Evaluation of water quality parameters and Humic substance status of Bangshi, Dhaleshwari and Padma Rivers in Bangladesh

Sharmin Yousuf Rikta¹, Md. Shiblur Rahaman², Jakia Jerin Mehjabin¹, Md. Khabir Uddin¹, Mohammad Mahbub Kabir¹ and Shafi Mohammad Tareq¹³
1- Department of Environmental Sciences, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh.
2- Department of Environmental Science and Disaster Management, Noakhali Science and Technology University, Noakhali-3814, Bangladesh.
3- School of Biosciences, The University of Nottingham, Jalan Broga, Semenyih, Selangor Darul Ehsan, Malaysia.
rikta.env@gmail.com
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ABSTRACT

Present study was designed to evaluate the physicochemical, biological and humic substances status of the Bangshi, Dhaleshwari and Padma rivers which are located at the central part of Bangladesh. These rivers were selected as study area due to the presence of different effluent discharging industries in surrounding areas as well as for their ecological and local economy contributions. Dissolved Oxygen (DO), pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS), turbidity, Electrical Conductivity (EC), Total Coliform and Total Organic Carbon (TOC) were determined to evaluate the physicochemical and biological water quality and compared with Department of Environment (DoE), Government of Bangladesh, surface water quality standard. Analyses of these parameters indicates high pollution load in the rivers although samples were collected in the rainy season. Dissolves organic matter (DOM) fluorescence was used to determine the humic substance status of the rivers. Humic substances or organic matter pollution was evident by the presence of protein like substances, humic and fulvic acids in the samples. It is high time to design effective seasonal river water quality monitoring program and take necessary measures to protect environment and ensure sustainable human development.

Keywords: Bangshi River; Dhaleshwari River; padma river; water quality; Humic substances; Bangladesh.

1. Introduction

The water environment quality issue is a subject of current concerned with the expansion of economy in any country (Zhang et al., 2009) especially, in Bangladesh where water resources deterioration and environmental degradation occurs continuously with enormous level of industrial agglomeration and urbanization stoop throughout the country. The water quality is determined by means of its physical, chemical and biological properties. Polluted surface water does not ensure a balanced ecosystem in which living things and the environment can not cooperate constructively with one another and water quality noticeably plays a vital role in this association (Ntengwe, 2006), as it is a key to preservation of a well-balanced environment. The environment, economic prosperity and developments of Bangladesh all are extremely governed by surface water and its regional and seasonal accessibility. Spatial and seasonal distribution of surface water is receptive to the monsoon climate and physiography.
of the country. The surface water of Bangladesh is susceptible to pollution from raw industrial and municipal wastewater, runoff from chemical industry and agricultural fields, and oil and lube spillage from the activities of sea and river ports (Bhuiyan et al., 2011).

Bangladesh is a land of river and lies at the deltaic or lower region of the three mighty river systems, the Ganga-Padma, the Brahmaputra-Jamuna and the Barak-Meghna. Perennial streams, beals and estuaries cover about 8 percent of the land area (Paul and Haq, 2010). Rivers have significant multi-usage components, such as sources of drinking water, irrigation, fishery and energy production and these greatly dependent on water quality, so water quality should be maintained at a definite level (Iscen et al., 2008). Surface water is playing a significant role to improve and facilitate quality of life of the human civilization. The quality of water resources depends on a substantial number of physicochemical and biological parameters and the extent and cause of any pollution load.

So, the assessment and monitoring of these parameters is inevitable to measure the water quality (Reddi et al., 1993). But unfortunately in Bangladesh the surface water bodies and surface water quality are being deteriorated day by day. The population outburst and escalating demands have created additional pressure on natural water resources like rivers and lakes. The altered water quality parameters have dangerous effects on aquaculture, fisheries and agricultural production (Singh et al., 2002). The assessment of water resources quality is a significant feature for any kind of developmental activities in any region or any country because rivers, lakes and artificial reservoirs are being used for water supply in almost all human and animal consumptive use purposes (Jackher and Rawat, 2003). Chemical composition of water depends on several hydrogeochemical processes functioning in a define environment so proper and effective measurement and monitoring of water quality parameters offer important information for water pollution abatement as well as water resources management in a sustainable way (Matthieu et al., 2005; USEPA, 1983).

2. Materials and Methods

2.1 Sample collection

Water samples were collected from the Padma, Dhaleshwari and Bangshi rivers, along 20km stretch of each of the river in 2km sampling interval. 10 samples were collected from each river and total 30 samples were collected between July to August. These rivers are located in the central part of Bangladesh and affected by different pollution loads. Padma is a major river in Bangladesh. It is the main distributary of the Ganges, flowing generally southeast for 120 kilometres to its confluence with the Meghna River near the Bay of Bengal (Allison, 1998). This river is a rich source of fisheries for the country and also a drinking and irrigation water source for the people living around it.

The Dhaleshwari River is a distributary, 160 kilometres long, of the Jamuna River in central Bangladesh (Majumdar, 1971). This river is subjected to industrial pollutions. This is also being used as irrigation and drinking water source by the local population. The Bangshi river is one of the most important rivers in Dhaka, the capital city of Bangladesh. It is an important tributary of the Dhaleshwari River. It originates from the foot of the madhupur tract. The river flows through the eastern part of Mymensingh district and travels southwards to fall into the Dhaleshwari after entering Dhaka district near the junction of Savar and Kaliakair upazilas. This river is heavily polluted by the industrial effluent discharged by the Dhaka Export Processing Zone (DEPZ).
2.2 Water quality parameters analyses

Physicochemical properties such as pH, Dissolved Oxygen (DO) and Total Dissolved Solid (TDS) were measured using pH meter (HM- 30P, pH Meter), DO Meter (970 DO2 Meter, Jenway, UK) and TDS meter (HANNA, HI 8734) respectively. Electrical Conductivity (EC) and turbidity were measured using EC Meter (CM- 31P) and Turbidity Meter (HANNA, HI 93703). Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were measured using 5-Days BOD test and Closed Reflux Colorimetric method respectively. Total Coliform of the samples was measured using Spread Plat technique with MacConkey Agar. Total Organic Carbon (TOC) was measured using Total Organic Carbon Analyzer (TOC-L CPN, Shimadzu, Japan).

2.3 Measurement of Humic substances

To remove the suspended materials from the samples, they were filtered using 0.45μm filter paper. The fluorescence intensity was determined using a Fluorescence Spectrophotometer (F- 4600, Hitachi, Japan). Excitation-Emission Matrices (EEMs) were created using FL Solutions software. To generate an EEM, excitation wavelengths were scanned from 225 to 500 nm in 5 nm steps and the emitted fluorescence detected between 240 and 600 nm in 2 nm steps. Excitation and emission slit widths were 5nm.

3. Results and discussions

3.1 Water quality parameters

Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties. Water quality parameters of Bangshi, Dhaleshwari and Padma river are presented in Table 1.

| Table 1: The water quality parameters of Bangshi, Dhaleshwari and Padma Rivers. |
|-----------------|-----------------|-----------------|-----------------|
| Parameters      | DoE Bangshi     | DoE Dhaleshwari | DoE Padma       |
|                 | Standa rdl Mean | Range Mean      | Range Mean      |
| pH              | 6-9 7.02 5.98-7.95 | 7.64 7.27-8.31 | 7.84 7.67-8.03 |
| DO (mg/L)       | >4.5-8 1.7 1.2-2.1 | 5 3.2-5.99 | 7.57 6.94-7.98 |
| BOD (mg/L)      | 50 - 113 56-173 | 3.77 4.67-2.95 |
| TDS (mg/L)      | 2100 1301 1040-1580 | 982.5 634-1265 | 420.6 255-370 |
| EC (μS/cm)      | 1200 2644 1980-3980 | 198.5 140-395 | 247.6 183-298 |
| Turbidity (FTU) | 10 189 120-287 | 99.5 59-163 | 29.02 23.89-35.41 |
| Total Coliform (CFU/100ml) | 1000 - 825 260-1880 | 1125 755-1390 | 1125 755-1390 |
| TOC (mg/L)      | - 69 50.88-82.82 | 3.17 2.86-3.77 |
| COD (mg/L)      | 200 145.2 133-156 | - - - - |

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3.2 Water quality status of the Bangshi River

The pH values of the Bangshi river varied from sampling place to sampling place. Figure 1 shows that, the pH value ranges from 7.95 to 5.98 and the average pH value is 7.02. The highest pH value was 7.95 at sampling site S10 and the lowest pH value was 5.98 at sampling site S3.

![Graphs showing pH, DO, TDS, EC, Turbidity, and COD values for 10 sampling sites of Bangshi River.](image)

**Figure 1:** The pH, DO, TDS, EC, Turbidity and COD values of 10 sampling sites of Bangshi River.

This might be due to the local chemistry of water body and receiving of acidic effluent from surrounding industries at sampling site S3. Dissolved Oxygen (DO) values of the river were in a critical situation. DO values of the river ranged from 2.1mg/L to 1.2mg/L and the average value was 1.7mg/L. The highest DO was at sampling site S8 and lowest DO was at sampling site S6. But all the values were below the DoE standard level indicating serious threat to aquatic life. Lower level of DO in Bangshi river may result from the presence of oxygen demanding organic substances discharged from surrounding industries. Total Dissolved Solid (TDS) concentration varied from 1580mg/L to 1040mg/L and the average...
TDS concentration was 1301mg/L. The highest TDS value was recorded at sampling site S4 and the lowest TDS value was recorded at sampling site S5. The TDS mainly indicates the presence of various kinds of minerals like ammonia, nitrite, nitrate, phosphate, alkalis, some acids, sulphates and metallic ions which are comprised of both colloidal and dissolved solids in water. Figure 1 shows that sampling site S5 had a low TDS value which means that sampling site may receive a huge amount of fresh water runoff from surrounding catchment area by canal. The Electrical Conductivity (EC) values range from 3980μS/cm to 1980μS/cm and the average EC is 2644μS/cm that indicates the exceedance of the permissible limit of the surface water quality standards (DoE, 1997). The Turbidity values also indicate that the water was highly turbid. Turbidity of the Bangshi river ranged from 287FTU to 120FTU and the average turbidity was 189FTU. The sampling site S6 was highly turbid and its turbidity was 287FTU. COD values of the Bangshi river at different sampling sites showed variation. The highest COD value 156mg/L was recorded at sampling site S10 and the lowest COD value 133mg/L was recorded at sampling site S4. The average COD value was 145.2 mg/L. Relatively higher COD values indicate the toxic condition and the presence of biologically resistant oxygen demanding chemicals like synthetic dyes (as the river water was coloured due to discharge from DEPZ) and noxious substances.

3.3 Water quality status of the Dhaleshwari River

The pH values of the water samples collected from Dhaleshwari river were ranged from 8.31 to 7.27 and the average pH value was 7.64. The average pH value showed that water was slightly alkaline and it was very useful for fresh water organisms. The normal range for pH in surface water systems is 6.5 to 8.5 and for groundwater systems is 6 to 8.5 (DoE, 1997). DO values varied sampling site to sampling site. DO values ranged from 5.99mg/L to 3.2mg/L and the average DO value was 5.0mg/L. It indicates that, DO value was excellent in this river. According to environmental quality standard (EQS), the following requirements for DO are prescribed; 6mg/L for drinking, 4 to 5mg/L for recreation and 4 to 6 mg/L for fish and livestock.

Biochemical Oxygen Demand (BOD) values exceed the limit of surface water quality standards (DoE, 1997). The permissible limit for BOD for inland surface water is ≤50 mg/L. Figure 2 showed that highest BOD value was 173 mg/L at sampling site S2 and the lowest BOD value was 56 mg/L at sampling site S7. Exceedance of BOD value might be due to the discharge from nearby industries, runoff of animal manures to the water body and the presence of hanging latrines on river banks. TDS values were ranged from 1265mg/L to 634 mg/L and the average TDS value was 982.5 mg/L. TDS values of the Dhaleshwari river were below the DoE standard of Bangladesh (2100 mg/L).

The EC of the water samples indicates the total concentration of saline substances and is also an indicator of salinity (Brady and Well, 2002). As most of the salts in the water are present in the ionic forms, capable of conducting current, therefore, conductivity is a good and rapid measure of the total dissolved solids. Dhaleshwari river water EC values were within the permissible limit of surface water quality standards (DoE, 1997). The highest EC value was 395μS/cm at sampling site S1 and the lowest value was 140μS/cm at sampling site S4 (Figure 3). Conductivity of water varies directly with the temperature and is proportional to its dissolved mineral matter content (Waghmare et al., 2012). Turbidity refers the transparency among different layers of aquatic system. Turbidity in water is caused by suspended and colloidal matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms.
Turbidity values were ranged from 163 to 59FTU and the average value was 99.5FTU. Total Coliform is known as an indicator for pathogenic organisms in any system. They are usually present in surface water, soil and feces of humans and animals. Analytical result showed that the total coliform of the Dhaleshwari river varied from 1880 CFU/100ml to 260 CFU/100ml and the average total coliform was 825 CFU/100ml (Figure 3), which was below surface water quality standards (DoE, 1997). Total Organic Carbon (TOC) of river water was determined. Organic matter content is typically measured as TOC, which is fundamental component of the carbon cycle. Organic matter in water consists of thousands of components including macroscopic particles, colloids, dissolved macromolecules and specific compounds. TOC values of this river water samples ranged from 82.82 mg/L to 50.88 mg/L and the average TOC value was 69 mg/L.

### 3.4 Water quality status of the Padma River

Water quality parameters showed that Padma river was not polluted during the sampling season. All the parameters were within the permissible limit recommended by DoE, Government of Bangladesh, except turbidity and total coliform. Figure 4 showed that the highest pH value was 8.03 at sampling site S5 and the lowest pH was 7.67 at sampling site S4. Average pH value was 7.84 which indicates that water was slightly alkaline and it was very useful for fresh water organism and aquatic environment. DO values were ranged from 6.94mg/L to 7.98mg/L and the average DO was 7.57mg/L which implies the water condition was quite good because the water body contain sufficient amount of dissolved oxygen. BOD values ranged from 2.95mg/L to 4.67mg/L and the average BOD was 3.77mg/L.
Figure 3: The EC, Turbidity, Total Coliform and TOC values of 10 sampling sites of Dhaleshwari River.

Figure 4: The pH, DO, BOD and TDS values of 10 sampling sites of Padma River.
Figure 4 shows that the highest BOD was recorded at sampling site S3 and the lowest BOD at sampling site S8. Sampling site S3 might contain more organic content than any other sampling sites. This sampling site may receive organic contents from surrounding agricultural field. TDS of Padma river water ranged from 255mg/L to 370mg/L. The average TDS value was 310.6mg/L which was within the permissible limit of surface water quality standards. The maximum TDS value 370mg/L was recorded at sampling site S1 and the minimum TDS value 255mg/L was recorded at sampling site S10. Figure 4 shows that the TDS values were changing according to the sampling site variations in a decreasing trend.

The electrical conductivity (EC) of water indicates the total number of solids dissolved in water, that’s why the water TDS and EC are related with each other. The Figure 5 showed the same changing pattern of EC to sampling site to sampling site with TDS. The maximum EC value was recorded at sampling site S7 and the minimum EC was at sampling site S8. The average EC value was 247.6 µS/cm and ranged from 183 to 298 µS/cm. Turbidity is an optical characteristic of water and it indicates the relative clarity of a liquid. Turbidity also control the photosynthesis process in aquatic system. The turbidity values of Padma river were ranged from 23.89FTU to 35.41FTU and the average value was 29.02FTU. Figure 5 shows that Total Coliform ranges from 755 CFU/100ml to 1390 CFU/100ml and the average value of Total Coliform was 1125 CFU/100ml which exceed the limit of surface water quality standards (DoE, 1997). Total Coliform and Fecal Coliform are indicators for pathogenic organisms. The maximum Total Coliform was recorded at sampling site S3 and the minimum Total Coliform was recorded at sampling site S2. Sampling site S3 may receive huge amount of domestic wastes containing faecal matters to the river body and open defecation along the sides of river bank. TOC indicates the organic carbon content of any system. Figure 5 shows that the highest TOC value was 3.77mg/L at sampling site S4 and the lowest value was 2.86mg/L at sampling site S2. The average TOC value was 3.17mg/L for this river water.
4. Humic substance status of the Rivers

Possible organic contaminants or humic substance contents in the water samples of three rivers were characterized by three-dimensional excitation emission matrix spectroscopy (3DEEM). Dissolved organic matter (DOM) contents were identified using relative fluorescence intensity of DOM expressed in Raman unit (RU, nm⁻¹).

Figure 6: The EEM plots of (a) Bangshi, (b) Dhaleshwari and (c) Padma River water samples. Three fluorescence peaks in all the surface water samples were identified which were always detectable in 3DEEM analysis with two characteristic excitation and emission wavelengths, one major peak and another one as a minor peak (Figure 6). Humic and fulvic acids are important substances in environmental water as they can complex with metal ions in the water that could alter the transport and bioavailability of many toxic metals in the water systems (Zhao and Nelson, 2005).

In the water samples of Bangshi river protein like substances which are mainly tryptophan and tyrosine were found at Ex/Em= 250-280/280-380 nm. Humic and fulvic like substances were detected at Ex/Em= 350-470/370-560 nm and Ex/Em= 320-420/380-480 nm respectively which indicates the presence of organic substances. On the other hand in the water samples of Dhaleshwari river protein like substances were detected at Ex/Em= 250-260/290-390 nm. Humic and fulvic like substances were detected at Ex/Em= 320-480/360-560 nm and Ex/Em= 320-450/360-490 nm respectively. Peaks detected at Ex/Em= 275-295/350-370 nm in the water samples of Padma river clearly indicates the presence of organic matter (protein like) in the samples. For this river humic and fulvic acids peaks were detected at Ex/Em= 370-440/440-520 nm and Ex/Em= 350-365/425-450 nm respectively. These fluorescence EEMs are typical for organic substances (Baker and Curry, 2004). The EEM peaks detected in most of the samples indicates the presence of chromophoric organic substances.

5. Conclusion

River water quality monitoring is a vital issue in countries like Bangladesh where rivers are being degraded day by day without considering any ecological impacts. Physicochemical analyses evaluate the rivers are subjected to pollution although the load measured is not a actual scenario as the water samples were collected in rainy season when water was more diluted. It is important to design the seasonal monitoring programme and to take necessary
steps to solve the problems. It is high time to protect the ecological balance and ensure sustainable human development by maintaining a healthy river system across the country.

6. References


