

Surface Water Quality of Balu River, Dhaka, Bangladesh

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Abstract

The Balu River, a critical water source in Dhaka, Bangladesh, is increasingly threatened by extensive pollution from industrial, agricultural, and domestic sources. This study assesses the water quality parameters of the river by water quality index approach, focusing on a 6 km stretch between Demra Ghat and Kamshair. Water samples were collected from five strategic points and analyzed for key parameters including pH, Turbidity, Chlorine, Phosphate, Iron, Color, CO₂, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS), and Nitrate levels. The findings reveal that while some parameters meet acceptable standards, critical indicators such as DO, BOD, and nitrate exceed permissible limits in certain locations, reflecting severe pollution from untreated industrial discharge, agricultural runoff, and municipal waste. The calculated Water Quality Index (WQI) by National Sanitation Foundation (NSF) method ranges from 31 to 37, categorizing the river's water quality as bad. This degradation poses significant environmental and public health risks, especially as the river serves agricultural, domestic, and ecological functions. The study underscores the urgent need for stringent enforcement of pollution control measures, advanced wastewater treatment technologies, and public awareness initiatives to safeguard this vital water resource.

Keywords

Surface water; Water quality; Dissolved Oxygen (DO); Biochemical Oxygen Demand (BOD); Water Quality Index (WQI)

1. Introduction

Bangladesh is a country surrounded by rivers (Uddin & Jeong, 2021a). It is a small, densely populated country located in South Asia (Yin et al., 2021). It is bordered by India to the west, north, and east, and by Myanmar (Burma) to the southeast. The largest delta in the subcontinent, the fertile Bengal delta, is where the nation is located (Steckler et al., 2008). Deltaic floodplains, which make up 80% of the nation, are crossed by roughly 257 rivers, including 59 transboundary rivers (S. N. Islam, 2016). The rivers, particularly those around the city, are experiencing increased pollution due to growing industrial activities (Sarkar et al., 2019). The Buriganga, Turag, Balu, and Shitalakshya rivers, which encircle the capital city Dhaka, are currently in a severely degraded state (M. Islam & Mostafa, 2019). Balu river is a river of Dhaka, Bangladesh and it is a tributary of the Shitalakshya river and has a connection with the Turag river through Tongi lake (Bhuiyan et al., 2021). The river is increasingly becoming the most polluted area, resulting in the continuous contamination of the Shitalakshya river (K. Hasan et al., 2014). Consequently, this pollution poses a significant threat to the pollution level Saydabad water treatment plant. The Madhupur Tract hills are the source of the Balu river, which runs through the capital city of Dhaka (Hassan & Southworth, 2017). It is a significant water source for the city and is utilized for irrigating land, fishing, and other purposes.

The population of Dhaka has grown exponentially over the past 70 years. In 1950, the population was only 335,760, but by 2025, it has reached to 24,652,900 with an average annual growth rate in urban Dhaka is 1.54 in the last year. Due to the accommodation of this huge population and industrial boom, surface water contamination is now a major hazard for human existence. Rivers are the most popular options among surface water sources for holding pollution (Singh et al., 2022). Tanneries, dyeing businesses, aluminum, iron, and steel workshops, plastic production, battery manufacture, washing, hardware, and cold storage facilities are only a few examples of industrial establishments around the river (Sultana et al., 2019). Surface water in Bangladesh is subjected to pollution through diverse means. Key contributors to the pollution of surface water include industrial waste, agricultural inputs such as fertilizers and pesticides, sewage discharge, and improper sanitation (Syeed et al., 2023a). Water that is contaminated cannot be utilized for drinking, household, and farming needs due to its inherent health hazards (M. K. Hasan et al., 2019). According to a research, Tejgaon industrial area alone discharge 12,000 m³ untreated effluent into Balu rivers through Shitalakshya (Roy et al., 2014). Untreated effluents poses serious threats to the aquatic ecology and phytoplankton diversity (Essa et al., 2024).

1.1 Objectives

The objectives of the study were:

- a) To evaluate the surface water quality by assessing key physico-chemical and biological parameters.
- b) To determine the Water Quality Index (WQI) by National Sanitation Foundation (NSF) method to justify its suitability for ecological purpose.

2. Literature Review

Surface water quality in rapidly urbanizing regions has been a major global concern, particularly in developing countries where unregulated industrial growth, population pressure, and inadequate wastewater treatment infrastructure accelerate river degradation (Ahmed et al., 2025). Bangladesh, a riverine nation with over 257 rivers, faces acute pollution challenges, especially around metropolitan Dhaka. Rapid industrialization along the Buriganga, Turag, Balu, and Shitalakshya rivers has intensified contamination levels, making these water bodies among the most polluted in the country (Uddin & Jeong, 2021b). Research shows that Dhaka's rivers consistently receive untreated industrial wastewater from dyeing factories, tanneries, metal workshops, plastic industries, and food-processing units, contributing significantly to organic pollution, heavy metals, and microbial contamination (Rakib et al., 2024). The Balu River, connected to the Turag River and part of the Shitalakshya system, plays a vital role in irrigation, fisheries, and domestic activities; however, it is increasingly threatened by effluent discharge, agricultural runoff, and sewage intrusion. Studies indicate that industrial areas such as Tejgaon alone discharge approximately 12,000 m³/day of untreated wastewater into the Balu–Shitalakshya river system. Such discharges severely affect aquatic ecosystems, reducing dissolved oxygen (DO) and elevating biochemical oxygen demand (BOD) beyond permissible limits, which disrupts phytoplankton productivity and fish habitats. Urban population expansion further aggravates pollution stress, with Dhaka's population rising dramatically from 0.3 million in 1950 to over 24 million in 2025, leading to increased sewage loads and solid waste disposal into surrounding rivers. Contemporary studies consistently report that key water quality parameters including nitrate, phosphate, turbidity, fecal coliforms, and total solids regularly exceed national and international standards, highlighting severe public health risks. To quantify environmental conditions, the National Sanitation Foundation's Water Quality Index (NSF-WQI) is widely used in Bangladesh for river assessments, offering a composite rating of ecological suitability based on physico-chemical and biological indicators. Prior assessments of the Balu, Buriganga, and Turag rivers using WQI methods have classified them as “bad” to “very bad,” with DO depletion and high BOD identified as principal drivers of ecological decline. Overall, the existing body of literature establishes that unchecked industrialization, rapid urban growth, and weak enforcement of environmental laws contribute to persistent pollution of the Balu River, necessitating continuous water quality monitoring and sustainable management strategies.

3. Methods

3.1 Study Area

The Balu river has a length of 44 km (Wikipedia contributors, 2022). In this study, a stretch of the Balu river measuring about 6 km, extending from Demra ghat to Kamshair, was examined. To collect water samples, this entire length was divided into five distinct segments (Figure 1).

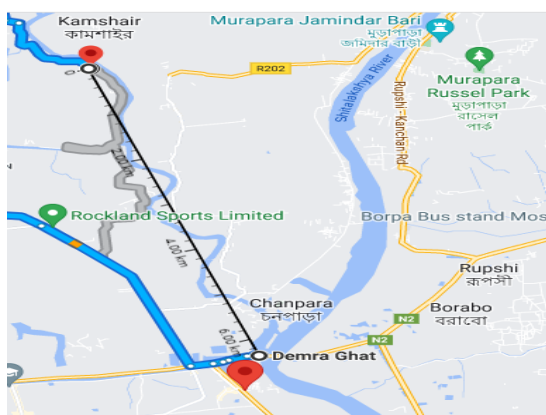


Figure 1. Study Area.

3.2 Sample Collection

Water samples were collected from five different locations spanning from Demra Ghat to Kamshair. A boat was employed to collect the samples from the midpoint of the river. Five 1-liter plastic bottles were utilized to collect the samples at various sampling points. Prior to the collection process, the bottles were thoroughly cleaned by distilled water. To ensure the integrity of the samples, the bottles were rinsed three times with the water to be sampled. At each sampling point, three water samples were collected at morning (9 am), noon (12 pm) and afternoon (3 pm) from two

feet depth from the water's surface and mixed thoroughly by taken same amount to form one-liter composite sample. The samples were immediately sealed to prevent exposure to air and protect against fungal and pathogenic contamination. The bottles were appropriately labeled, indicating the respective number and location name. Table 1 shows the sample collection points with geographic coordinates.

Table 1. Sampling points with geographic locations.

SL. No.	Sampling Point	Co-ordinates
1	Demra Ghat	23°43'19.2"N 90°29'53.1"E
2	Dhitpur Bazar	23°45'05.9"N 90°29'08.2"E
3	Nalchhata Itkhola Demra Baitul Ahmed Masjid	23°45'33.6"N 90°28'54.2"E
4	Balurpar Govt. Primary School	23°46'11.0"N 90°28'55.4"E
5	Eiderkandi- Fakirkhali Link Road	23°46'33.8"N 90°28'42.2"E

3.3 Laboratory Analysis

The collected samples were analyzed for Total Solids, pH, temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), total phosphate, Nitrate, fecal coliform and turbidity. pH was analyzed by digital pH meter, E coli by membrane filter technique, DO and BOD by titration method and other parameters were analyzed by UV-Vis Spectrophotometer.

4. Results and Discussion

4.1 Water Quality Parameters

From the water quality parameters as shown in Table 2 it is clear that the water quality in several areas is quite poor while comparing with Bangladesh Environmental Conservation Rules, ECR 2023. In samples 2 to 5, the DO levels are dangerously low, especially in sample 3, where it drops to just 0.4 mg/L which is far below the safe limit needed to support fish and other aquatic life. At the same time, sample 3 shows a very high BOD of 23 mg/L which is a strong sign of heavy organic pollution likely from waste or sewage. While the pH, temperature, and total solids seem to be within a normal range, the combination of low oxygen and high pollution levels is worrying. The high counts of fecal bacteria and nitrate in some samples further suggest the water might be contaminated by untreated waste or runoff from farms.

Table 2. Summary of results of water quality parameters.

Parameters	Unit	Concentration of different parameters				
		Sample 1 (S1)	Sample 2 (S2)	Sample 3 (S3)	Sample 4 (S4)	Sample 5 (S5)
Total solids	mg/l	267	296	342	349	311
pH	-	6.7	7.2	6.8	7.4	6.9
Temperature	°C	31	30	32	27	30
DO	mg/l	7.2	2.3	0.4	0.8	2
BOD	mg/l	3.5	4.3	23	6.1	4.9
Total phosphates	mg/l	0.06	0.04	0.07	0.05	0.03
Nitrate	mg/l	132.9	177.2	17	31	44.3
Fecal coliforms	CFU/100 ml	3.1×10^5	3.4×10^5	4.3×10^5	3.8×10^5	3.5×10^5
Turbidity	NTU	34	48	50	47	42

4.2 Water Quality Index (WQI)

The tested data were used to calculate the WQI by NSF method. NSF is a widespread method to determine the WQI of river water which country origin is United States of America (USA) and has been further developed from Horton, Dinius Water Quality Index (DWQI) (Syeed et al., 2023b). In NSF method 9 parameters are employed to find the WQI which are Dissolved Oxygen (DO), fecal coliform, pH, Biochemical Oxygen Demand (BOD), temperature, total phosphate, nitrate, turbidity, total solids and water quality can be expressed as excellent (90–100), good (70–90), medium (50–70), bad (25–50), very bad (0–25) (Syeed et al., 2023b).

The NSF water quality index can be calculated as shown in equation (i).

$$WQI = \sum W_i Q_i \text{ -----(i)}$$

Where, W_i = weighting factors of i^{th} parameter and Q_i = Sub index for i^{th} parameter.

Table 3 shows the water quality index of the water collected from different locations.

Table 3. WQI of water samples.

Parameters	Unit	Weightage W_i	Q _i value of different samples					W _i Q _i				
			Sample 1 (S1)	Sample 2 (S2)	Sample 3 (S3)	Sample 4 (S4)	Sample 5 (S5)	Sample 1 (S1)	Sample 2 (S2)	Sample 3 (S3)	Sample 4 (S4)	Sample 5 (S5)
Total solids	mg/l	0.07	63	59	53	52	57	4.41	4.13	3.71	3.64	3.99
pH	-	0.11	75	91	80	92	87	8.25	10.0	8.8	10.1	9.57
Temperature	°C	0.1	8	10	7	14	10	0.8	1	0.7	1.4	1
DO	mg/l	0.17	3.6	1.15	0.2	0.4	1	0.61	0.19	0.03	0.06	0.17
BOD	mg/l	0.11	62	79	8	50	54	6.82	8.69	0.88	5.5	5.94
Total phosphates	mg/l	0.1	92	94	93	95.8	96.5	9.2	9.4	9.3	9.58	9.65
Nitrate	mg/l	0.1	1	1	41	26	14	0.1	0.1	4.1	2.6	1.4
Fecal coliforms	CFU/100 ml	0.16	2	2	2	2	2	0.32	0.32	0.32	0.32	0.32
Turbidity	NTU	0.08	48	40	38	41	43	3.84	3.2	3.04	3.28	3.44
$WQI = \sum W_i Q_i$								34	37	31	37	35
Water Quality Ratings								Bad	Bad	Bad	Bad	Bad

5. Conclusion

The assessment of surface water quality along a 6 km stretch of the Balu river from Demra Ghat to Kamshair reveals a critical environmental concern. Through comprehensive testing and application of the NSF water quality index method, it was found that the WQI values at all five sampling points range from 31 to 37. This range falls distinctly within the “bad” category WQI ranges from 25–50 according to established NSF water quality classification standards. The consistently poor WQI ratings are primarily attributed to significantly low dissolved oxygen (DO) levels, elevated biochemical oxygen demand (BOD), and high concentrations of nitrate and fecal coliforms parameters that directly indicate the presence of untreated industrial waste, sewage, and agricultural runoff. The DO levels in several locations

were critically low poses serious hazards to aquatic life, while BOD peaked dangerously, signaling heavy organic load and microbial activity. High fecal coliform counts reinforce the likelihood of widespread microbial contamination, making the water unsafe for domestic or recreational use.

The WQI results highlight an alarming degradation of water quality in the Balu river, classifying it as unsuitable for most intended uses without significant treatment. Immediate, integrated interventions combining regulatory enforcement, improved wastewater treatment infrastructure, and public awareness are necessary to restore and protect this vital waterway from further ecological and public health deterioration.

6. Future Work

Ensuring clean and sustainable surface water is vital for the long-term well-being and development of Dhaka City. Rapid urbanization, expanding industrial zones, and population growth continue to exert pressure on river systems, including the Balu River. To support effective water resource management, future work may focus on the following areas:

- a) Pollution sources may be identified in future studies to trace contributions from industrial, domestic, and agricultural activities.
- b) Heavy metals and other toxic pollutants may be analyzed to provide a more complete understanding of chemical contamination in the river.
- c) Seasonal variations in water quality may be investigated to determine how DO, BOD, and microbial levels change throughout the year.
- d) Human health risks may be assessed for communities that use the river water for domestic, agricultural, or livelihood purposes.
- e) Fish species commonly consumed by local residents may be analyzed to evaluate potential carcinogenic and non-carcinogenic health risks associated with pollutant accumulation.
- f) Low-cost, nature-based treatment technologies such as constructed wetlands and floating treatment wetlands may be studied to assess their suitability for improving water quality in the Balu River.

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Biographies

Tanvir Ahmed is a professional Bangladeshi who has academic and voluntary experience in the fields of Civil Engineering, Business Administration, and sustainability. In 2024, he got his “B.Sc. in Civil Engineering” at the World University of Bangladesh (WUB) and is now pursuing “Master of Business Administration (MBA)” in Dual Specialties in “Management” and “Human Resource Management (HRM)”. In addition to his work, he has been working with other organizations like BD Clean, Eco-Network Global, YouthNet Global, Mission Green Bangladesh (MGB), OAB Foundation, and Climate Frontier, which focuses on climate change, environmental protection, and SDGs. As a professional, he is a member of The Institution of Structural Engineers (IStructE) as a Graduate Student Member and also has associated memberships with ASCI, ACI and APA. With technical skills, business skills and a promise of sustainability, Mr. Ahmed is determined to make a contribution towards engineering and environmental innovation.

Md. Robaet Hossain Khan is a Research Assistant at the Accident Research Institute (ARI) at the Bangladesh University of Engineering and Technology (BUET) in Dhaka. He is currently involved in a research project titled "Motorcycle accidents is an emerging public health concern in Bangladesh: lessons and challenges for policy advocacy," which is funded by a grant from the Bangladesh Bureau of Educational Information and Statistics (BANBEIS) under the Ministry of Education. He earned B.Sc. in Civil Engineering at the World University of Bangladesh in 2024.

Tariqul Islam is currently serving as an Assistant Engineer at Zimaflat Engineering, where he is involved in structural design, site supervision, and project coordination. He received his B.Sc. degree in Civil Engineering from the World University of Bangladesh in 2023. He obtained his Diploma in Engineering from Narsingdi Polytechnic Institute in 2017. He is a Member of the Institution of Diploma Engineers, Bangladesh (IDEB).

Md. Tanvir Ahammed Jesan is a youthful professional who is goal oriented and enthusiastic. He graduated with a Bachelor of Civil Engineering (B.Sc.) degree and is undertaking a Master's degree of Business Administration (MBA). This academic life is making him ready to have a diverse career as he takes technical skills and integrates them with managerial skills. In conjunction to his studies, he has worked as a Campus Ambassador in a series of organizations. These positions have enabled him to get hands-on experience in leadership, communication, teamwork, event

management and networking. These experiences not only have made him more confident but also have created a foundation of leadership in organizations and professional growth.

Md. Tanvir Ahmed was born in the northern region of Bangladesh. He successfully earned his undergraduate degree from the Department Civil Engineering of the World University of Bangladesh (WUB). He is now working as a lecture in the same department. Currently, Mr. Tanvir is actively pursuing a Master of Science (M.Sc.) in Civil Engineering at the Military Institute of Science and Technology (MIST). His research interests primarily focus on areas such as water and air quality, noise pollution, and wastewater treatment.

Rokhshana Parvin, a native of northern Bangladeshi, completed her undergraduate studies in Civil Engineering at the World University of Bangladesh (WUB). She currently serves as a lecturer at WUB and is concurrently pursuing a Master of Science (M.Sc.) in Civil Engineering at the Military Institute of Science and Technology (MIST).