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SEASONAL CHANGES OF SOME PHYSICAL AND CHEMICAL PARAMETERS OF WATER IN THE TURAG RIVER, DHAKA, BANGLADESH

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ABSTRACT: The study was carried out to determine the water quality of Turag River in Dhaka city and its seasonal variations due to changes in physico-chemical parameters throughout the post-monsoon, pre-monsoon and monsoon seasons from October 2020 to September 2021. Samples were collected in three separate seasons to evaluate different physical and chemical parameters of the water, such as temperature, water depth, transparency, pH, DO, alkalinity, hardness, etc., using established procedures. In all seasons, the pH and temperature levels of river water were within the standard limit. Water transparency exceeded the standard level during the pre-monsoon and monsoon seasons, but was below the permissible limit after the monsoon. The lowest concentration of dissolved oxygen (DO) and the highest concentration of free CO_2 were observed in all seasons, which seriously harmed aquatic organisms and destroyed their habitat in the river. The alkalinity of the Turag River exceeded the regulatory standard throughout each season. Total hardness levels exceeded the acceptable range in all seasons and water samples were classified as very hard. Positive and negative correlations were found in some water parameters. The comparative study showed that the environmental condition of the Turag River was significantly degraded due to the presence of a significant amount of pollutants released by Dhaka city. Therefore, effective measures should be taken to reduce the pollution level and alleviate the existing aquatic environmental problems in the Turag River.

Key words: Water quality, physical parameters, chemical parameters, aquatic ecosystem.

INTRODUCTION

Water is arguably the most crucial source of life and development (Mobin *et al.* 2014, Kumar *et al.* 2010). It is crucial for the survival of all living organisms, including humans, plants and animals (Ahatun *et al.* 2020, Hasan *et al.* 2015).

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Any interruption in the water supply can cause significant problems. Unfortunately, many cities dispose of their waste and industrial by-products inappropriately, leading to river water pollution. This pollution poses a serious threat to both humans and the environment. This is a widespread problem in developing countries where industrial and municipal wastes are often dumped into rivers located in urban areas (Mezgebe *et al.* 2015, Sumok 2001, Gebrekidan and Samuel 2011). Water quality in Bangladesh is negatively impacted by the country's increasing urbanization and industrialization (BCAS 2004). Many industries around the world dump their waste into rivers without considering their environmental impact. This careless waste disposal has raised concerns about contamination of soils, sediments, and water systems near industrial areas (Meghla *et al.* 2013, Chowdhury *et al.* 2007). According to Uddin *et al.* 2016 and Moniruzzaman et al. In 2009, many of the country's rivers were declared biologically and hydrologically dead due to careless disposal of household and industrial waste and infiltration by unscrupulous individuals.

The Buriganga, Balu, Turag and Shitalakshya rivers in Dhaka are facing severe pollution due to various factors. These include industrial waste, solid waste from neighboring towns, petroleum products from ships, launches and boats, and raw sewage. As a result, rivers have become heavily contaminated by municipal and industrial wastewater. This untreated discharge caused significant contamination of surface waters, as reported in various studies carried out by Meghla *et al.* 2013, Kamal *et al.* 1999, Karn and Harada 2001.

The Turag River is a vital branch of the Buriganga and is of immense importance in Bangladesh. However, the river is currently facing serious environmental problems and water pollution, which have led to a biological and hydrological impasse (Rahman *et al.* 2021, Uddin and Jeong 2021, Whitehead *et al.* 2018). The river is surrounded by a large number of factories including textiles, cotton, rubber, resin, organic chemicals, paper, synthetic drugs, oil refineries, tanneries and densely populated areas (Rahman *et al.* 2021, Uddin and Jeong 2021, Islam *et al.* 2018). Moreover, nearby residents threw all kinds of solid, liquid and chemical waste into the Turag River (Rahman *et al.* 2021, Uddin and Jeong 2021, Islam *et al.* 2018). As a result, a complex mixture of harmful organic and inorganic substances from industry and household waste is discharged into the Turag River, further deteriorating its water quality.

The Turag River was declared an Ecologically Critical Area (ECA) by the Department of Environment (DoE) in September 2009 due to the alarming increase in the values of several physico-chemical parameters in the river water. It is important to evaluate the water quality indicator of Turag River to recognize the source of contaminants and pollution. In Bangladesh, the riverine environment is strongly influenced by seasonal variations. It is therefore essential to determine seasonal changes to assess temporal variations in water pollution, as mentioned in a study by Bhuyan *et al.* 2010.

This study is of great importance in providing information on the current status of water quality of the Turag River. The current water quality status of Turag River was verified in this study by comparing its water quality indicators with relevant standard values. To understand temporal fluctuations and their effects throughout the year, water quality measurements were also compared between the river's three seasons. Thus, the objectives of the present study are as follows: a) To observe the water quality, ecological status and condition of the Turag River. b) Evaluate how the physicochemical characteristics of river water vary according to the seasons. c) Compare water quality parameters between the three distinct seasons from six different points on the river.

MATERIAL AND METHODS

The research was carried out on the Turag River located in Dhaka, Bangladesh, which constitutes the upper branch of the Buriganga River. Its geographical coordinates are $23^0$45' N latitude and $90^0$19' E longitude. The river has its source in the Bangshi River, it feeds significantly into the Dholeswari River and extends over 62 km with an average width of 82 m. The river joins the Buriganga River at Mirpur and enters the Balu River via the Tongi Khal (Chowdhury and Chowdhury 2004, Tania et al. 2021, Mobin et al. 2014, Meghla et al. 2013). Despite its length of 62 kilometers and average width of 82 meters, the Turag River is heavily polluted and considered one of the most contaminated rivers in Bangladesh (Islam et al. 2012, Tania et al. 2021). Its total area extends to 386 square miles (Uddin 2005). Various studies carried out by Chowdhury and Chowdhury 2004, Tania *et al.* 2021, Mobin *et al.* 2014, Meghla *et al.* 2013, Islam *et al.* 2012 showed the extent of the pollution of the river.

Water samples were collected from six distinct sites of Turag River, namely Gabtoli Bridge (S-1), Tamanna Park (S-2), Switch Gate (S-3), Briulia Bridge (S - 4), Rustompur (S- 5) and Ashulia Bridge (S-6) (Fig. 1). The GPS locations of each site were recorded as follows: S-1: $23^0$47'13" N and $90^0$20'18" E; S-2: $23^0$49'6" N and $90^0$20'25" E; S-3: $23^0$49'45" N and $90^0$20'23" E; S-4: $23^0$50'31" N and $90^0$20'26" E; S-5: $23^0$52'31" N and $90^0$21'1" E; S-6: $23^0$53'31" N and $90^0$21'37" E. Water sample collection took place on a monthly basis during post-monsoon (November 2020 to February 2021), pre-monsoon (March to June 2021) and monsoon (July to October 2021) between 7:30 a.m. to 11:00 a.m. Before sampling, the bottles were cleaned and washed with detergent solution and distilled water and finally dried. 1000 ml of water was collected approximately 10-15 cm below surface level by plastic bottles, from six sampling sites. After collection, the vials were carefully screwed shut and labeled with the corresponding identification number.

Various water samples were analyzed, such as color, odor, temperature, water depth, transparency, velocity, pH, DO, free CO2, alkalinity and hardness. On-site measurements were taken for the first six parameters, while the others were analyzed in the laboratory. To determine the color and smell of water, we used our senses of sight and smell, respectively. To estimate the water depth, we used a rope with a medium-sized stone and a tape measure. Water temperature was also measured with a centigrade thermometer. To record the transparency of the water, we used a Secchi disk. To analyze the speed of water, a plastic bottle, a rope, a tape measure and a stopwatch were used. The pH of the water was analyzed using the Helige Color Comparator. On the other hand, other parameters such as DO, free CO2, alkalinity and hardness were evaluated in the laboratory using the titration method. IBM SPSS 22.0 and Microsoft Excel 2016 were used for statistical analysis of the collected data. Using this software, the mean, standard variation, correlation between variables, two-way ANOVA, and independent sample t-test were calculated.

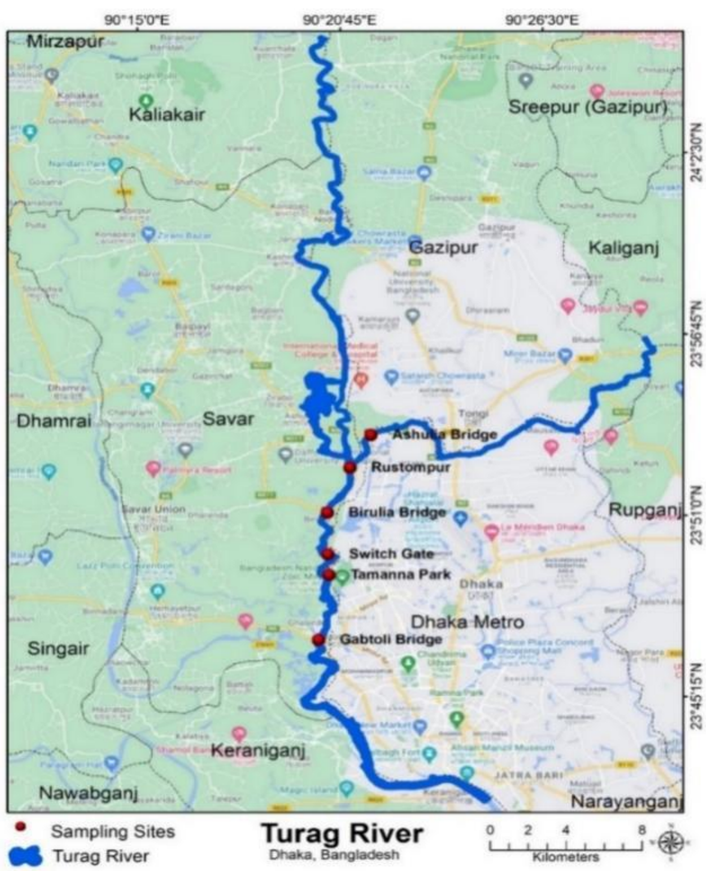

Fig. 1. The study area showing the sampling sites

RESULTS AND DISCUSSION

Different physicochemical parameters of the Turag River were observed and recorded during the study period (Tables 1 and 2). Water samples collected from different sampling sites in the Turag River were dark in color and smelled bad, indicating a contaminated aquatic environment. Rahman et al. (2015) observed a blackish water color in lakes. This could be due to industrial effluent pollution which was also found in the Bangshi River by Mahbub et al. (2014).

During this study, it was found that the highest temperature was observed during the monsoon season compared to the pre-monsoon and post-monsoon seasons. The seasonal average water temperature was recorded at 23.63°C (±0.74) during the post-monsoon period, 26.91°C (±0.81) during the pre-monsoon period and 28. 17°C (±0.76) during the monsoon period. Similar to the present study, Mobin et al. (2014) found that the water temperature of the Turag River varied between 23 and 31 °C. The lowest temperature was also recorded during the post-monsoon season by Apollos et al. (2016). According to EQS (1997) and DPHE (2018) (Table 1), the temperature studied during all periods was found to be within the acceptable range. The difference between pre-monsoon, monsoon and post-monsoon periods was statistically significant (Table 3).

The water depth varied during the three periods: post-monsoon, pre-monsoon and monsoon. In the post-monsoon period, the seasonal values of water depth were 155.33 cm (±86.41), while in the pre-monsoon period, it was 85.65 cm (±13. 02) and during the monsoon period it was 158.12 cm (±10.80). The water depth of all water samples collected from six locations varied between 61.5–112 cm, 127–182 cm and 55–296 cm during the pre-monsoon, monsoon and post-monsoon season, respectively (Table 1). The water depth at a certain location is an important physical element that influences water quality (Shah & Pandit 2012; Rahman *et al.* 2015). Minimum water depth at low temperatures was documented by Kundu (1996). Singh *et al.* (2010) also observed the minimum water depth in summer or before monsoon. The ANOVA results showed a significant difference during all periods, and the post-hoc test confirmed statistically significant differences between monsoon and post-monsoon periods (Table 3). According to this research, the least transparency was found at S-3 during pre-monsoon and at S-1 during monsoon and post-monsoon seasons. The highest transparency values were observed at S-2 during the pre-monsoon and post-monsoon seasons, and at S-6 during the monsoon period. Water transparency was observed to vary between 27 and 36 cm by Haider *et al.* (2017).

Mobin *et al.* (2014) reported the lowest and highest water transparency values in Turag River in Ashulia as 10 cm in April and 45.83 cm in July, respectively. However, their observed transparency values, ranging from 9.5 to 44 cm, were lower than the values obtained in this study. According to Wahab *et al.* (1994) and Haider *et al.* (2017), the transparency range observed during the pre-monsoon and monsoon seasons was not within the standard limit (Table 1), showing that the Turag River may not be an ideal habitat for aquatic life. Table 4 shows significant differences at a significance level of $p < 0.01$ ($F = 141.139$, $p = 0.000$).

During different periods, the average values of water speed varied; throughout the pre-monsoon period the average value was 2.33 m/s (±0.63), during the monsoon period it was 5.20 m/s (±0.70) and during the post-monsoon it was 3.76 m/s (±0.99) (Table 2). Significant differences were observed between water velocity values during all periods (Table 3). Hafiz *et al.* (2017) measured water velocities ranging from 0.60 m/s to 0.90 m/s for the Turag, Buriganga and Balu rivers. Additionally, Mahmud *et al.* (2017) reported that water velocity during monsoon season was higher than during pre-monsoon and post-monsoon seasons in Padma River.

All sites had alkaline water. During the pre-monsoon period, the pH values varied between 7 and 8, indicating the alkaline nature of the river water. pH measurements were consistent throughout most of the monitoring period. During the monsoon period and post-monsoon, the pH values ranged from 7.0 to 8.5 and 7.5 to 8, respectively. These results are slightly different from those of Mobin et al. (2014) who reported an average pH value of 6.83 (±0.06) in the Turag River. The pH standards for freshwater bodies are 6.5 to 8.5 (EQS 1997, Haider 2017) and 6.5 to 9.0 (Swingle 1967). The pH levels in this study were within the acceptable range, as shown in Table 02. Based on Table 3, it can be concluded that there were no notable differences between the calculated pH values ($F = 2.259$, $p = 0.112$).

Maintaining sufficient levels of dissolved oxygen (DO) is crucial for maintaining optimal water quality, ensuring the survival of aquatic creatures, and promoting waste degradation by microorganisms (Islam *et al.* 2010, Meghla *et al.* 2013). Depending on the season, the DO content in water was found to be different. The average DO levels throughout the pre-monsoon, monsoon and post-monsoon periods were recorded at 2.76 mg/L, 4.49 mg/L and 1.72 mg/L, respectively. This trend in DO levels was also observed by Meghla *et al.* 2013. It was found that the DO content was significantly lower during the pre-monsoon and post-monsoon seasons compared to the monsoon season. Additionally, during the pre- and post-monsoon periods, the DO content was found to be below the permissible level (DoE 2016), as shown in Table 2. A study by Hossain *et al.* (2012) revealed that the low DO concentration is due to the low flow of the river during dry periods. The ANOVA result demonstrated that the average

Table 1 Physical parameters of the Turag River water during pre-monsoon, monsoon and post-monsoon period

Parameters	Sampling sites	Pre-monsoon (Feb – May)		Monsoon (June - Sept)		Post-monsoon (Oct- Janu)		Standard
		Average	Range	Average	Range	Average	Range	
Temperature (ºC)	S-1	25.5		28.25		23.5		
	S-2	26.5		27.5		24.5		
	S-3	27		27		22.75		
	S-4	27.25		28.5		23.5	22 to 26ºC	20 to 30ºC (EQS 1997) (DPHE 2018)
	S-5	27.5	25 to 29ºC	29	26 to 31ºC	23		
	S-6	27.75		28.75		24.5		
	Mean ± SD	26.91 ± 0.81		28.17 ± 0.76		23.63 ± 0.74		
Water Depth (cm)	S-1	74.62		136.5		75		
	S-2	100.52		161.95		188.25		
	S-3	88.325	61.5 to 112 cm	162.0		223.2		
	S-4	66.35		161.7		58.73		
	S-5	96.75		160.1	127 to 181 cm	273.88	55 to 296 cm	
	S-6	87.375		166.47		112.90		
	Mean ± SD	85.65±13.02		158.12±0.80		155.33 ±86.4		
Transparency (cm)	S-1	44.5		45.62		19.3		
	S-2	48.9		61.15		30.51		
	S-3	41.57		55.55		25.32		
	S-4	48.57	35 to 54 cm	47.4	40 to 69 cm	28.62	15 to 34 cm	40 cm or less (Wahab *et al.* 1994)
	S-5	42		53.4		29.15		
	S-6	49.32		64.23		30.3		
	Mean ± SD	45.81 ± 3.56		54.56 ± 7.35		27.20 ± 4.29		
Water Velocity (m/sec)	S-1	2.63		4.65		3.32		
	S-2	3.10		6.07		5.43		
	S-3	2.19		5.15		3.31		
	S-4	1.24	1.10 to 3.20 m/sec	4.53	3.5 to 6.8 m/sec	2.69	2.0 to 6.0 m/sec	
	S-5	2.68		6.07		4.41		
	S-6	2.13		4.73		3.38		
	Mean ± SD	2.33 ± 0.64		5.20 ± 0.70		3.76 ± 0.99		

Note: SD=Standard Deviation

variations in DO levels were highly significant during all periods, as shown in Table 3. In Turag River, the amount of free CO_2 varied among sites and regions. month. Unfortunately, during the pre-monsoon period, the average value of free CO_2 exceeded the standard limit (WHO 1995, Singh et al. 2010). The highest mean value of free CO_2 was recorded before the monsoon season, reaching 52.59 mg/L (±18.91), which is excessively high (Table 2). The Surma-Kushiyara

Table 2 Chemical parameters of water during pre-monsoon, monsoon and post-monsoon period. (SD=Standard deviation)

Parameters	Sampling sites	Pre-monsoon (Febr – May)		Monsoon (June - Sept)		Post-monsoon (Octo- Jan)		Standard
		Average	Range	Average	Range	Average	Range	
pH	S-1	7.2	7.0 to 8.0	7.83	7.0 to 8.5	7.62	7.5 to 8.0	6.5 to 9.0 (Swingle 1967) 6.5-8.5 (EQS 1997)
	S-2	7.62		7.73		7.87		
	S-3	7.47		7.6		7.77		
	S-4	7.75		8.1		7.7		
	S-5	7.77		7.6		7.87		
	S-6	7.85		7.97		7.62		
	Mean ± SD	7.61±0.24		7.80 ± 0.20		7.74 ± 0.11		
DO (mg/L)	S-1	1.92	1.4 to 4.0 mg/L	4.45	3.5 to 5.2 mg/L	2.02	0.5 to 3.0 mg/L	≥ 5.0 (DoE 2016)
	S-2	2.35		4.6		0.85		
	S-3	2.97		4.2		2.55		
	S-4	3.67		4.3		1.42		
	S-5	3.07		4.67		1.20		
	S-6	2.57		4.75		2.32		
	Mean ± SD	2.76 ± 0.61		4.49 ± 0.22		1.72 ± 0.67		
CO_2 (mg/L)	S-1	79.46	25.0 to 89.5 mg/L	19.42	11 to 23 mg/ L	29.20	15.0 to 32.5 mg/L	22 mg/L (WHO 1995; Singh *et al.* 2010)
	S-2	42.82		17.60		21.24		
	S-3	67.84		16.81		23.68		
	S-4	57.49		17.49		20.63		
	S-5	37.24		16.89		19.30		
	S-6	30.70		14.35		16.91		
	Mean ±SD	52.59 ± 18.91		17.09±1.64		21.83±4.24		
Alkalinity (mg/L)	S-1	1057.4	945 to 1080 mg/L	474.57	335 to 522 mg/L	569.3	444 to 688.5 mg/L	>100 mg/L (Rahman 1992)
	S-2	1038.7		433.23		455.65		
	S-3	991.3		469.43		541.42		
	S-4	1038.3		389.2		513.32		
	S-5	961		460.25		535.82		
	S-6	1056.1		466.6		677.92		
	Mean ±SD	1023.8±39.02		448.87±32.6		548.90±73.8		
Hardness (mg/L)	S-1	520.70	447 to 569 mg/L	262.92	115 to 207 mg/L	206.8	155 to 209 mg/L	123 mg/L (Huq & Alam 2005)
	S-2	461.78		167.25		158.67		
	S-3	558.10		150.72		161.05		
	S-4	492.63		186.23		167.65		
	S-5	497.78		130.37		168.05		
	S-6	533.70		171.07		168.45		
	Mean ±SD	510.78± 33.95		178.1± 5.72		171.77±17.6		

Table 3 One way ANOVA for water parameters

Water Parameters	Pre monsoon Vs Monsoon Vs Post monsoon		
	F value	**p value**	**Specification**
Temperature	105.018	0.000*	Significant
Depth	13.589	0.000*	Significant
Transparency	141.139	0.000*	Significant
Velocity	77.290	0.000*	Significant
pH	2.259	0.112	Not Significant
DO	130.111	0.000*	Significant
Free CO_2	71.253	0.000*	Significant
Alkalinity	816.826	0.000*	Significant
Hardness	1341.234	0.000*	Significant

*p< 0.01
*The mean difference is significant at the 0.05 level

project area also reported equally high values of free CO2 (FAP-16 1992). Mean free CO2 values showed a significant difference between sites (Table 3).

During each season, the alkalinity of the Turag River exceeded the regulatory threshold of 100 mg/l. During pre-monsoon and monsoon, S-1 had the highest alkalinity levels (as shown in Table 2). In a study by Meghla *et al.* (2013), the highest alkalinity values were observed during the pre-monsoon season (581.0 ± 188.57), compared to the post-monsoon season (404.0 ± 30.19), the two seasons showing higher alkaline water than the monsoon season (150.0 ± 12.54). Similarly, Ahatun *et al.* (2020) recorded comparable results for the Korotoa River, where alkalinity concentrations were 82.66 mg/L during the wet season and 207.3 mg/L during the dry season. Meanwhile, Islam et al. (2015) found higher alkalinity levels in Brahmaputra River water throughout the dry season. All mean values had significant differences across all time periods, as shown in Table 3.

The average total hardness of the reservoir water was measured three times: before, during and after the monsoon. The average total hardness was 510.78 mg/L (± 33.95) during the pre-monsoon period, 178.1 mg/L (± 45.72) during the monsoon season and 171.77 mg/ L (± 17.63) during the post-monsoon period. Total hardness levels were observed to exceed the standard limit of 123 mg/L and were particularly high during the pre-monsoon season. This was supported by a study conducted by Meghla *et al.* (2013) and could be attributed to various factors such as municipal garbage dumping, unconstitutional drainage of industrial by-products, oil spill from boats and other factors leading to decreased water flow in rivers. The results were supported by one-way ANOVA analysis, which revealed a significant difference between the mean values of all periods. The results are summarized in Table 1 and Table 2. Correlation refers to

Table 4 Correlation coefficient between different physico-chemical parameters of Turag River during pre-monsoon period

Parameter	Temperature	Water Depth	Transparency	Water Velocity	pH	DO	CO_2	Alkalinity	Hardness
Temperature	1								
Water Depth	0.341282	1							
Transparency	0.387431	0.017726	1						
Water Velocity	-0.24222	0.698352*	-0.0814	1					
pH	0.445552	0.10122	0.277596	-0.18563	1				
DO	0.675642*	-0.10252	0.212107	-0.56606*	0.327812	1			
CO_2	-0.72612*	-0.57175	-0.46145	-0.16246	-0.54565*	-0.29816	1		
Alkalinity	-0.38031	-0.34565	0.39871	-0.14887	-0.05685	-0.45375	0.191102	1	
Hardness	-0.00044	-0.16009	-0.39398	-0.26903	-0.09969	-0.09357	0.339233	0.022856	1

Table 5 Correlation coefficient between different physico-chemical parameters of Turag River during monsoon period

Parameter	Temperature	Water Depth	Transparency	Water Velocity	pH	DO	CO_2	Alkalinity	Hardness
Temperature	1								
Water Depth	-0.3613	1							
Transparency	-0.06416	0.335327	1						
Water Velocity	0.056477	-0.02973	0.239866	1					
pH	-0.07551	0.130247	-0.12614	-0.33079	1				
DO	-0.07654	0.306479	0.167498	0.092689	0.203351	1			
CO_2	-0.14982	-0.28427	-0.63901*	0.017221	0.150575	0.061434	1		
Alkalinity	-0.31836	0.12109	0.064395	-0.05289	0.157119	0.360655	0.160902	1	
Hardness	-0.19428	-0.03047	-0.35949	-0.53711	0.407602	0.127565	0.368572	-0.00142	1

Table 6 Correlation coefficient between different physico-chemical parameters of Turag River during post-monsoon period

Parameter	Temperature	Water Depth	Transparency	Water Velocity	pH	DO	CO_2	Alkalinity	Hardness
Temperature	1								
Water Depth	-0.15205	1							
Transparency	0.237918	0.289819	1						
Water Velocity	0.195925	0.472975	0.269523	1					
pH	-0.0811	0.288375	0.083856	0.373048	1				
DO	-0.06607	-0.11283	-0.34661	-0.61387*	-0.12007	1			
CO_2	-0.20437	-0.18231	-0.75899*	-0.12565	-0.03007	0.228184	1		
Alkalinity	0.124559	-0.22864	-0.09767	-0.48605	-0.26436	0.667477*	-0.21414	1	
Hardness	-0.05715	-0.44453	-0.73582*	-0.32937	-0.24847	0.215712	0.652058*	0.278204	1

the relationship between two variables. When one variable increases, the other variable also increases, this is called a positive correlation. On the other hand, when one variable increases while the other decreases, this is considered a negative correlation. The strength of the correlation can be classified as weak, moderate or strong, depending on the correlation coefficient values. A correlation value between -0.8 and -1.0 indicates a significant correlation, while a coefficient ranging from -0.5 to -0.8 suggests a moderate correlation. A correlation coefficient between 0 and -0.5 indicates weak correlation (Nair et al. 2005, Shroff et al. 2015).

During the pre-monsoon period, there was a moderately positive correlation between temperature and DO (r = 0.676), water velocity and water depth (r = 0.698), as well as an inverse relationship between water velocity and DO (r = -0.566), pH and free CO2 (r=-0.546), free CO2 and temperature (r=-0.726) (Table 4). During the monsoon period, there was a moderate negative correlation between transparency and free CO2 (r = -0.639) (Table 5). During the post-monsoon period, there was a moderately positive correlation between dissolved oxygen (DO) and total alkalinity (r=0.667), as well as between free CO2 and total hardness (r=0.652). On the other hand, over the entire period, a moderate negative correlation was observed between transparency and free CO2 (r=-0.759), as well as between hardness and transparency (r=-0.736), DO and water speed (r= -0.613) (table 6). Mobin et al. (2014) also observed a positive relationship between DO and water temperature. In summary, DO, water velocity and transparency are important water parameters because they are significantly correlated with most water parameters.

CONCLUSION

The majority of physicochemical characteristics were determined to be above the danger threshold, although several crucial quantities, including DO, were alarming and free CO2, total alkalinity were found very high during all periods. The range of transparency and total hardness was not within the standard limit. The Turag River ecosystem needs to be managed to maintain an ecologically healthy aquatic habitat. To avoid any type of pollution, individuals must be informed of their duties and manufacturers must be aware of the problem of pollution and their ethical and social responsibilities to prevent this problem.

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LITERATURE CITED

AHATUN, S., ISLAM, M.S., KABIR, M.H., REHNUMA, M., and HOQ, M.E. 2020. Water quality and fish diversity in Korotoa River of Bogura, Bangladesh. *Bangladesh Journal of Fisheries,* **32**(1), 61-72. https://doi.org/10.52168/bjf.2020.32.08

APOLLOS, T.G., RAJI, A., and MODIBBO, U. 2016. Seasonal variation of water quality parameters of Zobe Reservoir Dutsinma Katsina State, Nigeria. *Hydrology Current Research,* **7**, 261. https://doi.org/10.4172/2157-7587.1000261

BCAS (BANGLADESH CENTRE FOR ADVANCED STUDIES). 2004. The state of Bangladeshi water, Series 5, Bangladesh Centre for Advanced Studies, Dhaka, Bangladesh.

BHUIYAN, M.A.H., RAKIB, M.A., DAMPARE, S.B., GANYAGLO, S., and SUZUKI, S. 2010. Surface water quality assessment in the central part of Bangladesh using multivariate analysis. *KSCE Journal of Civil Engineering,* **15**(6), 995-1003. https://doi.org/10.1007/s12205-011-1079-y

CHOWDHURY, A.G., and CHOWDHURY, A. 2004. An assessment of water resources and flood management of Dhaka city. Water resources management and development in Dhaka city, Geothe-institute, Dhaka, Bangladesh, 40-45.

CHOWDHURY, A.M.S., RAHMAN, M.A., RAHMAN, M.M., MOHIUDDIN, A.S.M., and ZAMAN, M.B. 2007. Nature and the extent of industrial pollution in river water around Dhaka city. *Bangladesh Journal of Environmental Science,* **13**(1), 46-49.

DOE (DEPARTMENT OF ENVIRONMENT). 2016. Environmental Quality Standard (EQS) of Bangladesh.

DPHE. 2018. Department of Public Health Engineering, Government of Bangladesh. Retrieved July 31, 2019. http://old.dphe.gov.bd/index.php?option=com_content&view=article&id=125&Itemid=133

EQS (ENVIRONMENTAL QUALITY STANDARD). 1997. Bangladesh Gazette, registered nr. DA-1, Ministry of Environment, Government of Bangladesh.

FAP-16. 1992. Environmental impact assessment case study Surma-Kushiyara Project. Bangladesh Flood Action Plan, Ministry of Irrigation, Water Development and Flood Control Flood Coordination Organisation (FECO) 11. pp 4.

GEBREKIDAN, M., and SAMUEL, Z. 2011. Concentrations of Heavy Metals in Drinking Water from Urban Areas of the Tigray Region, Northern Ethiopia. *Momona Ethiopian Journal of Science,* **3**, 105. https://doi.org/10.4314/mejs.v3i1.63689

HAFIZ, R.B., and RAHMAN, A. 2017. Simulation of hydrodynamic parameters of Dhaka peripheral river system of Bangladesh. *International Journal of Scientific & Engineering Research,* **8**(9),1125-1130.

HAIDER, M.A., SHAHRIAR, S.I.M., HOSEN, M.H.A., CHHANDA, M.S., and KHATUN M.M. 2017. A study on water quality parameters and benthos abundance in freshwater homestead ponds of Dinajpur, Bangladesh. *International Journal of Fisheries and Aquatic Studies*, **5**(2), 27-32.

HAQUE, M.I. 2008. Water resources management in Bangladesh. Anushilan, Chuadanga and Dhaka, pp. 24-84.

HASAN, S.J., TANU, M.B., HAIDER, M.I., AHMED, T., and RUBEL, A.S.A. 2015. Physicochemical characteristics and accumulation of heavy metals in water and sediments of the river Dakatia, Bangladesh. *International Journal of Fisheries and Aquatic Studies*, **2**(5), 300-304.

HOSSAIN, M.D., RAHMAN, M.M., CHANDRA, J.B., SHAMMI, M., and UDDIN, M.K. 2012. Present status of water quality of The Bangshi River, Savar, Dhaka, Bangladesh. *Bangladesh Journal of Environmental Research*, **10**, 17-30.

HUQ, S.M.I., and ALAM, M.D. 2005. A Handbook on Analysis of Soil, Plant and Water. BACER-DU, University of Dhaka, Bangladesh.

ISLAM, J.B., AKTER, S., BHOWMICK, A.C., UDDIN, M.N., and SARKER, M. 2018. Hydro-environmental pollution of Turag River in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research*, **53**(3), 161-168. https://doi.org/10.3329/bjsir.v53i3.38261

ISLAM, M.S., FERDOUS, J., NASMI, S., and KABIR, M.H. 2015. Seasonal variations in water quality and its effects on fish production in the Brahmaputra River at Mymensingh of Bangladesh. *Bangladesh Journal of Environmental Science*, **29,** 18-24.

ISLAM, M.S., TUSHER, T.R., MUSTAFA, M., and MAHMUD, S. 2012. Effects of solid waste and industrial effluents on water quality of Turag River at Konabari industrial area, Gazipur. *Bangladesh Journal of Environmental Science and Natural Resources,* **5**(2), 213–218. https://doi.org/10.3329/jesnr.v5i2.14817

ISLAM, M.S., SURAVI and MEGHLA, N.T. 2010. Investigation on water quality in the Ashulia beel, Dhaka. *Bangladesh Journal of Fisheries Research,* **14**(1-2), 55-64.

KAMAL, M.M., MALMGREN-HANSEN, A., and BADRUZZAMAN, A.B.M. 1999. Assessment of pollution of the River Buriganga, Bangladesh, using a water quality model. *Water Science & Technology,* **40**(2), 129-136. https://doi.org/10.2166/wst.1999.0104

KARN, S.K., and HARADA, H. 2001. Surface water pollution in three urban territories of Nepal, India and Bangladesh. *Environmental Management,* **28**(4), 483-496. https://doi.org/10.1007/s002670010238

KUMAR, G.N.P., SRINIVAS, P., CHANDRA, G.K., and SUJATHA, P. 2010. Delineation of groundwater potential zones using remote sensing and GIS techniques: A case study of Kurmapalli Vagu Basin in Andhra Pradesh, India. *International Journal of Water Resources and Environmental Engineering*, **2**(3), 70-78.

KUNDU, N.K. 1996. Effect of textile effluents on plankton and benthos population in the river Bangshi near Savar, Dhaka. M.Sc Thesis, Department of Zoology, Jahangirnagar University, Dhaka, pp. 114.

MAHMUD, I.H., PAL, P.K., RAHMAN, A., and YUNUS, A. 2017. A study on seasonal variation of hydrodynamic parameters of Padma River. *Journal of Modern Science and Technology*, **5**(1), 1-10.

MAHBUB, A., TANVI, H.M., and AFRIN, L.T. 2014. An evaluation of environmental and social impact due to industrial activities -a case study of Bangshi River around Dhaka export processing zone (DEPZ), Bangladesh. *International Research Journal of Environmental Sciences,* **3**(2), 103-111.

MEGHLA, N.T., ISLAM, M.S., ALI, M.A., SURAVI and SULTANA, N. 2013. Assessment of physicochemical properties of water from the Turag River in Dhaka City, Bangladesh.

International Journal of Current Microbiology and Applied Sciences, **2**(5), 110-122. http://www.ijcmas.com/Archives/vol-2-.

MEZGEBE, K., GEBREKIDAN, A., HADERA, A., and WELDEGEBRIEL, Y. 2015. Physico-chemical parameters of Tsaeda Agam river in Mekelle, Ethiopia. *Bulletin of the Chemical Society of Ethiopia,* **29**(3), 377-385. http://dx.doi.org/10.4314/bcse.v29i3.5

MOBIN, M.N., ISLAM, M.S., MIA, M.Y., and BAKALI, B. 2014. Analysis of physicochemical properties of the Turag River water, Tongi, Gazipur in Bangladesh. *Journal of Environmental Science & Natural Resources,* **7**(1), 27-33. https://doi.org/10.3329/jesnr.v7i1.22140

MONIRUZZAMAN, M., ELAHI, S.F., and JAHANGIR, M.A.A. 2010. Study on Temporal Variation Physico-chemical Parameters of Buriganga River Water through GIS (Geographical Information System) Technology. *Bangladesh Journal of Scientific and Industrial Research*, **44**(8), 327-334. https://doi.org/10.3329/bjsir.v44i3.4406

NAIR, A., ABDULLAH, G., MOHAMMAD, I., and FADIEL, M. 2005. *Pollution Research*, **24**(1), 1-6.

RAHMAN, A., JAHANARA, I., and JOLLY, Y.N. 2021. Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh. *Water science and engineering*, 14(2), 139-148. https://doi.org/10.1016/j.wse.2021.06.006

RAHMAN, M.A., SULTANA, S., and SALAM, M.A. 2015. Comparative Analysis of Some Water Quality Parameters of Three Lakes in Jahangirnagar University Campus, Savar, Bangladesh. *Bangladesh Journal of Zoology*, **43**(2), 239-250.

RAHMAN, M.S. 1992. Water quality management in aquaculture. BRAC Prokashana, Bangladesh, 84.

SHAH, J.A., and PANDIT, A.K. 2012. Physico-chemical characteristics of water in Wular lake-a Ramsar site in Kashmir Himalaya. *International Journal of Geology, Earth & Environmental Sciences*, **2**(2), 257-265.

SHROFF, P., VASHI, R.T., CHAMPANERI, V.A., and PATEL, K.K. 2015. Correlation study among water quality parameters of groundwater of Valsad district of South Gujarat (India). *Journal of Fundamental and Applied Sciences*, **7**(3), 340-349. http://dx.doi.org/10.4314/jfas.v7i3.3

SINGH, M.R., GUPTA, A., and BEETESWARI, K.H. 2010. Physico-chemical Properties of Water Samples from Manipur River System, India. *Journal of Applied Sciences and Environmental Management*, **14**(4), 85-89. https://doi.org/10.4314/jasem.v14i4.63263

SUMOK, P. 2001. River water quality monitoring: sharing Sarawak experience. 6th Sabah 21 Inter-Agency Tropical Ecosystem (SITE) Research Seminar, Proceedings, Kota 22 Kinabalu, Malaysia, 13-14 September, 2001, p. 4.

SWINGLE, H.S. 1967. Standardization of Chemical Analysis for Water and Pond Muds. *FAO Fisheries Report*, **4**, 397-421.

TANIA, A.H., GAZI, M.Y., and MIA, M.D. 2021. Evaluation of water quantity–quality, foodplain land use, and land surface temperature (LST) of Turag River in Bangladesh: an integrated approach of geospatial, field, and laboratory analyses. *SN Applied Sciences*, **3**, 63. https://doi.org/10.1007/s42452-020-04011-3

UDDIN, H.M. 2005. Initial environmental impact assessment of the Turag- Buriganga naval transport. M.Sc. dissertation (unpublished), Department of Geography and Environment, Jahangirnagar University, Dhaka.

UDDIN, M., MONIRUZZAMAN, M., HAQUE, M.A., HASAN, M.A., and KHAN, M. 2016. Seasonal variation of physicochemical properties of water in the Buriganga River, Bangladesh. *World Applied Sciences Journal*, **34**(1), 24-34. https://doi.org/10.5829/idosi.wasj.2016.34.1.22871

UDDIN, M.J., and JEONG, Y.K. 2021. Urban river pollution in Bangladesh during last 40 years: Potential public health and ecological risk, present policy, and future prospects toward smart water management. *Heliyon*, **7**(2), e06107. https://doi.org/10.1016/j.heliyon.2021.e06107

WAHAB, M.A., AHMED, Z.F., HAQ, M.S., and BEGUM, M. 1994. Compatibility of silver carp in the polyculture of cyprinid fishes. *Progressive Agriculture*, **5**, 221-227.

WHITEHEAD, P.G., BUSSI, G., HOSSAIN, M.A., DOLK, M., DAS, P., COMBER, S., PETERS, R., CHARLES, K.J., HOPE, R., and HOSSAIN, S. 2018. Restoring water quality in the polluted Turag-Tongi-Balu River system, Dhaka: Modelling nutrient and total coliform intervention strategies. *The Science of the Total Environment*, 631-632, 223-232. https://doi.org/10.1016/j.scitotenv.2018.03.038

WHO (WORLD HEALTH ORGANIZATION). 1995. Guideline for Drinking Water Quality. Geneva.

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