Seasonal Variation of Water Quality Constituents in the Turag River

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Abstract: **Unplanned urbanization enhances environmental threats. Environmental threats increases water pollution that creates harmful impacts on the distribution of aquatic species. The present study is focused to evaluate the seasonal variation of water quality parameters in the Turagriver. Water samples were collected from 5 locations in north and south sides of the Turagriver during summer and winter seasons. The quality of water was found jeopardy. Dissolved oxygen (DO) of water samples were detected 4.9 to 5.7 mgL-1 during summer season. In winter, DO was found 0.78 to 0.95 mgL-1. The chemical oxygen demand (COD) was found higher in winter as compared to summer season. Heavy metals (Cr, Ni and Mn) in water samples were found higher than that of standard limit in both the seasons. Disposal of industrial wastewater was found to be the main causes for the pollution of water. It is suggested that disposal of wastewater should be treated properly before discharge into water bodies. Consequently, water will be contaminants free for community people and aquatic species that will help to protect of sustainable livelihood.**

Keywords: **Pollutions, industrial effluents, aquatic organisms, Heavy metals.**

I. INTRODUCTION

Water quality issues are one of the key problems throughout the world in the twenty-first century [1]. Due to climate change these problems are going to be more aggravated in the future, resulting in higher water temperatures, melting of glaciers, and an intensification of the water cycle [2], with potentially more floods and droughts on earth [3]. The most severe impact of water pollution is the lack of sanitation and safe drinking water which affects more than a third of the people in the world [4]. In addition, exposure to pathogens or to chemical toxicants via food chain is increasing because of irrigating plants with contaminated water and bioaccumulation of toxic chemicals by aquatic organisms, including seafood and fish or direct contact with polluted water during recreation. Surface water pollution has been drawing more attention for many decades [4].

Bangladesh has unplanned industries which are not operated according to proper effluent treatment strategies and untreated or partially treated effluent has been throwing into the nearby water body which demolishes the aquatic environment [5]. From manmade activities industrial effluents, agricultural runoffs, land runoffs, municipal wastes, hospital wastes and mine pollutions are the most common factors for influencing biogeochemistry of water body. The government of Bangladesh has focused on industrial development from the last decades for improving living standard of mass people and keeping a constant GDP growth more than 7%. Therefore, the extreme use of water for industrial purpose exerts pressure on surface water and thereby pollutes water resources as proper effluent treatment is not imposed [6].

The Turag River is the upper affluent of the Buriganga, a major river in Bangladesh. Main source of pollution of Turag river water are various consumer goods industries (soap and detergent), garments industries, pharmaceuticals byproducts, lots of tanneries, dyeing industries, aluminum industries, battery manufacturing, match industries, ink manufacturing industries, textile, paint, iron industries, pulp and paper factories, chemical factories, frozen food factories and steel workshop etc. Most of the industries discharge their effluents directly or indirectly into the Turag River without any precaution causing pollution of the surface water. Moreover, many sewerage and municipal sewage drainage system have become a dumping ground of all kinds of solid, liquid and chemical waste that polluted the river bank [7]. Consequently, hard mixture of hazardous chemicals, both organic and inorganic are released into Turag river water resulting in different chemical and biochemical reaction in the river system and thus deteriorate the water quality. For this reason, water causes the adverse effect of surrounding land and aquatic ecosystem as well as creates subsequent impact on the livelihood of the local community [8].

Fresh water, one of the vital elements of the earth, has a strong correlation with all kinds of lives for sustaining [9]. The strategies taken in Bangladesh for saving rivers from pollution have completely failed against recent industrial development [10]. This problem is intensified by unplanned urbanization, industrialization, changes of land use pattern and lack of public awareness. The Turag is an important river in Bangladesh that are flowing through the north side of Dhaka mega city. Rapid industrial growth has been increasing on the bank city of Gazipur at Tongi arena under the Bangladesh Master Plan-1959. A variety of industries like garments, textile, spinning, jute, metal industries, tobacco, pharmaceuticals, chemical, pesticides, food processing, tanneries and many more are located in this industrial zone. The rhythm of proper waste disposal and waste management system has not kept pace with this industrial growth. Therefore, the Turag has been a dumping station for this area and industrial zone. Considering the above idea, the present study was undertaken to analyze the selected water quality constituents in the Turag River during summer and winter seasons.

II. MATERIALS AND METHODS

2.1 Area and time frame of the study

For the selection of study area, a preliminary survey was carried out at two locations on the bank of Turag River. These locations were north side and south side of Turag River (200 m East from Turag Bridge). Five (5) points were selected in both north side and south side of Turag river for data collection based on some specific criteria like generation of large amount waste from near commercial activities, situation of local market, dumping and disposal of different wastes of fish, meat and vegetable processing and industrial wastewater. Disposal of industrial and municipal waste into the river body are the common practices in this study areas. Geographical coordinates of the selected study areas were23°52'56.7"N 90°24'07.0"E for north side and 23°52'54.8"N 90°24'07.2"E for south side of Turag river. The present study was conducted for 1 year (March, 2018 to February, 2019). Water samples and data collection were taken in both summer (March) and winter season (December) within the study period.

2.2 Data collection and sampling

For the collection of data five (5) points were selected in both north and south sides of the Turag River and water samples were collected from selected locations. Prior that plastic bottles were cleaned with 2% HNO3 solution. Water samples were collected at 0.5 m depth.

2.3 Water quality parameters

Various physical parameters of water samples such as color and odor, total suspended solid (TSS), total dissolved solid (TDS) and total solid (TS) of collected water samples were measured. Chemical parameters such as pH, dissolved oxygen (DO), chemical oxygen demand (COD), electrical conductivity (EC) and salinity were studied in the laboratory of Environmental Science Department of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. Heavy metals (Cr, Ni, Pb, and Cd) of water were determined by following the procedures of the standard methods at Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka.

2.4 Physical parameters

2.4.1 Color and odor

After taking water sample in a clean glass beaker, color was evaluated by physical observation. The odor of water sample was evaluated at room temperature.

2.4.2 Total solid (TS)

According to American Public Health Association [11] total solid (TS) of water samples were detected with a few modifications. TS was calculated by using the following formulae-

Total Solid (TS) in mg per liter = Total suspended solid (TSS) + Total dissolved solid (TDS)

2.4.3 Total suspended solid (TSS)

To determine total suspended solid (TSS) in collected water samples with the standard methods [11]. At first, water samples were filtered. Total non-filterable residue was the retained material on a standard glass-fiber after filtration of a well-mixed sample. Glass-fiber filter was placed on membrane filter apparatus. Then filter was vacuumed and washed with three successive 20 ml portions of distilled water. Continued suction to remove all traces of water and discarded. After that transferred filter to ceramic crucible and dried in oven at l03 to 105°C temperature for 1 hr. After drying, transferred it into desiccator to cool and immediately weighed before use. After that, the pre-dried and weighed glass-fiber was setup in membrane and 100 ml of well mixed suitable sample (convenient the required sample volume will yield between 5 to 200 mg of TSS) was taken for under vacuum. After that filter was washed with three successive 10 ml portions of distilled water and continued vacuum for complete removal of moisture. Finally, filter was carefully removed from apparatus to crucible for drying in oven at 103 to 105°C temperature for 1 hr. and cooled in desiccator and weighed. TSS was calculated by following formulae-

Total Solid (TS) in mg per liter = [(A-B) X 1000]/Sample volume (ml)

Where, A= Weight of filter and residue (mg) and B= Weight of filter (mg)

2.4.4 Total dissolved solid (TDS)

Amount of TDS was measured by using TDS meter (Model: DDSJ-308A). A requisite amount of sample was taken in a beaker, probe of the TDS meter was immersed and making sure that the sensor was fully immersed until the reading was stabilized.

2.4.5 Optical density

Optical density measures the cleanliness of the water. Visible Spectrophotometer (Model: 723N) was used to determine optical density of the collected water samples at 660 and 465 nm wavelength of light.

2.5 Chemical parameters

2.5.1 Dissolved oxygen (DO)

Dissolved oxygen of water was measured by a digital dissolved oxygen (DO) meter (Model: HI 8424, HANNA) of the collected water samples in the laboratory of Environmental Science Department. First DO meter was standardized by distilled water and buffer solution. Then 50 ml of sample was taken in clean 100 ml plastic beaker and then probe of the DO meter was immersed into water and waited for constant reading. Then DO reading was recorded in the notebook.

2.5.2 pH

First pH meter (Model: pH 211, HANNA) was standardized by distilled water and buffer ion. Then 50 ml of sample was taken in clean 100 ml plastic beaker and then probe was immersed in water and waited for constant reading. Finally recorded the pH value.

2.5.3 Chemical Oxygen Demand (COD)

COD was determined by following the procedures of standard [12] using the following formula-

COD (mg per liter) = (A-B) x M x 8000/Sample (ml)

Where, A= ml, FAS used for blank,

B=ml, FAS used for sample

M= Molarity of FAS

2.5.4 Salinity

Salinity was measured by using salinity meter (Model: DDSJ-308A). Taking a requisite amount of water sample in a beaker, probe of the salinity meter was immersed, making sure that the sensor was fully covered until the reading was stabilized.

2.5.5 Electrical conductivity (EC)

Electrical conductivity was measured by using conductivity meter (Model: DDSJ-308A). Taking a requisite amount of water sample in a beaker, probe of the conductivity meter was immersed making sure that the sensor was fully covered until the reading was stabilized.

2.5.6 Heavy metals

Heavy metals (Cr, Cd, Mn and Ni) of water sample were analyzed in the Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka. For digestion, 5 mL of concentrated nitric acid (70%) was added to the 0.5 g of water samples and kept for 24 hr. Then the samples were digested in Kjeldahl flask. Then the mixture was digested by heating the flask in a heating mantel at 200°C for 2 h and after 30 min cooling, 3 ml HCIO4 acid was added to the sample [13]. After adding HClO4 acid, 200°C temperature for 3 hr. was used to heat it [14]. Then these sample solutions were cooled for 30 min. and Whatman filter paper 42 were used for filtration and made the volume to 50 ml with distilled water. Heavy metals in the digested samples were determined using atomic absorption (Perkin Elerner Model 2380) and results were expressed in ppm in water.

2.6 Data processing and statistical analysis

The collected data were processed for analysis. These data were verified to remove all possible errors and inconsistencies. Tabular technique was used for the analysis of data by using simple statistical tools such as averages and percentages. Finally, the processed data were taking to a master sheet, from which classified tables were prepared revealing the finding of the study. MS Excel and MS word were used for processing and analysis purpose. The final data were presented in tables and figures with bar graph.

III. RESULTS AND DISCUSSION

3.1 Water quality

Water is the second most important resource for life to exist after air. As a result, water quality has been elaborated extensively in the scientific literature. Water quality means "the physical, chemical, and biological features of water". Water quality is a measure of the condition of water relative to the requirements of the biotic species and/or to any human need or purpose [15]. It is the measurement of the state of water relative to the requirements of the biotic species and to any human need or purpose. It is mostly used by reference to a set of standards against which compliance, generally achieved through treatment of the water, can be measured. The most common standards used to measure water quality relate to health of ecosystems, safety of human contact, and drinking purposes [16].

3.2 Physical parameters

Physical properties of the collected river water samples were assessed by examining the parameters such as color, odor, total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), and Optical density (OD).

The recorded color and odor of the water samples from the Turag River of two different seasons (summer and winter) were presented in Table 1. Color of the collected water was transparent in the North and South sides of Turag River in summer season. Conversely color of the collected water was blackish in both North and South sides during winter season. In case of odor, the collected water samples were found with a bad odor during winter season but odorless during summer season. Color and odor represent an important indicator for evaluation of water. Any unexpected form of color/odor of any water implies its pollution/contamination but level of pollution obviously depends on intensity of color and/or odor present at that water [17]. Besides that, water samples collected from the Turag river were black in color and had foul bad odor that indicate the pollution of aquatic environment and this might happen due to the contamination by industrial effluents, sewage water and tannery wastes. Almost similar observation was reported that on water of the Turag River polluted by discharges of sewerage as well as industrial wastewaters, solids or semi-solids wastes, inorganic or organic chemicals from different industries or different water transports etc [18].

Total solids (TS) found in the wet season in the Turag river were 56 and 62 mg/L in North and South sides of river, respectively (Table 1). Conversely, in winter season, TS values were 245and 236 mg/L in North and South sides of river, respectively (Table 1), higher values of total solids are mainly due to the presence of silt and clay particles in the river water [19]. Almost similar results were reported [20, 18] that on water of the Buriganga and Turag river in wet and dry seasons, on the other hand the TS value of the Turag river was 380 mg/L in year 2006 [21]. TS values were higher in winter season because of higher disposal of different wastes by transportation vehicles and business activities, flow of water was stopped and higher rate of evaporation than the summer season.

Total suspended solids (TSS) means the suspended impurities present in the water. Measurement of suspended substances is important as they are responsible for pollution of the aquatic environment. The TSS of water in the Turag river were recorded 47 and 48.4 mg/L in North and South sides of river, respectively in the summer season (Table 1). On the other hand, in winter season, TSS values were 107.3 and 104.6 mg/L in North and South sides of river, respectively (Table 1). Similar results of Burigangariver were reported as TSS 48, 54 and 1.77 mg/L in Sadarghat, Shuyarighat and Chunwalaghat, respectively. TSS values were 99.3, 107 and 338 mg/L in Sadarghat, Shuyarighat and Chunwalaghat, respectively [20]. In the winter season TSS value was higher than the value of summer season because of relatively higher deposition of wastes (sewerage waters, industrial effluents, solids etc.) along with no or less rainfall was occurred in the winter season. Therefore, washout of the deposited wastes in river water was almost absence in winter or dry season compared to wet or summer season, which enhanced wastes concentration/intensity in per unit volume of water. However, the recorded TSS value of waters in North and South sides of river in both season was within the limits of irrigation and Bangladesh standard (Table 1).

The total dissolved solids (TDS) of water sample in Turag River were 8 mg/L in north side and 12 mg/L in south side of Turag River during summer season. But in winter season the TDS were recorded 186 and 157.2 mg/L in north and south side of river (Table 1). The standard of TDS for domestic water supplies is 500 ppm by United State Public Health (USPH) [22]. The acceptable standard of TDS for drinking water is 1000 mg/L [23], for irrigation standard it is <450 mg/L and for fishing standard it is 500 mg/L. So, TDS concentration in Turag River of all locations were suitable for irrigation and fishing. In water, TDS are composed different minerals such as carbonates, bicarbonates, chlorides, phosphates and nitrates of calcium, magnesium, sodium, potassium and manganese, organic matter, salt and other particles [24]. Islam and Azam stated that, the maximum TDS were observed during the post-monsoon as large amount of sediment load were transported from the watershed during the rainy season [25]. In dry and wet seasons, almost similar pattern of findings of different solids of Burigangariver were reported [20].

Optical density represents the similar message as turbidity measurement. Optical density measures the cleanliness of water. Wavelength of 660 nm were used to measure optical density. The optical density of water sample in Turag river was 0.034 and 0.041 in north and south side of the river during summer season while, in winter it was 0.234 and 0.304 in north and south side of the river, respectively (Table 1). Higher optical density values are positively correlated with higher amount of pollutants present in water that indicated high intensity of pollution.

TABLE 1. Physical Properties of Different Water Samples Collected from Turag River in summer and Winter Season

Parameter	Summer season		Winter season		Standard values	
	North side of river	South side of river	North side of river	South side of river	Irrigation standard (Ayers and Westcot, 1976)	Bangladesh standard for Fisheries (EQS,1997)
Color	Transparent	Transparent	Black	Black	Greenish brown	Colorless
Odor	Odorless	Odorless	Bad odor	Bad odor	Odorless	Odorless
TS (mg/L)	56	62	245	236	-	-
TSS (mg/L)	47	48.4	107.3	104.6	150	200
TDS (mg/L)	8	12	186	157.2	<450	500
Optical density, OD660nm	0.034	0.041	0.234	0.304	-	-

3.3 Chemical parameters

Chemical properties of the Turag river water was evaluated by assessment of parameters such as Dissolver Oxygen (DO), Chemical Oxygen Demand (COD), pH, Salinity and Electrical Conductivity. Oxygen is required for every living organism. Free oxygen or dissolved oxygen (DO) is needed for respiration in case of aquatic organisms. The DO of water sample in Turag river collected from north side and south side was 5.7 and 4.9 mg/L in summer season (Figure 1a), However, in winter season the recorded DO was 0.95 and.0.78 mg/L in north side and south side, respectively (Figure 1a). DO concentration decreased in winter season as compared to summer season. In the case of dissolved oxygen, standard for sustaining aquatic life is 5 mg/L or ppm, whereas drinking water, it is 6 mg/L [19]. The bearable range of DO for domestic water supplies is 4.0 to 6.0 ppm by United State

Public Health (USPH) standard and 3.0 ppm (ISI) standard [22]. The standard range of DO for fish culture is 5 ppm to saturation [26] and more than 5.0 ppm [27]. The optimum DO in natural water is 4.0 to 6.0 ppm [22]. According to the environmental quality standard (EQS), the following requirements for DO are prescribed: 6.0 ppm for drinking, 4.0 to 5.0 ppm for recreation, 4.0 to 6.0 ppm for fish and livestock, and the DO levels below 1 ppm will not support fish [7]. On the basis of the present study, the recorded values of DO (Figure 1a) of all water samples collected from the Turag river were not within the acceptable range in winter or dry season. Right amount of dissolved oxygen is necessary for good water quality. While dissolved oxygen levels in water drop below 5.0 mg/L, then the aquatic life acts under stress of respiration. Accumulation of huge amount of industrial effluents could be the main reasons for lowering DO value.

Chemical oxygen demand (COD) is the amount of the oxidation of reduced chemicals in water. It is commonly used to measure the amount of organic compounds present in water which makes COD as an indicator of organic pollution in surface water [28]. COD pointing to a deterioration of the water quality caused by the discharge of industrial effluent and excessive organic wastes. The COD of water sample in the Turag River was 30 mg/L in north side and 40 mg/L in south side of the river in summer seasons (Figure 1b). While in dry season the CODs were recorded 450 and 520 mg/L in north and south sides of the river, respectively (Figure 1b). The obtained result indicates that COD values were much higher in winter season. The higher amount of organic compounds in water demands higher amount of dissolved oxygen to oxidize and as a result reduced the quality of water for fish and other aquatic life. It was stated that the average values of the COD of the Turag river in three distinct seasons were 121.05 mg/L in pre-monsoon; 102.6 mg/L in monsoon and 181.7 mg/L in post-monsoon season [25]. The pH of the water samples of the Turag River was recorded 7.5 and 7.31innorth and south sides of the river, respectively in summer season (Figure 1c). But in winter season the pH values were recorded 6.41 and 6.3 in north and south sides of the river, respectively (Figure 1c). The higher values of pH indicated that there is high concentration of chloride, bicarbonate, and carbonate ions [24]. The standard of Bangladesh, FAO and Bangladesh Environment Conservation Act recommended pH range is 6.5 to 8.5 for irrigation water ([23], [29]). For aquaculture the recommended pH is 6.5 to 8.0, for drinking water is 6.5 Considering standard values of pH, the Turag river water in all locations both in summer and winter seasons was suitable for aquatic life.

The salinity or salt concentration of water indicates the presence of ionic substances that may come from the reaction of metals and acids present in water. The salt concentration of water samples in the Turag River were 0.1% in both sides (north and south) of the river in summer season (Figure 1d). to 8.5, recreational water is 6.0 to 9.5, industrial water is 6.0 to 9.5 and livestock water is 5.5 to 9.0 ([23], [29], [26]). The pH standard limits for inland surface water is 6.5 to 8.5 [30]. The recorded pH in wet season was slightly acidic and in the dry season was slightly alkaline. Conversely in winter season the salt concentration was 0.04% in both sides of the river (Figure 1d). In the winter season, salinity was higher because of the high concentration of the pollutants in the river water as many of the chemicals contain salts.

Electrical conductivity (EC) itself is not a human or aquatic health concern, but it can serve as an indicator of other water quality problems. High values of EC shows that a large amount of ionic substance present in water [31]. Increasing levels of EC and cations are the products of decomposition and mineralization of organic materials [32]. The EC of the water samples in the Turag River were recorded 210 µs/cm in north and 190 µs/cm in south sides of the river in summer season (Figure 1e). Whereas, in winter season the EC were recorded 720 µs/cm in north and 740 µs/cm in south sides of the river (Figure 1e). In winter season, EC is higher than summer season. In summer season the water of the river was mostly rain water, which was relatively fresh. Generally, rain water contains minimum values of EC, on the other hand, in winter season, the river water had been polluted by discharges of different pollutants along with runoff of water from different sources were responsible for enhanced EC values. It was reported that the seasonal averages of EC of the Turag River in three distinct seasons were 488.75µs/cm (pre-monsoon); 354.5 µs/cm (monsoon) and 477.2 µs/cm (post-monsoon), respectively [25]. Seasonal variations showed higher value of EC in pre-monsoon and lower value in monsoon due to dilution with rain water.

3.4 Heavy metals in water sample

The heavy metals (Cd, Cr, Ni and Mn) concentration in water samples are presented in Table 2. Among the heavy metals, highest concentration was found 0.196 mg/L of Cart south side of river in winter season and the lowest concentration was 0.003 mg/L Cd found at both sides of Turag River in summer season. Among all heavy metals, the concentrations exceeded the standard values except Cd which indicates the heavy metal pollution occurred in Turag river water from nearby sources. Cd concentration was within the standard limit of Bangladesh, WHO (World Health Organization), TSE-266 and EPA (Environmental Protection Agency) as presented in Table 2. Regarding heavy metals of Turag River, the average values of Ni in three distinct seasons were 0.019 mg/L (pre-monsoon); 0.017 mg/L (monsoon) and 0.021 mg/L (post-monsoon) [25]. The highest value of Cd and Cr was observed in the Turag River were (0.03 ppm) and (0.02 ppm) [33]. The standard values of Cd for drinking, irrigation and livestock water are 0.005, 0.01 and 0.5 ppm, respectively [23].

IV. CONCLUSIONS

Based on the study of water quality parameters in the Turag river during winter and summer seasons, in summary, our results demonstrated that physical and chemical properties of water (especially DO, BOD and COD, pH, EC, heavy metals) were found higher than that of standard limits for sustainability of aquatic species. For this reason, it is necessary to reduce water pollution as much as possible through public awareness and existing rules and regulations of environmental degradation.

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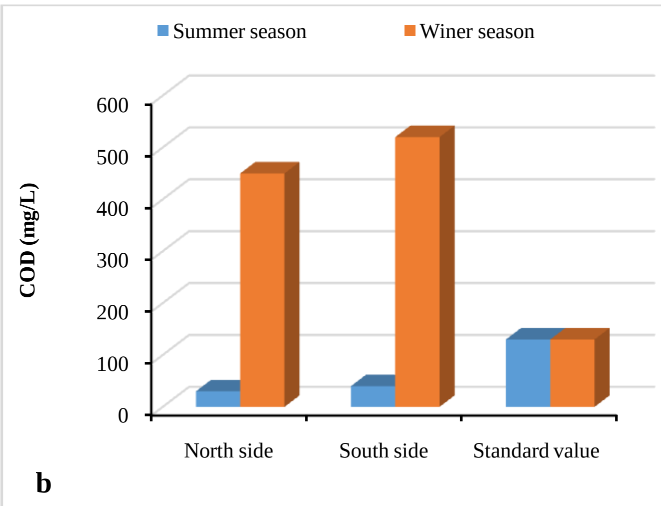

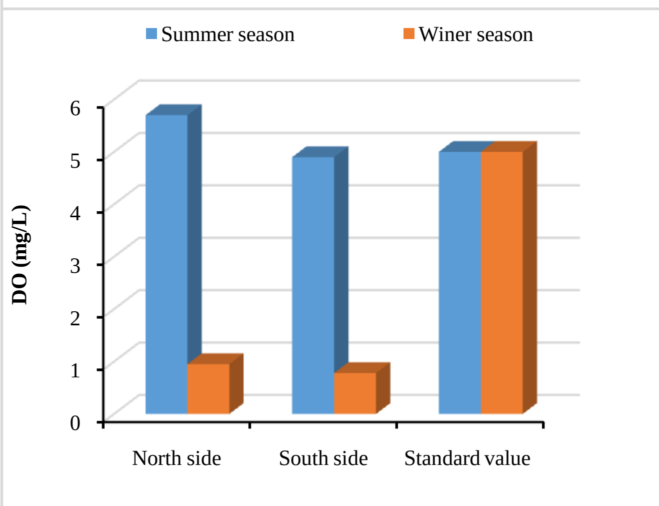

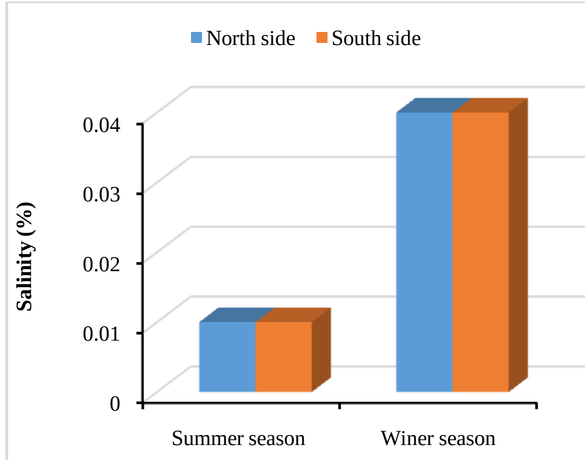

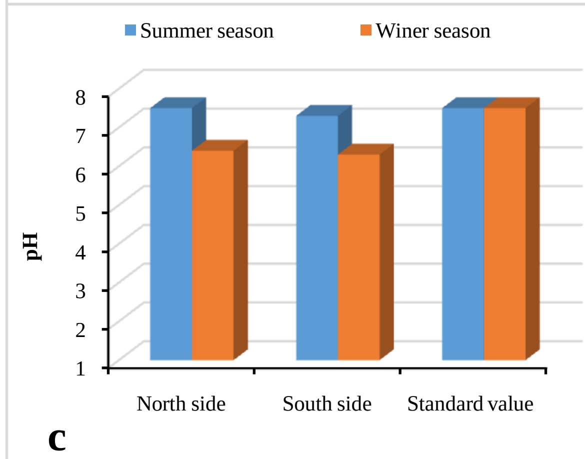

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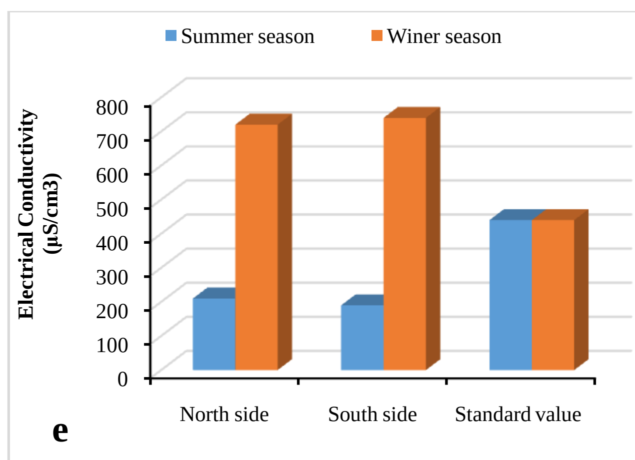

Fig 1. Recorded (a) DO, (b) COD, (c) pH, (d) salinity and (e) EC values of Turag River water at summer and winter season.

TABLE 2. Heavy metal content (ppm) in water sample of Turag River in summer and winter season

Heavy metals	Summer season		Winter season		Standards			
	North side of river	South side of river	North side of river	South side of river	Bangladesh	WHO	EPA	TSE-266 (2005)
Cadmium (Cd)	0.003	0.003	0.005	0.005	0.005	0.01	0.01	0.005
Chromium (Cr)	0.143	0.165	0.187	0.196	0.05	0.05	0.05	0.01
Nickel (Ni)	0.056	0.064	0.072	0.084	-	0.05	0.05	0.05
Manganese (Mn)	0.087	0.093	0.124	0.130	0.1	0.02	-	0.02

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