# A STUDY OF WATER QUALITY PARAMETERS IN TURAG AND KARNATULI (BANSHI) RIVERS: A COMPARATIVE APPROACH

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## ABSTRACT

Rivers surrounding Dhaka have been exposed to severe degradation due to rapid urbanization, industrial expansion, and unregulated waste discharge. This study investigates and compares the water quality of the Turag and Karnatuli (Banshi) rivers through both field and statistical analyses to identify seasonal, spatial, and parameter-based variations. Seven sampling stations—three along each river and one at their junction—were analyzed during the wet and dry seasons. The selected physico-chemical parameters included pH, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Temperature, and Turbidity. Laboratory testing followed APHA (2017) and WHO (2017) standards, while statistical evaluations were conducted using Microsoft Excel and Python-based analytical tools.

Results revealed that water quality deteriorated significantly during the dry season, with mean COD ranging from 78 to 87 mg/L Turag stations, indicating intense organic and chemical pollution. Conversely, DO improved from 0.6–0.8 mg/L (wet) to 2.4–4.5 mg/L (dry), reflecting reduced microbial activity and limited self-purification. The Turag River consistently showed higher TDS (up to 492 mg/L) and turbidity (55–71 NTU) than the Karnatuli River, confirming its greater exposure to industrial and municipal discharges.

Correlation analysis identified strong positive relationships among COD, TDS, and Turbidity, suggesting a common pollution source. Principal Component Analysis (PCA) revealed that COD, TDS, and Turbidity were the dominant parameters explaining over 80% of total variance, and cluster analysis grouped the Turag stations as a high-pollution zone, distinct from the moderately impacted Karnatuli. The radar chart comparison confirmed the Turag's elevated normalized pollution indices across parameters.

Overall, the study concludes that the Turag River is more polluted than the Karnatuli (Banshi) River, primarily due to untreated industrial effluents and poor waste management. Strengthening effluent treatment facilities, enforcing environmental regulations, and implementing continuous water quality monitoring are urgently recommended to safeguard these critical aquatic ecosystems.

***Keywords:*** *Water quality, Turag River, Karnatuli (Banshi) River, Seasonal variation, Statistical analysis*

# 1. INTRODUCTION

Bangladesh is a riverine nation whose surface water resources support agricultural activities, fisheries, transport as well as household functions. The quality of key rivers around Dhaka, such as the Turag and the Karnatuli (Banshi), have been seriously diminished over the past few decades by fast urbanization and uncontrolled industrial growth. The rivers are regularly fed with unprocessed industrial and sewage effluents, and solid waste, which cause decreasing dissolved oxygen (DO) and increasing concentrations of organic and chemical pollution (Ahmed et al., 2021; Hossain and Sultana, 2020). This has not only caused a threat to the aquatic ecosystem but also poses a threat to the community that relies on these waters as regards to their health and socio-economic stability.

The degrading state of the Turag River has been highlighted in a number of studies and the river has been ranked among the most polluted rivers in Bangladesh (Rahman et al., 2019). Banks of the Karnatuli (commonly known as the Banshi) River, being less industrialized, is also experiencing agricultural runoff and localized discharges of effluents. The comparison of these rivers can thus give us some understanding of the spatial and temporal trends of contamination as well as contribute to the development of site-specific management plans.

The physico-chemical parameters that are usually used to measure water quality are pH, DO, COD, TDS, EC, temperature, and turbidity - all of which serve as important indicators of pollution or ecological stress (WHO, 2017). The seasonal change is a significant factor: at the time of a wet season, the pollutants are washed away by increasing the flow, in a dry season, the discharge decreases, and the contaminants are concentrated (Islam et al 2022).

Although there are some independent studies of the river system of Dhaka, there are few studies that compare Turag and Karnatuli rivers under similar analytical platforms through the application of the modern statistical analysis tools like the correlation matrix, Principal Component Analysis (PCA) and cluster analysis. By filling in this gap, the current study will focus on presenting an in-depth comparative analysis of water quality in the two rivers through seasonal and station-level changes, as well as defining the major aspects that determine the level of pollution.

The results will be useful in helping policy makers and environmental managers and researchers to come up with effective monitoring and mitigation initiatives to protect river water in Bangladesh.

# 2. METHODOLOGY

## 2.1 Study Area

The study conducted was on two large rivers within the borders of Dhaka, Bangladesh, the Turag River and the Karnatuli (Banshi) River. The Turag River traverses the northwestern periphery of Dhaka and is a large tributary of Buriganga River. It has large industrial and domestic wastewater discharges in the surrounding industrial areas including Tongi and Mirpur and hence its popularity as one of the most polluted rivers in the area.

Conversely, the Karnatuli (Banshi) River is distributed on semi-urban and agricultural lands in the Savar, and it experiences relatively less industrial pressure, though, it is affected by agricultural runoff and localized domestic operations.

Seven monitoring stations (three on the Turag River T1, T2, T3; three on the Karnatuli (Banshi) River K1, K2, K3; and one station (J), which is situated at the meeting point of the two rivers, Amin Bazar) were used to collect the samples of water. The sites of sampling were chosen in such a way as to sample upstream, middle and downstream parts and hence cover spatial variation in sources of pollution and stream features.

Despite the small number of sampling stations, the sampled sites were important sites of pollution and the almost less affected sections along the rivers. The sampling design offers a moderate spatial representation of the water quality conditions, and the seasonal sampling during wet and dry seasons offers a time variability of the water quality condition and allows the meaningful comparative analysis.

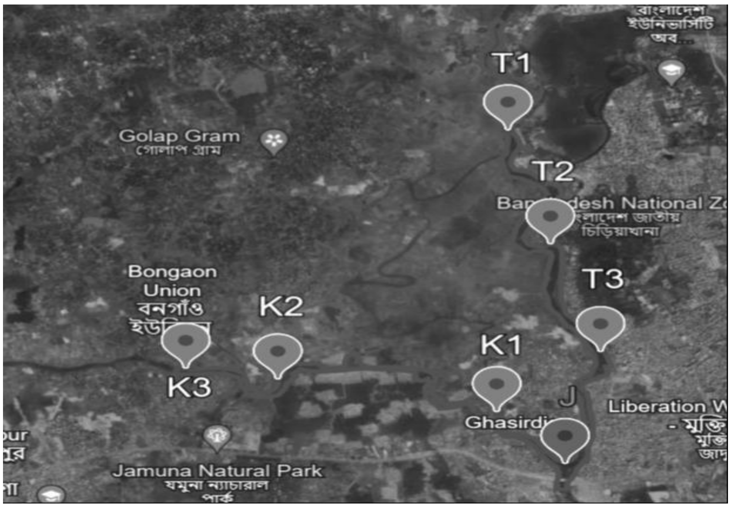


Figure 1: Map of the Study Area

## 2.2 Sample Collection and Field Observation

The two seasons of wet season (monsoon) and dry season (winter) of 2024 were used in collecting the water samples. Seasonal changes in the river water quality were captured by sampling each station in the two seasons. The samples were collected in clean bottles made of polyethylene, and they were rinsed with the same water before being collected. Portable meters were used to measure temperature, pH, and electrical conductivity (EC). Laboratory samples were stored in 4°C and taken to Environmental Engineering Laboratory in Daffodil International University.

## 2.3 Laboratory Analysis

Standard analytical procedures following the guidelines of APHA (2017) and WHO (2017) were used to determine physico-chemical parameters. The parameters analyzed included:

- pH (Hydrogen ion concentration)
- DO (Dissolved Oxygen)
- COD (Chemical Oxygen Demand)
- TDS (Total Dissolved Solids)
- EC (Electrical Conductivity, in µS/cm and ppm)
- Temperature
- Turbidity

Each parameter provides a different insight into water quality: for instance, DO indicate organic pollution and biological activity, while COD and TDS are strong indicators of industrial and chemical contamination (Rahman et al., 2019; Ahmed et al., 2021).

Table 1: Summary of Water Quality Parameters and Analytical Methods

| Parameter | Unit | Method / Instrument | Reference |
|---|---|---|---|
| pH | – | Digital pH meter | APHA (2017) |
| DO | mg/L | Winkler’s titration | APHA (2017) |
| COD | mg/L | Closed reflux, dichromate titration | APHA (2017) |
| TDS | mg/L | Gravimetric method | WHO (2017) |
| EC | µS/cm | Conductivity meter | APHA (2017) |
| Temperature | °C | Mercury thermometer | Field Measurement |
| Turbidity | NTU | Nephelometric method | WHO (2017) |

## 2.4 Data Processing and Statistical Analysis

All collected data were processed using Microsoft Excel and Python-based tools for advanced statistical analysis. Descriptive statistics were calculated to determine the range, mean, and standard deviation of each parameter. The weighted arithmetic index method was used to calculate the Water Quality Index (WQI) in order to determine the overall water quality condition of the study rivers. Each parameter was given a weight which corresponded to the relative significance, and quality ratings were determined based on the usual permissible limits suggested by World Health Organization (WHO, 2017) and the Department of Environment, Bangladesh (DoE, 2019).

To explore relationships among parameters, Pearson's correlation matrix was computed for both wet and dry seasons. Boxplot analysis was performed to visualize seasonal variation, while Principal Component Analysis (PCA) was used to identify dominant variables influencing water quality. Hierarchical cluster analysis was applied to classify stations with similar pollution characteristics, and a radar chart was used to compare normalized mean parameter values between the Turag and Karnatuli rivers.

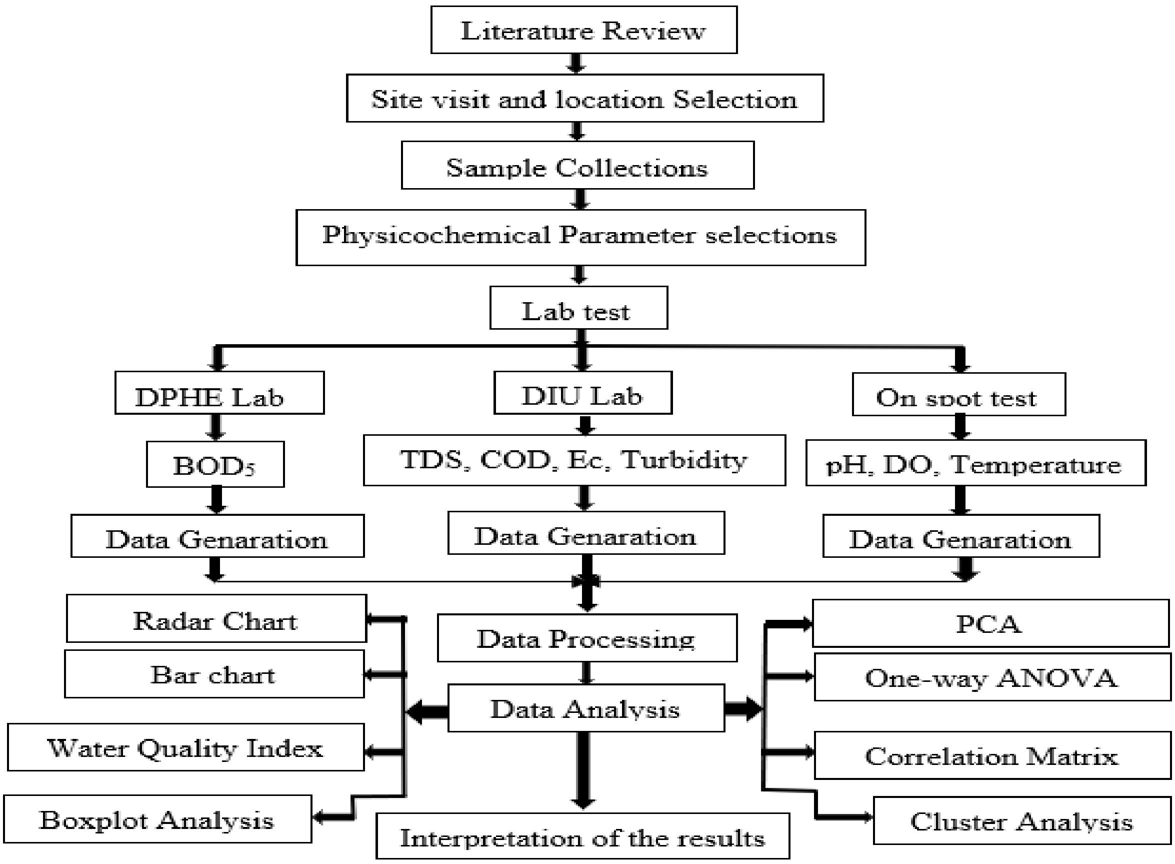


Figure 2: Flowchart of Methodology

## 2.5 Quality Assurance

To ensure data reliability, all instruments were calibrated before measurement, and duplicate samples were analyzed for 10% of total samples. Outliers were cross-checked with field notes to minimize human error. Data consistency was validated using correlation strength and statistical variance checks (Miah et al., 2022).

# 3. ILLUSTRATIONS

## 3.1 Descriptive Statistical Analysis

Comparative analysis of Turag and Karnatuli (Banshi) rivers shows a significant difference between the spatial and seasonal parameters of water quality. Seasonal variations had a strong effect, in that the levels of the pollutants in the dry season were higher and in the wet season, the levels were lower but relatively dilute. COD and TDS concentration in the Turag River were always higher in the river at stations T2 and T3, as a result of untreated industrial effluents and heavy runoff in urban areas. Conversely, the Karnatuli River showed relatively lower concentrations, which means that there is less industrial pressure and partial self-purification. These spatial variations are in line with the prior results that showed the degradation of the peripheral rivers in Dhaka following an uncontrolled discharge of waste (Rahman et al., 2019; Ahmed et al., 2021).

Figure 3 is where the boxplot of the water quality parameters of the wet season can be seen and the same applies to the dry season which is presented in Figure 4. pH, DO and COD, TDS, EC, Temperature and Turbidity are exhibited on both plots. The increase in the difference in dry-season values suggests increased variation and pollutant concentration due to the decreased flow and low dilution potential.

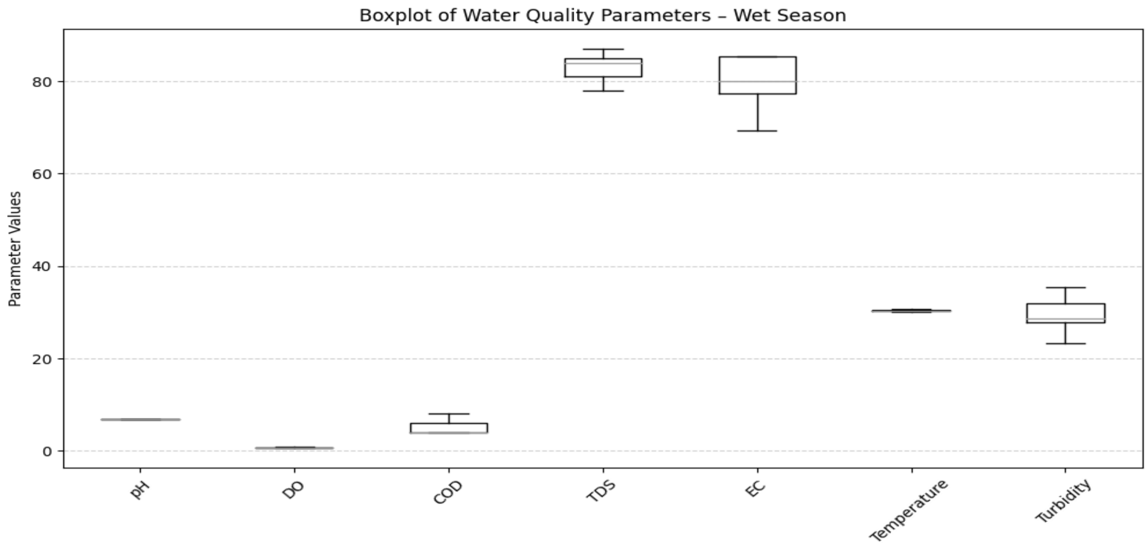


Figure 3: Boxplot of Water Quality Parameters (Wet Season)

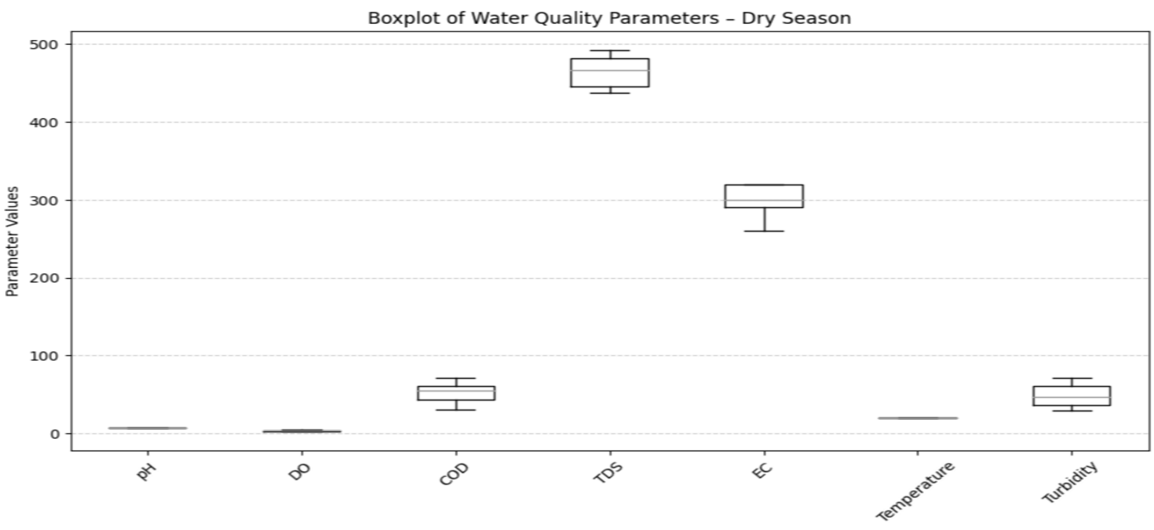


Figure 4: Boxplot of Water Quality Parameters (Dry Season)

### 3.2 Seasonal and Spatial Characteristics

The pH value was found to be 6.7-6.8 in the wet season indicating that the environment was slightly acidic to neutral, whereas in the dry season, the pH was 7.3-7.6 indicating limited organic acidic input due to surface runoff. The amount of dissolved oxygen (DO) was also typically greater during the dry season (2.4-4.5 mg/L) than during the wet season (0.6-0.8 mg/L), indicating an increased aeration and reduced oxygen requirements by microbes.

On the other hand, the COD values rose considerably during the dry season of 71 mg/L respectively especially at stations T3 and J, whereby the industrial and domestic discharges are concentrated. The Karnatuli River stations (K1-K3) had a relatively lower concentration that indicates lesser industrial effects and more successful natural recovery.

The comparison of the average seasonal water quality parameters is provided in Table 2. According to the table, COD, TDS and EC were very high in the dry season compared to the wet season in which the averages of DO and turbidity were very high. Such patterns are consistent with Hossain and Sultana (2020), who identified the same seasonal patterns in other urban rivers in Bangladesh.

Table 2: Descriptive Statistics of Water Quality Parameters (Wet & Dry Seasons)

| Parameter | Season | Min | Max | Mean | Range |
|---|---|---|---|---|---|
| pH | Wet | 6.7 | 6.8 | 6.76 | 0.10 |
| | Dry | 7.3 | 7.58 | 7.44 | 0.28 |
| DO (mg/L) | Wet | 0.6 | 0.8 | 0.67 | 0.20 |
| | Dry | 2.4 | 4.49 | 3.35 | 2.09 |
| COD (mg/L) | Wet | 39 | 71 | 53 | 32 |
| | Dry | 78 | 87 | 83 | 9 |
| TDS (mg/L) | Wet | 437 | 492 | 460 | 55 |
| | Dry | 40 | 40 | 40 | 0 |
| EC (μS/cm) | Wet | 130 | 160 | 148 | 30 |
| | Dry | 69 | 85 | 78 | 16 |
| Temp (°C) | Wet | 30.1 | 30.6 | 30.34 | 0.5 |
| | Dry | 19.8 | 20.2 | 20.00 | 0.4 |
| Turbidity (NTU) | Wet | 23.14 | 35.47 | 30.20 | 12.33 |
| | Dry | 29.8 | 71 | 47.10 | 41.2 |

### 3.3 Water Quality Index (WQI) Analysis

The results of Water Quality Index (WQI) are presented in tabular form in Table 3 in wet and dry seasons, respectively. The WQI was found to be between 185.24 and 214.36 and 281.63 and 462.88 in the wet and dry seasons respectively. Based on the classification criteria, in both seasons, all sites are in the category of unsuitable to drinking, irrigation and aquatic life.

Table 3 draws a comparison between the WQI distribution and the station and season. As the table reveals, there is an obvious increase in the values of the WQI in the dry season, and it underlines intense water quality damage because of low flow and concentrated discharge. The Turag River stations had always a greater WQI score than that of the Karnatuli River, proving that the anthropogenic influence was stronger.

Table 3: Water Quality Index (WQI) for Wet and Dry Seasons

| Station | WQI (Wet) | WQI (Dry) | Comment | Possible Uses |
|---|---|---|---|---|
| T1 | 214.36 | 356.41 | Unsuitable | Treatment required |
| T2 | 208.92 | 381.57 | Unsuitable | Treatment required |
| T3 | 196.45 | 462.88 | Unsuitable | Treatment required |
| T4 | 201.73 | 439.65 | Unsuitable | Treatment required |
| T5 | 185.24 | 297.14 | Unsuitable | Treatment required |
| T6 | 198.87 | 325.09 | Unsuitable | Treatment required |
| T7 | 192.11 | 281.63 | Unsuitable | Treatment required |

As indicated by the WQI trend, the Turag stations (T1-T3) and the junction (J) are the most polluted areas, whereas Stations at the Karnatuli River have relatively less pollution.

### 3.4 One-Way ANOVA

One-way ANOVA test was done to test the significance of seasonal change in the water quality parameters (Table 4). The differences between all parameters were significant ($p < 0.05$), which proves that the pollutant concentrations in the dry season are higher in the statistically significant ($p < 0.05$) way than the wet season. Parameters such as TDS, EC, and Temperature showed the greatest changes and the p-values were not greater than 1.0x10-11, which showed that lower flow and evaporation enhances the degree of concentration during dry months.

Table 4: One-way ANOVA Results for Seasonal Variation of Water Quality Parameters

| Parameter | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| pH | 1.56 | 1 | 1.56 | 221.16 | $4.29\times10^{-9}$ |
| DO (mg/L) | 27.44 | 1 | 27.44 | 91.88 | $5.65\times10^{-7}$ |
| COD (mg/L) | 7684.57 | 1 | 7684.57 | 71.88 | $2.06\times10^{-6}$ |
| TDS (mg/L) | 508444.57 | 1 | 508444.57 | 2019.74 | $9.60\times10^{-15}$ |
| EC (µS/cm) | 169402.20 | 1 | 169402.20 | 593.10 | $1.38\times10^{-11}$ |
| Temp (°C) | 372.35 | 1 | 372.35 | 14480.11 | $7.27\times10^{-20}$ |
| Turbidity (NTU) | 1290.05 | 1 | 1290.05 | 9.56 | $9.34\times10^{-3}$ |

### 3.5 Correlation Matrix Analysis

The correlation analysis by Pearson (Figures 5 and 6) shows that there is interdependence between physicochemical parameters of both seasons. During the dry season, there was a positive correlation ($r > 0.8$) between COD, TDS, EC, and Turbidity, which means that they have a common source, which is industrial and domestic effluents.

During wet season, the relationships were overall weaker because of the dilution effects, still, the strong associations between some pairs of variables were observed, namely, TDS-Temperature ($r = 0.80$) and COD-DO ($r = 0.81$). Such findings agree with those of Ahmed et al. (2021) and reinforce the idea that, even in the seasonally diluted environment, anthropogenic sources and thermal/hydrological processes remain in control of water quality.

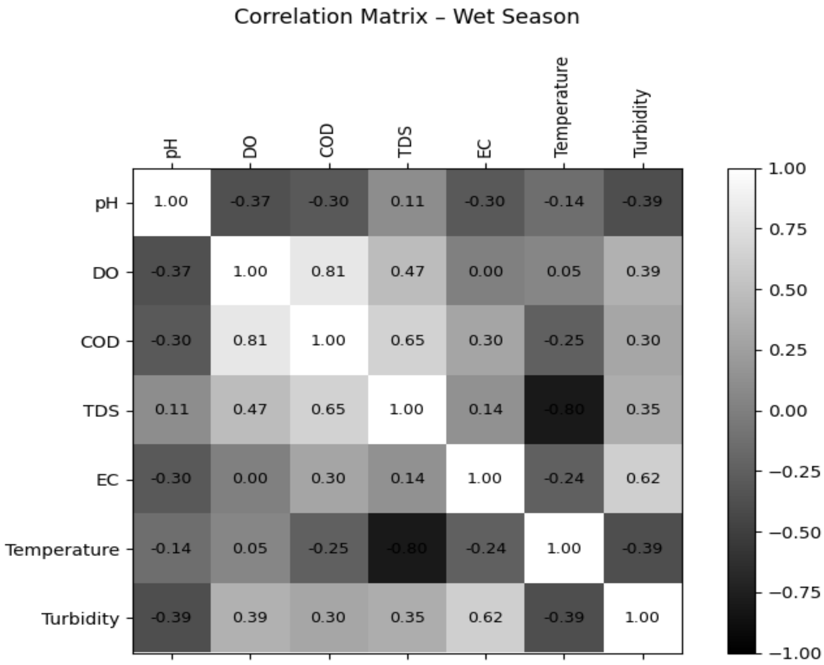


Figure 5: Correlation Matrix for wet season

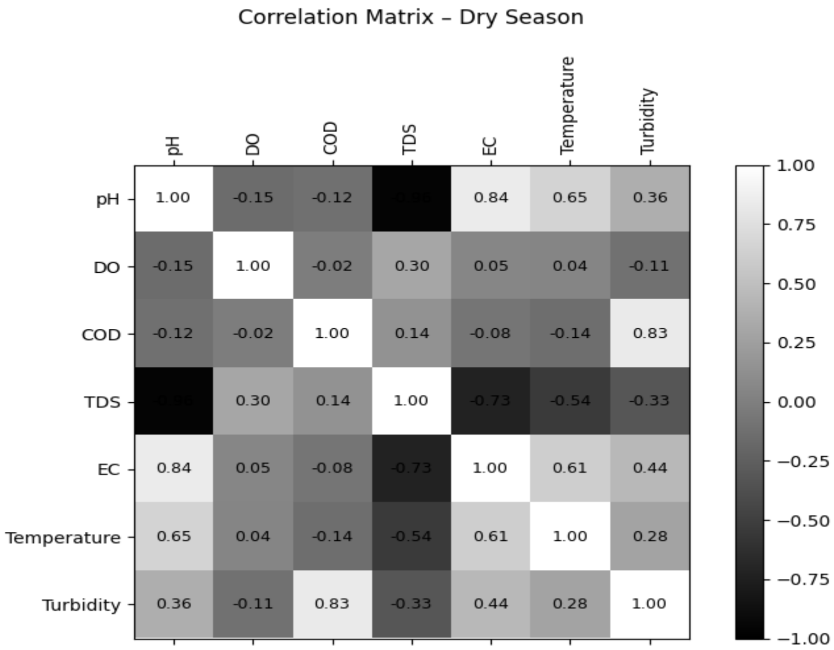


Figure 6: Correlation Matrix for dry season

### 3.6 Principal Component and Cluster Analysis

The Principal Component Analysis (PCA) of dry-season data revealed three principal components and they explained about 82% of the total variance (Table 5). COD, TDS, and EC which are sources of industrial and chemical pollution dominated PC1. Temperature and DO were well loaded by PC2; they capture the hydrodynamic effects whereas PC3 was characterized by pH and indicates site-specific buffering mechanisms.

Cluster Analysis (CA) provided groupings of the seven sampling stations into two large clusters as indicated in Figure 7. Cluster 1, which includes Turag stations (T1-T3) and the Junction (J), had a high level of pollution, and Cluster 2, which is a group of Karnatuli stations (K1-K3), showed a comparatively improved water quality. The clustering pattern can be considered as the field evidence, that the Turag River is highly influenced by industrial effluents in comparison with Karnatuli (Banshi) River.

Table 5: PCA loading for dry season

| Variable | PC1 | PC2 | PC3 |
|---|---|---|---|
| pH_Dry | -0.281 | -0.236 | 0.589 |
| DO_Dry | 0.041 | -0.108 | -0.549 |
| COD_Dry | -0.229 | 0.583 | -0.113 |
| TDS_Dry | -0.472 | 0.162 | -0.148 |
| EC_Dry | -0.366 | -0.312 | 0.276 |
| Temperature_Dry | -0.341 | -0.409 | -0.197 |
| Turbidity_Dry | -0.382 | 0.356 | 0.126 |

### 3.7 Comparative Assessment Between Rivers

This is a comparative examination of the rivers as opposed to each other. The differentiation between the two rivers can be illustrated by a radar chart (Figure 7) created based on normalised data of the two rivers in dry season. The indices of COD, TDS and Turbidity are higher in the Turag river and comparatively better in the Karnatuli River in the form of DO and pH. These findings indicate that the Turag River suffered extreme pollution due to the untreated industrial and municipal outflows, but the Karnatuli River continues to support the moderate level of ecological integrity.

In general, the comparative outcomes highlight the necessity of the industrial wastewater treatment plants, constant monitoring of the effluent, and the management of the riparian zones to recover the riverine health. The same priorities of mitigation are highlighted in national environmental reports (Haque et al., 2023; Rahman et al., 2019).

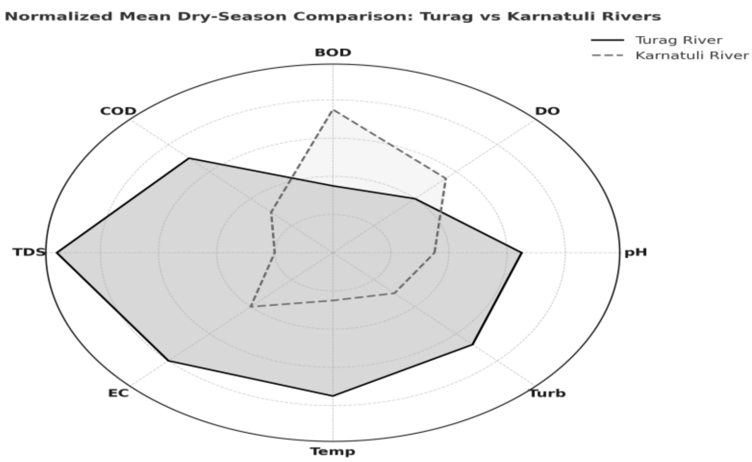


Figure 7: Radar chart for comparison of Turag vs Karnatuli river in dry season

### 3.8 Summary of Findings

The synthesized findings of the descriptive statistics, WQI, ANOVA and correlation, PCA, cluster and radar analysis give a complete picture of the water quality situation. The important findings that appear are the following:

a. During low flow during the dry season, water quality is greatly degraded because of low flow and the resultant concentrated discharge.

b. The two rivers have COD and TDS as the main pollution factors.

c. The predominance of organic and chemical contamination is supported by DO depletion and high COD-TDS.

d. The regions of industrial zones were identified by PCA and CA as some of the major sources of degradation.

e. And the Turag River is severely polluted and Karnatuli (Banshi) River is moderately affected.

## 4. CONCLUSIONS

This paper compares a comparative analysis of the physicochemical properties of two rivers (Turag and Karnatuli) and Banshi, it is evident that water quality shows a significant spatial and seasonal variation. Findings of the descriptive statistical test, WQI, ANOVA, correlation coefficient, PCA, and cluster analysis all suggest that the Turag River is seriously affected due to anthropogenic activities, especially the industrial effluents and urban runoff, more than the Karnatuli River.

The seasonal evaluation revealed that there was a significant increase in level of pollution in the dry season since flow was low and less in terms of dilution capacity. Parameters like COD and TDS were the major factors of total degradation and the level of DO was very low with the sign of the oxygen stress and ecological imbalance. Water Quality Index (WQI) proved that both rivers belong to the category of unsuitable to drinking, irrigation, and aquatic life, which is why remedial actions are urgently needed.

Principal Component Analysis (PCA) and Cluster Analysis (CA) identified industrial and chemical sources as the main contributors of contamination which involves the Turag stations and the junction into an extremely polluted cluster. On the other hand, the Karnatuli River stations had rather moderate pollution rates which implied the certain amount of natural self-purification.

Considering such results, the study highly suggests that a greater effort must be put in the management of industrial wastes and the enforcement of effluent management policies alongside continuous monitoring of the water quality to ensure that such vital river systems are not degraded further. Besides, the inclusion of community-based awareness interventions and eco-restoration approaches may be critical to the reconstruction of the ecological balance of urban rivers in Bangladesh.

The sampling stations were limited but the chosen locations are some of the areas where there is major pollution and areas that are comparatively less affected by the pollution in both rivers. Temporal variability of the seasons was established by sampling the wet and dry seasons and subjected to a significant comparative analysis. To strengthen the quality of river water further, future research might utilize more stations, extended period of monitoring and other biological parameters.

## ACKNOWLEDGEMENTS

The author gratefully acknowledges the Department of Civil Engineering, Daffodil International University, for providing laboratory facilities and academic guidance during the study. Sincere thanks are extended to the faculty members and laboratory staff for their continuous support and encouragement throughout the research work. The authors also acknowledge the contributions of co-author Jafor for his support and involvement in completing this work.

## DECLARATION OF USE OF AI

The author and co-author only relied on an artificial intelligence tool (ChatGPT, OpenAI) to facilitate the language refinement, grammatical errors, and sentence construction enhancement when preparing the manuscript. The author was involved in all research activities, such as data collection, data verification, statistical analysis, figure generation, interpretation of the results, and formulation of scientific conclusions. The AI tool was not utilized to come up with research ideas, analyzing data, or impacting on scientific interpretations. To ensure accuracy, originality and adherence to the standards of ethics, the author took time to review, edit and approve the final copy of the manuscript.

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