Cd, Cr, Pb, Hg, Se, and Ag, could be hazardous to human health and ecological health.

Metals, especially "toxic trace metals," are among the most common environmental pollutants, and their occurrence in water and in biota results from both natural and anthropogenic sources [2]. Their accumulation and distribution in the environment are increasing at an alarming rate which leads to deposition and accumulation into sediments in water systems, further affecting aquatic organisms [3–5]. Rapid industrial developments in countries such as China, India, and Bangladesh have led to serious problems with toxic heavy metal pollution. Inadequate treatment of industrial wastewater, as well as direct discharge of untreated wastewater are identified to be the major causes of river water pollution in developing countries.

In Bangladesh, the capital city of Dhaka is a densely populated urban area which is surrounded by the Buriganga, Turag, Balu, and Sitallakhya rivers. These major river systems have been experiencing huge pollution loads due to anthropogenic activities, with an abundance of studies reporting the pollution load in river water and bed sediments. Heavy metal loads in water and sediments of the Buriganga River was reported, and it was identified that the major sources of loads were from tannery, paint, municipal sewage, textiles, and agricultural activities [6]. Big polluters of the Buriganga River are identified to be long-standing tanneries at Hazaribagh, Dhaka-Demra-Narayngaj industrial zone, Kamrangir Char industries, as well as other riverside textile mills and dyeing industries which dump their wastes into the river. The Dhaka Water Supply and Sewerage Authority has not yet established any sewage treatment plant and in effect, sewage water is directly discharged into the Buriganga River without any treatment.

Most of the previous works involving the Buriganga River water and its surroundings studied the level of heavy metals in water, sediments, and fishes were limited to focus only on the comparison of some specific metals [7]. A study on the potential sources and risk assessments of nine metals (Pb, Cr, Mn, Co, Ni, Cu, Zn, As, and Cd) in the Buriganga River water and sediments was reported [2]. However, the complete spectrum of the 13 priority metals and their associated ecological risks is still to be studied in the Buriganga River. Furthermore, the recent relocation of the tannery industry (a major polluting industrial sector) from the Hazaribagh Area, and its impact in reducing the pollution load in the river has yet to be evaluated. Rivers are considered to be a dominant pathway for metal transport [8,9], and heavy metals have become significant pollutants of many river systems. During their transport, the heavy metals undergo numerous changes in their speciation due to dissolution, precipitation, sorption and complexation phenomena [10,11]. This further affects their behavior, bioavailability [12,13] and effects in water pollution level [7]. Hence, heavy metals are good indicators for monitoring changes in the water environment.

Therefore, this study was designed to screen a load of all 13 priority metals in the water and sediments of the Buriganga River during summer and winter seasons. Ecological risks posed by the 13 priority metals were calculated from data obtained from river water and sediments through the use of comprehensive indexes aimed to assess levels of pollution. This study may be the first to demonstrate the status of all priority metals in the Buriganga River.

2. Materials and methods

2.1. Sampling site and sample collection

The Buriganga River flows past the southwest outskirts of Dhaka city, the capital of Bangladesh. Its average depth is 7.6 m and its maximum depth is 18 m. The study focused on the Sadarghat port at the bank of the Buriganga River. With a rich history dating back thousands of years, the port now serves as a point of travel to millions of passengers heading to different destinations within Bangladesh. The unplanned and excessive industrial and commercial activities have affected the overall quality of the port and its environment.

Water and sediment samples were collected from eight sampling sites around the Sadarghat area (Fig. 1) during the period of summer and winter season in 2017. Using non-transparent plastic bottles, samples in each location were collected three times, with 15 d intervals between collections. Prior to sampling, the plastic bottles used for the collection were cleaned with detergent and treated with 10% (v/v) nitric acid solution overnight. Then, bottles were washed with deionized water and air-dried. During sampling, bottles were pre-washed with sampling water, filled with the desired samples, and immediately sealed to avoid air exposure. Collected samples were preserved with 0.5 mL concentrated nitric acid and stored in an ice chest with a temperature of 4°C [14].

Sediment samples were collected using a stainless-steel scoop and stored in airtight polyethylene bags with necessary labeling. Before collecting each sediment sample, the sampling scoop was washed with deionized water and rinsed several times using the sample sediment mixture in order to avoid possible contamination. The river bed sediment samples were collected at a depth of 0–15 cm from the top surface with a mass of about 500 g each. Sediment samples were air-dried at room temperature (25°C). The heterogeneous particle size fraction was homogenized by grinding using an agitate mortar and was stored in carefully marked glass bottles until chemical analyses were carried out.

2.2. Materials used and sample analysis

All reagents used in the analyses were analytical grade and purchased from Merck, Germany. A high precision calibrated electrical balance GR-200 (A&D Company Limited, Tokyo, Japan) was used for weighing all samples. Glassware, including pipettes and volumetric flasks,

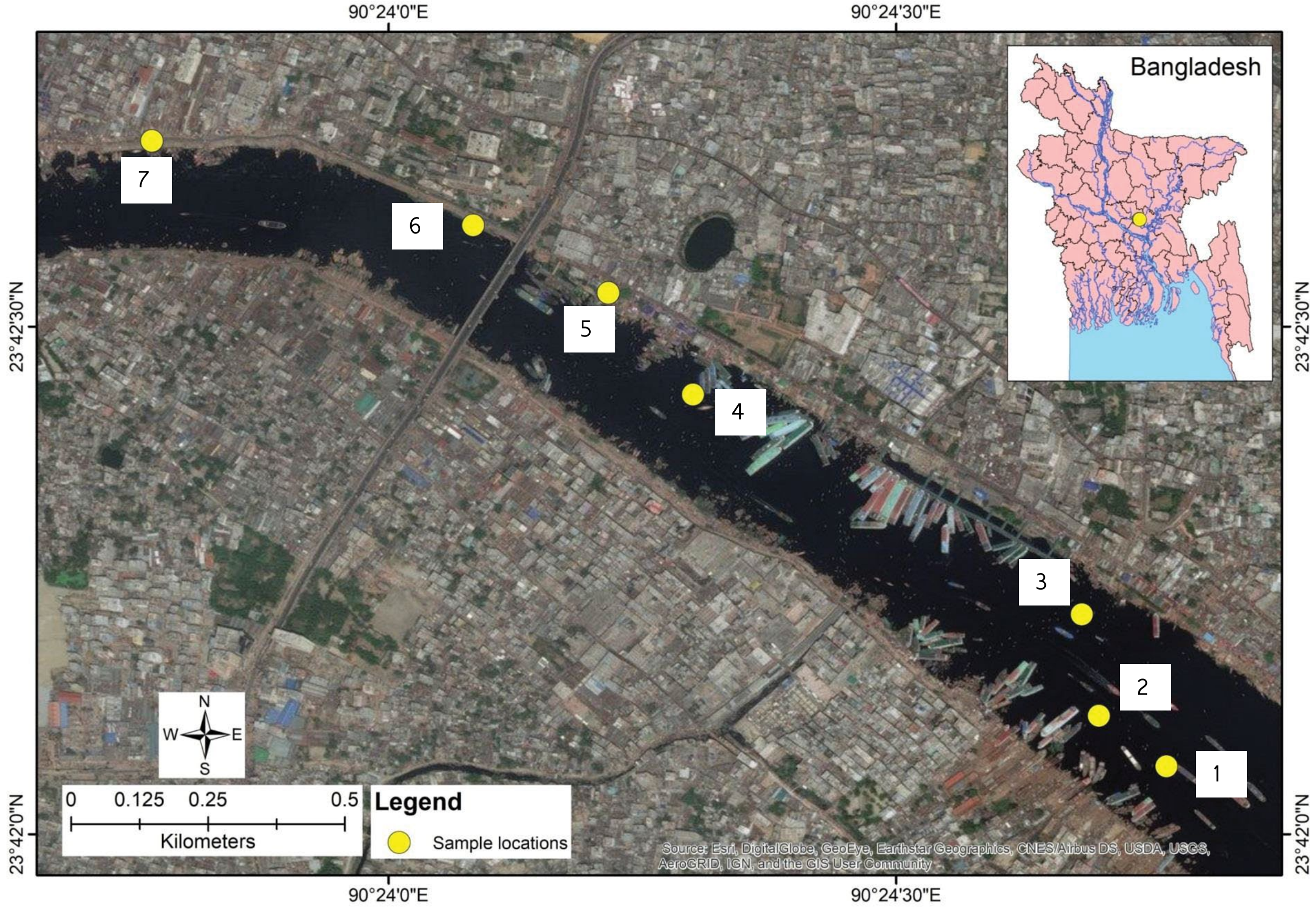

Fig. 1. Map showing the sampling location points in the study area.

were also calibrated and cleaned prior to experimentation. Deionized water was prepared by RF ultrapure water system (Barnstead) and was ensured to have a resistance greater than 18.0 MΩ-cm and conductivity less than 0.2 µS cm^{-1}.

The water and sediment samples were analyzed at Institute of National Analytical Research and Service (INARS), Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka, Bangladesh, which is an ISO/IEC 17025:2005 accredited laboratory. Prior to analysis, all preserved samples were brought at room temperature (25°C). Then, all samples were digested by applying the following procedures.

2.3. Sediment samples digestion procedure

About 10 g of sediment samples were weighed in clean and dry beakers. Afterwards, 20 mL concentrated nitric acid and 10 mL concentrated perchloric acid were added to each sample. Digestion was carried out through boiling over a hotplate with a temperature of 180°C–200°C until samples were almost dry. The process was repeated until a colorless solution is obtained, to ensure complete decomposition of samples and evaporation of volatile organic matter. After cooling to room temperature, the colorless sample solutions were transferred in 50 mL volumetric flasks and were filled to the mark with deionized water. The sample solutions were mixed uniformly and filtered into 100 mL non-transparent plastic bottles and preserved for further analysis. Blank samples were also prepared following the same procedure stated above.

2.4. Water sample digestion process

Using a pipette, 100 mL of the collected water sample was transferred to a 250 mL beaker. About 4–5 mL of concentrated nitric acid was added and the beaker was placed on a hot plate for digestion until a clear solution is obtained. Afterwards, the sample was transferred into a 100 mL volumetric flask and filled to the mark with deionized water. The resulting solution was filtered using a Whatman filter paper with 11 µm pore diameter, and preserved in a clean 250 mL non-transparent plastic bottle with label. Samples were preserved for further analysis. Blank solutions were also prepared through the aforementioned procedure.

2.5. Chemical analysis

The digested samples were analyzed for Pb, Cd, Cr, Se, Sb, Tl, Cu, Ni, Ag, and Be using graphite furnace atomic absorption spectrophotometer (Model: AA240Z, Varian, Australia). Zn was analyzed through flame atomic absorption spectrophotometer (Model: AA240FS, Varian, Australia). Hg levels were assessed through cold vapor hydride generation technique in atomic absorption spectroscopy (AAS; Model: AA240FS, Varian, Australia) and As was analyzed using electric hydride vapor generation technique in AAS (Model: SpcetraAA 220 equipped with electrothermal temperature controller (ETC-60), Varian, Australia). The analytical procedures were calibrated with the standard reference materials (Scharlau, 1,000 ± 4 ppm, traceable to National Institute of Standards and Technology). Preparation of calibration standards, samples, and their analyses were performed following the standard procedure [14,15]. The working standard solutions were freshly prepared before each analysis, and instruments were calibrated using these working standards. Samples were analyzed according to the standard laboratory format to maintain quality control. A duplicate sample was analyzed after five samples, while spike and reagent blank samples were analyzed after 10 samples. Spike recoveries for all metals were 90%–110% as calculated by the following equation (Eq. (1)). The number of replicate samples was three and each of the analyses was performed in triplicate to ensure statistical validity.

$$\text{Recovery}\left(\%\right)=\frac{\text{Concentration of spiked sample}-\text{Concentration of unspiked sample}}{\text{Amount of spike}}\times 100 \quad (1)$$

2.6. Heavy metal pollution index

Heavy metal pollution index (HPI) is an effective tool to assess heavy metals in water. It is used to determine a rating or weightage (Wi) for each metal constituent. The HPI for river water samples was calculated by using the following equation [16]:

$$\text{HPI}=\frac{\sum_{i=1}^{n}Q_iW_i}{\sum_{i=1}^{n}W_i} \quad (2)$$

where Q_i represents the ith parameter, W_i is the sub-index of the ith parameter, and n is the number of parameters considered. The sub-index (Q_i) of the parameter was determined by the following equation.

$$Q_i=\sum_{i=1}^{n}\frac{\left\{M_i\left(-\right)I_i\right\}}{\left(S_i-I_i\right)}\times 100 \quad (3)$$

where M_i stands for the monitored value of heavy metal of the ith parameter, I_i is the ideal value of the ith parameter, and S_i is the standard value of the ith parameter. The negative sign (−) designates the numerical difference of the two values, ignoring the algebraic sign.

2.7. Heavy metal evaluation index

The heavy metal evaluation index (HEI) method is also similar to the HPI. It provides overall quality of the water parameter with regards to heavy metals [17]. The HEI was calculated by the following equation:

$$\text{HEI}=\sum_{i=1}^{n}\frac{H_c}{H_{\text{mac}}} \quad (4)$$

where H_c indicates the monitored value of the ith parameter and H_{mac} indicates the maximum permissible concentration (MAC) of the ith parameter.

2.8. Degree of contamination

The combined effect of several parameters considered to be detrimental to household water is determined by the degree of contamination (C_d). It was adopted from previous studies [18,19]. The C_d was estimated as follows:

$$C_d=\sum_{i=1}^{n}\text{cf}_i \quad (5)$$

where $C_n=\left(\frac{\text{CA}_i}{\text{CN}_i}\right)-1$

cf_i stands for the contamination factor for the ith component, CA_i stands for the analytical value for the ith component, and CN_i stands for the upper permissible concentration of the ith component (N denotes the "normative value"). Here, CN_i was taken as MAC.

2.9. Geo-accumulation index and pollution load index

Geo-accumulation index (I_{geo}) is used for determining pollution in freshwater sediments. According to Müller [20], I_{geo} for metals is determined using the expression.

$$I_{\text{geo}}=\frac{\log_2\left(C_n\right)}{1.5\left(B_n\right)} \quad (6)$$

where C_n is the concentration of metals examined in soil samples and B_n is the geochemical background concentration of the metal (n). Factor 1.5 is the background matrix correction factor due to lithospheric effects.

The pollution load index (PLI) represents the number of times the heavy metal concentration in the sediment exceeds the background concentration [18,21]. It provides a simple and summative indication for assessing the level of heavy metal pollution in a particular sample. For the entire sampling site, PLI (Eq. 7) has been determined as the nth root of the product of the n-contamination factor (CF) [22].

$$\text{PLI}=\sqrt[n]{\text{CF}_1\times\text{CF}_2\times\text{CF}_3\times\ldots\times\text{CF}_n} \quad (7)$$

where CF is expressed as Eq. (8).

$$\text{CF}=\frac{C_{\text{metal}}}{C_{\text{baseline}}} \quad (8)$$

2.10. Nemerow pollution index

Nemerow pollution index (NI) is used to assess how several heavy metals pollutes water at a particular sampling site. This index considers the mean and maximum values of a single-factor pollution index, and also highlights the pollutants with high pollution degrees [23]. It is expressed as the following equation (Eq. 9).

$$\text{NI} = \sqrt{\frac{\left[\left(1/n\right)\sum\left(C_i/S_i\right)\right]^2 + \left[\max\left(C_i/S_i\right)\right]^2}{2}} \tag{9}$$

where n is the number of indices; C_i is the measured content of heavy metal n; S_i is the standard value. The heavy metal pollution in groundwater is divided by NI into 6° [24]. The pollution degree and pollution level of heavy metals in water were assessed with NI.

2.11. Ecological risk index and potential ecological risk

The ecological risk (Ei) and the potential ecological risk (PERI) were introduced by Singh et al. [25]. The Ei represents the ecological toxicity risk of a given pollutant and the PERI represents the integrated risk of toxicity of all considered pollutants. PERI comprehensively considers the synergy, toxic level, and concentration of the heavy metals, while Ei considers the ecological sensitivity of heavy metals [26,27]. Ei and PERI were evaluated for eight (n = 8) of the most reported heavy metals of great environmental concern (As, Cd, Cr, Cu, Mn, Ni, Pb, and Zn). The calculation of these two indices was limited to eight elements due to lack of data with respect to the toxic response factor (Tr) of the other elements. The Tr for As, Cd, Cr, Cu, Mn, Ni, Pb, and Zn are 10, 30, 2, 5, 1, 5, 5, and 1 [28], respectively. Ei and PERI were calculated using the following Eq. (10) and (11), respectively:

$$\text{Ei}_x = \text{Tr}_x \times \text{Cf}_x \tag{10}$$

$$\text{PERI} = \sum_{i=1}^{n} \text{Ei}_x \tag{11}$$

Based on the intensity, Ei and PERI can be classified into five and four different groups, respectively [29].

2.12. Statistical analysis

Pearson's correlation (r) matrices were computed to determine association among parameters. Descriptive statistics of the parameters were also computed to show their average behaviors and dispersions. All statistical analyses were performed using IBM SPSS Statistics, version 20 (IBM Corporation, Armonk, NY). Results of soil and sediment chemical analyses were assessed by principal component analysis (PCA) using Statview SE + Graphics TM software (Abacus Concepts, Inc., U.S.A.). PCA is a multivariate method used mainly for data reduction. It is aimed at finding components that explain the major variation within the data set. Each component is a weighted, linear combination of the original variables. Usually, only components with eigenvalues >1 are of interest. In order to make the components more interpretable, while still being orthogonal, a varimax rotation was used [28]. These methods have also been widely used in geochemical applications to associate pollution to potential sources [29,30]. However, the suitability of the data set for PCA was first assessed through conducting the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of Sphericity. Data normalization was done prior to calculate different indices where applicable. The cluster analysis (CA) was performed to identify the similarity of studied priority metals according to their potential source.

3. Results and Discussion

3.1. Descriptive statistics

The sampling was conducted in two seasons, summer and winter. The metal concentration data of the sediment samples (summer and winter) are summarized in Table 1. The results of metal concentrations in water samples from both seasons are presented in Table 2. The range, mean, and standard deviation of trace metals (μg/kg), respectively, were found as follows: 850–3,140; 2,150; 864.75 for As, 11,500–326,000; 110,642.86; 108,437.1 for Pb, 70–735, 280.57, and 244.66 for Cd, 10,600–38,700; 22,471.43; 9,621.45 for Cr, 35–1,271; 624.57; 406.98 for Hg, 1,300–51,000; 21,042.86; 17,639.34 for Ni, 2,100–407,700; 168,957.14; 146,579.97 for Cu, 62,700–399,300; 222,300.00; 123,451.54 for Zn, 10–30, 15.71, and 7.87 for Se, 400–1,400; 1,057.14; 395.21 for Ag, 6–15, 10 and 3.21 for Sb, 4–24, 13 and 6.90 for Tl, 5–16, 10.14, and 3.89 for Be, and 270–610, 394.29, and 109.07 for Co. Cd, Cr, Hg, Ni, Zn, and Ag in sediments were highest in S5 sample (Rocketghat). Cu, Se, Sb, and Tl concentration were highest in S2 sample (Sluicegate ghat). Whereas, the highest values of As, Be, and Co were found in S4 sample (Steamer ghat). Pb was predominant at S7 sample (Mitford ghat).

The data of sediment samples (winter) are also presented in Table 1. The range, mean, and standard deviation, respectively, of each trace metals (μg/kg) were found as follows: 1,180–2,720; 2,028.57; 663.84 for As, 12,530–322,060; 107,755.71; 106,209.85 for Pb, 72–712, 269.14, and 232.80 for Cd, 11,200–35,400; 21,217.14; 8,799.67 for Cr, 103–1,150; 606.43; 370.65 for Hg, 1,530–48,600, 19,712.86; 16,491.32 for Ni, 2,500–387,560; 159,065.71; 138,160.58 for Cu, 60,700–392,400; 208,772.86; 119,509.73 for Zn, 10–30, 15.71, and 7.87 for Se, 425–1,310; 1,002.14; 343.53 for Ag, 5–15, 9.57, and 3.21 for Sb, 8–17, 12.14, and 3.02 for Ti, 6–13, 9.86, and 2.61 for Be and 286–572, 378.71, and 97.48 for Co. Cd, Cr, Hg, Ni, and Zn in sediments were highest in Rocketghat sampling point (S5 sample). Se, Sb, and Tl values were highest in Sluicegate ghat (S2 sample). Be, Co, and Ag concentrations were highest in Steamerghat and Babubazzar ghat (S4 and S6 sample, respectively). As, Pb, and Cu concentrations were predominant in Sluicegate ghat, Mitford ghat, and Sadarghat, respectively. Pb, Cr, Cu, Zn, As, and Ag were the dominant trace metals in the study area. Similar trace metal (Cr, As, and Pb) distribution scenario was also reported by Islam et al. [31] in the sediments from the upstream and downstream of the study area in the Buriganga River. The pattern of metal

Table 1
Concentration (µg/kg) of priority heavy metals in sediments at different sampling points

	Summer				Winter			
Parameters	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
As	2,150	865	850	3,140	2,026	664	1,180	2,720
Pb	110,643	108,437	11,500	326,000	107,756	106,209	12,530	322,060
Cd	281	245	70	735	269	233	72	712
Cr	22,471	96,217	10,600	38,700	21,217	8,799	11,200	35,400
Hg	625	407	35	1,271	606	371	103	1,150
Ni	21,043	17,639	1,300	51,000	19,713	16,491	1,530	48,600
Cu	168,957	146,580	2,100	407,700	159,066	138,161	2,500	387,560
Zn	222,300	123,452	62,700	399,300	208,773	119,510	60,700	392,400
Se	16.0	7.87	10	30	15.71	7.87	10	30
Ag	1,057	395	400	1,400	1,002	344	425	1,310
Sb	10.0	3.22	6	15	9.57	3.21	5	15
Tl	13.0	6.90	4	24	12.14	3.024	8	17
Be	10.2	3.89	5	16	9.86	2.61	6	13

concentrations in both summer and winter season is very similar, indicating that seasons do not have a significant effect in the priority metal concentration in the study area. The results of the normality test showed that there is no significant relationship in the metal concentration between the two seasons. We carried out the normality test by using the one-sample Kolmogorov–Smirnov (K–S) test, in order to check the seasonality of the data sets [32] (data not shown). However, significant seasonality among the metal concentrations in the water from the study area was observed from data obtained 10 y prior to this study [33]. This difference might be due to the reduction of river flow in the recent years; as well as the recent relocation of the tannery industry, which is a major contributor of metals in the water, from the study area.

Tables 3 and 4 show the statistical analysis of metal-to-metal correlation matrix in terms of linear correlation coefficient (r) values (significant at 0.05) in sediment and water, respectively. The listed r values reveal the high degree of positive correlations and significant linear regression relation between various pairs of metals, reflecting their identical source and simultaneous release into the Buriganga River. The inter-metallic correlation coefficients in composite effluents with $p < 0.05$ were: As–Pb ($r = 0.59$), As–Cd ($r = 0.61$), Pb–Ag ($r = 0.54$), Cd–Hg ($r = 0.69$), Cd–Ni ($r = 0.66$), Cd–Cu ($r = 0.50$), Cd–Zn ($r = 0.67$), Cr–Hg ($r = 0.69$), Cr–Zn ($r = 0.81$), Cr–Sb ($r = 65$) < Hg–Cu ($r = 0.64$), Hg–Zn ($r = 0.83$), Zn–Sb ($r = 0.51$), Zn–Tl ($r = 0.64$), Be–Tl ($r = 0.57$), As–Sb ($r = 0.60$), se–Cr ($r = 0.51$), Ag–Tl ($r = 0.65$), Ag–Be ($r = 0.73$), and Be–Sb ($r = 0.63$). Most of the metals showed positive correlation except for very few metals with no significant correlation. In addition, KMO test and Bartlett's test of Sphericity were used to check if PCA results were acceptable. The KMO value was more than 0.5 for the water and sediment parameters, while Bartlett's test of Sphericity was assumed to be significant ($p < 0.05$). These indicated that parameters used in the present study are appropriate for PCA. PCA results identify the number of PCs retained to recognize the physicochemical variables (Table 5). Based on the results, four PCs explained 92% of the total variance in the rotated R-mode data matrix. Table 5 shows the variance magnitude and percentage of eigenvalues attributed to each factor before and after varimax rotation, which were obtained by PCA of priority metal concentrations in sediment samples. PCA was employed to evaluate the extent of metal contamination and infer the hypothetical location of sources of heavy metals [34–36]. The PCA leads to a reduction of the initial dimension of the dataset to three components which can explain the data for summer and winter samples. Therefore, these three factors play a significant role in explaining metal contamination in the study area. The first factor (PC1), which has the loadings for all parameters except factor 1 (winter and summer) could be better explained as anthropogenic source, because most of the metals of this component are highly accumulated in the sediments. Probable sources are industrial discharges, municipal waste, household garbage, and urban runoff.

Cluster analysis (CA) was applied to identify different geochemical groups which enable clustering of the samples with similar metal contents both in sediment samples (Fig. 2) and water samples (Fig. 3). Sampling point S1 (Sadarghat gate) and S4 (Steamer ghat), S3 (Mosque ghat) and S7 (Mitford ghat), and S5 (Rocket ghat) and S6 (Babubazar ghat), were clustered for both seasons and could be linked to their point source of pollution. In the sediment samples from both seasons, CA results reveal Ni, Zn, Hg, Cd, and Cr forms a cluster depicting the possibility of similar source of occurrences (Fig. 2). However, two clusters is observed in the case of water samples, but the cluster metals are similar for both summer and winter seasons. Pb, Cr, Cd, and Zn formed one cluster, while grouping is observed among Ag, Sb, Tl, and Be in the other cluster. These clusters might be linked to the industries located in the vicinity of the study, which includes leather, toys, paint, and textile industries [2,31]. The presence of Hg (>600 mg/kg) in the sediments point out a new concern in the study area which might be from the hospital discharge in the study area. In

Table 2
Concentration (μg/L) of priority heavy metals in water at different sampling points

Season	As	Pb	Cd	Cr	Hg	Cu	Zn	Se	Ag	Sb	Tl	Be	Ni
Summer	ND	114 ± 35.3	5 ± 0.84	57 ± 11.9	36 ± 2.23	460 ± 33.1	670 ± 77.7	ND	ND	ND	3 ± 54	ND	70 ± 16.4
	ND	ND	ND	34 ± 7.07	5 ± 0.31	530 ± 38.2	96 ± 11.1	ND	ND	ND	ND	ND	60 ± 14.0
	ND	11 ± 3.41	ND	36 ± 7.49	368 ± 22.8	410 ± 29.5	410 ± 47.6	ND	10 ± 2.1	5 ± .51	7 ± 1.3	4 ± 1.	60 ± 14.0
	ND	ND	ND	34 ± 7.07	421 ± 26.1	240 ± 17.3	358 ± 41.5	ND	ND	ND	ND	ND	50 ± 11.7
	ND	16 ± 4.96	ND	35 ± 7.28	23 ± 1.43	160 ± 11.5	420 ± 48.7	ND	ND	ND	ND	ND	80 ± 18.7
	ND	ND	ND	34 ± 7.07	13 ± 0.81	565 ± 40.7	50 ± 5.80	ND	ND	ND	ND	ND	60 ± 14.0
	ND	ND	ND	35 ± 7.28	10 ± 0.62	325 ± 23.4	180 ± 20.9	ND	ND	ND	ND	ND	60 ± 14.0
	ND	10 ± 3.1	4 ± 0.67	36 ± 7.49	7 ± 0.43	225 ± 16.2	220 ± 25.5	ND	5 ± 1.05	3 ± 0.31	ND	ND	50 ± 11.7
Winter	ND	85 ± 26.4	5 ± 0.84	45 ± 9.36	25 ± 1.55	428 ± 30.8	635 ± 73.7	ND	ND	ND	ND	ND	62 ± 14.5
	ND	12 ± 3.72	ND	48 ± 9.98	14 ± 0.87	490 ± 35.3	125 ± 14.5	ND	ND	ND	ND	ND	54 ± 12.6
	ND	11 ± 3.41	ND	25 ± 5.2	380 ± 23.6	375 ± 27.0	385 ± 44.7	ND	10 ± 2.1	ND	5 ± 0.9	4	65 ± 15.2
	ND	ND	ND	19 ± 3.95	384 ± 23.8	248 ± 17.9	379 ± 44.0	ND	ND	ND	ND	ND	38 ± 8.89
	ND	11 ± 3.41	3 ± 0.50	42 ± 8.74	12 ± 0.74	180 ± 13.0	395 ± 45.8	ND	ND	ND	ND	ND	65 ± 15.2
	ND	ND	ND	27 ± 5.62	17 ± 1.05	535 ± 38.5	65 ± 7.54	ND	ND	ND	ND	ND	70 ± 16.4
	ND	ND	ND	31 ± 6.45	5 ± 0.31	270 ± 19.4	158 ± 18.3	ND	ND	ND	ND	ND	52 ± 12.2
	ND	10 ± 3.1	2 ± 0.34	26 ± 5.41	12 ± 0.74	240 ± 17.3	210 ± 24.4	ND	5 ± 1.05	2.0	ND	ND	45 ± 10.5

ND = not detectable, for As = <5.0 ppb, Pb = <10.0 ppb and Cd, Cr, Se, Ag, Sb, Ti, Be = <1.0 ppb

Table 3
Pearsons correlation among 13 priority heavy metals in river water samples during summer season

	Pb	Cd	Cr	Hg	Ni	Cu	Zn	Ag	Sb	Tl	Be
Pb	1										
Cd	0.765*	1									
Cr	0.996**	0.790*	1								
Hg	–0.173	–0.302	–0.164	1							
Ni	0.42	0	0.355	–0.373	1						
Cu	0.196	–0.029	0.214	–0.188	–0.048	1					
Zn	0.778*	0.517	0.761*	0.296	0.446	–0.278	1				
Ag	–0.162	0.038	–0.118	0.458	–0.257	–0.053	0.135	1			
Sb	–0.167	0.078	–0.121	0.428	–0.285	–0.08	0.12	0.997**	1		
Tl	0.266	0.073	0.294	0.515	0.085	0.218	0.489	0.801*	0.764*	1	
Be	–0.111	–0.216	–0.083	0.591	–0.051	0.123	0.217	0.893**	0.859**	0.928**	1

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Table 4
Pearsons correlation among 13 priority heavy metals in river water samples during winter season

	Pb	Cd	Cr	Hg	Ni	Cu	Zn	Ag	Sb	Tl	Be
Pb	1										
Cd	0.850**	1									
Cr	0.515	0.534	1								
Hg	–0.201	–0.37	–0.619	1							
Ni	0.227	0.229	0.368	–0.265	1						
Cu	0.252	–0.133	0.262	–0.147	0.482	1					
Zn	0.747*	0.750*	0.197	0.307	0.058	–0.25	1				
Ag	–0.153	–0.197	–0.403	0.521	0.113	–0.062	0.105	1			
Sb	–0.119	0.105	–0.26	–0.223	–0.415	–0.329	–0.18	0.317	1		
Tl	–0.104	–0.256	–0.298	0.65	0.315	0.091	0.195	0.893**	–0.143	1	
Be	–0.104	–0.256	–0.298	0.65	0.315	0.091	0.195	0.893**	–0.143	1.000**	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

addition, sampling sites 3 and 4 exhibited elevated Hg concentrations (>350 mg/L), which indicates the possibility of having a point source in the vicinity of the sampling sites (Table 2). The metal concentration data in river sediments from some rivers (Bangladesh, India, and China) are presented in Table 6, showing high variations in the metal concentration level.

3.2. Geo-accumulation index

In the summer season the I_{geo} values were –4.52 to –2.635 for As, –1.38 to 3.44 for Pb, –2.68 to 0.71 for Cd, –3.67 to –1.80 for Cr, –4.1 to 1.1 for Hg, –6.29 to –1.00 for Ni, –5.01 to 2.60 for Cu, –1.18 to 1.49 for Zn, –6.49 to –4.91 for Se, 1.93 to 3.74 for Ag, –8.55 to –7.23 for Sb, –20.72 to –18.13 for Tl, –9.81 to –8.14 for Be and –3.40 to –2.22 for Co (Fig. 4a). I_{geo} for Cd, Hg, Zn, and Ag had the highest values in S5 (Rocket ghat) sample. The I_{geo} value for Pb and Cu were highest in S7 (Mitford ghat) and S1 (Sadarghat gate) sample, respectively. Ag was the most predominant and Tl was the least predominant species in all the samples. S5 (Rocket ghat) and S6 (Babubazar ghat) samples were found to have the highest Ag contents. The order of I_{geo} value in the summer season samples was found to be Ag > Pb > Cu > Zn > Hg > Cd > Cr > Co > Ni > As > Se > Sb > Be > Tl.

In winter season, the I_{geo} values were –4.05 to –2.84 for As, –1.26 to 3.42 for Pb, –2.64 to 0.66 for Cd, –3.59 to –1.93 for Cr, –2.54 to 0.94 for Hg, –6.06 to –1.07 for Ni, –4.76 to 2.52 for Cu, –1.23 to 1.46 for Zn, –6.49 to –4.91 for Se, 2.02 to 3.64 for Ag, –8.81 to –7.23 for Sb, –19.72 to –18.63 for Tl, –9.55 to –8.44 for Be and –3.32 to –2.32 for Co (Fig. 4b). The value of I_{geo} for Cd, Hg, and Zn was highest in S5 sample. The highest I_{geo} for Pb, Cu, and Ag were found in S7 (Mitford ghat), S1 (Sadarghat gate), and S6 (Babubazar ghat) samples, respectively. I_{geo} of Ag was also the most dominant and Tl was the least dominant in all samples. The order of I_{geo} values in the samples obtained in winter season was Ag > Pb > Cu > Zn > Hg > Cd > Cr > Co > Ni > As > Se > Sb > Be > Tl.

Table 5
PCA for the heavy metals in both of the seasons season

PCA (rotated component matrix)									
Summer					Winter				
	PC1	PC2	PC3	PC4		PC1	PC2	PC3	PC4
Pb	–0.052	0.936	0.302	0.126	Pb	–0.092	0.899	0.225	–0.05
Cd	–0.082	0.933	–0.292	–0.023	Cd	–0.204	0.942	0.078	0.208
Cr	–0.019	0.951	0.236	0.146	Cr	–0.411	0.481	0.569	0.004
Hg	0.648	–0.166	–0.018	–0.392	Hg	0.681	–0.097	–0.485	–0.49
Ni	–0.147	0.193	0.897	0.024	Ni	0.228	0.178	0.837	–0.09
Cu	0.05	0.047	0.017	0.962	Cu	0.013	–0.13	0.775	–0.212
Zn	0.292	0.737	0.451	–0.385	Zn	0.236	0.911	–0.235	–0.235
Ag	0.933	–0.006	–0.24	–0.031	Ag	0.946	–0.056	–0.037	0.306
Sb	0.907	0.01	–0.293	–0.05	Sb	0.019	–0.055	–0.335	0.916
Tl	0.931	0.242	0.21	0.157	Tl	0.978	–0.033	0.12	–0.114
Be	0.981	–0.11	0.115	0.092	Be	0.978	–0.033	0.12	–0.114
Eigenvalues	4.062	3.332	1.442	1.303	Eigenvalues	3.6	2.823	2.114	1.353
% of Variance	36.926	30.294	13.109	11.843	% of Variance	32.725	25.659	19.218	12.303
Cumulative %	36.926	67.22	80.328	92.171	Cumulative %	32.725	58.385	77.603	89.906
	PC1	PC2	PC3	PC4		PC1	PC2	PC3	PC4
SW1	–0.208	2.295	0.637	0.437	WW1	–0.316	2.162	0.487	–0.223
SW2	–0.504	–0.613	–0.087	1.136	WW2	–0.635	–0.591	0.924	–0.191
SW3	2.428	–0.272	0.285	0.228	WW3	2.420	–0.081	0.297	–0.283
SW4	–0.143	–0.393	–0.409	–1.368	WW4	–0.201	–0.300	–1.892	–1.284
SW5	–0.498	–0.405	1.630	–1.144	WW5	–0.419	0.617	–0.012	0.018
SW6	–0.502	–0.658	–0.133	1.365	WW6	–0.354	–1.043	1.231	–0.169
SW7	–0.532	–0.492	–0.010	–0.004	WW7	–0.543	–0.627	–0.205	–0.134
SW8	–0.041	0.539	–1.914	–0.649	WW8	0.048	–0.137	–0.829	2.267

The I_{geo} value is delineated into seven grades from 0 to 6 as follows: $I_{geo} > 5$ (grade 6:extremely contaminated), I_{geo} 4 to 5 (grade 5: strongly to extremely contaminated), I_{geo} 3 to 4 (grade 4: strongly contaminated), I_{geo} 2 to 3 (grade 3: moderately to strongly contaminated), I_{geo} 1 to 2 (grade 2: moderately contaminated), I_{geo} 0 to 1 (grade 1: uncontaminated to moderately contaminated), and $I_{geo} < 0$ (grade 0: uncontaminated). According to Usero et al. [22], the study area exhibited grade 3 which means moderate to strongly contaminated by trace metals. Similar findings (moderate to strong) were reported in 2015 in the same study area [2]. However, results from the previous study were different from that of this study in terms of the order of I_{geo} contribution and most contributing metals being Ag and Pb.

3.3. Contamination factors

The contamination factors (CFs) of metals in sediments obtained during summer season were as follows: As, 0.065–0.242; Pb, 0.575–16.300; Cd, 0.233–2.450; Cr, 0.118–3.178; Hg, 0.088–3.178; Ni, 0.019–0.750; Cu, 0.047–9.060; Zn, 0.660–4.203; Se, 0.017–0.050; Ag, 5.714–20.000; Sb, 0.004–0.010; Tl, 0–0; Be, 0.002–0.005; Co, 0.142–0.321 (Fig. 5). The highest CFs value was found for Ag (20.00) at S6 (Babubazar ghat) sample, and the lowest value was found in Tl (0) at all of the summer sediment samples. The order of CFs value was found to be Ag > Pb > Cu > Zn > Hg > Cd > Ni > Cr > Co > As > Se > Sb > Be > Tl.

On the other hand, CFs of metals in sediments obtained during winter season were as follows: As, 0.091–0.209; Pb, 0.627–16.103; Cd, 0.240–2.373; Cr, 0.124–0.393; Hg, 0.258–2.875; Ni, 0.023–0.751; Cu, 0.056–8.612; Zn, 0.639–4.131; Se, 0.017–0.050; Ag, 6.071–18.714; Sb, 0.003–0.010; Tl, 0–0; Be, 0.002–0.004; Co, 0.151–0.301. The highest CFs value was found in Ag (20.00) at S6 (Babubazar ghat) sample and the lowest value was found in Tl (0) at all of the winter samples. The order of CFs value for winter sediment samples was found to be Ag > Pb > Cu > Zn > Hg > Cd > Ni > Cr > Co > As > Se > Sb > Be > Tl.

According to Hakanson [24] and Bonnail et al. [37], the CFs classification falls into four degrees: no/low contamination (CF < 1), moderate contamination (CF = 1 to <3), considerable (CF = 3 to <6), and very high contamination (CF > 6). CF results showed that 6 metals, namely Ag, Pb, Cu, Zn, Hg, and Cd contributed more to pollution, and that all sampling points exhibited moderate to very high level of contamination in both seasons (Fig. 5). A similar high contamination level was reported in the Buriganga River sediments in a previous study [31]. However, for most contributing metal pollutant

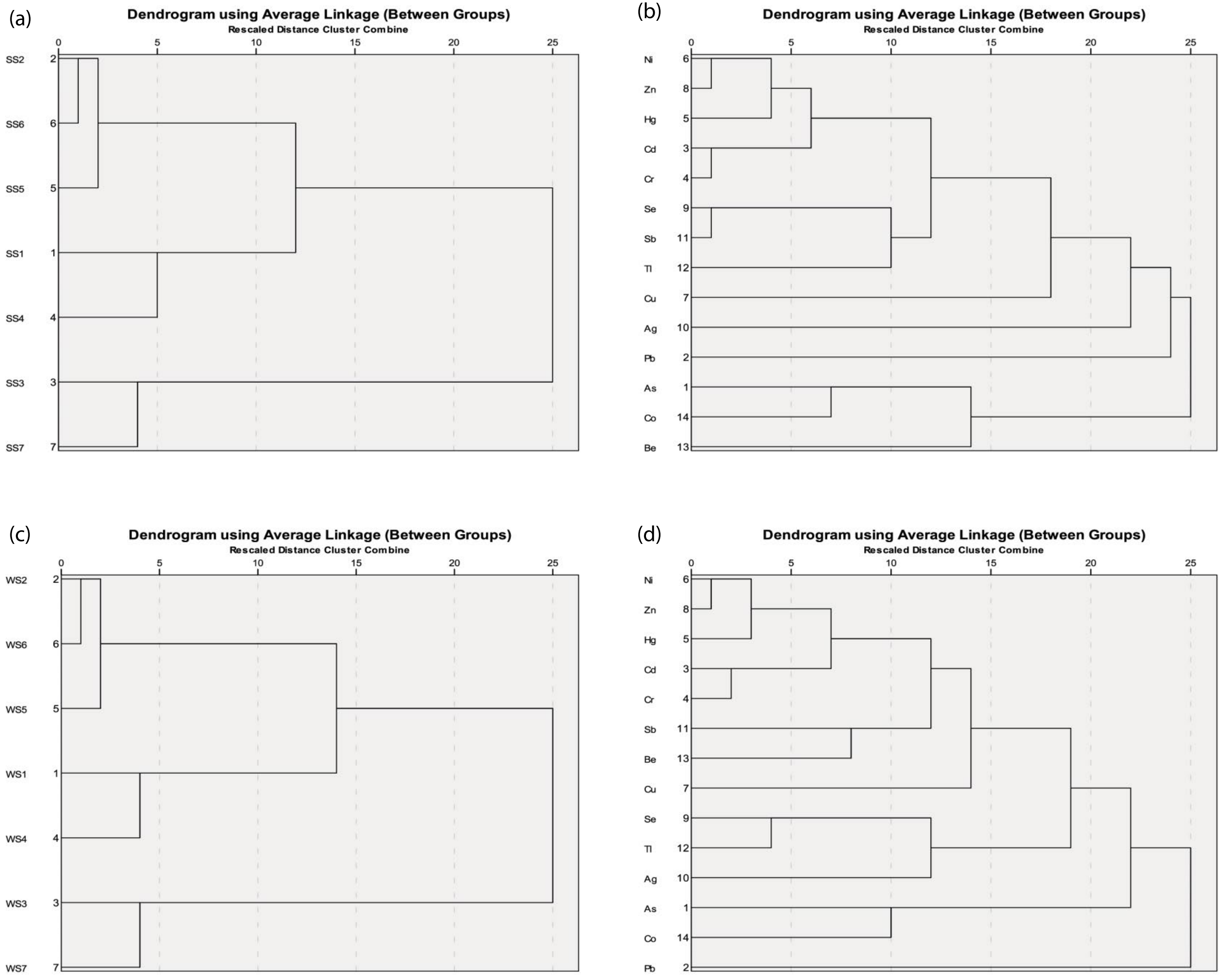

Fig. 2. Dendogram showing the cluster analysis for sediment samples. (a) Cluster for sampling sites in summer season, (b) cluster for studied parameters in summer season, (c) cluster for sampling sites in winter, and (d) cluster for studied parameters in winter season.

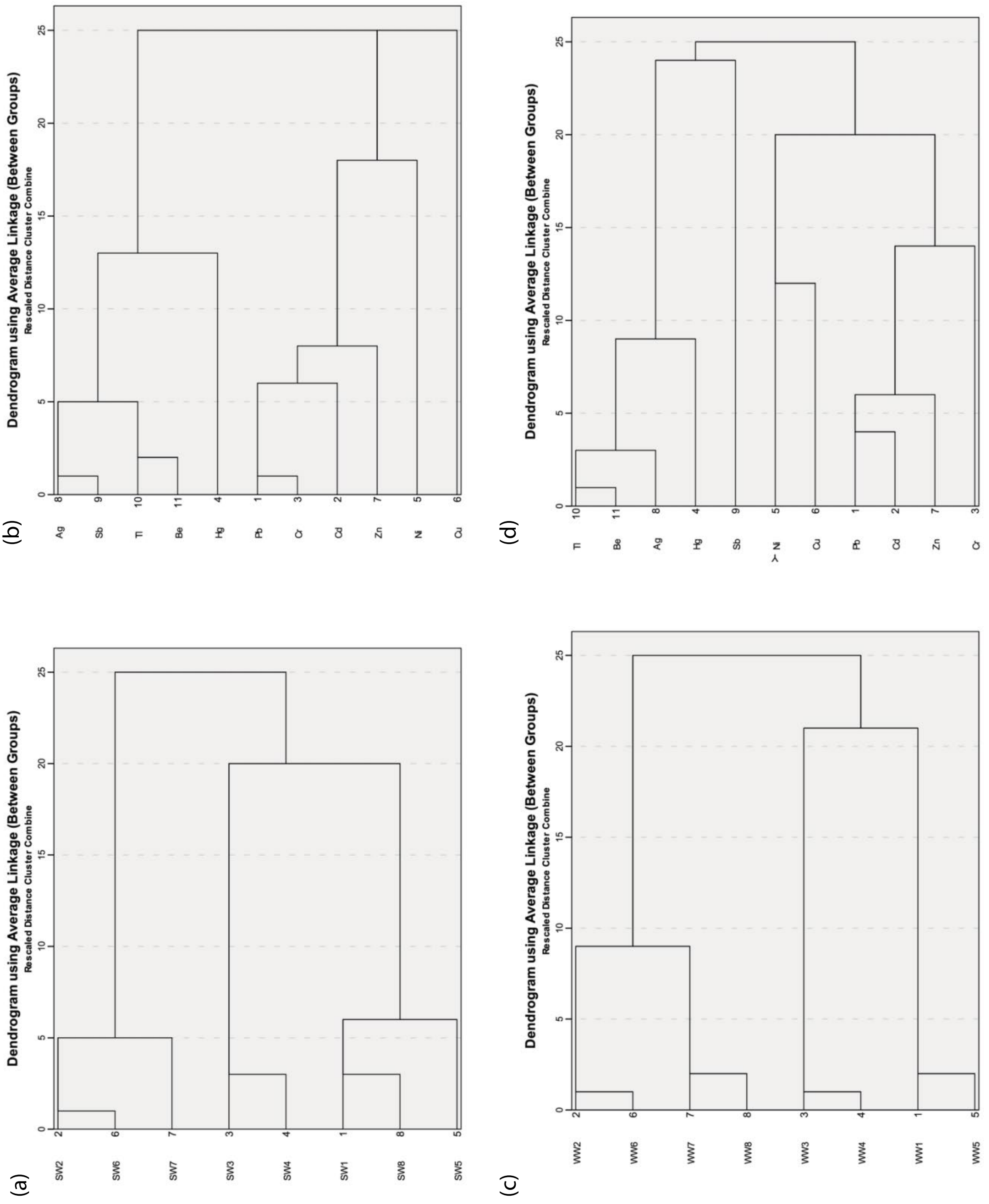

Fig. 3. Dendogram showing the cluster analysis for river water samples. (a) Cluster for sampling sites in summer season, (b) cluster for studied parameters in summer season, (c) cluster for sampling sites in winter, and (d) cluster for studied parameters in winter season.

Table 6
Comparative metal concentration (mg/kg) data in some river sediments

Location	Cr	Ni	Cu	As	Cd	Pb	Zn	References
Buriganga River, Bangladesh	22.4	21.04	168.9	2.15	0.281	110.64	222.3	This study
Buriganga River, Bangladesh	297	240	280	21	7.7	731	NA	[31]
Korotoa river, Bangladesh	109	95	76	25	1.2	58	NA	[38]
Buriganga River, Bangladesh	1,399	50	61.86	19.25	7.29	68.36	54.54	[2]
Bangshi river, Bangladesh	98	26	31	1.9	0.61	60	NA	[39]
Yellow river, China	41–128	NA	30–102	14–48	NA	26–78	NA	[40]
Ganges river, India	1.8–6.4	NA	0.98–4.4	NA	0.14–1.4	4.3–8.4	NA	[41]
Gomoti river, India	8.15	16	5.0	NA	2.4	40	NA	[42]

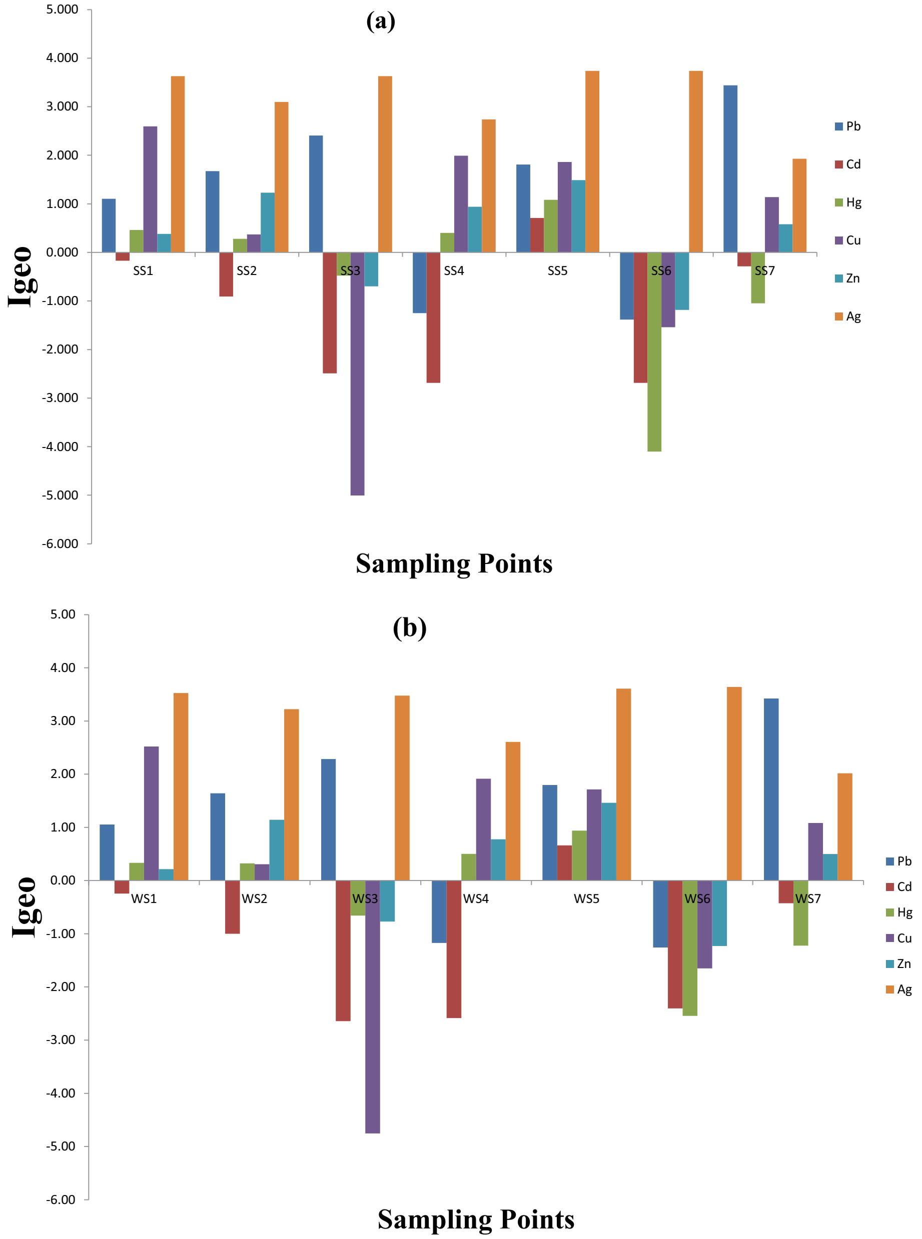

Fig. 4. Geo-accumulation index (I_{geo}) values for priority heavy metals in sediments from different sampling points. (a) summer and (b) winter.

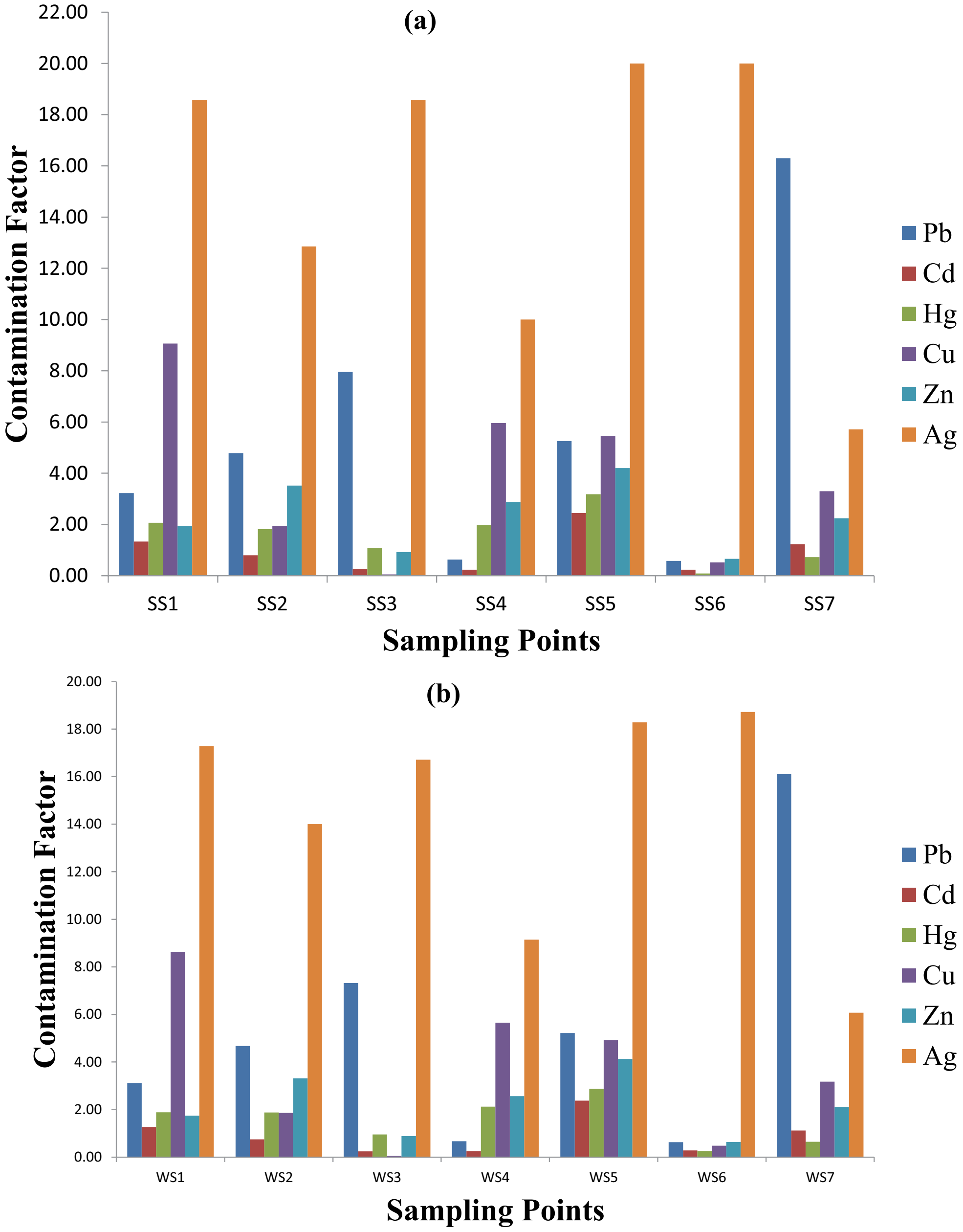

Fig. 5. Contamination factor (CF) values for priority heavy metals in sediments from different sampling points. (a) summer and (b) winter.

in both seasons, the previous study indicated Pb [31] while the current study showed Ag.

3.4. Potential ecological risk index

A potential ecological risk index (PERI) was applied to detect the potential ecological risk (PER) level of heavy metals in the sediments of Buriganga River during the summer and winter seasons (Fig. 6). The PER values for As, Cr, Ni, Zn, Tl, and Co in all samples were lower than 40, indicating low ecological risk degree. Cd and Hg had the highest PER for S5 (Rocket ghat) in both seasons, signifying that the said sampling site was at a higher ecological risk degree. In addition, Pb may also cause a higher ecological risk degree for both seasons at S7 (Mitford ghat). The highest PER value of Cu was found in S1 (Sadarghat gate) and S7 (Mitford ghat) samples, showing moderate ecological risk by the metal.

The results from PERI found S5 (Rocket ghat) having maximum values at 265.01 and 247.23 for summer and winter, respectively. The average PERI in all sediment samples was 144.03 and 138.85 for summer and winter season, respectively. From the viewpoint of pollution level in every sampling site at both seasons, S2 (Sluice gate), S3 (Mosque ghat), S4 (Steamer ghat), and S6 (Babubazar ghat) had potential ecological risk indices below 150, indicating low ecological

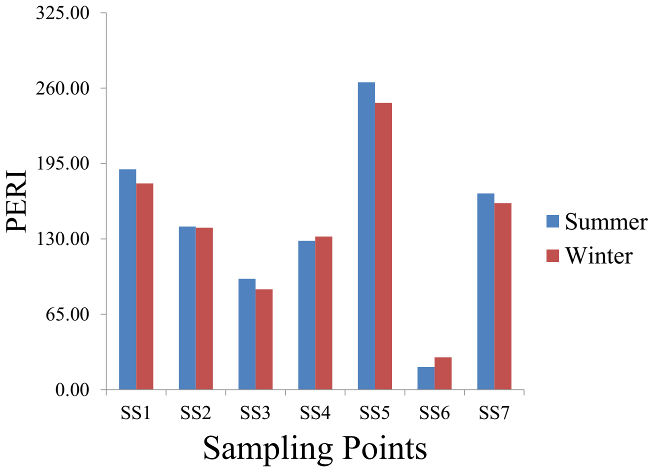

Fig. 6. Potential ecological risk index (PERI) for sediments samples in both seasons.

risk. Whereas, S1 (Sadarghat gate), S7 (Mitford ghat), S5 (Rocket ghat), and S6 (Babubazar ghat) displayed the moderate potential ecological risk. The findings of this study is in agreement with the PERI findings from a previous study that analyzed urban rivers in Dhaka city [31].

3.5. Pollution load index

The PLI was determined for the sediment samples. According to Chandrasekaran et al. [44], PLI > 1 indicates that samples are polluted while PLI < 1 indicates that samples are unpolluted. This study demonstrated that all the studied samples are unpolluted in terms of all the (13 metals) priority metals' PLI. However, the high values for CFs (such as CFs near 1) in contributing metals such as Ag, Pb, Cu, Cd, Hg, Cr, Ni, and Zn induced PLI > 1, indicating a polluted condition for five out of seven sampling locations in both seasons. Moreover, location S5 (Rocket ghat) had the highest PLI. Ahmed et al. [2] reported that 100% sampling points had PLI > 1, which indicated a polluted condition in the Buruganga river. In another study, Islam et al. [31] also reported a polluted condition in the sediments of the river.

The order of PLI for all sampling locations in summer season is S5 (Rocket ghat) > S1 (Sadarghat gate) > S2 (Sluice gate) > S7 (Mitford ghat) > S4 (Steamer ghat) > S3 (Mosque ghat) > S6 (Babubazar ghat). While in winter season, the order is S5 (Rocket ghat) > S2 (Sluice gate) > S1 (Sadarghat gate) > S7 (Mitford ghat) > S4 (Steamer ghat) > S3 (Mosque ghat) > S6 (Babubazar ghat). From this study, it was also observed that the sediments of the river are vulnerable in terms of trace metal loads. Due to the polluted sediments, the aquatic ecosystem of the river might be degraded in terms of species diversity and richness. PLI serves as a good tool for the decision-makers to easily identify whether the sediments are polluted or not, and make necessary actions with regards to such results [43].

3.6. Degree of contamination

To examine the water quality in terms of priority metal concentration, the Buriganga River water was assessed using different indices. The results of the degree of contamination (C_d) is shown in Fig. 7 wherein, "sw" means summer water sample and "ww" means winter water sample. The degree of contamination (C_d) value ranged from 4 to 420 in the summer season, and from 4 to 379 in the winter season (Fig. 7). The mean values were 109.55 and 105.13 for summer and winter samples, respectively, and showed no significant differences. In summer season, S2 (Sluice gate) and S7 (Mitford ghat) samples had low C_d value. S7 (Mitford ghat) and S6 (Babubazar ghat) samples had C_d values indicating moderate degree of pollution. Whereas, S5 (Rocket ghat) showed a relatively high degree of contamination. C_d values were 367 for S3 (Mosque ghat) and 420 for S4 (Steamer ghat). In the summer season, samples from S1 (Sadarghat gate), S3 (Mosque ghat) and S4 (Steamer ghat) had highest C_d values indicating high degree of contamination.

In winter season, only S7 (Mitford ghat) sample consisted of low degree contamination. The C_d values of S2 (Sluice gate), S5 (Rocket ghat), and S7 (Mitford ghat) showed a moderate degree of contamination. Whereas, S1 (Sadarghat ghat) > and S6 (Babubazar ghat) indicated a relatively high degree of contamination. The C_d values were 379 for S3 (Mosque ghat) and 383 for S4 (Steamer ghat), which showed high deviation from other winter samples and further indicated high degree of contamination.

This study demonstrates that the pollution level is high in the study area in terms of C_d. Comparing to previous literature studying the river, Ahmed et al. [2] reported a low value of C_d (maximum 14.8), while Islam et al. [31] found a higher level of C_d (maximum 235). On the other hand, a slightly higher finding (maximum 420) is observed in the present study. These observations clearly indicates that the water quality in terms of metal loading is degrading through time, which can be attributed to the untreated or partially treated discharge from industries and municipal sewerage. Monitoring of industrial treatment facilities would have improved the situation. Unfortunately, the present situation reflects the detrimental effects of inconsistent regulatory activities and strategy in pollution reduction.

3.7. Heavy metal evaluation index

The HEI was calculated to examine a load of priority metals in river water (Fig. 8). The HEI scale categorizes samples into low contamination (HEI < 150), medium contamination (HEI = 150–300), or high contamination (HEI > 300). High HEI values in summer samples were found at S3 (Mosque ghat) (HEI = 771.94) and S4 (Steamer ghat) (HEI = 422.49), while in winter samples S3 (Mosque ghat) and S4 (Steamer ghat) had an HEI value of 385.08; further reflecting a high level of metal contamination in surface water. Interestingly, the other sample locations showed low metal contaminations in both of the seasons. This difference might be due to the high concentration of Hg in sampling locations 3 and 4.

The HPI, was calculated based on international and local water quality parameters (Fig. 9). The scale is as follows: HPI < 300; low contamination, HPI 300–600; medium contamination, HPI > 600; high contamination. The results from the summer season revealed that S2 (Sluice gate) has low contamination (271.67), S7 (Mitford ghat) and S8 have

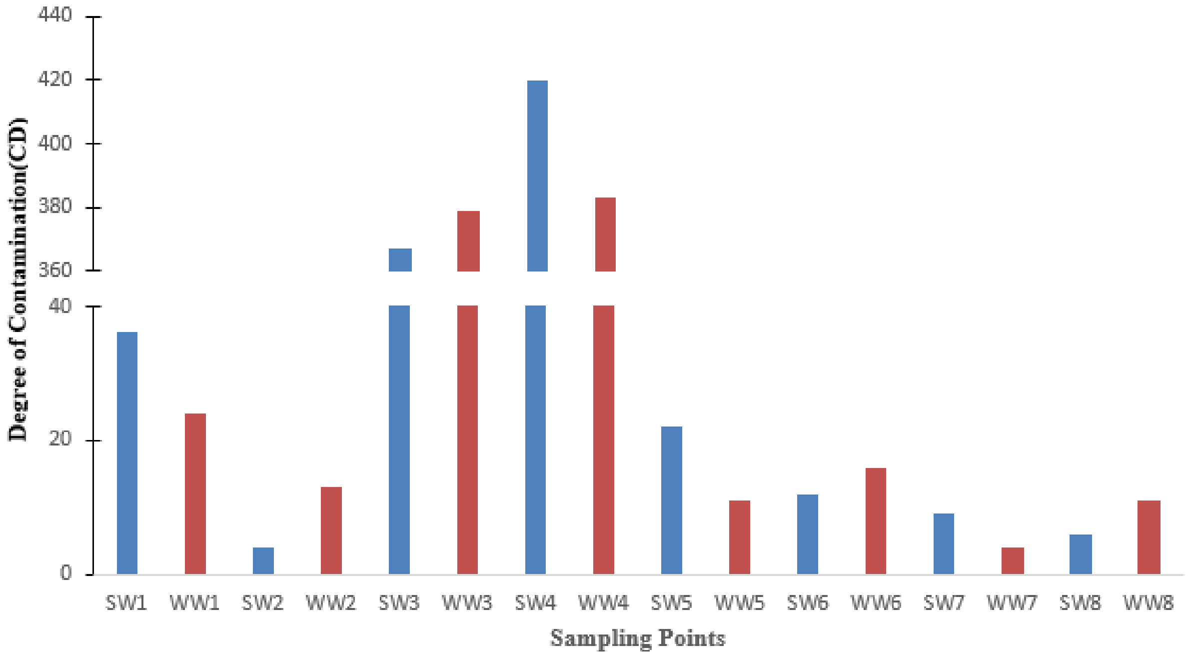

Fig. 7. Degree of contamination (CD) in different sampling points of Buriganga River in both summer and winter season. SW, summer water sample; WW, winter water sample.

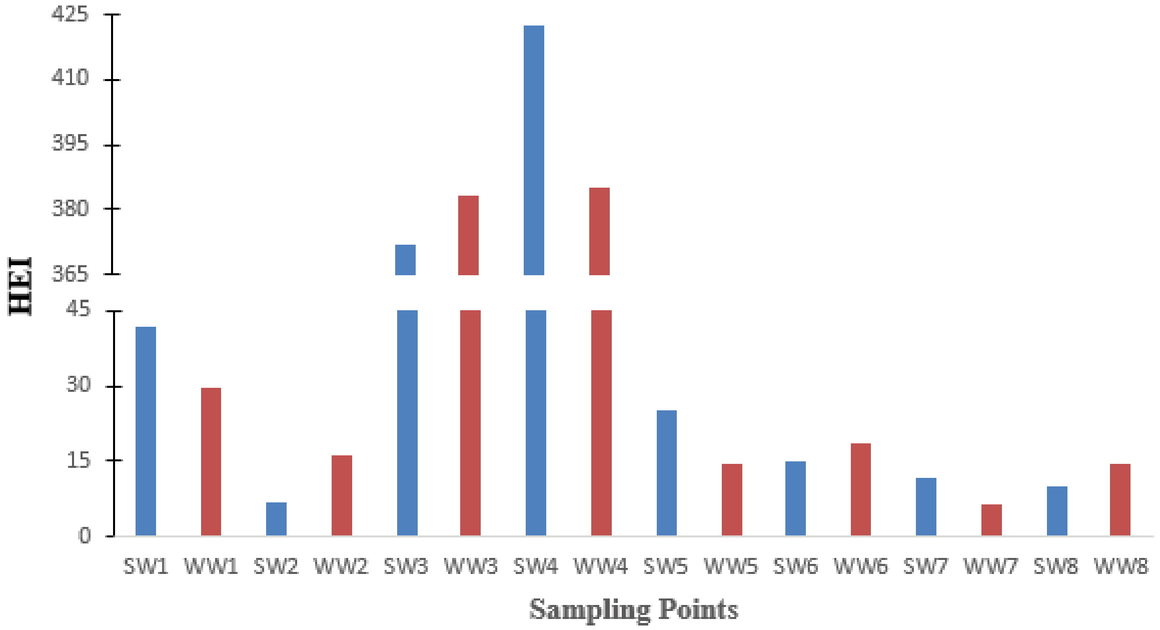

Fig. 8. Heavy metal evaluation index (HEI) in different sampling points of Buriganga River in both summer and winter season. SW, summer water sample; WW, winter water sample.

medium contamination (542.26 and 393.94, respectively), while S1 (Sadarghat gate), S3 (Mosque ghat), S4 (Steamer ghat), S5 (Rocket ghat), and S6 (Babubazar ghat) have high contamination with HPI values exceeding 600. However, in the winter season, all sampling locations exhibited high heavy metal contamination (HPI > 600), except for S7 (Mitford ghat) with a low HPI (271.55). This can be attributed to low dissolution effects of metal pollution, as well as the low flow condition of the river in the winter time. Heavy commercial activities, along with different metal industries, in the vicinity of the study area could have contributed to the metal occurrences.

In addition, Nemerow index (NI) was calculated to observe the multiple metal effects on water quality. The scale/degree to NI is depicted as follows: Class 0: no pollution (≤0.5), Class 1: clean (0.5–0.7), Class 2: warm (0.7–1.0),

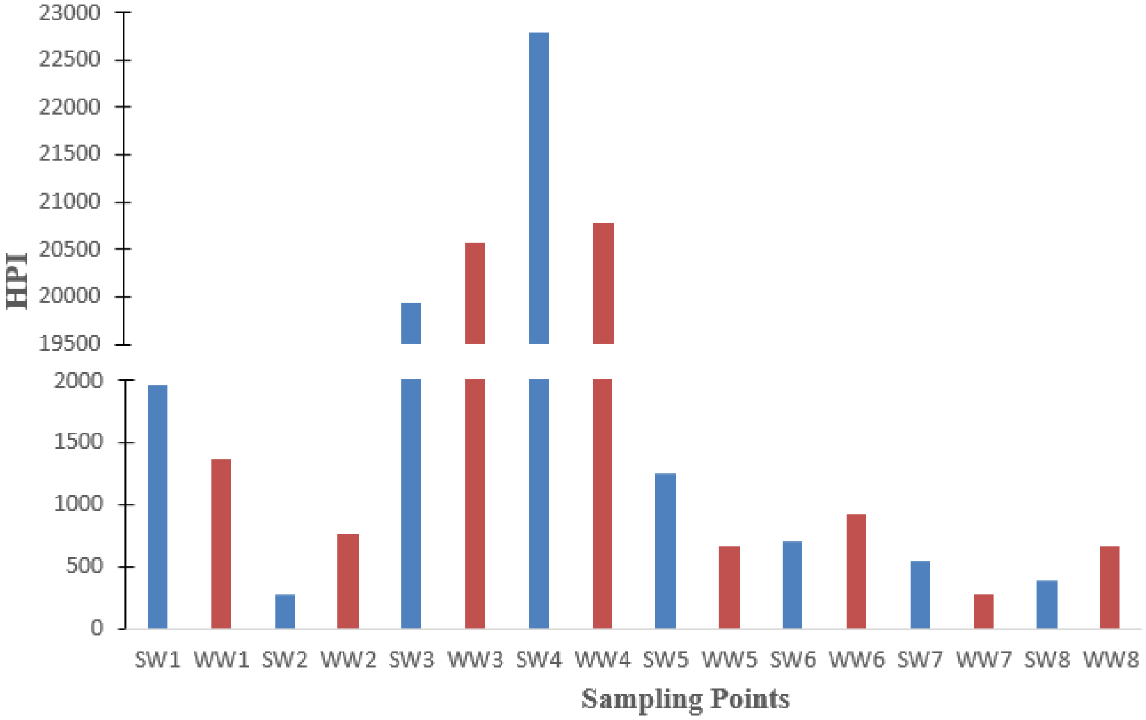

Fig. 9. Heavy metal pollution index (HPI) in different sampling points of Buriganga River in both summer and winter season. SW, summer water sample; WW, winter water sample.

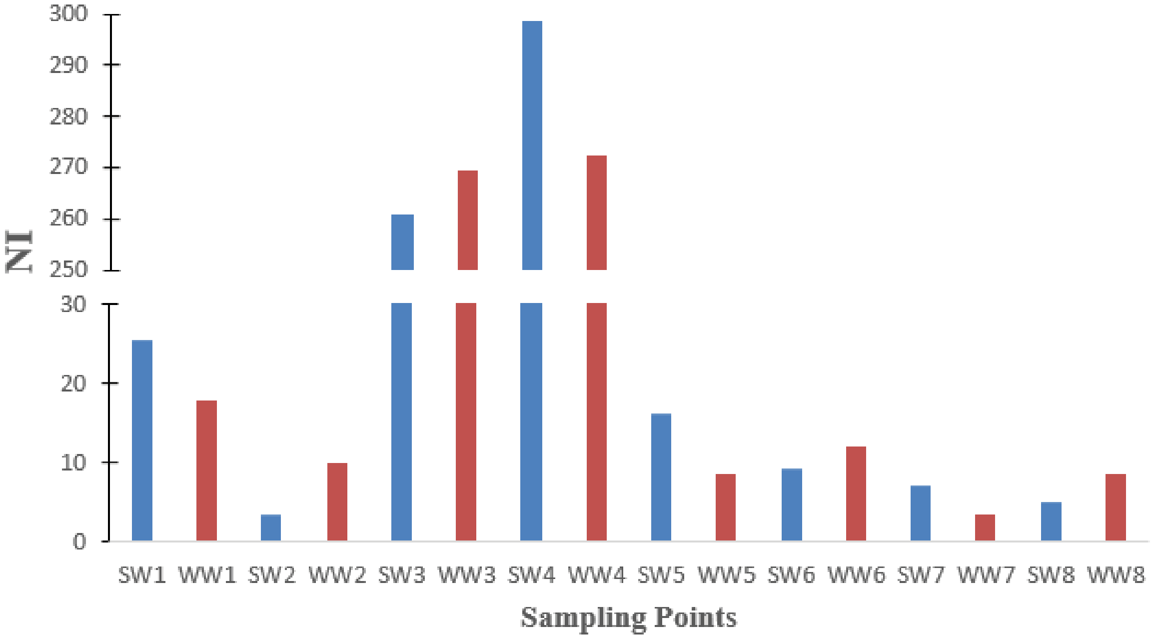

Fig. 10. Nemerow Index (NI) in different sampling points of Buriganga River in both summer and winter season. SW, summer water sample; WW, winter water sample.

Class 3: polluted (1.0–2.0), Class 4: medium pollution (2.0–3.0), and Class 5: severe pollution (>3.0) [25]. The results of NI is presented in Fig. 10. From the findings, water from all sampling locations in both seasons exhibited severe pollution due to the priority metals in the Buriganga River (Fig. 10). It is alarming to have such results from the river water, even after implementing regulatory bindings for industrial discharge and relocating the tannery industry from the vicinity of the Buriganga River to another area (Savar). The possible metal sources could be from the non-point locations such as industries, domestics, and hospitals around the study area.

Overall, the findings showed elevated levels of priority metals in the water and sediment of the Buriganga River near the Sadarghat Area. Multivariate indices for both sediment and water samples implied the elevated metal concentration's ecological risk to the river. The most contributing metals are found to be Ag, Pb, Cu, Cd, Hg, As, Cr, and Zn. Although the tannery industry has been relocated out of the bank of Buriganga River, the water quality situation has yet to be improved. One possible reason is the presence of other sources of metals such as industries that continue to discharge wastes into the river.

4. Conclusion

This study was able to report, for the very first time, a complete spectrum of 13 priority metal pollutants in the Sadarghat area of the Buriganga River. The findings showed that the river water and sediments hosted high levels of some priority metals, which may pose serious threats to the environmental and ecological health. Among the 13 metals, Ag, Cu, Cd, Pb, Hg, Cr, and Zn must be considered seriously in order to avoid deleterious environmental or ecological consequences. This report brings the potential for further research that could bring a more comprehensive and complete assessment of priority pollutants that need to be addressed in important environmental and economical landmarks like the Buriganga River. Results from this study can be a useful tool for the scientific community and the government in creating better policies and methodologies toward improving the environmental conditions of water bodies in Bangladesh.

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