Table: Physical properties of sediment in the studied five rivers around Dhaka, Bangladesh

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stations** | **Water content** (%) | | **Particle size distribution** (%) | | | | | |
| **Moisture** | | **Sand** | | **Silt** | | **Clay** | |
| Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy |
| S1 (Dhaleshwari) | 30.69 | 32.47 | 16 | 22 | 51 | 43 | 28 | 35 |
| S2 (Dhaleshwari) | 32.41 | 30.11 | 16 | 11 | 62 | 62 | 27 | 26 |
| S3 (Dhaleshwari) | 30.14 | 30.58 | 57 | 47 | 30 | 26 | 17 | 23 |
| S4 (Dhaleshwari) | 29.58 | 31.62 | 71 | 59 | 18 | 27 | 13 | 18 |
| S5 (Dhaleshwari) | 33.78 | 32.84 | 75 | 61 | 19 | 24 | 9 | 10 |
| S6 (Dhaleshwari) | 31.45 | 30.92 | 69 | 65 | 23 | 8 | 15 | 25 |
| S7 (Dhaleshwari) | 30.98 | 34.52 | 15 | 12 | 63 | 65 | 28 | 25 |
| S8 (Turag) | 30.74 | 35.80 | 9 | 15 | 52 | 53 | 43 | 31 |
| S9 (Turag) | 33.67 | 32.26 | 16 | 19 | 25 | 29 | 63 | 51 |
| S10 (Turag) | 31.47 | 33.18 | 7 | 11 | 60 | 57 | 30 | 35 |
| S11 (Buriganga) | 30.19 | 36.46 | 72 | 55 | 21 | 25 | 17 | 19 |
| S12 (Buriganga) | 31.47 | 34.51 | 16 | 14 | 28 | 29 | 58 | 56 |
| S13 (Balu) | 33.58 | 35.79 | 75 | 68 | 19 | 22 | 9 | 11 |
| S14 (Balu) | 34.90 | 37.18 | 18 | 20 | 54 | 43 | 30 | 35 |
| S15(Shitalakshya) | 35.64 | 37.24 | 12 | 15 | 63 | 63 | 28 | 25 |
| S16(Shitalakshya) | 32.15 | 38.75 | 15 | 15 | 28 | 30 | 61 | 58 |
| S17(Shitalakshya) | 30.28 | 34.56 | 18 | 13 | 27 | 31 | 59 | 51 |
| Mean ± SD | 31.94±1.7 | 34.04±2.5 | 33.94±2 | 30.70±21 | 37.82±17 | 37.47±16 | 31.47±18 | 31.41±14 |

**Particle size distribution**

The sand, silt and clay content of the studied river sediments ranged from 7-75%, 18-63% and 9-63% during winter and 11-68%, 8-65% and 10-58% during rainy season, respectively (Table 12). Particle size analysis revealed an overall dominance of mud (silt and clay). It is suggested that this high mud content was due to the low fluvial discharge which could have facilitated flocculation and subsequent settling of suspended particles (Nair *et al*., 1982). Substantial changes in the concentration of silt and sand were found during the winter and rainy seasons at stations 6 and 11 (Table 12). The difference could have been formed by sedimentation processes (Nair *et al*., 1982). Minor variation in the concentration of clay content was recorded during both seasons at all stations (Table 12). Sand is a loose granular material formed by the disintegration of rock, while silt is a dust-like sediment material transported and deposited by water, ice, and wind.

**Total Iron**

The total iron (Fe) content of the studied river sediments ranged from 25780 to 47390 mg kg-1 during the winter and from 23970 to 50390 mg kg-1 during the rainy season, as shown in Figures 13. The maximum Fe content was observed at station 10 in the Turag river during both seasons. The reference value of Fe in the Earth’s crust is 30890 mg/kg (Turekian and Wedepohl, 1961) and the measured Fe content in the present study exceeded the reference level. Iron is the most abundant transition metal in the Earth’s crust, yet it is not commonly reported as a soil or sediment pollutant (Zhang *et al*., 2016). But sediments may accumulate pollutants as sinks or release them as a secondary source. A previous study reported that sediments in the Nanfei river in eastern China were predominantly affected due to the contribution of the iron–steel manufacturing industry (Zhang *et al*., 2016).

**Figure 13: Iron (Fe) content of the studied river sediments during the winter and rainy season**

|  |  |  |
| --- | --- | --- |
| **Stations** |  | |
| **Fe (mg/kg)** | |
| Winter | Rainy |
| S1 (Dhaleshwari) | 29400 | 26700 |
| S2 (Dhaleshwari) | 32100 | 34970 |
| S3 (Dhaleshwari) | 27970 | 23970 |
| S4 (Dhaleshwari) | 25780 | 23990 |
| S5 (Dhaleshwari) | 36480 | 35130 |
| S6 (Dhaleshwari) | 35130 | 38700 |
| S7 (Dhaleshwari) | 38900 | 43480 |
| S8 (Turag) | 44210 | 45600 |
| S9 (Turag) | 43980 | 47900 |
| S10 (Turag) | 47390 | 50395 |
| S11 (Buriganga) | 40100 | 42650 |
| S12 (Buriganga) | 44600 | 46870 |
| S13 (Balu) | 30460 | 32700 |
| S14 (Balu) | 31790 | 26320 |
| S15(Shitalakshya) | 33460 | 30790 |
| S16(Shitalakshya) | 34100 | 36500 |
| S17(Shitalakshya) | 26710 | 25110 |
|  |  |  |

**4.2 Concentration of heavy metals in river sediment**

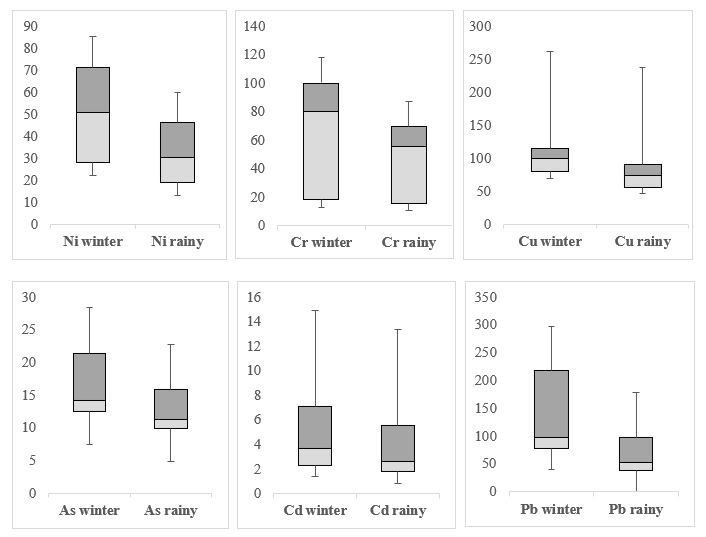
The mean concentration of Chromium (Cr), Nickel (Ni), Copper (Cu), Arsenic (As), Cadmium (Cd) and Lead (Pb) in sediments of the studied five rivers is presented in Table 14. The seasonal variation and distribution of these heavy metals are presented in Figure 14 and Table 14. A wide range of values for metal concentrations was observed among the sampling stations. Factors such as geomorphological setup, land runoff, high amount of municipal sewage, industrial wastewater together with organic detritus might have played a vital role in the variation of metals (Rahman *et al*., 2019). Metals concentrations in sediment during winter season were higher than the rainy season. This may be due to the flushing of the metals from rather immobilized deposits like domestic and industrial sludge in rainy season (Ali *et al*., 2018; Guangming *et al*., 2018).

**Table 14: Total concentration of heavy metals (mg/kg \*) in sediment collected from the studied five rivers around Dhaka, Bangladesh.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Heavy metals concentration** (mg kg-1) | | | | | | | | | | | | |
| **Stations** | **Cr** | | **Ni** | | **Cu** | | **As** | | **Cd** | | **Pb** | |
| Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy | Winter | Rainy |
| S1 (Dhaleshwari) | 106.58 | 92.69 | 34.35 | 19.18 | 69.95 | 40.34 | 9.12 | 7.96 | 4.43 | 2.66 | 105.9 | 50.73 |
| S2 (Dhaleshwari) | 104.28 | 88.40 | 27.10 | 17.21 | 75.12 | 41.56 | 13.79 | 9.88 | 3.82 | 2.97 | 96.14 | 38.90 |
| S3 (Dhaleshwari) | 89.77 | 66.92 | 59.33 | 37.52 | 71.13 | 49.47 | 26.17 | 15.48 | 2.95 | 2.10 | 77.36 | 32.79 |
| S4 (Dhaleshwari) | 71.55 | 55.56 | 49.17 | 26.08 | 92.34 | 69.77 | 25.35 | 18.77 | 2.36 | 1.79 | 90.48 | 43.40 |
| S5 (Dhaleshwari) | 100.15 | 64.50 | 50.68 | 30.62 | 100.22 | 73.19 | 28.37 | 20.96 | 2.10 | 1.45 | 79.10 | 53.55 |
| S6 (Dhaleshwari) | 86.20 | 60.35 | 23.32 | 11.72 | 189.14 | 98.28 | 14.20 | 10.42 | 1.50 | 0.82 | 63.44 | 37.88 |
| S7 (Dhaleshwari) | 105.53 | 69.37 | 22.18 | 14.95 | 112.23 | 96.72 | 21.37 | 19.88 | 1.36 | 0.97 | 40.55 | 33.47 |
| S8 (Turag) | 18.19 | 15.70 | 81.17 | 40.76 | 100.19 | 73.87 | 12.54 | 11.36 | 3.69 | 2.17 | 233.47 | 98.10 |
| S9 (Turag) | 17.16 | 12.74 | 85.22 | 39.43 | 105.64 | 87.20 | 14.23 | 10.78 | 5.14 | 3.60 | 250.11 | 170.4 |
| S10 (Turag) | 13.56 | 11.13 | 57.59 | 47.01 | 98.65 | 80.78 | 19.87 | 18.90 | 2.90 | 2.79 | 217.8 | 108.6 |
| S11 (Buriganga) | 93.30 | 74.47 | 71.63 | 49.94 | 177.37 | 141.4 | 12.81 | 9.88 | 7.10 | 5.56 | 259.10 | 155.4 |
| S12 (Buriganga) | 118.10 | 86.82 | 79.25 | 55.88 | 261.10 | 147.9 | 9.32 | 7.98 | 9.10 | 7.94 | 297.40 | 177.9 |
| S13 (Balu) | 17.11 | 10.37 | 39.41 | 29.73 | 75.15 | 56.47 | 7.49 | 6.67 | 2.31 | 1.96 | 64.10 | 35.98 |
| S14 (Balu) | 12.90 | 9.44 | 25.78 | 21.94 | 79.57 | 53.71 | 8.53 | 6.90 | 1.53 | 1.15 | 59.80 | 31.48 |
| S15(Shitalakshya) | 80.03 | 51.37 | 28.10 | 16.78 | 105.20 | 71.89 | 20.68 | 15.71 | 9.11 | 8.70 | 96.87 | 76.52 |
| S16(Shitalakshya) | 62.13 | 40.75 | 71.22 | 46.14 | 115.48 | 85.56 | 19.83 | 13.92 | 14.93 | 10.16 | 190.40 | 98.47 |
| S17(Shitalakshya) | 58.80 | 44.82 | 69.53 | 50.63 | 169.29 | 91.33 | 21.77 | 15.84 | 12.70 | 9.42 | 210.65 | 95.44 |
| Ranges | 12.9 – 118.1 | 9.44 –92.69 | 22.18 – 85.22 | 11.72 – 55.88 | 69.95 – 261.1 | 40.3 – 147.9 | 7.49 – 28.37 | 6.67 – 20.96 | 1.36 – 14.93 | 0.82 – 10.16 | 40.55 – 297.4 | 31.4 – 177.9 |
| Mean±SD | 67.9±36 | 50.3±28 | 51.4±21 | 32.6±13 | 117.5±50 | 79.9±29 | 16.7±6 | 13.1±4 | 5.1±3 | 3.8±2 | 143.1±73 | 78.7±41 |

\*based on dry weight

The trends in metal concentrations found in this study agreed with the trend observed in Pearl River sediment in China (Cheung *et al*., 2003) and also with the results reported by the Hong Kong Environmental Protection Department (EPD, 1995). Pb concentration (ranging from 40.55 to 297.4 mg kg-1 during winter season and 31.4 to 177.9 mg kg-1 during rainy season) of the present observation was much higher than that of the threshold effect level (TEL) (35 mg kg-1), set by MacDonald *et al*. (2000). It was apprehended from the observation that high level of Pb in the river sediment was indicative of the fact that the source of higher Pb content was not only the industrial effluents but also some other outlets. Long-term accumulation of Pb from motor vehicles emission might be one of the major sources of higher Pb content in the water and sediment (Islam *et al*., 2018). From the observation, it would mean that the sediment of the studied five rivers is not safe for humans through ingestion and dermal contact, as well as for the safe growth of aquatic organisms in terms of its Pb content. The concentrations of heavy metals at station 12 and station 11 in the Buriganga river and followed by station 17 in the Shitalakshya river, station 8 and station 9 in the Turag river were much higher than others stations indicates that river flow and rapid urbanization activities drove heavy metals contamination in the river sediment (Liu *et al*., 2016, Liu *et al*., 2020).



**Figure 14: Heavy metals distribution in sediment collected from the five rivers around Dhaka, Bangladesh (winter and rainy season)**

Metal concentrations in sediment samples followed the descending order of station 12> station 11> station 17> station 9> station 16> station 8> station 10> station 5> station 6> station 15> station 4> station 1> station 3> station 2> station 7> station 13> station 14. Interestingly, this descending order of heavy metals among the sampling sites did not follow a downstream pattern, which might be due to the metal input in sediments from site-specific characteristics, such as flow of the river, pollution sources, and waste disposal from the urban system (Jolly *et al*., 2016; Ali *et al*., 2019; Jolly *et al*., 2019).

The urban activities like industrial effluent discharges, municipal waste water, household garbage and urban runoff of Dhaka megacity are the main causes of higher metal input at the investigated sampling stations. The average concentration of heavy metals in sediments were in the decreasing order of Pb>Cu>Cr>Ni>As>Cd. In the present study, the highest level of Cr was observed at S12 station (118.1 and 86.82 mg/kg, winter and rainy season, respectively) (Table 14) in the Buriganga river. An elevated concentration of Cr was observed at stations (S1–S7), which might be due to the effluents discharged from the tanneries and urban sewage system as the main sources of Cr in the Dhaleswari river systems of the relocated Hemayetpur tannery estate (sampling stations S1–S7) in northwestern Dhaka city, Bangladesh (Ahsan *et al*., 2019; Hossain *et al*., 2021). The liquid waste from the tannery industries ultimately goes into the water and sediments of the Dhaleshwari river and causes immense harm to the aquatic life and biota in this river (Hasan *et al*., 2020). The river water, mixed with the pollutants, flows downstream into the Buriganga river and consequently, the Buriganga river water and sediments continue to get polluted by it. Hence, the waste discharged from tannery industry was most probably responsible for elevated Cr level in the exposed sediment (Jolly *et al*., 2021). With an environment-friendly well-equipped tannery estate remaining elusive, the prospects for growth of the tannery industry itself might be in jeopardy.

The Cr concentrations of the present study were compared to other study conducted in Bangladesh and other countries (Table 15). Chromium concentration in sediments of the present study was found higher than the other studies (Datta and Subr, 1998; Cheung *et al*., 2003; Karbassi *et al*., 2008; Liu *et al*., 2016). The acceptance of sediment quality guidelines (SQGs) by numerous specialists for toxicological assessment of sediment related metals has fostered the supervision of aquatic conditions, safety of biota, and the accomplishment of ecological environmental policies and guidelines (Edyta *et al*., 2010). However, SQGs including threshold effect level (TEL), probable effect level (PEL), effect range low (ERL), severe effect level (SEL), lowest effect level (LEL), etc., were applied to evaluate the possible biotic influence of metals estimated in the sediment samples. Chromium concentration of the present study was also compared to several sediment standard quality guidelines and it was evident that Cr concentration level was higher than ASV, CUC, TRV, LEL, TEL, PEL, SEL and ERL (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) values (Table 15).

**Table 15: Comparison of metal concentration in sediment (mg/kg dry weight) with some reference values and some reported values**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Study location | Cr | Ni | Cu | As | Cd | Pb | References |
| Dhaleswari river, Bangladesh | 55-106 | 11-59 | 40-189 | 7-28 | 0.82-4 | 32-105 | This study |
| Turag river, Bangladesh | 11.1-18.1 | 39-85 | 73-105 | 10-19 | 2.1-5 | 98-250 | This study |
| Buriganga river, Bangladesh | 74-118 | 49-79 | 141-261 | 71-12 | 5-9 | 155-297 | This study |
| Balu river, Bangladesh | 9.4-17.1 | 21-39 | 53-79 | 6-8 | 1.1-2 | 31-64 | This study |
| Shitalakshya river, Bangladesh | 40.7-80 | 16-71 | 71-169 | 13-21 | 8.7-14 | 76-210 | This study |
| Pearl river, China | 23-79 | 10-37 | 35-230 | 4-22 | 1-8.47 | 23-176 | Cheung *et al*. (2003) |
| Shur River, Iran | 41–128 | NA | 30–102 | 14–48 | NA | 26–78 | Karbassi *et al*. (2008) |
| Luanhe river estuary, China | 10-35 | 14-50 | 2-110 | 4.5-42 | 0.2-30 | 11.67 | Liu *et al*. (2016) |
| Jamuna River, Bangladesh | 110 | 33 | 28 | NA | 1.5 | 19 | Datta and Subr (1998) |
| ASV (Average shale value) | 90 | 68 | 45 | 13 | 0.3 | 20 | Turekian and Wedepohl (1961) |
| CUC (Continental upper crust) | 92 | 47 | 28 | 5 | 0.09 | 17 | Rudnick and Gao (2003) |
| TRV (Toxicity reference value) | 26 | 16 | 16 | 6 | 0.6 | 31 | USEPA (2011) |
| LEL (Lowest effect level) | 26 | 16 | 16 | 6 | 0.6 | 31 | MacDonald *et al*. (2000) |
| TEL (Threshold effect level) | 37 | 18 | 36 | 5.9 | 0.59 | 35 | MacDonald *et al*. (2000) |
| PEL (Probable effect level) | 90 | 36 | 108 | 17 | 3.5 | 91 | MacDonald *et al*. (2000) |
| SEL (Severe effect Level) | 110 | 75 | 110 | 33 | 10 | 250 | MacDonald *et al*. (2000) |
| ERL (Effect Range Low) | 81 | NA | 34 | NA | 9.6 | 46.7 | MacDonald *et al*. (2000) |

*“NA” Not available.*

The mean concentration of Ni in sediment of the studied five rivers was found as 51.4±21 and 32.6±13 mg kg-1 in the winter and rainy season, respectively (Table 14). The highest concentration of Ni was observed at S9 station 85.22 mg kg-1 and 11.72 mg kg-1 at station 6, during winter and rainy season, respectively. Actually, this S9 sampling station was municipal waste throwing area in Turag river. Higher amount of Ni was found at the site near to the district urban area, which indicates the higher input of Ni in sediment that might be originated from urban and industrial wastes (Mohiuddin *et al*., 2011). Nickel concentration in sediments of the present study was higher than the other studies conducted in Bangladesh and other region of the world (Datta and Subramanian, 1998; Karbassi *et al*., 2008; Liu *et al*., 2016; Baki *et al*., 2018; Jolly *et al*., 2019). Ni concentration of the present study was also compared to the several sediment quality guidelines and it was found that Ni concentration level for the present study was higher than ASV, CUC, TRV, LEL, TEL, SEL, PEL and ERL (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) in the winter season and lower when compared to the rainy season (Table 15).

The mean concentration of Cu in sediment of the studied five rivers was found 117.5±50 and 79.9±29 mg kg-1 for the winter and rainy season, respectively (Table 14). The highest concentration of Cu was observed at S12 (261.1 mg kg-1) in the Buriganga river during winter and the lowest was observed at S1 (40.34 mg kg-1) in the Dhaleswari river during the rainy season (Table 14). The higher level of Cu was found in the study area which is may be the result of anthropogenic activities such as vehicle and coal combustion emissions (Liu *et al*., 2016), car lubricants (Mohiuddin *et al*., 2011) and natural phenomenon such as metal contents of rocks and parent materials, processes of soil formation (Yi *et al*., 2011; Baran *et al*., 2019). Copper concentration in sediments of the present study was higher than the other studies (Datta and Subramanian, 1998; Karbassi *et al*., 2008; Liu *et al*., 2016; Baki *et al*., 2018; Jolly *et al*., 2019; Rahman *et al*., 2021; Jolly *et al*., 2021). Cu concentration of the present study was also compared to several sediment standard quality guidelines and it was found that Cu concentration level for the present study was higher than TRV, ASV, SEL, PEL, LEL, TEL, CUC and ERL (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) in the winter season and lower when compared to the rainy season (Table 15).

In the present study, the concentration of As in five rivers sediment ranged from 7.49 to 28.37 mg kg-1 and 6.67 to 20.96 mg kg-1 during the winter and rainy season, respectively (Table 14). The highest concentration of As was observed at S5 (28.37 mg kg-1) in the Dhaleswari river sediment during winter and the lowest was observed at S13 (6.67 mg kg-1) in the Balu river sediment during the rainy season. The mean concentration of As was found 16.7±6 and 13.1±4 mg kg-1 for the winter and rainy season, respectively (Table 14). Recently, the anthropogenic activities such as treatment of agricultural land with arsenical pesticides (Zheng *et al*., 2008; Jolly *et al*., 2019), 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 (Baeyens *et al*., 2007, Baran *et al*., 2019). Arsenic concentration in river sediments of the present study were compared to other study conducted in Bangladesh and other countries and found that As concentration was relatively higher in the present study than the previous studies (Qing *et al*., 2015; Liu *et al*., 2016; Baki *et al*., 2018; Jolly *et al*., 2019; Rahman *et al*., 2021; Jolly *et al*., 2021; Yi *et al*., 2021). Arsenic concentration of the present study was also compared to the several sediment quality guidelines and it was found that As concentration level for the present study was higher than TRV, ASV, SEL, PEL, LEL, TEL, CUC and ERL (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) in the winter season and lower when compared to the rainy season (Table 15).

The concentration of Cd in the studied five rivers sediment ranged from 1.36 to 14.93 mg kg-1 and 0.82 to 10.16 mg kg-1 during the winter and rainy season, respectively (Table 14). The highest concentration of Cd was observed at S16 (14.93 mg kg-1) in the Shitalakshya river sediment during winter and the lowest was observed at S6 (0.82 mg kg-1) in the Dhaleswari river sediment during the rainy season. The mean concentration of Cd was found 5.1±3 and 3.8±2 mg kg-1 for the winter and rainy season, respectively (Table 14). Higher Cd concentration in the sediments of the studied rivers might be related to industrial activity., i.e., battery, alloys, coating (electroplating) production, (Ahsan *et al*., 2019; Ali *et al*., 2019) atmospheric emission (Rahman *et al*., 2021) and Cd plated items (Qing *et al*., 2015). Higher Cd levels during winter might be attributed to the variation in water capacity of the river, where water input to the river is generally limited in winter, resulting in the precipitation of contaminants in the sediment (Ali and Khan, 2017; Nargis *et al*., 2021). Cadmium concentration in sediments of the present study were compared to the other studies conducted in Bangladesh and other regions of the world and found that Cd concentration was higher in the present study (Datta and Subramanian, 1998; Chen *et al*., 2012; Qing *et al*., 2015; Rahman *et al*., 2021; Nargis *et al*., 2021). Cadmium concentration in the present study was also compared to the several sediment quality guidelines and it was found that Cd concentration level for the present study was higher than TRV, ASV, LEL, TEL and CUC (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) in the both seasons and lower when compared to PEL, SEL and ERL as mentioned in Table 15.

In the present study, the concentration of Pb in five rivers sediment ranged from 40.55 to 297.4 mg kg-1 and 31.4 to 177.9 mg kg-1 during the winter and rainy season, respectively (Table 14). The highest concentration of Pb was observed at S12 (297.4 mg kg-1) in the Buriganga river sediment during the winter and the lowest was recorded at S14 (31.4 mg kg-1) in the Balu river sediment during the rainy season. The mean concentration of Pb was found 143.1±73 and 78.7±41 mg kg-1 for the winter and rainy season, respectively (Table 14). The highest level of Pb in sediments at S12 site may be due to the effects of point and nonpoint pollution sources, such as textile and dyeing industries waste water in the Shaympur area of the Buriganga river, where the investigated station was located, municipal runoffs, atmospheric deposition, leaded gasoline, chemical manufacturing, and steel works in the urban areas of Dhaka megacity (Guangming *et al*., 2018; Jolly *et al*., 2021). In sediment, Pb was observed notably higher in winter season compared to the rainy season which indicates that there was a considerable change in organic profile by resuspension and/or deposition or by changes in redox and pH conditions (ElNemr *et al*., 2007; Jin-Jun *et al*., 2021). Lead concentration in the present study was found higher than some other studies (Cheung *et al*., 2003; Chen *et al*., 2012; Qing *et al*., 2015; Jolly *et al*., 2019; Jin-Jun *et al*., 2021). According to the sediment quality guidelines, Pb concentration level for the present study was higher than ASV, TRV, LEL, PEL, SEL, TEL, CUC and ERL (Turekian and Wedepohl, 1961; USEPA, 2011; MacDonald *et al*., 2000; Rudnick and Gao, 2003) in the both seasons.