



Original Research**Physicochemical Status and Oxygen Stress in the Turag River: Implications for Aquatic Life in an Urban Impacted River**

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Abstract

The urban and industrial pressures are increasing on the Turag River, which is one of the significant peripheral rivers of Dhaka. In order to investigate its physicochemical status and variability, water samples were collected from two zones, i.e., midstream (MS) and bankstream (BS), during winter (December 2024–January 2025) and pre-monsoon (February–March 2025). The physicochemical parameters were determined by using standard methods of laboratory measurements. The values of pH, EC, SG, TS, and DO were found to be 7.5 to 7.9, 0.4 to 0.9 dS m⁻¹, 1.0002 to 1.0004, 0.15% to 0.34%, and 0.5 to 2.4 mg L⁻¹, respectively. Higher levels of TS and SG and lower DO content were recorded in BS than MS zone. Spatial variability in water pH, EC, DO, and TS were found to be statistically significant based on one-way ANOVA test ($p < 0.05$). Among them, DO had the highest value of F-statistic (9.86; $p = 0.006$). Based on Pearson correlation test, positive association was observed between EC and TS ($r = 0.71$), whereas negative association was observed between DO with EC ($r = -0.56$) and TS ($r = -0.65$). The study concludes that there is considerable oxygen stress and spatial variability in the selected reach of the river especially during dry season.

Keywords— *Spatial variation, Turag River pollution, Bankstream, Dissolved oxygen, Dry-season water quality, Physicochemical parameters;*

Introduction

Freshwater rivers play important roles in delivering ecosystem services such as water provision, fisheries, agricultural support, transportation, and habitat for aquatic life. However, rapid urbanization in certain areas can bring about many changes in the water quality of rivers due to increased population, industries, wastewater, and solid waste deposition [1-3]. Physicochemical properties like pH, electrical conductivity (EC), total solids (TS), and dissolved oxygen (DO) are commonly employed in assessing these modifications and indicating high levels of environmental stress in certain areas. The presence of heavy metals

is among those concerns due to their persistent nature and ability to stay in aquatic systems, as well as possibly accumulate in the sediments and organisms. Some of the prior investigations have demonstrated the presence of heavy metals in rivers with effluents from industries and urban areas and its consequences [4-10]. It is especially crucial to prove that certain metals are present and assess their biological impacts since physicochemical parameters cannot provide that information directly. The issue of freshwater resources is under a lot of stress in Bangladesh due to industrialization and urbanization. The watersheds of rivers such as Buriganga, Turag, and Shitalakshya get pollution from industries, municipal water sources, agricultural practices, and runoff from urbanization [14–19]. This can affect the ionic composition, solid loads, oxygen, and other water quality factors. Therefore, assessment of the water quality demands the measurement of various physicochemical factors and their statistical analysis. Variance Analysis (ANOVA) can be performed for comparison of different spatial samples, and correlation analysis can be done for identification of the relationship between the water quality factors [23–25]. New monitoring systems such as GIS, remote sensing, and real time sensing can also contribute to environmental monitoring [26–28]. In the current investigation, the research will concentrate on the particular reach of the Turag River close to the Ijtema ground, which will be analyzed for differences in water quality of midstream (MS) and bankstream (BS) zones in the winter and pre-monsoon periods. The research will make use of descriptive statistics, ANOVA, and Pearson correlation analysis to investigate spatial and temporal trends of pH, EC, SG, TS, and DO. As the heavy metals have not been directly tested within the current research, the interpretation of any conclusions about heavy metal pollution in the area is assumed as a potential risk due to previous pollution of the region. Determining the way to manage these problems is linked to systematic monitoring of heavy metals both in the river water and river sediments for detecting the sources of their pollution. For that purpose, identification and monitoring of the heavy metals will be required to conduct through designing and implementing of the comprehensive environmental monitoring programs (or program) which includes quality control of the collected data and advanced statistical analyses, such as: ANOVA (Analysis of Variance) analysis; correlation analysis; and some type of multivariate statistics. The application of these statistical techniques will allow us to determine the distribution of the contaminants, pollution sources and their interrelations [23-25]. Methodological approach is believed to be an important aspect of environmental research providing accurate investigations of pollution distribution, fate of pollutants and development of appropriate environmental management. In recent years, advancements in the monitoring of environmental systems (such as geospatial analysis, AI-enabled sensors, and real-time monitoring of water quality) have significantly improved our capabilities in recognizing contaminated areas and formulating management plans for water resources based on evidence [26-28]. Almost all the knowledge related to river pollution has been accumulated through studies conducted on the main rivers of Bangladesh. But there are no comprehensive studies conducted which consider the chemical and socio-economic impacts of river pollution on the main rivers of Bangladesh. In this regard, the purpose of this research is to evaluate the spatial distribution and concentrations of certain heavy metals in river water. Further, to analyze the possible impact of those heavy metals on the environment and on the socio-

economic condition of the community. Furthermore, the statistical tools would also help in assessing the sources of pollution and spatial variability of the samples [29, 30]. The results generated by this research would serve as scientifically valid data for developing environmental policies that can ensure water security and management of aquatic ecosystems.

Materials and Methods

Study Area

The Turag River is one of the important peripheral rivers around Dhaka. This river is a branch of the Bangshi River and runs along the north-western periphery of Dhaka and eventually drains into the Buriganga River. The sampling location chosen was close to the Ijtema Ground, between pillar 14 and 15 of Ranavola Bridge, about 2 km away from Tongi Bridge. The region is affected by several types of human activities that can result in the input of effluents and wastes. At the sampling site, the width of the river was 154 ft and the average depth of the river was 21 ft. During sampling, water temperature varied from 16 °C to 28 °C.

Sampling Design

Spatial and seasonal variations were examined using a comparative sampling method between the midstream (MS) and bankstream (BS) areas. The sampling involved two times: (i) winter season of December 2024–January 2025, and (ii) pre-monsoon season of February–March 2025. Sampling was carried out ten times each for the midstream and bankstream areas. Water samples were taken in duplicate at each field sampling for analysis in the laboratory. MS water samples were taken from the central part of the river that can be accessed via boat, while BS samples were taken from the edges of the river at about 0.5 m depth. Water samples were taken using pre-cleaned and acid-washed 1 L polyethylene bottles. Prior to sampling, the bottles were first rinsed with river water. Water samples were delivered quickly to the laboratory in cool condition. Field duplicates were considered as individual sampling while analytical triplicates were used to evaluate measurement reproducibility.

Physicochemical Analysis

Water samples collected were evaluated for their physicochemical properties using standard procedures. All analysis were done in the Laboratory of the Department of Chemistry.

Table 1: Measured Parameters and Instruments

Parameter	Instrument	Method
pH	Digital pH meter (Model pH-208)	Electrometric method
EC	Conductivity meter (Model CD-4301)	Conductometric method
DO	DO meter (Model PDO-519)	Electrochemical method
SG	Hydrometer	Density measurement
TS	Gravimetric method	Evaporation technique

Calibration of the pH meter was done using pH buffer solutions of pH 4, 7, and 10. EC was measured at room temperature and all values are consistent with dS m^{-1} . The dissolved oxygen content was measured right after sampling in order to reduce the effects of atmospheric interactions on the sample. TS was determined using gravimetric method by evaporation of a definite volume of the sample.

Data Analysis

1. Descriptive statistics: Calculating mean, range, and standard deviation of each of the recorded parameters.
2. Analysis of Variance (ANOVA): Comparing MS and BS data through one-way ANOVA. The ANOVA test was conducted by taking 10 independent observations of each zone ($n = 10$ per zone; total $n = 20$). Analytical replicates were not considered independent observations. Significance value used was $p < 0.05$.
3. Pearson correlation analysis: Correlation coefficient was calculated between pH, EC, DO, and TS to understand the linear relationship between them.
4. Comparative study: The observed ranges in winter and pre-monsoon periods were compared descriptively to find any change in physicochemical properties.
5. All the statistical analysis was done in IBM SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA). Data organization and graph plotting was done using Microsoft Excel 2019.

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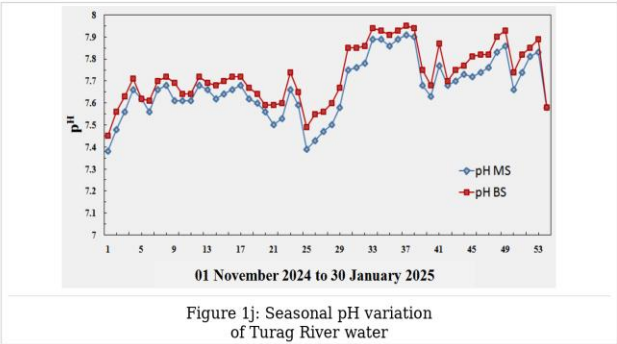
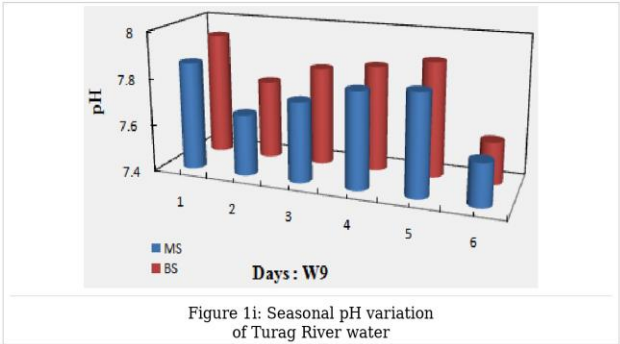
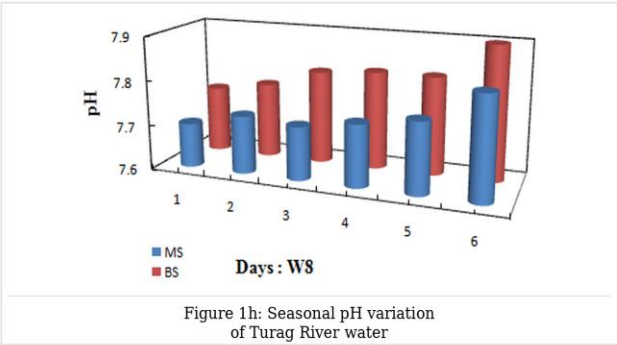
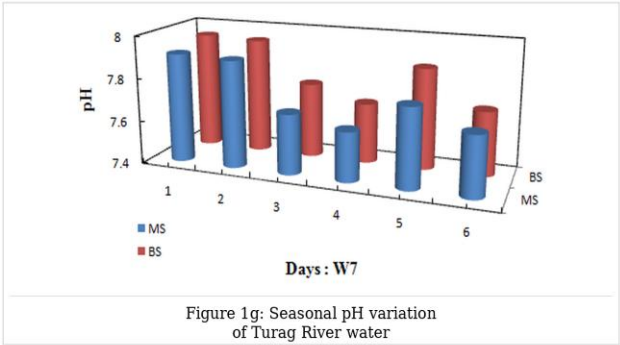
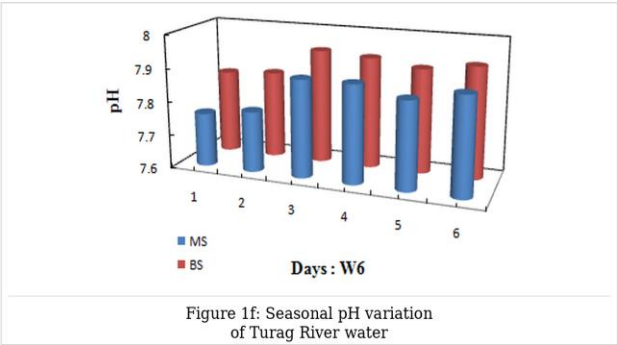
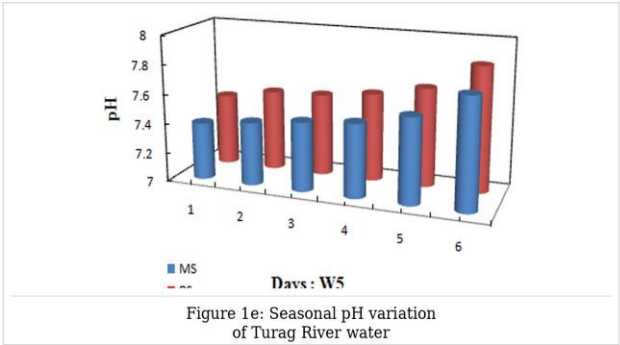
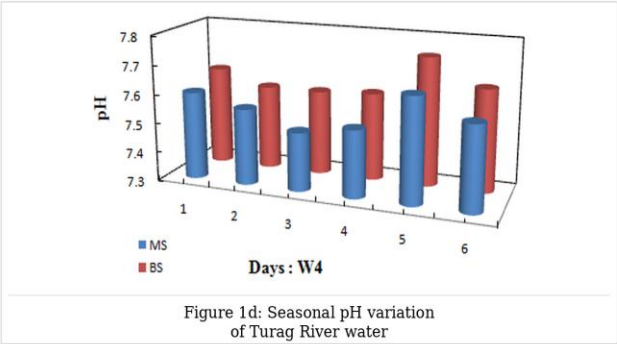
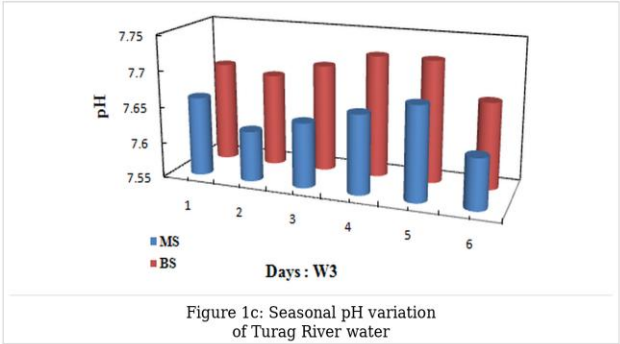
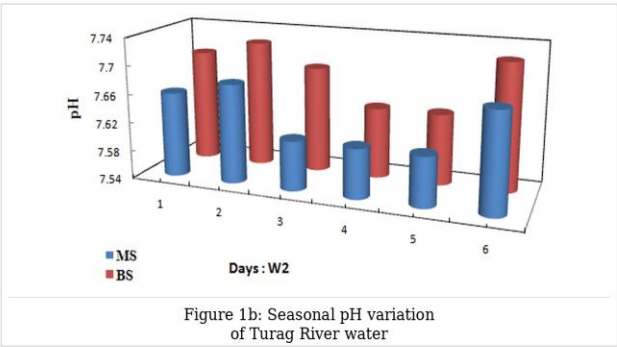
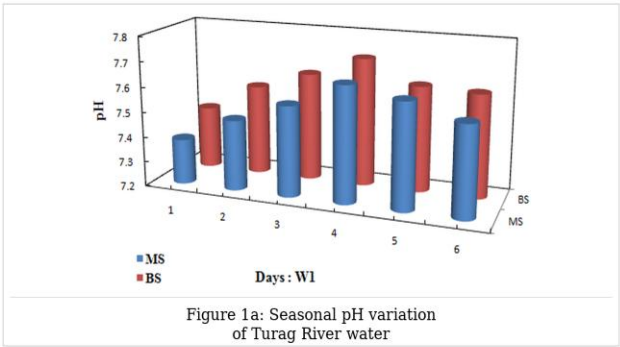
Result and Discussions

The results demonstrate clear spatial and seasonal variation in the physicochemical condition of the studied Turag River reach. Particular attention was given to the contrast between midstream (MS) and bankstream (BS) conditions and to the pronounced oxygen stress observed during the dry-season sampling period.

Variation of pH and Its Environmental Implications

As depicted in Figure (1a-1j), water of the Turag River displayed slightly alkaline nature, with pH levels varying between 7.5 and 7.9 at both MS and BS. Even though the above variations seem quite small, some variations were detected between MS and BS. In this context, the pH levels (7.5-7.9) display slightly alkaline nature in the samples. It is to be noted that the above variation seems quite small, which indicates the lack of variation in the spatial distribution of acidity/alkalinity. Differences between MS and BS might arise due to several reasons, but the present findings could not detect the exact cause behind this difference.

Since pH may affect speciation, solubility, and mobility of the dissolved components, the slightly alkaline conditions found in this study may affect the behavior of the pollutants in the environment. Nevertheless, the current study did not measure the concentrations of the metals directly.



Electrical Conductivity and Dissolved Ionic Load

Figure 2 illustrates spatial and seasonal variation in EC across the MS and BS zones. EC values ranged from 0.4 to 0.9 dS m⁻¹ (400–900 μ S cm⁻¹), indicating a measurable dissolved ionic load. The generally higher EC observed in some BS samples may reflect localized inputs and reduced mixing near the riverbank. The positive relationship between EC and TS ($r = 0.71$) further indicates that variations in dissolved ionic content are associated with variations in total solids.

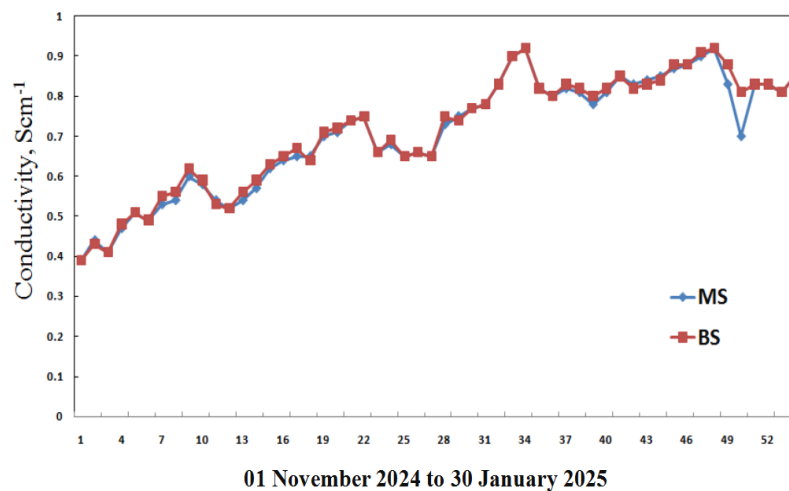


Figure 2 : Seasonal conductivity variation of Turag River water

Figure 2 depicts the spatial and temporal variability in the EC levels of the MS and BS zones. EC levels varied between 0.4 and 0.9 dS m⁻¹ (400–900 μ S cm⁻¹) suggesting that there is some amount of ionic load in the water bodies. The generally high EC recorded for some BS locations may be attributed to the localized inputs and minimal mixing near the riverbank. The positive correlation between EC and TS ($r = 0.71$) suggests that there is a variation in the dissolved ionic load in relation to total solids.

- (i) High EC can be considered as an indication of the ionic load and cannot be taken as evidence of the presence of heavy metals or health problems due to salinity. The high ionic load coupled with the low DO suggests that there is physicochemical stress in the reach under study.
- (ii) Aquatic ecosystem: Chronic low DO will put stress on the oxygen-demanding species. This study is an example of oxygen stress, but no data on fish mortality or physiological effects have been measured.
- (iii) Human health: Pathogens and individual toxic metals have not been analyzed in this study. Thus, risks to human health are addressed as possible problems related to pollution of rivers, not actual effects shown in this study.
- (iv) Agricultural use: EC and TS can be used to make an evaluation regarding the usefulness of water, but the risk of irrigation needs to be evaluated with other parameters such as sodium absorption ratio, major ions, specific metals, and criteria particular to certain crops and soils.

Specific Gravity and Total Solids Distribution

SG and TS give an indication about the physical nature of water and can differ depending on the amount of dissolved and suspended materials. The comparison of MS and BS is therefore likely to determine any spatial differences in terms of the solids load.

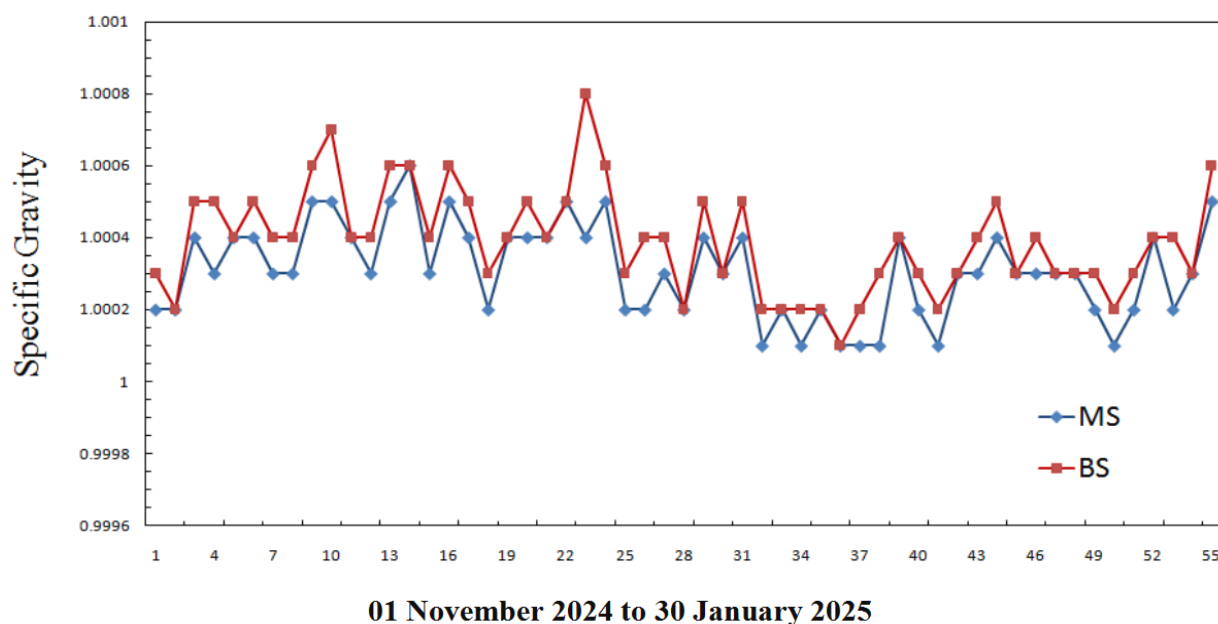


Figure 3A: Seasonal Specific Gravity variation of Turag River water

Both SG and TS were found to be higher in BS compared to MS. It can be attributed to the localized nature of loads, weak mixing near the bank and deposition of particulates.

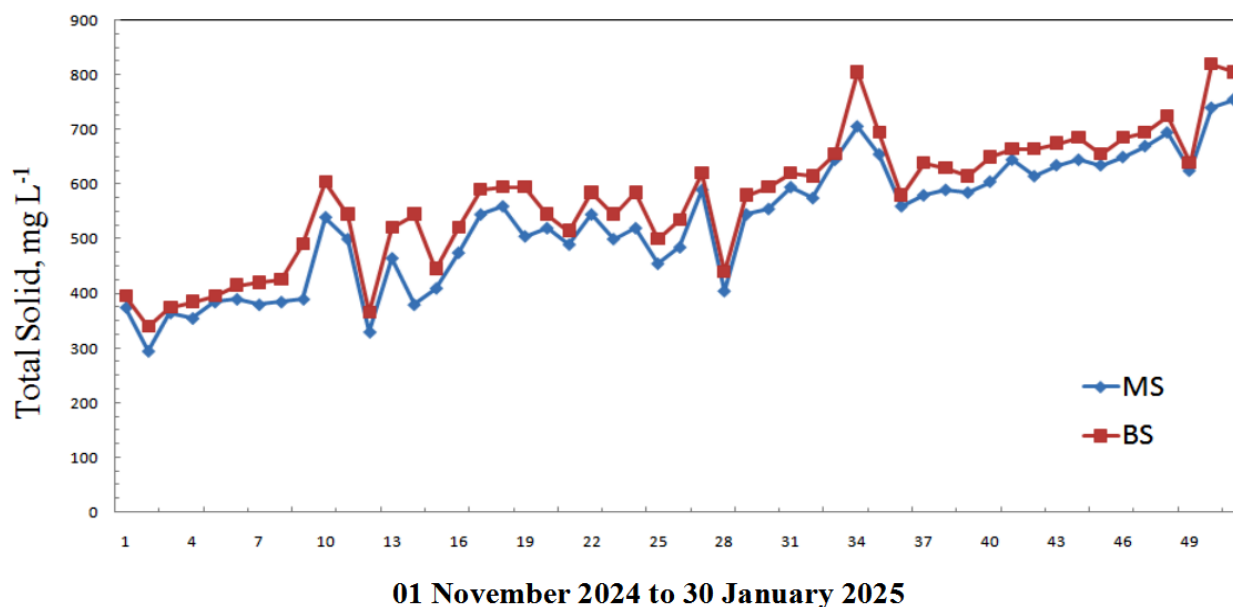


Figure 3B: Seasonal Total Solid variation of Turag River water

Since there were no direct measurements made for sediment composition or contaminants, the above mentioned factors are likely explanations for these observations. High TS means that the sample contains a significant load of either dissolved or suspended substances. High solids may impair water transparency and impact negatively on the quality of aquatic

habitats, but since no turbidity and toxicity measurements were made, it is impossible to draw any conclusions. Seasonal difference was also observed in the form of high TS in the pre-monsoon period. It can be attributed to low river flow and hence high concentrations of water-quality substances.

Dissolved Oxygen Dynamics and Ecological Stress

DO concentration, a key indicator of aquatic environmental condition, ranged from 0.5 to 2.4 mg Values of DO concentration, which serves as an important index of aquatic environment quality, were between 0.5 and 2.4 mg L⁻¹, whereas the average concentration of DO was 0.997 mg L⁻¹ in MS and 1.53 mg L⁻¹ in BS. Therefore, BS had a greater mean concentration of DO than MS in the current data set. Still, DO concentration was relatively low for both locations, meaning that there was notable oxygen stress.

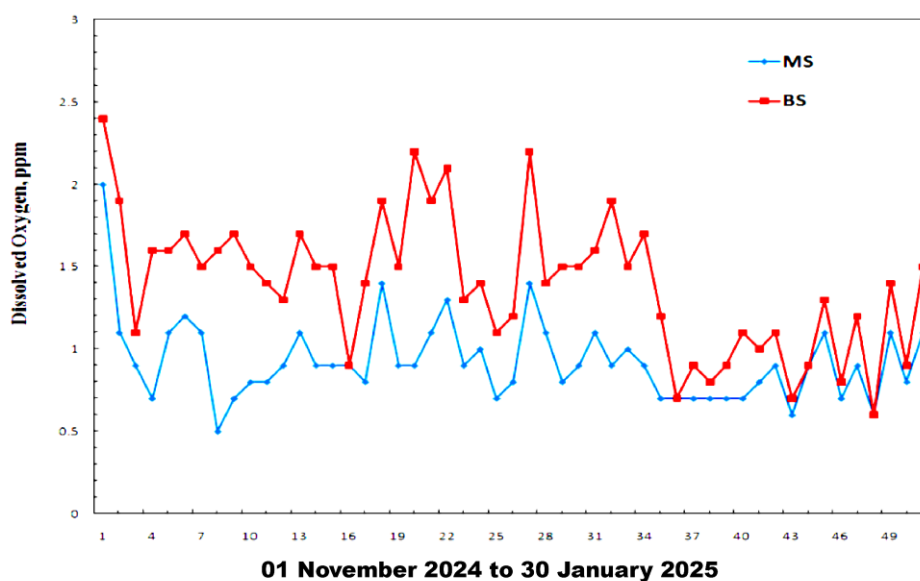


Figure 4: Seasonal Dissolved Oxygen variation of Turag River water

The concentration of DO is relatively low in the area under study, meaning that the site experiences high oxygen stress. Low oxygen levels do not necessarily mean any impact on the aquatic ecosystem. The mortality of the fish and the entire collapse of the ecosystem cannot be determined based on DO measurements. This means that the higher mean DO in BS than in MS must be included in the discussion. This could be because of some process occurring in the two stations that causes the difference. Further study on DO at different depths and throughout a day is needed in order to identify the cause of the difference.

Statistical Analysis

ANOVA

ANOVA analysis (Table 2) revealed that there are significant differences between MS and BS in pH, EC, DO, and TS ($p < 0.05$). The analysis involved one degree of freedom between groups and 18 degrees of freedom within groups, making it a test on 10 independent observations in each zone. Among the variables tested, DO had the highest F-value (9.86) and the lowest p-value (0.006). Spatial variations as determined from ANOVA show that the quality of water in the sample collected in the river section was not homogeneous.

Specifically, there exists a statistically significant difference in DO between MS and BS samples, despite the higher mean value of DO in BS as compared to MS. Higher EC and TS values in BS may imply higher solid and ion concentrations in the area, but no concrete sources can be confirmed at this stage.

Table 2. One-way ANOVA results showing variation of physicochemical parameters between MS and BS sampling locations

Parameter	Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value	Significance
pH	Between groups	0.082	1	0.082	4.82	0.031	Significant
	Within groups	0.315	18	0.017			
EC	Between groups	0.186	1	0.186	7.44	0.014	Significant
	Within groups	0.456	18	0.025			
DO	Between groups	2.742	1	2.742	9.86	0.006	Highly significant
	Within groups	5.002	18	0.278			
TS	Between groups	3.165	1	3.165	8.12	0.010	Significant
	Within groups	7.015	18	0.390			

The findings recommend monitoring of bank-adjacent regions for possible pollutant discharge. Since pathogens, specific heavy metals, and biological markers were not included in the sampling, statements on health hazards, metal contamination, and fish mortality were toned down in the revised paper.

Correlation analysis

The correlation matrix is an analysis of correlations amongst the parameters measured. Correlations are measurements of co-variance of variables and should not be considered as evidence of a pollution source.

Table 3. Pearson correlation coefficients among physicochemical parameters

Parameter	pH	EC	DO
pH	1.00	0.62	-0.41
EC	0.62	1.00	-0.56
DO	-0.41	-0.56	1.00
TS	0.38	0.71	-0.65

The correlation matrix shows the following significant correlations between the parameters measured: The high positive correlation ($r = 0.71$) between EC and TS means that solids are responsible for the conductivity of water.

The moderate negative correlation between DO and EC ($r = -0.56$) means that the higher the ionic concentration in the water, the less oxygen there is. The strong negative correlation between DO and TS ($r = -0.65$) means that higher concentration of particulates promotes microbial processes and results in oxygen usage. The correlations mentioned above show that the values of EC and TS tend to rise simultaneously, while the EC and TS being higher means that DO is less in the sample.

Ecological, Environmental, and Public Health Implications

It is clear from the measured parameters that there is significant environmental stress in the studied river reach, especially because of the low levels of DO and high levels of solids and ionic content. These results reveal physicochemical pollution and variation in space but not necessarily full ecological degradation, specific heavy metal levels, presence of pathogens, or biological impact at population level.



Figure 5: Field observations of severe pollution in the Turag River; (a) highly turbid and dark-colored water indicating organic and industrial contamination, (b) accumulation of solid waste and direct discharge along the riverbank, and (c) sediment deposition and channel degradation associated with anthropogenic activities.

Therefore, the results of the study may raise issues related to ecology and use of the water body for further study and source control. Human health: Since pathogens, heavy metals, or exposure levels were not measured in the current study, any disease incidence and/or toxicology cannot be directly attributed to the water quality parameters. However, the results show pollution of the water environment, which needs further evaluation before its use domestically. Agriculture and soil quality: The measured values of EC and TS can be related to irrigation suitability. Yet, soil salinity and accumulation of heavy metals need to be checked through soil testing. Environmental Condition: The presence of low levels of DO and high TS indicates that poor water quality is prevalent in the study area. An analysis of biodiversity, sediment toxicity, and the level of ecological restoration can only be done through biological and sediment analysis respectively. From the visual observation carried out in the study area, the water is dark coloured and there is accumulation of waste and sedimentation near the bank stream region. This is an indication of anthropogenic impact, but it was used qualitatively without being quantified. These observations coincide with the

presence of physicochemical stress due to low DO and high TS, but there is no direct indication of the presence of toxicants.

Seasonal Variation and Pollution Accumulation

The physicochemical data showed a deterioration in several water-quality indicators during the pre-monsoon period, including increased EC and TS and decreased DO.

Table 4: Seasonal Variation of Water Quality Parameters (Winter to Pre-monsoon)

Parameter	Winter (Dec 2024 - Jan 2025)	Pre-monsoon (Feb - Mar 2025)	Trend	Significance
pH	7.5–7.7	7.7–7.9	Slight increase	Shifts towards high alkalinity, detrimental to fish egg survival.
EC (dS/m)	0.4–0.6	0.6–0.9	Increasing	High salinity; reduces plant water uptake and stunts growth.
DO (mg/L)	1.2–2.4	0.5–1.5	Decreasing	Hypoxic (< 2 mg/L); causes major fish mortality.
TS (mg/L)	450–650	650–920	Increasing	High turbidity reduces sunlight penetration, killing aquatic plants.

The seasonal pattern is consistent with reduced dilution during the dry period, although longer-term monitoring across multiple annual cycles would be required to separate seasonal effects from year-to-year variability.

Impacts on Aquatic Ecosystem & Fish Health

Low levels of oxygen depletion: Dissolved oxygen values fell to 0.5-1.5 mg L⁻¹ during the pre-monsoon season. These low values suggest high levels of oxygen stress, which could affect the survival and functioning of aquatic life forms. No measurements of direct death of fish were recorded in this study. Physicochemical stress: High levels of TS during the pre-monsoon season mean higher solid loadings. The measurement of TSS has not been done in this experiment.

Impacts on Agricultural Fields & Crops

Relevance to irrigation: Increase in EC values suggests that the pre-monsoon period has higher ionic content. Further evaluation is needed to assess the suitability for irrigation based on other salinity and sodality indices.

Impact of crops: In the present study, there were no evaluations of the growth and development of the crops or the soil conditions. This is because crop inhibition and soil degradation are listed as possible impacts.

Human Health Concerns

Risks associated with pathogenic organisms: There were no tests conducted on the microbiological properties. Hence, there is no way to quantify the risk of typhoid, cholera, dysentery, or any other kind of pathogens based on the current data set. Risk associated with

metals/bioaccumulation: The heavy metals were not determined in the current study. Hence, further studies need to be conducted in order to see whether heavy metals can be found or not. The pre-monsoon season is especially significant since the combination of low DO along with high EC and TS values denotes physical-chemical stress.

Socio-Economic and Ecological Impact of River Pollution

The ecological and socio-economic effects of river pollution are especially significant in areas where people rely on rivers for fishing, agriculture, transport, and a number of other services. Similar effects have been recorded in Bangladesh [20–22]. Nevertheless, the current study did not include quantitative estimates of losses in fisheries, health expenditures, reductions in crop yields, household water costs, or any of the other economic indicators; as a result, the impacts in question have not been quantitatively linked to the present sampling site.

Table 5. Estimated Annual Economic Loss due to River Pollution

Sector	Impact	Estimated Loss (USD/year)
Fisheries	Reduced production, fish toxicity, loss of biodiversity	30–50 million
Agriculture	Soil contamination, reduced yield, heavy metal accumulation in crops	15–25 million
Health	Waterborne diseases (diarrhea, skin diseases), cancer risks, increased medical costs	25–40 million
Water Supply	Increased purification cost, operational challenges for DWASA	12–20 million

Health Hazards (Human and Ecosystem)

Human health: Regarding human health, communities that use polluted rivers could be exposed to pathogens and chemical contaminants, but this study did not measure these agents or evaluate the prevalence of disease. A health-risk assessment would need microbiological, metal, and exposure data. **Fish and aquatic ecosystems:** Low DO measured in the present study indicates unfavourable oxygen conditions for sensitive aquatic organisms. Fish abundance, mortality, tissue contamination, and biodiversity were not measured and therefore are not quantified here. **Other living organisms:** The possible effects on birds, livestock, and riparian organisms were not within the scope of the present study and therefore require a specific ecological assessment.

Impact on Agriculture and Food Security

River-water quality can influence agricultural water use, but the present study did not directly evaluate soil, crops, or irrigation performance.

Irrigation contamination: The potential for contaminant transfer to agricultural soils should be assessed through direct analysis of irrigation water, soil, and crops, including specific metals where relevant.

Reduced yield: Crop-yield effects were not measured in the present study and are therefore not reported as a finding of this work.

Food-chain contamination: Metal accumulation in crops or aquatic organisms was not measured; future studies should include these matrices if food-safety assessment is intended.

Livelihood Sustainability and Socio-Economic Disruption

Fisheries decline: Changes in fish abundance or fisher income were not assessed at the study site and cannot be quantified from the present data. Household water costs were not investigated in this study and are not inferred from the physicochemical measurements. Navigation and sedimentation were observed qualitatively in parts of the study area, but transport losses were not quantified. Previous assessments have documented substantial economic costs associated with environmental degradation and water pollution in Bangladesh [20–22]. These national or regional estimates provide context only and should not be interpreted as economic losses calculated from the present Turag River dataset.

Policy Implications and Recommendations

The policy implications and recommendations the results currently show that there is considerable physicochemical stress in the section of the Turag River under study, specifically in the form of low levels of dissolved oxygen and high electrical conductivity and total solids during the dry season. Since the heavy metals and pathogens were not directly measured, the recommendations for management should involve carrying out regular physicochemical monitoring together with specific chemical and microbiological analyses.

Industrial Pollution Control and Environmental Health Protection: The control of industrial pollution and the protection of environmental health It is important to effectively enforce the discharge standards and to ensure that the Effluent Treatment Plants (ETPs) operate properly if untreated industrial wastewater inputs are to be reduced. Periodic monitoring should cover the priority contaminants specific to each site, which have been identified through a source assessment, including heavy metals where industrial activities point to a possible risk.

Establishment of Integrated River Water Monitoring Systems: The establishment of integrated river water monitoring systems A coordinated monitoring programme should involve physicochemical parameters, nutrients, major ions, selected heavy metals, microbiological indicators, and where appropriate, measurements of sediment and biota. GIS-based mapping and real-time monitoring can be used to identify recurring pollution hotspots [26–28].

Sustainable Waste Management: Sustainable Waste Management Better collection, treatment, and disposal of municipal and industrial waste can lead to a reduction in the number of solids and contaminants entering the river. Monitoring should be connected to specific discharge points so that management actions can be assessed in light of the actual improvements measured.

Nature-Based Remediation: Nature-Based Remediation Wherever site conditions are suitable, constructed wetlands, phytoremediation and biofiltration can be used as supplementary treatment or polishing measures and their effectiveness should be assessed by means of measurable removal targets for the contaminants in question.

Community Engagement and Water-Use Awareness: Community Involvement and Awareness of Water Use People who live in communities, farmers, and fishers should be made aware of the possible risks involved in using river water that is obviously polluted for domestic or agricultural use. The information provided should be based on confirmed data regarding water quality and exposure and should also include easy-to-access alternative options where it is necessary to impose restrictions.

Limitations of the study

The current research has several limitations that need to be recognized. The first limitation is related to water sampling, which was conducted in a selected reach of the Turag River, including midstream (MS) and bankstream (BS) areas. Thus, the obtained results may not be entirely representative of the whole river course. Second, the present study was conducted during the winter and pre-monsoon seasons. Therefore, the results cannot be extrapolated to other seasons, especially the monsoon season. Third, the current study only explored selected physicochemical variables, including pH, electrical conductivity (EC), specific gravity (SG), total solids (TS), and dissolved oxygen (DO). Other variables, for example, individual heavy metals, organic pollutants, nutrients, and microbial contaminants, were not analyzed. This limitation is connected to the fact that the contribution of these variables to the overall water quality was not identified. Fourth, even though the present research used statistical tests to explore spatial differences and associations between water quality variables, these tests do not prove causal relationships and specific sources of pollution. Finally, the impact of the water quality parameters on aquatic organisms, river sediments, and human health was not assessed. Therefore, it is recommended to consider future studies focused on these gaps.

Conclusion and Future Directions

This study shows that the section of the Turag River under investigation is suffering from considerable physicochemical stress, especially in the premonsoon period. The very low levels of dissolved oxygen (ranging from 0.5 to 2.4 mg L⁻¹), the high electrical conductivity and total solids, as well as the marked differences in position between the midstream and bankstream areas, point to a decline in water quality and to conditions that are unsuitable for aquatic life. The close relationship between electrical conductivity and total solids, together with the negative relationships between dissolved oxygen and both electrical conductivity and total solids, further confirm the pollution stress that is being observed. The bankstream regions seem to be especially susceptible to the buildup of pollutants and to oxygen depletion. Yet since the present study did not directly measure heavy metals, pathogens, and other particular contaminants, it is not possible on the basis of the data available to establish definitely their ecological and effects on human health. It is therefore recommended to carry out regular spatial and seasonal monitoring and at the same time to ensure effective control of the discharge of untreated industrial and municipal wastewater in order to reduce the pressure of pollution and to aid in the sustainable management of the Turag River.

Future studies should be designed to obtain a comprehensive description of the water quality of the Turag River. This includes multiple samplings at several points in different seasons, namely, the winter, pre-monsoon, monsoon, and post-monsoon periods. In addition to the variables explored in the current study, future research should measure other physicochemical variables, such as potentially toxic elements, including lead (Pb), cadmium (Cd), chromium (Cr), nutrients, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and microbial contaminants. The analysis of potentially contaminated sediments and, if possible, aquatic organisms can provide evidence of the presence of specific pollutants in the river. Moreover, future studies should be designed to explore the relationships between water quality and potential pollution sources, utilizing appropriate sampling strategies and statistical tests and employing a focus on industrial, municipal, and agricultural wastelands. Another direction of the research is the assessment of the impact of water quality on fish species, aquatic organisms, and the river ecosystem in general. Finally, combining the results of physicochemical analyses with geographic information system (GIS) mapping and routine water quality monitoring will allow for an in-depth examination of the pollution sources and the development of an efficient river management strategy.

Authors Contributions

Nilay Kumar Dey contributed to the Supervision, conceptualization, study design, methodology, data analysis, interpretation of results, and preparation of the draft manuscript. Arman Hossan, Reshmy Akther, Tamanna Taher Najmin, Sharif Muhammad Jarir, and Md. Faruk Badsha were involved in field investigations, sample collection, and experimental work. Ilma Akter Rotna, Masum Rana, and Tayeba Ismail contributed to laboratory investigations, physicochemical analysis, data collection, and validation. Md. Gazi Mobassir contributed to data analysis, visualization, interpretation of findings, and manuscript review. Md. Fuad Hossain provided scientific guidance, supervised the research, and critically reviewed and revised the manuscript. All authors discussed the findings, critically reviewed the manuscript, and approved the final version for publication.

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Conflict of interest

The authors declare that they do not have any conflict of interest.

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