*Geo-accumulation index (Igeo)*

The criterion to evaluate the metal pollution in sediments is the *Igeo* that has been widely used since the late 1960s which is calculated by Eq (X) shown in Table X. In the present study, Igeo for the elements Cr, Ni, Cu, As, Cd and Pb is measured and presented in Table 3. Calculated Igeo values for both seasons showed that Cd and Pb have the maximum geo-accumulation index having positive values in all five rivers. In Shitalakshya and Buriganga the Igeo values of Cd revealed strongly to extreme pollution in both season having the values of 4.74 being highest and 4.16 in winter season and in rainy season the values were 4.39 and 3.88 respectively. In Turag, Dhaleshwari and Balu the Igeo values of Cd in winter season were 3.08, 2.43 and 2.06 indicating strongly to moderately strong pollution and in rainy season the values were 2.63, 1.88 and 1.74 ranging in (2-3) moderate to strong pollution and (1-2) moderate pollution. The Igeo values of Pb in Buriganga, Turag and Shitalakshya were 3.21, 2.96, 2.39 in winter season ranging in (3-4) strongly polluted and (2-3) moderate to strong polluted and in rainy season the values were 2.47, 2.02 and 1.58 respectively indicating (2-3) moderate to strong pollution and (1-2) moderate pollution. In Dhaleshwari and Balu the Igeo values of Pb in winter were 1.34 and 1.05 indicating moderate pollution respectively where it was (0-1) unpolluted to moderate polluted in rainy season having the values of 0.45 and 0.17 respectively. In Buriganga the Igeo values of Cu in winter and rainy season were 1.67 and 1.10 respectively indicating moderate pollution. In Dhaleshwari and Balu the Igeo values of Pb in winter and rainy season, As in winter season in Shitalakshya, Cu in Shitalakshya and Turag in rainy season and all five rivers in winter season lied between (0-1) indicating unpolluted to moderately polluted. All the other HMs of Cr, Ni, Cu, As have the negative values of Igeo indicating no pollution in rainy and winter season by such heavy metals. Rakib et al. (2021a) also found Igeo for Ti, Fe, Cu, Rb, Sr, Zr, Pb and Zn in the sediments beloged to class zero, indicating the sediments in Hatiya, Chairman Ghat, and ship-breaking yards along the marine coast of Sitakundo were unpolluted by these HMs.

Table X: Geoaccumulation index (*Igeo*) of HMs for sediments of Balu, Buriganga, Dhaleshwari, Shitalakshya and Turag River, Bangladesh

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Season | River | Cr | Ni | Cu | As | Cd | Pb |
| Winter | Balu | -3.18 | -1.68 | 0.2 | -1.29 | 2.06 | 1.05 |
| Buriganga | -0.36 | -0.44 | 1.67 | -0.84 | 4.16 | 3.21 |
| Dhaleshwari | -0.52 | -1.52 | 0.5 | -0.08 | 2.43 | 1.34 |
| Shitalakshya | -1.02 | -0.98 | 0.91 | 0.09 | 4.74 | 2.39 |
| Turag | -3.06 | -0.47 | 0.59 | -0.35 | 3.08 | 2.96 |
| Rainy | Balu | -3.77 | -2 | -0.29 | -1.52 | 1.74 | 0.17 |
| Buriganga | -0.75 | -0.95 | 1.1 | -1.13 | 3.88 | 2.47 |
| Dhaleshwari | -0.95 | -2.29 | -0.1 | -0.49 | 1.88 | 0.45 |
| Shitalakshya | -1.57 | -1.59 | 0.29 | -0.37 | 4.39 | 1.58 |
| Turag | -3.37 | -1.27 | 0.25 | -0.56 | 2.63 | 2.02 |
| Maximum  (*Mmax*) |  | -0.36 | -0.44 | 1.67 | 0.09 | 4.74 | 3.21 |
| Minimum  (*Mmin*) |  | -3.77 | -2.29 | -0.29 | -1.52 | 1.74 | 0.17 |
| Mean (N=10) |  | -1.86 | -1.32 | 0.51 | -0.65 | 3.1 | 1.76 |

*Enrichment Factor (EF)*

EF is measured to identify the anthropogenic level of impact in sediments, the contribution of each element to the enrichment of sediment of an individual site and can be calculated by Eq. (X)., shown in Table X. The EF values of HMs in the Balu, Buriganga, Dhaleshwari, Shitalakshya and Turag River sediments for both winter and rainy seasons are depicted in Table 2. EF values of Shitalakshya in rainy season were very high enrichment and lay in 20 ≤ EF < 40 which exceed in winter season having extremely high enrichment, EF ≥ 40. At every point, EF values were of Cd in the winter and rainy seasons were significantly higher than other metals and lay in the 5≤ EF ≤ 20 groups, indicating significant enrichment. The EF values of Pb indicate significant enrichment in Buriganga, Shitalakshya and Turag in winter and Buriganga in rainy season. In Shitalakshya EF values of Cd ranged from 28.03 to 48.96 in winter while 28.66 to 38.63 in rainy season and in Pb it was 4.47 to 12.20 in winter while 3.84 to 5.87 in rainy season. The EF values of Cd in the winter season in Buriganga ranged from 18.23 to 21.01; which was 13.42 to 17.44 in rainy season and the EF values of Pb in winter season ranged from 9.98 to 10.30 while 5.63 to 5.86 in rainy season. In Turag EF values of Pb in the winter season ranged from 7.10 to 8.78; which was 3.322 to 5.50 in rainy season. The other rivers, Dhaleshwari and Balu have the range of EF values of Cd were 3.60 to 15.52; 4.96 to 7.81 in winter and 2.18 to 10.26; 4.50 to 6.17 in rainy season respectively which indicate moderate enrichment to significant enrichment. The range EF values of Pb in Dhaleswari and Balu were 1.61 to 5.56; 2.91 to 3.25 in winter and 1.19 to 2.94; 1.70 to 1.85 in rainy season respectively indicating deficiency to minimal enrichment to moderate enrichment. The EF values of Cu in Buriganga, Dhaleswari, and Shitalakshya indicated moderate enrichment in winter while it was Buriganga and Shitalakshya in rainy season. All the other ranges of Cr, Ni, As lied in EF<2 indicating deficiency to minimal enrichment in all five rivers. Hossain et al. (2021b) reported moderate to severe enrichment by Mn, Zn, Cu, Pb, Ni, and Cr in the sediment cores of different ship-breaking areas of Shitakundo, Bangladesh. In another study, Tamim er al. (2016) showed minimal enrichment of Cr, Zn, K, Ti, Cu, Rb, Sr, Cs, Hf, and Hg in the sediment sample of Buriganga river near Hazaribagh area, Dhaka, Bangladesh. Most significant rivers can be oredered based on the enrichment value as Shitalakshya > Buriganga > Turag > Dhaleshwari> Balu.

Table 2: Enrichment Factors (EF) of HMs for sediments of Balu, Buriganga, Dhaleshwari, Shitalakshya and Turag River, Bangladesh

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Season | River | Cr | Ni | Cu | As | Cd | Pb | Fe |
| Winter | Balu | 0.17 | 0.48 | 1.71 | 0.61 | 6.38 | 3.08 | 1.00 |
| Buriganga | 0.85 | 0.81 | 3.53 | 0.63 | 19.62 | 10.14 | 1.00 |
| Dhaleshwari | 1.02 | 0.56 | 2.14 | 1.50 | 8.85 | 3.95 | 1.00 |
| Shitalakshya | 0.73 | 0.84 | 2.94 | 1.60 | 40.69 | 8.43 | 1.00 |
| Turag | 0.12 | 0.76 | 1.54 | 0.81 | 8.98 | 8.01 | 1.00 |
| Rainy | Balu | 0.12 | 0.40 | 1.29 | 0.55 | 5.34 | 1.77 | 1.00 |
| Buriganga | 0.62 | 0.54 | 2.22 | 0.48 | 15.43 | 5.74 | 1.00 |
| Dhaleshwari | 0.79 | 0.35 | 1.42 | 1.13 | 6.35 | 2.09 | 1.00 |
| Shitalakshya | 0.52 | 0.58 | 1.90 | 1.21 | 32.13 | 4.63 | 1.00 |
| Turag | 0.10 | 0.40 | 1.15 | 0.67 | 6.11 | 4.05 | 1.00 |
| Maximum  (*Mmax*) |  | 1.02 | 0.84 | 3.53 | 1.60 | 40.69 | 10.14 | 1.00 |
| Minimum  (*Mmin*) |  | 0.10 | 0.35 | 1.15 | 0.48 | 5.34 | 1.77 | 1.00 |
| Mean (N=10) |  | 0.50 | 0.59 | 1.99 | 0.94 | 14.99 | 5.19 | 1.00 |

*Pollution index (PI), Modified Pollution index (MPI) and the Modified Degree of Contamination (mCd)*

The limitations of single metal indices led to the development of multi-metal indices. The two most widely used such indices, developed by Hakinson (1980) and Nemerow (1991), include the modified degree of contamination (*mCd*) and the pollution index (*PI*). Brady et al. (2015) developed a modified pollution index (*MPI*) considering enrichment factor. The highest *PI* values were observed of 29.59 and 22.71 in winter and rainy season respectively, both in Shitalakshya river indicating heavily polluted condition (PI>3). In all five rivers the *PI* values were >3 indicating heavily polluted condition in all five rivers having heavily pollution sequence of Shitalakshya > Buriganga > Turag > Dhaleshwari > Balu in both seasons. The maximum *mCd* values were observed in Shitalakshya river in both seasons having the values of 9.2 and 6.67 in winter and rainy season respectively, indicating severely polluted (8< *mCd* <16) which is also observed in Buriganga in winter season having value of 8.15. In winter Turag and in rainy season Buriganga were moderately polluted to heavily polluted (4< *mCd* <8). Dhaleshwari and Balu were moderately polluted (2< *mCd* <4) in winter which was also in Turag in rainy season. Dhaleshwari and Balu in rainy season were slightly polluted (1.5< *mCd* <2). According to *MPI*, Shitalakshya and Buriganga were in heavily polluted condition in both seasons (*MPI*>10). In Turag and Dhaleshwari in winter season the *MPI* values indicated severely polluted (5<*MPI*<10). In Dhaleshwari, Turag, Balu in rainy season were moderately to heavily polluted (3<*MPI*<5) which was also in Balu in winter season. According to *MPI*, the sequence of rivers was Shitalakshya > Buriganga > Turag ≥ Dhaleshwari > Balu in both seasons.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Rivers | *PLI* | | *PI* | | *MPI* | | *mCd* | |
| Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy |
| Balu | 1.08 | 0.78 | 4.76 | 3.82 | 4.75 | 3.94 | 2.08 | 1.52 |
| Buriganga | 3.54 | 2.56 | 19.94 | 16.48 | 14.49 | 11.31 | 8.15 | 6.07 |
| Dhaleshwari | 1.94 | 1.27 | 6.61 | 4.53 | 6.62 | 4.72 | 3.03 | 1.98 |
| Shitalakshya | 3.08 | 2.07 | 29.59 | 22.71 | 29.5 | 23.23 | 9.2 | 6.67 |
| Turag | 2.06 | 1.45 | 10.12 | 7.1 | 6.96 | 4.57 | 4.91 | 3.23 |
| Maximum (*Mmax*) | 3.54 | 2.56 | 29.59 | 22.71 | 29.5 | 23.23 | 9.2 | 6.67 |
| Minimum (*Mmin*) | 1.08 | 0.78 | 4.76 | 3.82 | 4.75 | 3.94 | 2.08 | 1.52 |
| Mean (N=5) | 2.34 | 1.63 | 14.20 | 10.93 | 12.46 | 9.55 | 5.47 | 3.90 |

*Ecological Risk Index (RI)*

Potential ecological risk factor (*Eir*) of the studied HMs follows the order as Pb>Cu>Cr>Ni~Cd>As in all five rivers. Single factor pollution in S8-S12, S17 of Pb in winter season exceeded *Eir* >320 indicating very high risk. Single factor of Pb in S8-S12 in rainy season were in high risk (160<*Eir*≤320). In winter the single factor values of Pb in S2-S6, S13-S15, Cu in S12 and in rainy season, Pb in S5, S8, S15-S17 were in considerable risk (80<*Eir*≤160). Moderate risk (40<*Eir*≤80) was observed in Cu in S6, S11, S16, S17, Pb in S7 in winter and S11, S12 of Cu, S1-S4, S6, S7, S13, S14 of Pb in rainy season. All the other sites were below the values of 40 indicating low risk. According to the classification of Potential ecological risk (*RI*), S8-S12, S16, S17 in winter was observed a severe risk (*RI*≥400) by Cr,Ni,Cu,As,Cd and Pb. S1-S6 and S15 in winter and S8-S12, S16, S17 in rainy season, the *RI* value indicate a considerable risk (200≤ *RI* < 400). Moderate risk (110≤ *RI* < 200) was observed in S7, S13, S14 in winter and S1, S2, S4-S7, S15 in rainy season. All the other sampling point were having low potential ecological risk (*RI*<110). The *RI* values in winter in Buriganga (S11, S12), Turag (S8-S10) and Shitalakshya (S16, S17) revealed a severe risk and in rainy season it was considerable potential ecological risk. The *RI* values of Dhaleshwari and Balu rivers indicated considerable and moderate risk respectively in winter which was moderate and low risk in rainy season.

Table X

Potential Ecological Risk Factor and Potential Ecological risk index of HMs in Shitalakshya, Buriganga, Turag, Dhaleshwari and Balu River sediment.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sites | River | Potential ecological risk factor (*Eir*) | | | | | | | | | | | | Risk Index *(RI) = Σ Eir* | |
| Cr | | Ni | | Cu | | As | | Cd | | Pb | |
|  |  | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy |
| S1 | Dhaleshwari | 30.79 | 26.78 | 8.08 | 4.51 | 24.87 | 14.34 | 4.21 | 3.67 | 8.86 | 5.32 | 164.15 | 78.63 | 240.96 | 133.26 |
| S2 | 30.13 | 25.54 | 6.38 | 4.05 | 26.71 | 14.78 | 6.36 | 4.56 | 7.64 | 5.94 | 149.02 | 60.29 | 226.23 | 115.16 |
| S3 | 25.93 | 19.33 | 13.96 | 8.83 | 25.29 | 17.59 | 12.08 | 7.14 | 5.9 | 4.2 | 119.91 | 50.82 | 203.07 | 107.92 |
| S4 | 20.67 | 16.05 | 11.57 | 6.14 | 32.83 | 24.81 | 11.7 | 8.66 | 4.72 | 3.58 | 140.24 | 67.27 | 221.74 | 126.51 |
| S5 | 28.93 | 18.63 | 11.92 | 7.2 | 35.63 | 26.02 | 13.09 | 9.67 | 4.2 | 2.9 | 122.6 | 83 | 216.39 | 147.44 |
| S6 | 24.9 | 17.43 | 5.49 | 2.76 | 67.25 | 34.94 | 6.55 | 4.81 | 3 | 1.64 | 98.33 | 58.71 | 205.52 | 120.3 |
| S7 | 30.49 | 20.04 | 5.22 | 3.52 | 39.9 | 34.39 | 9.86 | 9.18 | 2.72 | 1.94 | 62.85 | 51.88 | 151.04 | 120.94 |
| S8 | Turag | 5.25 | 4.54 | 19.1 | 9.59 | 35.62 | 26.26 | 5.79 | 5.24 | 7.38 | 4.34 | 361.88 | 152.05 | 435.02 | 202.03 |
| S9 | 4.96 | 3.68 | 20.05 | 9.28 | 37.56 | 31 | 6.57 | 4.98 | 10.28 | 7.2 | 387.67 | 264.12 | 467.09 | 320.26 |
| S10 | 3.92 | 3.22 | 13.55 | 11.06 | 35.08 | 28.72 | 9.17 | 8.72 | 5.8 | 5.58 | 337.59 | 168.33 | 405.1 | 225.63 |
| S11 | Buriganga | 26.95 | 21.51 | 16.85 | 11.75 | 63.06 | 50.28 | 5.91 | 4.56 | 14.2 | 11.12 | 401.61 | 240.87 | 528.59 | 340.09 |
| S12 | 34.12 | 25.08 | 18.65 | 13.15 | 92.84 | 52.59 | 4.3 | 3.68 | 18.2 | 15.88 | 460.97 | 275.75 | 629.07 | 386.12 |
| S13 | Balu | 4.94 | 3 | 9.27 | 7 | 26.72 | 20.08 | 3.46 | 3.08 | 4.62 | 3.92 | 99.35 | 55.77 | 148.37 | 92.84 |
| S14 | 3.73 | 2.73 | 6.07 | 5.16 | 28.29 | 19.1 | 3.94 | 3.18 | 3.06 | 2.3 | 92.69 | 48.79 | 137.77 | 81.26 |
| S15 | Shitalakshya | 23.12 | 14.84 | 6.61 | 3.95 | 37.4 | 25.56 | 9.54 | 7.25 | 18.22 | 17.4 | 150.15 | 118.61 | 245.05 | 187.61 |
| S16 | 17.95 | 11.77 | 16.76 | 10.86 | 41.06 | 30.42 | 9.15 | 6.42 | 29.86 | 20.32 | 295.12 | 152.63 | 409.9 | 232.42 |
| S17 | 16.99 | 12.95 | 16.36 | 11.91 | 60.19 | 32.47 | 10.05 | 7.31 | 25.4 | 18.84 | 326.51 | 147.93 | 455.49 | 231.42 |
| Maximum (*Mmax*) |  | 34.12 | 26.78 | 20.05 | 13.15 | 92.84 | 52.59 | 13.09 | 9.67 | 29.86 | 20.32 | 460.97 | 275.75 | 629.07 | 386.12 |
| Minimum (*Mmin*) |  | 3.73 | 2.73 | 5.22 | 2.76 | 24.87 | 14.34 | 3.46 | 3.08 | 2.72 | 1.64 | 62.85 | 48.79 | 137.77 | 81.26 |
| Mean (N=17) |  | 19.63 | 14.54 | 12.11 | 7.69 | 41.78 | 28.43 | 7.75 | 6.01 | 10.24 | 7.79 | 221.80 | 122.09 | 313.32 | 186.54 |

*Modified Hazard Quotient (mHQ)*

The *mHQ* distribution of each HMs varies the sampling sites, and it is particularly similar from the trend shown by the other comprehensive risk indicators. According to the average values of *mHQ* in all sites*,* attention should be given to Cd, Cu, Pb, Ni in all sites, contributing high to considerable severity of contamination in winter and considerable to moderate severity of contamination in rainy season. While in both seasons, As, Cr were having moderate to low severity of contamination. The average value of *mHQ* in Buriganaga, Pb,Cd,Cu in winter and Cd in Shitalakshya in both seasons showed extreme severity of contamination. In Buriganga Cu,Cd in rainy season and in Shitalakshya and Turag Cu in winter and rainy season respectively the *mHQ* values revealed very high severity of contamination. Ni, Cu, Cd, Pb in winter in Buriganga, Dhaleshwari and Turag, Turag, Shitalakshya respectively and Pb in rainy season in Buriganga revealed high severity of contamination. The average values of *mHQ* of Ni, Cu, Cd, Pb in Turag and Cu in Dhaleshwari and Shitalakshya, Pb in Shitalakshya and Ni in Buriganga in rainy and Cd in Dhaleshwari, Cu in Balu and Ni in Shitalakshya in winter indicated considerable severity of contamination. Most other average values of *mHQ* of Cd, Cu, Pb, Ni, As and Cr were in range of moderate to low severity of contamination in all the five rivers.

*Toxic Risk Index (TRI)*

The toxic risk index developed by Zhang et al. was applied to provide a more comprehensive of their risk to the biota in the aquatic environment. In S16 the *TRI* value was 15.73 by Cd in winter which indicate considerable toxic risk (15> *TRI* ≥ 20). S17, S12 in winter season and S16 in rainy season have moderate toxic risk (10> *TRI* ≥ 15) by Cd,Cu and Cd respectively. The sampling site S6,S11 and S17 in winter and S11,S12 in rainy season by Cu had low toxic risk (5 > *TRI* ≥ 10) and in S9,S11,S12,S15 in winter and S11,S12,S15,S16 in rainy season the TRI value of Cd ranged in low toxic risk, respectively which was also in S8-S12,S17 by Pb in winter season. All the other *TRI* values of Cr, Ni, Cu, As, Cd, Pb in both seasons were in range of *TRI*<5 having no toxic risk concern.

Table X

Toxic risk index *TRI* of HMs in Shitalakshya, Buriganga, Turag, Dhaleshwari and Balu River sediments.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sites | Rivers | Cr | | Ni | | Cu | | As | | Cd | | Pb | |
|  |  | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy |
| S1 | Dhaleshwari | 1.52 | 1.32 | 1.63 | 0.91 | 2.68 | 1.55 | 0.9 | 0.79 | 4.67 | 2.8 | 2.57 | 1.23 |
| S2 | 1.48 | 1.26 | 1.29 | 0.82 | 2.88 | 1.59 | 1.37 | 0.98 | 4.02 | 3.13 | 2.33 | 0.94 |
| S3 | 1.28 | 0.95 | 2.81 | 1.78 | 2.73 | 1.9 | 2.59 | 1.53 | 3.11 | 2.21 | 1.88 | 0.8 |
| S4 | 1.02 | 0.79 | 2.33 | 1.24 | 3.54 | 2.68 | 2.51 | 1.86 | 2.49 | 1.89 | 2.19 | 1.05 |
| S5 | 1.42 | 0.92 | 2.4 | 1.45 | 3.85 | 2.81 | 2.81 | 2.08 | 2.21 | 1.53 | 1.92 | 1.3 |
| S6 | 1.23 | 0.86 | 1.11 | 0.56 | 7.26 | 3.77 | 1.41 | 1.03 | 1.58 | 0.86 | 1.54 | 0.92 |
| S7 | 1.5 | 0.99 | 1.05 | 0.71 | 4.31 | 3.71 | 2.12 | 1.97 | 1.43 | 1.02 | 0.98 | 0.81 |
| S8 | Turag | 0.26 | 0.22 | 3.85 | 1.93 | 3.84 | 2.83 | 1.24 | 1.13 | 3.89 | 2.29 | 5.66 | 2.38 |
| S9 | 0.24 | 0.18 | 4.04 | 1.87 | 4.05 | 3.35 | 1.41 | 1.07 | 5.41 | 3.79 | 6.07 | 4.13 |
| S10 | 0.19 | 0.16 | 2.73 | 2.23 | 3.79 | 3.1 | 1.97 | 1.87 | 3.05 | 2.94 | 5.28 | 2.63 |
| S11 | Buriganga | 1.33 | 1.06 | 3.4 | 2.37 | 6.81 | 5.43 | 1.27 | 0.98 | 7.48 | 5.86 | 6.28 | 3.77 |
| S12 | 1.68 | 1.23 | 3.76 | 2.65 | 10.02 | 5.68 | 0.92 | 0.79 | 9.59 | 8.36 | 7.21 | 4.31 |
| S13 | Balu | 0.24 | 0.15 | 1.87 | 1.41 | 2.88 | 2.17 | 0.74 | 0.66 | 2.43 | 2.06 | 1.55 | 0.87 |
| S14 | 0.18 | 0.13 | 1.22 | 1.04 | 3.05 | 2.06 | 0.85 | 0.68 | 1.61 | 1.21 | 1.45 | 0.76 |
| S15 | Shitalakshya | 1.14 | 0.73 | 1.33 | 0.8 | 4.04 | 2.76 | 2.05 | 1.56 | 9.6 | 9.16 | 2.35 | 1.86 |
| S16 | 0.88 | 0.58 | 3.38 | 2.19 | 4.43 | 3.28 | 1.97 | 1.38 | 15.73 | 10.7 | 4.62 | 2.39 |
| S17 | 0.84 | 0.64 | 3.3 | 2.4 | 6.5 | 3.5 | 2.16 | 1.57 | 13.38 | 9.92 | 5.11 | 2.31 |
| Maximum (*Mmax*) |  | 1.68 | 1.32 | 4.04 | 2.65 | 10.02 | 5.68 | 2.81 | 2.08 | 15.73 | 10.7 | 7.21 | 4.31 |
| Minimum (*Mmin*) |  | 0.18 | 0.13 | 1.05 | 0.56 | 2.68 | 1.55 | 0.74 | 0.66 | 1.43 | 0.86 | 0.98 | 0.76 |
| Mean (N=17) |  | 0.97 | 0.72 | 2.44 | 1.55 | 4.51 | 3.07 | 1.66 | 1.29 | 5.39 | 4.10 | 3.47 | 1.91 |

*mERMQ* and *CSI*

Mean ERM quotient (*mERMQ*) is proposed for assessing the potential effects of multiple HMs contamination in sediment and the contamination severity index (*CSI*) is new index based on ERL (effect range low) and ERM (effect range medium) values to study severity of HM contamination in sediments which was first proposed by Pejman et al. for the toxicity boundaries and adverse effect on the biota as well as weighted values for each heavy metal attributed by the ratio of PCA/FA as site-specific factor (Jafrabad et al). In S8-S12 (Turag and Buriganga), S15-S17 (Shitalakshya) the *mERMQ* and *CSI* value indicated 49% probability of toxicity and ultra-high contamintaion severity in winter and very high severity of contamination in rainy season. 21% probability of toxicity and moderate severity to low severity was found in S2, S6, S7 (Dhaleshwari), S13, S14 (Balu) in winter and low to moderate to low severity in S1-S8 (Dhaleshwari), S13-S14 found in rainy season. The other 79% sampling sites had low to very low severity of contamination in both seasons, but severity was higher in winter than rainy season. Severity degree and toxicity degree revealed that sampling sites of Buriganga, Shitalakshya and Turag were highly contaminated and toxic and the sampling sites of Balu and Dhaleshwari were moderate to low contaminated and toxic in both seasons.

Mean ERM quotient (*mERMQ*) and Contamination severity index (*CSI*) of sampling sites of Shitalakshya, Buriganga, Turag, Dhaleshwari and Balu River sediment.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| River | | Dhaleshwari | | | | | | | Turag | | | Buriganga | | Balu | | Shitalakshya | | |
| Sites | | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 | S17 |
| ***CSI*** | W | 2.61 | 2.2 | 3.07 | 2.79 | 2.72 | 1.73 | 1.3 | 8.51 | 9.68 | 6.53 | 9.76 | 12.75 | 1.85 | 1.36 | 3.28 | 9.21 | 9.18 |
| R | 1.63 | 1.48 | 1.76 | 1.47 | 1.75 | 1.11 | 1.26 | 2.42 | 4.18 | 2.94 | 4.88 | 6.32 | 1.19 | 0.91 | 2.58 | 4.08 | 4.07 |
| ***mERMQ*** | W | 0.53 | 0.49 | 0.55 | 0.52 | 0.54 | 0.41 | 0.37 | 0.78 | 0.85 | 0.67 | 0.97 | 1.15 | 0.34 | 0.27 | 0.59 | 0.96 | 0.97 |
| R | 0.33 | 0.31 | 0.34 | 0.32 | 0.36 | 0.24 | 0.28 | 0.4 | 0.53 | 0.46 | 0.67 | 0.78 | 0.24 | 0.19 | 0.45 | 0.6 | 0.61 |

W – Winter, R- Rainy