A STUDY OF WATER QUALITY PARAMETERS IN TURAG AND KARNATULI RIVERS: A COMPARATIVE APPROACH

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A thesis submitted to the Department of Civil Engineering, Daffodil International University in Partial Fulfillment of the Requirements for the Degree of

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DEDICATION

I would like to dedicate this work to my parents and beloved teachers, who raised and guided me in every single moment of my life.

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In the name of Allah, the Most Gracious, the Most Merciful,

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ABSTRACT

Water quality assessment plays a pivotal role in understanding the health and ecological status of freshwater ecosystems. This study investigates the spatial and temporal variations in water quality parameters in the Turag and Karnatuli rivers, employing a comparative approach. Seven sampling locations along the rivers were selected, considering factors such as industrial activities and ecological significance. Water samples were collected during both wet and dry seasons to capture seasonal variability. A comprehensive suite of water quality parameters, including pH, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Electrical Conductivity (EC), Total Dissolved Solids (TDS), temperature, and turbidity, were analyzed. Statistical analyses, including Water Quality Index (WQI) calculations and correlation matrices, were employed to elucidate patterns and relationships among the parameters.

Results indicate distinct seasonal variations, with water quality generally better during the wet season and deteriorating during the dry season, attributed to increased anthropogenic activities. Stations such as T1, J, and K1 exhibit higher pollution levels, as indicated by maximum parameter values. The analysis revealed that during the dry season, parameters including DO, COD, EC, and TDS significantly increased across most stations. Notably, the water quality at T1 station in the Turag River was worst in the wet season, while K1 station in the Karnatuli River had the best conditions. In contrast, the Turag River exhibited worse water quality in the dry season compared to the Karnatuli River, with T3 station showing the highest WQI value. Correlation analyses unveiled intricate relationships among water quality parameters, such as the positive correlation between DO and COD and the negative correlation between temperature and TDS in the wet season, and the positive correlation between pH and EC, and COD and turbidity in the dry season.

Findings from this study contribute valuable insights into the environmental health of the Turag and Karnatuli rivers, providing a basis for informed decision-making and targeted management strategies to safeguard these vital aquatic ecosystems.

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CHAPTER-I

INTRODUCTION

1.1 Background

Water is an element of nature that is easily accessible. It is an important source of life on Earth. It is often used for a variety of activities, including drinking, washing, bathing, cleaning, cooking, irrigation, and other industrial and home applications. Unluckily, nature and human activities are polluting our available water sources daily. Pollution of surface water (rivers, lakes, and ponds), groundwater, and seawater puts at risk human and animal lives. Though water is widely seen as a reusable resource, proper care is required to maintain it, as it is highly at risk of pollution as a result of rising economic growth, urbanization, and human activities caused by growing populations.

Bangladesh's physiography defines her as a riverine country. There are almost 700 rivers that typically flow south. The major rivers are the primary sources of water for agriculture and commercial traffic.

Dhaka has seen significant industrialization in recent decades, particularly in the dyeing, washing, and textile industries. According to research, there are about 7,000 industries in the Dhaka metropolitan region, with the majority located in three groups: Hazaribagh, Tejgaon, and the Dhaka-Narayanganj-Demra dam area (Roy, 2009). However, among all of these, dyeing industries and tanneries are the primary pollutants of waterways. Waste from these industries is normally sent through the sewage system, which flows straight into the rivers that surround the city. In reality, rivers have become dumping grounds for a variety of solid, liquid, and chemical wastes. (The Daily Star, September 10, 2011)

Turag River comes from the Karnatuli River, which is an important source of the Buriganga River. It travels through Gazipur before joining the Buriganga near Mirpur in Dhaka. The Turag and Karnatuli River runs through the heart of Bangladesh. The river is reshaping the landscape and significantly impacting the lives of numerous individuals along its banks. However, the Turag and Karnatuli river, like many others globally, faces issues like pollution and misuse, impacting the health and well-being of its users. Despite these problems, the Turag and Karnatuli continue to provide a key source of life and livelihood for the Bangladeshi people. It is a symbol of capacity and the eternal relationship between humans and the environment.

The discharge of wastewater without enough treatment from the surrounding industries and communities, agricultural run-off, and disposal of garbage on the banks of the river contribute to increased pollution of the river water.

At the time of the dry season, the water volume drops, and the water's condition becomes worse compared to the wet season. The people who live near the Turag and Karnatuli Rivers rely on the water for a variety of activities, including domestic, fishing, drinking, and agriculture. For these reasons, it is important to pay attention to the water quality of the Turag and Karnatuli Rivers. As a result, the current study aimed to analyze the water quality of the Turag and Karnatuli Rivers by considering some standard parameters.

1.2 Study Area

The study area comprises the Turag and Karnatuli rivers, each with three designated sampling points. The Turag river three points are named T1, T2 and T3 on the other side Karnatuli river three points are named K2, K2 and K3, additionally, a junction point where the two rivers converge is included for water sample collection (shown in fig 1.1). These rivers were chosen due to their ecological significance and the presence of various industrial and residential activities along their banks. Sampling points were strategically selected to capture variations in water quality across different locations and to assess the impact of pollution on the rivers' ecosystems. The study area encompasses both the natural flow of the rivers and the areas influenced by human activities, providing a comprehensive understanding of water quality dynamics in the region.

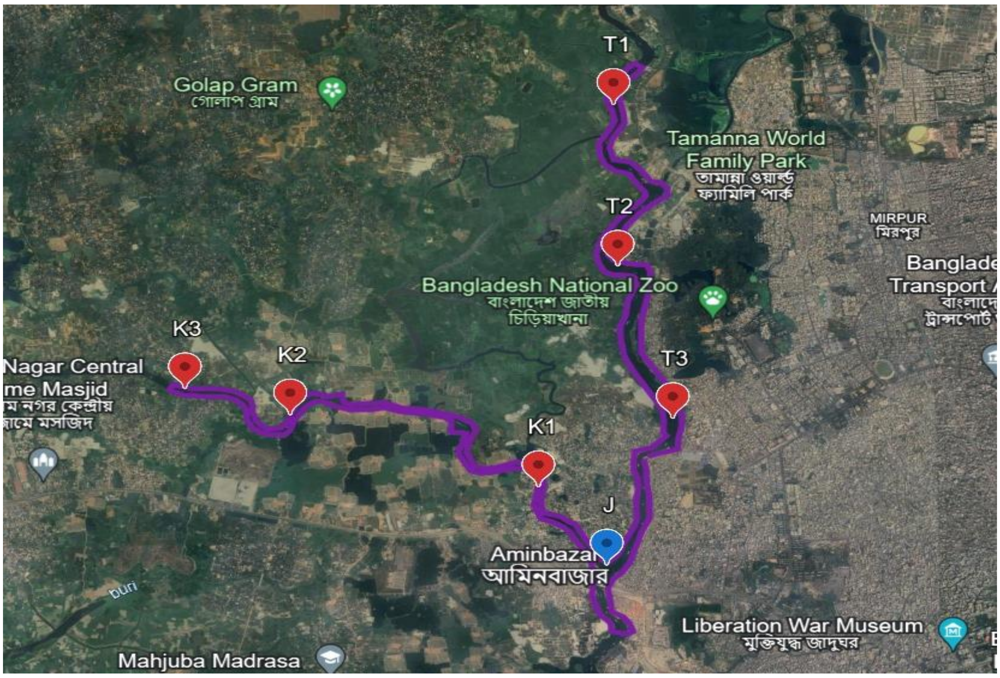


Fig. 1.1 Study Area

1.3 Objective

The objective of our studies are as follows

i. To measure the spatial and temporal variations of the water quality parameters of Turag and Karnatuli river.

CHAPTER-II

LITERATURE REVIEW

2.1 General

Water, an indispensable element for survival, stands alongside air, sunlight, and food, forming the cornerstone of life. Its quality has emerged as a paramount global concern in the 21st century, drawing the collaborative efforts of scientists, academics, politicians, water experts, artists, and citizens across diverse demographics, with a special emphasis on engaging younger generations. The United Nations Environment Assembly (UNEA) acknowledged this imperative reality during its third session in December 2017, adopting Resolution 3/10 titled "Addressing water pollution to protect and restore water-related ecosystems" (UNEP/EA.3/Res.10).

Water pollution, a pervasive global challenge, jeopardizes rivers and the well-being of communities reliant on these vital water sources. In the context of the Turag and Karnatuli rivers, a critical need arises to pinpoint pollution sources and comprehend contributions to effective environmental management.

A research paper from 2012 underscores the critical levels of pollution in the Turag River, particularly in proximity to industrialized areas. The situation demands urgent measures to mitigate pollution and prevent further degradation of water quality. Continuous monitoring and proactive interventions are indispensable to safeguard the ecosystem and public health. (Rahman et al., 2012)

Literature on the Turag and Karnatuli Rivers sheds light on the multifaceted challenges faced by these water bodies, including pollution, industrial growth, and urbanization. Despite these challenges, various endeavors have been undertaken to enhance river quality and protect its ecosystem.

To address existing gaps and challenges, more research is imperative. Building effective seasonal river water quality programs and undertaking necessary measures are vital steps toward safeguarding the ecosystem and fostering sustainable human growth. Collaborative efforts and ongoing research endeavors will play a pivotal role in shaping a future where water resources are resilient and thriving.

2.2 Sources of River Pollution

i. **Industries Waste Disposal:** The discharge of industrial waste can harm river ecosystems by introducing chemicals. Proximity to industrial zones near the Turag and Karnatuli rivers raises concerns about the direct impact of industrial discharges on water quality. (Rabbani et al., 2017)

ii. **Tanneries Waste Disposal:** The leather industry, a significant economic contributor, poses environmental challenges due to its waste. Tannery effluents contain various pollutants, including chromium, which can harm aquatic life and water quality. Investigating the specific impacts of tannery waste on the Turag and Karnatuli rivers is essential. **(**The Business Standard, 22 March 2024).

iii. **Dhaka City Waste Waters Direct Disposal:** Urbanization brings unique challenges to river health, with untreated wastewater from cities directly impacting water quality. The disposal of Dhaka city's wastewater into the Turag and Karnatuli rivers requires scrutiny to understand the scale and nature of this urban contribution. (Rabbani et al., 2017)

iv. **Oil Leaking from Streamers:** Navigation routes contribute to water quality degradation, with oil leakage from steamers identified as a potential threat. Addressing oil spills and their consequences on river ecosystems is crucial for the Turag and Karnatuli rivers. **(**The Business Standard, 22 March 2024).

2.3 Parameters of Concern

Water quality parameters contain chemical, physical, and biological qualities. It can be analyzed or monitored depending on the water parameters that are of concern.

Environmental standards promulgated under the Environment Conservation Rules 1997 (Standard, 1997) aim to limit the volume and concentrations of pollution discharged into the environment (Uddin et al., 2021). The Bangladesh Environment Conservation Act, 1995 (GoB, 1995) (Act 1 of 1995) has been followed as a guiding principle for water quality parameters and standards. Important parameters for drinking, fisheries, agricultural/irrigation, and industrial water use are given below

Here will describe the importance of the parameters we measure to find the water quality of a river.

2.3.1 pH

pH is a chemical term that indicates the acidity or basicity of a solution. Water sources should have a pH measurement level between 6.5 to 8.5 on a scale. A pH of 7 is considered neutral, while values below 7 indicate acidity and values above 7 indicate alkalinity (Gorde et al., 2013). The pH of water has a major impact on aquatic species' survival, as well as the dissolution and toxicity of chemicals and heavy metals in the water. Maintaining an optimal pH level is crucial for the survival of aquatic organisms and the overall health of water bodies.

2.3.2 Dissolved Oxygen (DO)

DO indicates the amount of oxygen available in the water. Water bodies collect oxygen from both the atmosphere and plants in the water. Adequate levels, typically above 5 mg/l (Fikresilasie et al., 2011), are essential for supporting fish and other aquatic life. Low DO can lead to hypoxia, harming aquatic organisms and indicating poor water quality. Water temperature, salinity, and air pressure all have an effect on the amount of dissolved oxygen in the water.

2.3.3 Biochemical Oxygen Demand (BOD_5)

BOD_5 measures the amount of oxygen consumed by microorganisms breaking down organic matter in water. High BOD_5 levels, exceeding 5 mg/l (Fikresilasie et al., 2011), indicate pollution and potential harm to aquatic life. The higher the BOD_5, the faster oxygen is depleted in the stream. High BOD_5 and low dissolved oxygen have similar consequences like causing aquatic organisms to become stressed, suffocate, and ultimately die.

2.3.4 Chemical Oxygen Demand (COD)

COD assesses the amount of oxygen required for chemical oxidation. Elevated COD levels signify the presence of harmful chemicals, affecting water quality. Safe levels vary but are generally below 125 mg/l (Fikresilasie et al., 2011). Higher COD levels increase oxidizable organic material in samples. It lowers dissolved oxygen levels and potentially causes anaerobic conditions harmful to aquatic life forms.

2.3.5 Total Dissolved Solids (TDS)

TDS measures the concentration of dissolved substances in water. While safe levels depend on the source, typical freshwater TDS ranges from 50 to 500 mg/l (Gorde et al., 2013). Elevated TDS may impact water taste and indicate potential contaminants. High TDS levels, particularly due to dissolved salts, can significantly impact various aquatic life forms.

2.3.6 Electrical Conductivity (EC)

EC gauges water's ability to conduct an electric current, correlating with TDS. Standard EC levels vary, but freshwater typically ranges from 50 to 800 µS/cm (Fikresilasie et al., 2011). Elevated EC suggests higher TDS and potential water quality issues.

2.3.7 Temperature

Water temperature influences biological and chemical processes. Safe levels vary by species, but for freshwater ecosystems, temperatures between 10 to 25°C are generally optimal. Extreme temperatures can stress aquatic life and alter ecosystem dynamics.

2.3.8 Turbidity

Turbidity measures water clarity by assessing the presence of suspended particles. Safe levels depend on the water body and its designated use. High turbidity can interfere with light penetration and impact aquatic habitats, with typical standards below 5 NTU (Gorde et al., 2013) (Nephelometric Turbidity Units).

2.4 Relevent studies

(Tahmina et al., 2018) Conducted a comprehensive study on Turag River water quality and emphasized the need for regular monitoring to detect variations in parameters such as Temperature, pH, Salinity, TDS, TA, EC, TH, Chloride content, Free CO_2, DO, Nitrate and Sulfate. It was observed by them that the water quality of the river reached to critical point of pollution in both seasons. Therefore, it is high time to take initiative to save the river from further pollution.

(Hafizur et al., 2017) Explored the seasonal variations in water quality parameters in the Turag River, noting significant differences between the dry and wet seasons. These variations were attributed to changes in precipitation, land use, and anthropogenic activities in the catchment area.

A comparative approach in studying water quality parameters is crucial for understanding regional variations and identifying potential sources of pollution. In a study by (Uddin et al., 2021) on a neighboring river system, similarities and differences in water quality trends were observed, emphasizing the importance of contextual factors in the interpretation of results.

The impacts of urbanization on river water quality have been a recurrent theme in the literature. (Kabir et al., 2022) conducted a study in an urbanizing watershed similar to the Turag and Karnatuli catchment areas, highlighting the influence of increased impervious surfaces on water quality. Understanding these urban-rural gradients is essential for implementing effective management strategies to mitigate water quality degradation.

A study was carried out on the Turag River to observe and identify the present pollution sources of the Turag River. From the field visits, it is clear that there are numerous illegal domestic sewage outfalls directly discharging waste into the river. The main reason behind this spatial pollution pattern in the Turag within above mentioned area is that a huge load of untreated toxic liquid chemical waste is directly dumped into the river from Hazaribagh tanneries through the Bashila Khal at the downstream and from the Tongi Industrial Area at Tongi Bridge and Iztema Field area. This very high pollution concentration diffuses to other parts of the river through upstream flow during the rainy season and some tidal activity during the dry season. About 28 minor waste disposal outlets to the Turag River. Heavy metals like lead, arsenic, zinc, etc. easily mix with water bodies because of the lack of ETP (Effluent Treatment Plant) and also the inadequate capacity of ETP. So, people called the Turag River one of the drains of Dhaka city and in some sort of cases, it is quite applicable for its blackish color, unbearable odor, and of course no aquatic life in the water. (Islam et al., 2018)

In their investigation into Turag River water contamination, Rahman and Islam noted alarming levels of CO_2 and alkalinity, posing significant risks to aquatic ecosystems and human health. They observed that industrial waste and refuse undergo minimal treatment before disposal into the river, exacerbating pollution concerns (Rahman et al., 2012).

In their 2006 study on heavy metal contamination in the Turag River's water and sediments around Tongi, H. M. Zakir, Sharmin Shila, and Shikazono Naotatsu found notable impacts from untreated urban sewage and industrial discharge. These pollutants significantly influenced the water chemistry in the Tongi area, breaching recommended standards for surface water quality. Elevated levels of heavy metals, including Mn, Zn, Cr, Cu, and Pb, were observed in both water and sediment samples, indicating substantial pollution. The study attributed these findings to direct discharges of municipal and industrial waste into the river (Zakir et al., 2006).

In 2012, a study conducted by Islam et al. investigated the impact of industrial effluents and solid waste on the Turag River's water quality, revealing concerning findings. According to a 2009 industrial survey by the Bangladesh Center for Advanced Studies (BCAS), only about 40% of sectors had Effluent Treatment Plants (ETPs), while 10% were under construction, leaving 50% with no established ETPs. Consequently, approximately half of the industrial waste ended up untreated in rivers. The study attributed the Turag River's discolored, foul-smelling water to industrial effluents. Upstream water exhibited low levels of various parameters and slightly alkaline pH due to high Dissolved Oxygen (DO) content. However, ongoing waste disposal significantly increased metal concentrations, with Fe, Zn, Pb, Cu, and Cd being the most prevalent. Downstream water was found to be extensively contaminated, rendering it unsuitable for aquaculture or human use (Islam et al., 2012).

In 2012, Hossain, Salam, and T. Islam conducted an extensive study of the Turag River to assess its contamination levels. Focused on the stretch from Tongi Bridge to Ejtema Field, the investigation aimed to gauge the severity of pollution in this area. Concentrations of five heavy metals (Pb, Cd, Cu, Cr, and Zn) in the river water were evaluated, revealing significant correlations among them. The study concluded that the Turag River is indeed contaminated, posing risks to human health due to pollutants present in fish, silt, and water samples (Hossain et al., 2012).

In 2014, Mobin and collaborators conducted a study focusing on the chemical and physical attributes of the Turag River. Sampling water from three distinct research sites, they observed elevated physicochemical characteristics beyond typical levels. The presence of a foul odor and dark coloration in the river water indicated contamination, posing threats to both human health and aquatic ecosystems. Their findings underscored concerns about the Turag River's water quality, emphasizing the urgency of implementing effective strategies to mitigate pollution and address environmental challenges affecting its aquatic ecosystem (Mobin et al., 2014).

In their 2015 study, Nizel and Islam investigated the pollution levels in the Turag River and the associated health challenges among the local population. Their findings revealed concerning implications for both human use and aquatic life sustainability due to the compromised water quality of the Turag River. Specifically, they noted alarmingly low levels of dissolved oxygen (DO) alongside other adverse river characteristics. The study highlighted that the Turag River exhibited significantly elevated maximum concentrations of turbidity, BOD_5, hardness, TDS, and COD, surpassing permissible limits. Moreover, they provided evidence of a myriad of health issues afflicting the surrounding population, including skin conditions, dysentery, diarrhea, respiratory ailments, anemia, and childbirth complications. Furthermore, prevalent diseases such as malaria, dengue, cholera, and yellow fever were observed in the area, exacerbating health burdens. The populace also grappled with respiratory problems and olfactory pollution, exacerbating their distress (Nizel et al., 2015).

In their 2013 study, Sultana et al. investigated the efficacy of effluent treatment plants (ETPs) for wastewater treatment. Their findings shed light on the severe contamination of Bangladesh's rivers due to runoff from diverse industrial operations. Their study recommended a proactive approach to mitigate pollution by advocating for the implementation of waste treatment measures by industrial establishments. Rather than diverting municipal drains to alternate locations, the emphasis was placed on treating industrial waste before its discharge into rivers (Sultana et al., 2013).

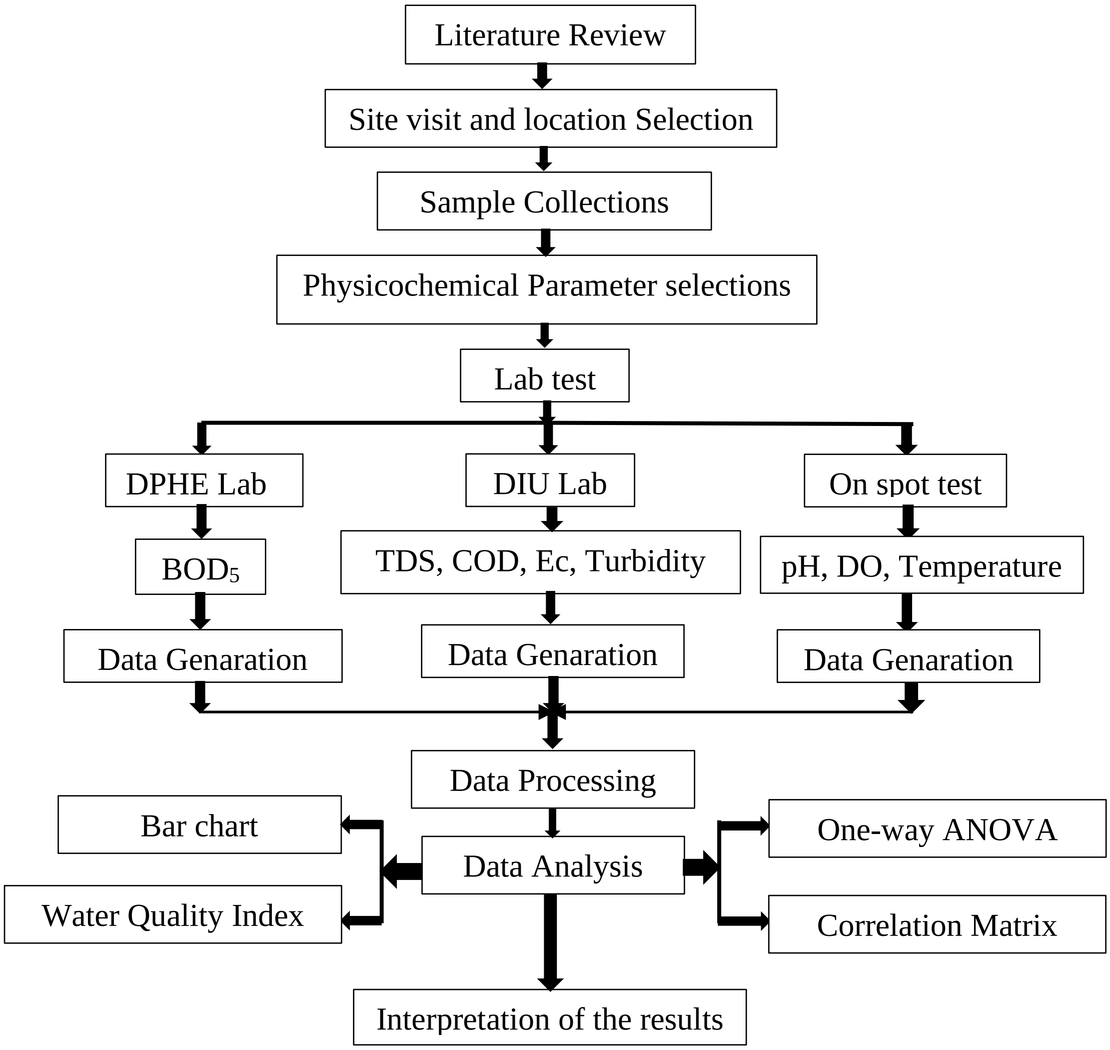
CHAPTER-III

METHODOLOGY

3.1 General

Water is the world's most valuable natural resource, essential for sustaining life and growth (Kumar et al., 2010). Its quality varies spatially and temporally. To assess water quality, samples are collected from different sites, considering seasonal and local influences. Factors like sampling points, geographic locations, collection time, techniques, and methodology also impact water quality. The following sections will discuss various seasons and geographical zones, the impact of the Turag and Karnatuli rivers, and detail our water quality assessment procedures.

3.2 Flow Diagram



3.2.1 Selection of Sampling Points

These rivers were chosen as the research region because of the existence of several effluent-dispensing industries in the surrounding areas, as well as their ecological and local economic significance.

In the selection of sampling points in river water, many factors must be focused on to guarantee that the data collected is appropriate and useful. Samples were collected from different locations across the Turag and Karnatuli Rivers. Samples of Geographical points were determined by the Global Positioning System (GPS). We mainly tried to collect the samples from the places where the water gets mostly polluted by different elements like household waste, industry waste, animal wastes, human wastes, and many more things (shown in Fig. 3.1). We selected these places for getting the near accurate value depending on which we can comment on the water quality of the rivers.

We collected the samples from 7 different points of the rivers. Three samples are from the Turag River, three from the Karnatuli River and one from the junction point of both rivers there is one more river connection present there that river is the Buriganga River. The reason for collecting samples from different collections is that the water quality varies both temporally and spatially, due to this it is nearly impossible to represent water quality accurately by a single sample collected from a single location.

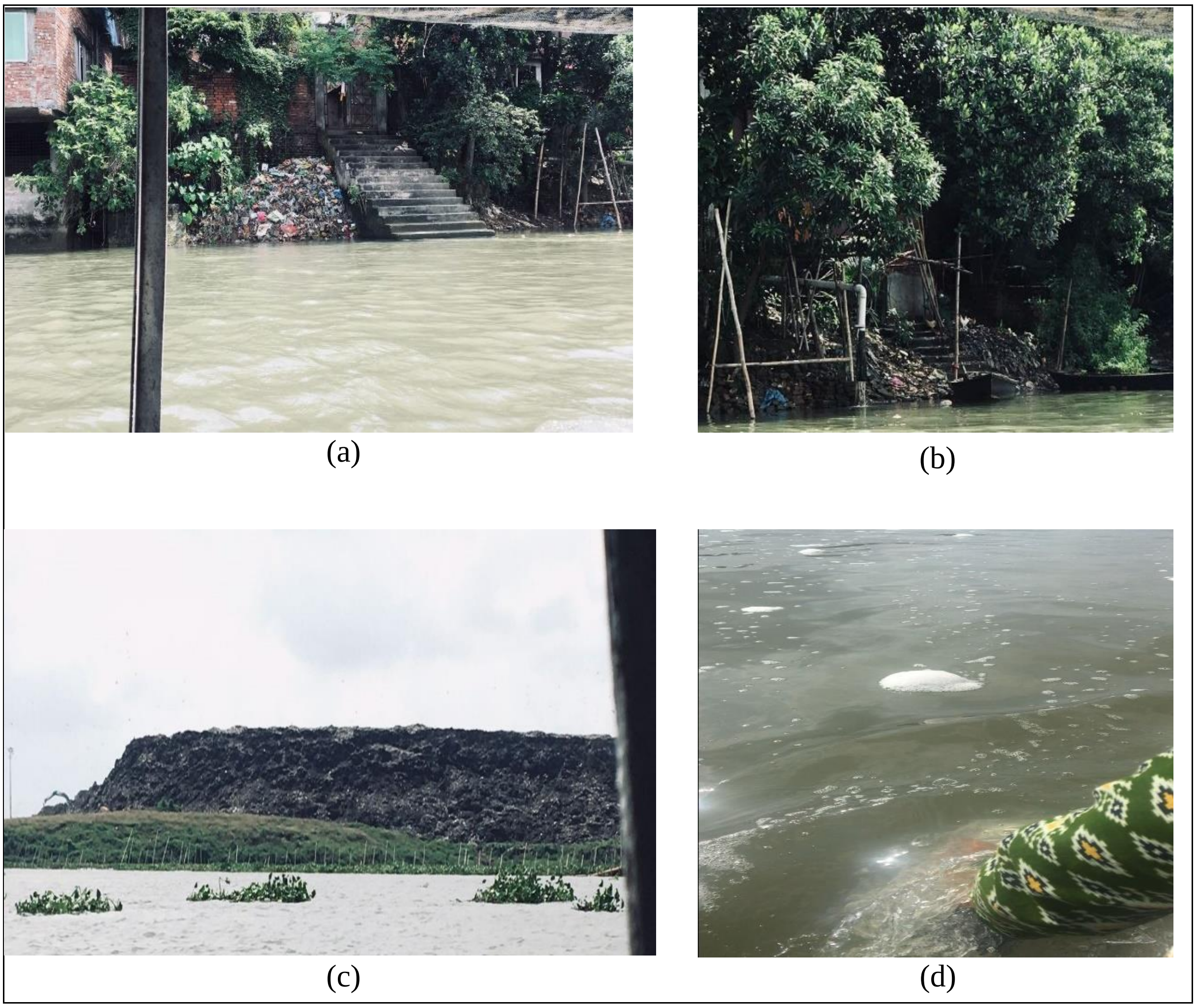


Fig. 3.1 Monitoring Stations (a) Household wastes near the river (b) Human wastes disposal in river (c) Wastes pile beside the river (d) Industrial wastes disposal

3.2.2 Literature review

Before collecting the samples and locations we study these related previous papers to understand the criteria. We studied many papers based on the Turag and Karnatuli rivers. After studying a variety of papers, we chose some important parameters that are helpful in understanding the water conditions.

3.2.3 Site Investigation and Site Selection

Throughout the site research, we decided to use the knowledge gathered from earlier articles. First of all, we divided the Turag River area into three zones and the Karnatuli River into three zones and also we selected a junction point. For selecting these zone locations we first visited the Turag and Karnatuli rivers by boat (Fig. 3.1). That day we watched the river conditions and the waste disposal points near the river depending on these things we selected the sampling collecting locations. This was the first step of our research. In this way, our samples were different from one another sources.

Before Collecting samples we make sure that Point origins should be different from one another. Then we had in mind that Samples should be easily collectible and accessible so that we don't face any problems in collecting the sample. We collect samples in two seasons. So we choose points in such a way that we can get water in two seasons. We collect a sample 10m inside the river. So that the boat should not go through the middle of the river. We consider the geographical, physical, and chemical traits of the river. We had this in mind the locations should be representative and meaningful for water quality. Sampling locations were chosen depending on the flow and water quality of the river.

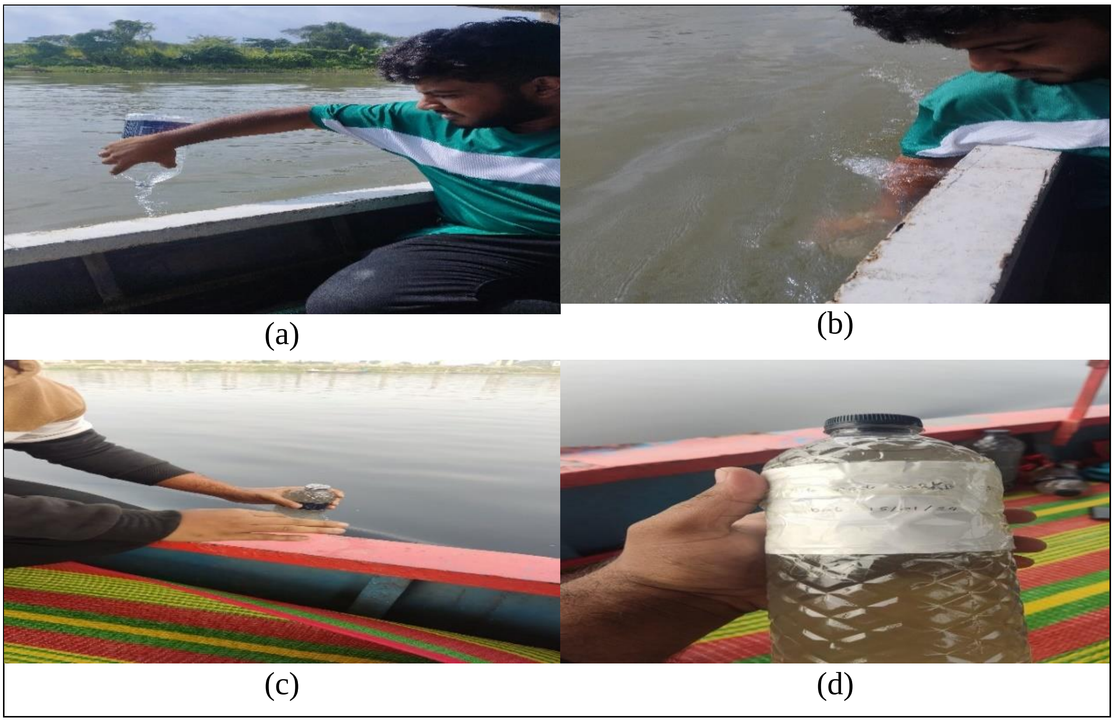
3.2.4 Collection of Sample

We collected samples from the rivers where different types of wastes are mostly being disposed of. All samples were collected and analyzed throughout both the wet (April to September) and dry (October to March) seasons. To collect the water samples easily we hired a boat so that we could collect the samples from the right places. For collecting the sample maintain a minimum 10-meter distance from the corner of the river. During the collection of the samples we fully deep our wrists into the water so that no bubbles can create. Water samples were collected in 2-liter plastic bottles. To prevent contamination, the bottles were cleaned and rinsed with water three times before testing. Following sampling, all instruments and procedures were used to protect water samples from any fungal or other pathogenic attack.

Table 3.1 Locations of the sampling points of Turag and Karnatuli River

Station Code	**Station Name**	**Coordination**	
		Latitude	**Longitude**
T1	Turag River Priyanka Housing	23.8358500	90.3378170
T2	Turag River Thamanna	23.8182910	90.3398180
T3	Turag River Diabari	23.7999990	90.3424870
J	Buriganga River Near Amin Bazar	23.7858504	90.3359631
K1	Karnatuli River Amin Bazar Market	23.7945040	90.3294450
K2	Karnatuli River Brick Field	23.8027900	90.3052310
K3	Karnatuli River Konda Bridge	23.8058420	90.2949580

Our main goal is to find out the water quality and how much it is polluted. So we carefully collect the samples. Before collecting the samples we cleaned the bottles with river water and collected the water in the bottle. While collecting the samples we avoid the surface water of the river. To avoid air bubbles the sampling bottles were immediately sealed and placed in a safe place. The necessary information for each sample, such as the date and time of collection, location, and so on, was noted in the notebook.



(a) (b)

(c) (d)

Fig. 3.2 Sample collection process (a) Bottle rinsing (b) Water colletion (c) Bottle Capping (d) Bottle leveling

After collecting the samples, the sample bottles were stored and they were taken to the lab for analysis. (shown in fig. 3.3)

Fig. 3.3 Sample placed primarily in the lab

3.2.5 Parameter Selection and On-Spot Test

Water assessment refers to the method of studying and studying water samples to discover their physical, chemical, and biological qualities. This research is important for many purposes like water consumption safety, environmental observation, industrial operations, and agricultural activities.

In this work we select 9 parameters which is discussed in the chapter 2. Out of this 9 parameters some of them like pH, DO, EC, Turbidity and temperature are tested on spot (shown in fig 3.5) because the parameters we choose vary with the temperature and weather conditions can change their properties.

(a) (b)

Fig. 3.4 On spot physiochemical parameters test (a) Temperature Test, (b) Turbidity, pH, DO, EC test

3.2.6 Lab Test

After collecting all samples and finishing the on-spot test some parameter samples were taken to our university Lab from the field. After reaching there the remaining parameters like Total dissolved solids (TDS), Biochemical Oxygen Demand (BOD_5), and chemical oxygen demand (COD) are being tested shown in Figure 3.6

Table 3.2 Physicochemical parameter Lab test and Method

Physicochemical Parameter	Unit	Methods/ Equipment
pH		pH Meter. Model No: (HACH_HQ pH/ORP)
DO	mg/l	DO Meter. Model No: (HACH_HQ2100) Portable Multi-Meter
BOD_5	mg/l	5-Day Incubation
COD	mg/l	Spectrophotometer. Model No: (HACH_DR-6000)
TDS	mg/l	TDS Meter. Model No: HANNA DiST-2
EC	µS/cm	EC Meter.
Temperature	°C	pH Meter. Model No: (HACH_HQ pH/ORP)
Turbidity	NTU	Turbidity Meter. Model No: Hach2100Q

Fig. 3.5 Samples testing in laboratory (a) pH, DO and Turbidity test, (b) Spectrophotometer, (c) COD Reactor, (d) Digital Balance (0.01), (e) Sample mix with regent vials, (f) Preparing sample for TDS test, (g) Sample after removing from oven, (h) Notes the results

CHAPTER-IV

RESULT AND DISCUSSIONS

4.1 General

The main piler of a paper is the result and discussion. In this part, the output of the work has been discussed. There the discussion is made about the work that has been done, what the results are being achieved through the tests, if the result is good or bad, if good why it is good or if it is bad then what needs to be done to make it better, etc. Many important elements of a paper are discussed in this part. So need to be careful during work on the results so no mistakes take place and due to this any wrong information does not come up.

Here in this paper few types of analysis are being generated to find the best possible results. By testing the Turag and Karnatuli river water this study state that this water is too much polluted. This pollution level is generally so high that it can also affect the humans and other animals health. This pollution rate is generally so high in the dry season but in the wet season, this pollution rate remains a little bit under control.

4.2 Variation of pH

The bar chart is shown in Fig 4.1 it represents the value of pH. The Y-axis shows the value of pH and the X-axis represents the station code. The blue bars are for the wet season and the orange bars represent the dry season value.

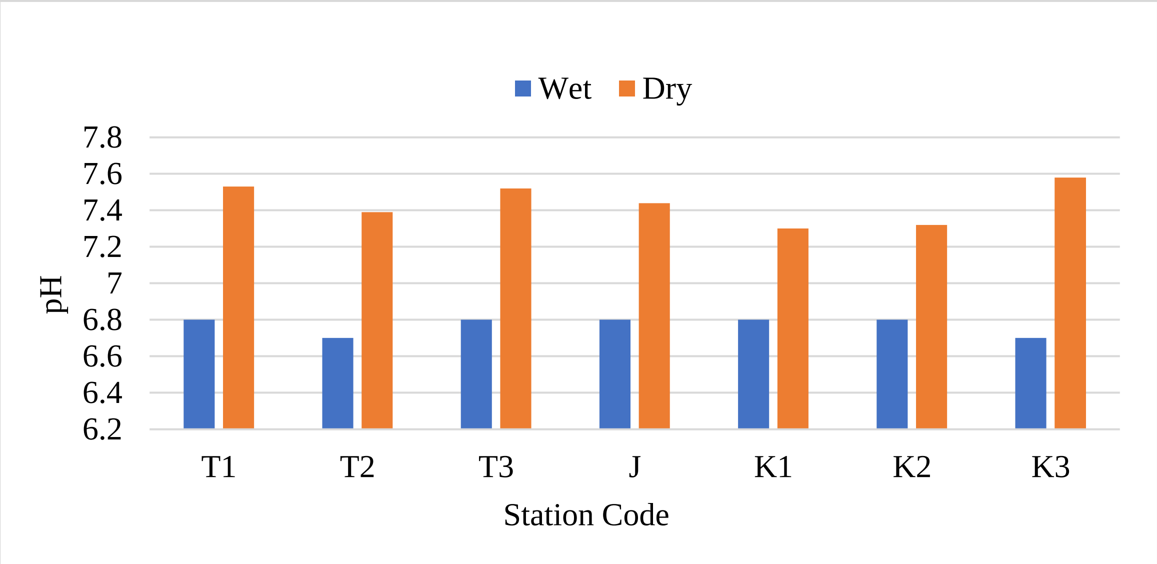


Fig. 4.1 Variation of pH of the wet and dry season

4.2.1 Seasonal Variation

This chart shows that pH value is highly vary is season to season. In the wet season, the value is much less than compared to the dry season. Knows that the pH value lies between 0 to 14. Where 7 is considered as the neutral value. If the value is less than 7 it will be considered acidic and if it is higher than 7 it will be considered base. The chart shows the all the sampling points in the wet season the pH value is less than 7 during the wet season the water mostly remains acidic but it changes in the dry season this value pH value increases and goes a little bit up to 7 and it becomes base. From the chart also notice that the place values are different from each other in different seasons. In the wet season, this value remains so less than the value of the dry season. The same for all points value is much less in the wet season than in the dry season.

The value of pH changes generally for the chemicals, minerals, pollutants, soil or bedrock composition, and any other contaminants that connect with the water. Some various chemicals and pollutants help to increase the pH value if any type of rock is present in the groundwater this also causes to increase in the pH value. That means the pH value is highly related to the environment.

4.2.2 Station-to-Station Variation

During the wet season pH value is the same for the T1, K1, and J stations. But at the T2 station, this value decreased compared to the T1, K1, K2, and J stations. Again the value of pH is increased at the T3 station compared to T2 and K3 stations and the value remains the same for the T1, K1, K2, and J stations.

In the season dry pH value at the T1 station is much higher than the K1 and J stations. The T2 stations value is less compared to station T1 and J stations but higher than the K1 and K2 stations. The T3 station value is close to the value of station T1 and it is much higher than the T2, T3, K1, and K2 station values but it is much lesser than the K3 station value.

4.3 Variation of DO and Temperature

Temperature affects the amount of dissolved oxygen in surface water and how it varies on a daily and seasonal basis. Compared to warm water, cold water can store more dissolved oxygen. The dissolved oxygen content is highest in the winter and early spring when the water temperature is low.

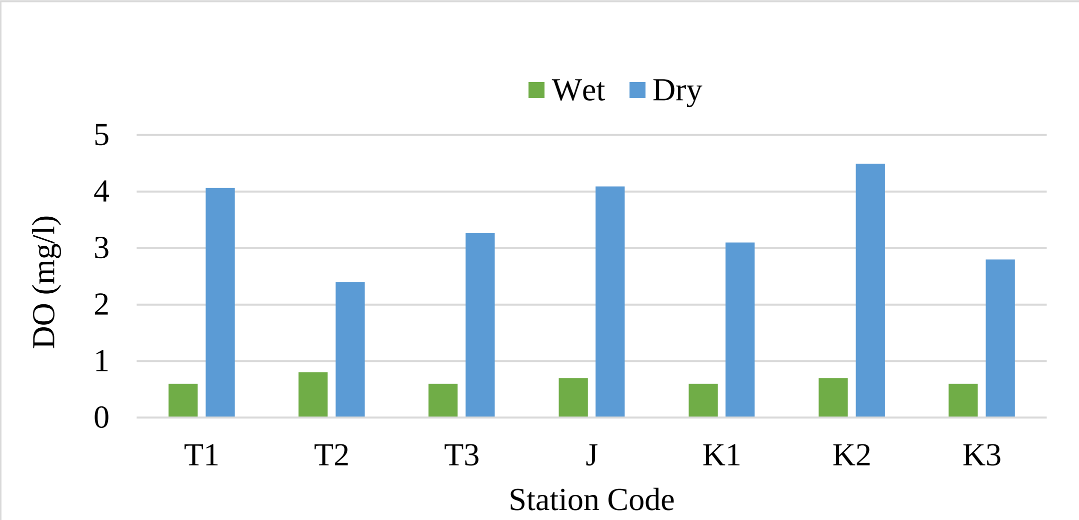


Fig. 4.2 Variation of DO of wet and dry season

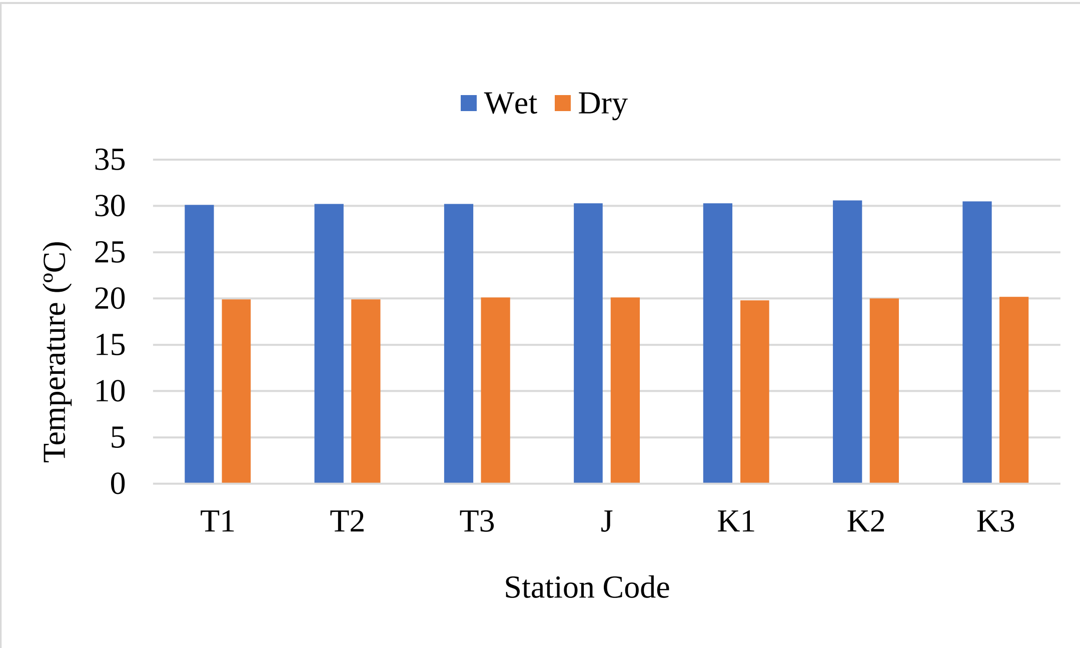


Fig. 4.3 Variation of Temperature of wet and dry season

4.3.1 Seasonal Variation

The chart in Fig 4.2 also shows that the value of dissolved oxygen is much higher in the dry season compared to the wet season and Fig 4.3 shows that the temperature of the wet is much more compared to the dry season. As for the weather conditions of Bangladesh in the wet season, the place is so hot that it gets a little cooler during the rainy time or else the temperature gets so high but it opposite in the dry season this time weather becomes much cooler and temperature remain clodest you know the value of dissolved oxygen depends on the temperature and this value increases when the temperature is low and decreases when the temperature is high. Fig 4.2 and 4.3 well represent this relation between the temperature and dissolved oxygen.

4.3.2 Temporal Variation

From Fig 4.3 can see that the temperatures are much closer to each other points during the different seasons. In the season of wet, the temperature is close at all points and averages between 30 degrees to 30.7 degrees and it goes lower in the dry season and averages between 20.3 degrees to 19.8 degrees. These values are close to all the sample collecting points.

The fig 4.2 represents the value of dissolved oxygen which is connected to temperature as discussed above. So the temperature variation also causes the same variation of dissolved oxygen. So during the wet season, the dissolved oxygen value is almost the same at all sampling points. But in the season of dry, this value fluctuates much more because of the low temperature. Sampling point T1 has much more dissolved oxygen compared to point K1 but it has very little fluctuation between T1 and sampling point J. Point T2 has the minimum amount of dissolved oxygen camper to all the points. Sampling points K2, J, and T1 consume the most amount of dissolved oxygen in their locations accordingly.

4.4 Variation of dry season BOD_5

The amount of dissolved oxygen (DO) that aerobic bacteria growing on the organic material present in a water sample consume at a given temperature over a given amount of time is represented by the analytical parameter known as biochemical oxygen demand, sometimes referred to as biological oxygen demand or BOD_5 (Wikipedia). Microorganisms' use of dissolved oxygen determines the BOD_5 level. The water will become more contaminated as the BOD_5 level rises.

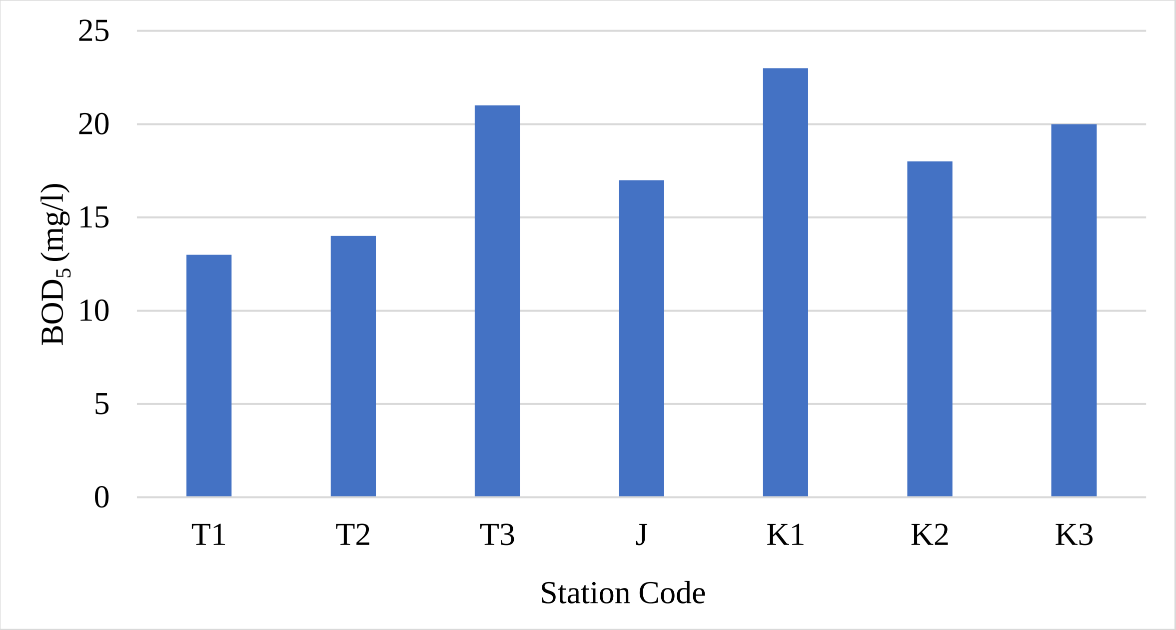


Fig. 4.4 Variation of BOD_5 of dry season

4.4.1 Spatial Variation

In the fig 4.4 shows the BOD_5 value of the dry season. The Y-axis represents the value of BOD_5 and the X-axis represents the station codes. Fig 4.4 shows that station K1's microorganisms consume the highest DO compared to other stations so its BOD_5 level is high and depending on BOD_5 this station is more polluted compared to others. After that stations T3 and K3 consume some DO and their pollution level comes next to K1 station. The Stations T1 and T2 have the minimum BOD_5 level so their pollution level is also the lowest. Station K2 and J these two's BOD_5 levels are medium in all stations.

4.5 Variation of COD

The total oxygen consumed by strong oxidants in wastewater during the chemical breakdown of both organic and inorganic materials is referred to as the chemical oxygen demand or COD. It functions as a gauge for the amount of inorganic chemical content in wastewater samples and the oxidation susceptibility of particulate debris. The accumulation of solid debris, soluble organic compounds, antifreeze, leftover food waste, emulsified oils, and dying bacterial cells are all causes of elevated COD levels in wastewater. These cells contribute to the general rise in COD by aiding in the breakdown and release of dissolved organic carbon (DOC).

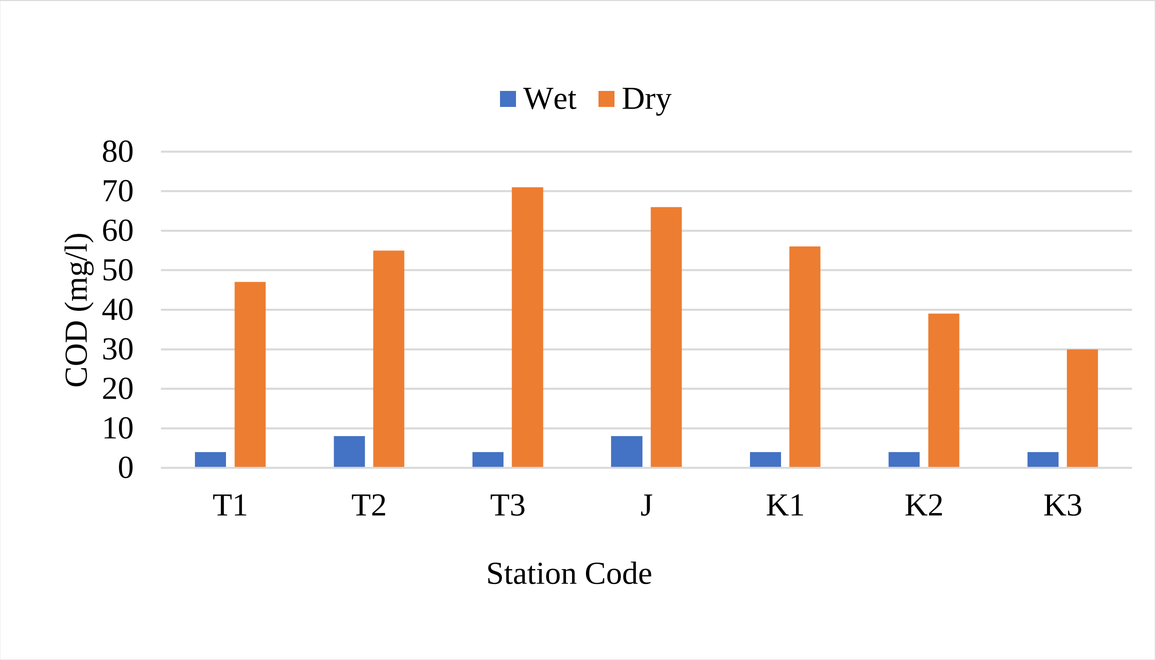


Fig. 4.5 Variation of COD of wet and dry season

4.5.1 Seasonal Variation

The bar chart in Fig 4.5 shows that the COD value is maximum in the dry season and much less in the wet season. In the season of dry, the amount of solid waste and other materials affecting the COD value accumulate in higher quantities so the value of COD is increased. However materials accumulate less in water during the wet season due to rain and heavy flow of water and reduce the chemical oxygen demand.

4.5.2 Temporal Variation

The chart in Fig 4.5 shows that the value of COD in wet seasons is maximum at the junction point station name ‘J’ at this point the Turag and Karnatuli rivers are connected with the Burigranga rivers. At the station of T1, T3, K1, K2, and K3 value is the same.

In the dry season COD value is much higher than in the wet season. The highest value is at the station at T3 which is located at Turag River Diabari Ghat. Here most of the waste is being thrown reason it is a ghat for all boats so most people use this location for travel. The solid wastes get much accumulate at this place and increase the COD value. Similar to the wet season at the junction point the value COD is also higher in the dry season. As the stations T1, T2, K2, and K3 are located at a greater distance from the Buriganga fig 4.5 shows the value of COD is also decreasing with that. The COD value decreased at stations K3, K2, T1, T2, and K1 accordingly.

4.6 Variation of TDS

Minerals and ions that have been dissolved in water to a specific extent are among the organic and inorganic constituents that make up total dissolved solids, or TDS. Particles are absorbed into the water when they flow through pipes, stones, or other surfaces. TDS in water can originate from a variety of sources, including minerals in water treatment chemicals, runoff from road salts, and chemicals or fertilizers from agricultural areas. The most prevalent ingredients are typically the cations of calcium, magnesium, sodium, and potassium, and the anions of carbonate, hydrogen carbonate, chloride, sulfate, and nitrate.

Electroconductivity is also connected to total dissolved solids. As the total dissolved solids increased, so did the electro-conductivity. Total dissolved solids facilitate the passage of electricity through water. That means it works as a conductor of electricity.

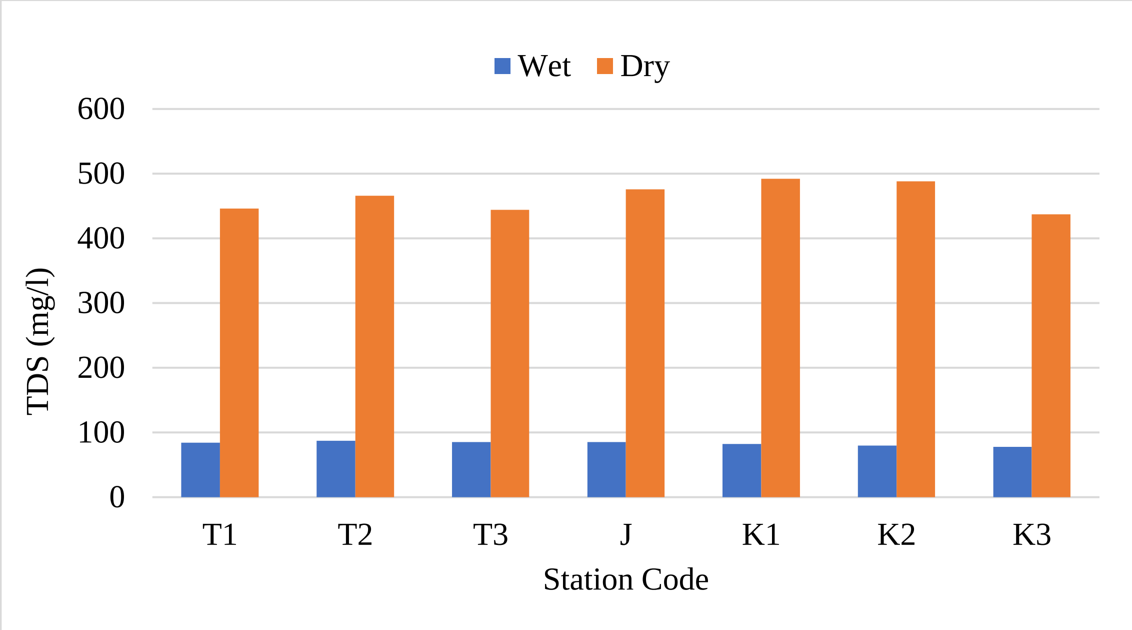


Fig. 4.6 Variation of TDS of the wet and dry season

4.6.1 Spatial Variation

Total dissolved solids (TDS) in water change for many reasons discussed earlier. At the Turag and Karnatuli rivers, the value of total dissolved solids changes highly in the two seasons. In the wet season value total dissolved solids amount remains at a tolerable level and in the dry season as the rain percentage and the wind speed decreases the movement of the river water becomes minimal so the total dissolved solids level increases. The chart in Figure 4.6 represents the same situation. It shows how the value varies in both seasons at different stations. In the dry season, the value didn't fluctuate much it remained close at all stations. But in the dry season, it fluctuates much at different stations depending on the locations and near environment of the location. This chart in Figure 4.6 also shows that the water gets more polluted during the dry season and when the dry season progresses to change into the wet season with time the water also starts to turn to be good with time.

4.6.2 Temporal Variation

As the value didn't fluctuate much in the dry season and remained at suitable levels so values of different stations almost remain close to each other. But in them, the value of the T2 station is highest and the value of the T2 and J station is the same at 85 mg/l. The lowest value at the K3 station is 78 mg/l. T2 station is Turag River near Tamanna housing which is a place where some industries take place. There most of the waste is being disposed of at the Turag River. So the amount of solid increases at this location. Station K3 is located a bit distance from locals so there not as much dissolved solids are found compared to other locations.

In the dry season amount of solid waste increases and brings the fluctuation of values in different stations. Station J, K1, and K2 have the maximum amount of dissolved solids. Station J represents the junction point which is connected with the Buriganga River where most of Dhaka city wastes is disposed with the water the wastes also travels as the K1 and K2 are located near the junction point so for this reason these two locations have the maximum amount of TDS which is 492 mg/l and 488mg/l respectively. As in the wet season, K3 has the minimum amount of TDS. Also, same as the wet season T2 station has the maximum amount of dissolved solids in the Turag River due to its location. Stations T3 also have a fair amount dissolved solids in their locations which makes the water quality poor. The water level is between 300-500 ppm the water quality is poor (Kent Ro). The amount of TDS is discovered in these two rivers in the dry season its value is above 400 mg/l so all locations quality is poor at the during season.

4.7 Variation of EC

One of the best markers of the quality of the water is conductivity. The ability of water to carry an electrical current over a specific distance is measured by its electrical conductivity, which is often expressed in Siemens (S) per distance. Aquatic life and water quality may suffer from large variations in conductivity. An abrupt increase (or reduction) in conductivity is typically a sign of water pollution, which is typically caused by sewage leaks or agricultural runoff that raises the concentration of dissolved particles in the water. As per the World Health Organization (WHO), the maximum value of electrical conductivity that is acceptable is 400 microsimens per centimeter (µS/cm). (Atlas Scientific)

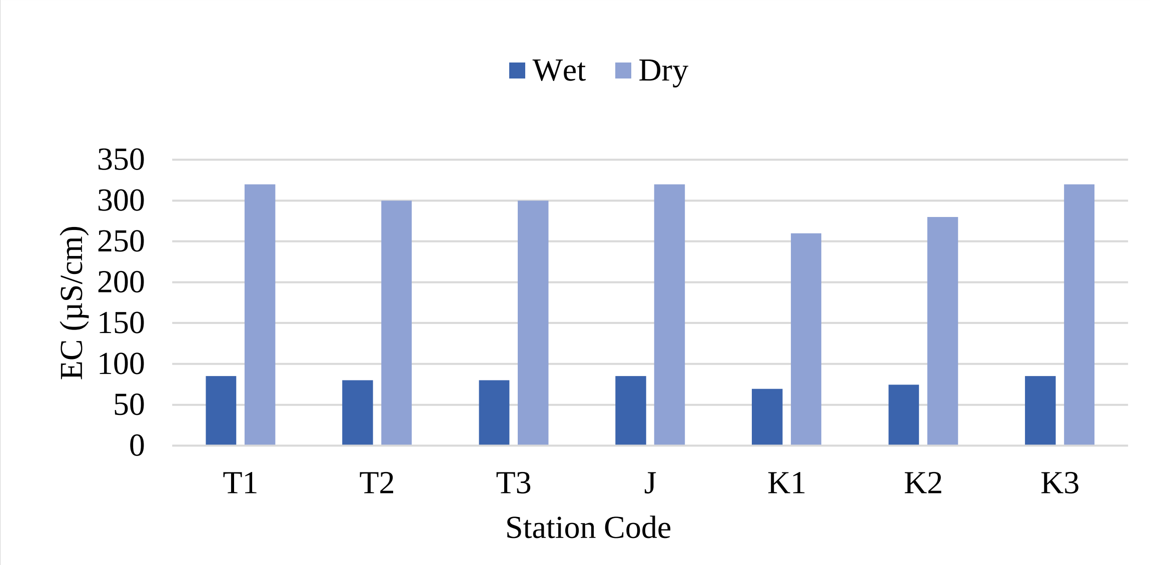


Fig. 4.7 Variation of EC of wet and dry season

4.7.1 Seasonal Variation

Fig 4.7 shows that the value of EC in the Y-axis is very much higher in the dry season compared to the wet season. In the dry season, water accumulates fewer solids in it so electricity doesn't have many conductors for it so it is not able to travel much. Because electricity can't transfer in between non-conductors. In the previous figure, 4.7representst as discussed that the amount of total dissolved solids amount is high in the dry seasons so the electricity gets high amounts of conductors in this season so electricity can easily travel in maximum distance and that's why the value of electro conductivity increases in this season. In the wet season electricity doesn't get enough conductors and it cannot travel much so the value remains lower.

4.7.2 Station Wise variation

The rate of fluctuations of value in the wet season is much lower at the different stations shown in Fig 4.7. Its average value is around 80 µS/cm. Where the highest value is at the T1, J, and K3 stations. The three stations also had the maximum value of total dissolved solids. T2 (Turag River Thamanna) and T3 (Turag River Diabari Ghat have the same amount of electro conductivity that's means the pollution rates of these two location are is similar to each other the stations K1 and K2 are much closer values but K1 has this value which is also the minimum value between all stations. That states the amount of total dissolved solids amount is also minimum at this station.

In the dry season solid wastes are increased in the water so the value of solid wastes increases in this season. Due to the increase of solids in the water electro conductivity also increases depending on it the chart in Fig 4.7 shows the same high rate of electro conductivity in the dry season. Station T1, J, and K3 have the maximum EC in their locations and the other stations have little low amount of EC in them. The minimum conductivity at the K1 station.

4.8 Variation of Turbidity

The term "turbidity" describes a liquid's clarity. A liquid with a high turbidity level is not very clear, but one with a low turbidity level is. When solid particles are suspended in a liquid, turbidity results. The liquid may appear hazy or murky due to the light being scattered by these particles. A common heuristic method for testing water quality is turbidity. Lower quality is usually implied by more turbidity. (aosts.com)

Although turbidity does not always pose a threat to a community's inhabitants, it can make wastewater treatment techniques less hygienic. If suspended materials are not sufficiently filtered out, they could endanger human health. Heavy metals may find their way into the water supply as a result of excessive turbidity. These metals could include cadmium, lead, and mercury, all of which are harmful to people. By lowering the amount of available food, deteriorating breeding grounds, and impairing fish gill function, turbidity can be harmful to aquatic life. (aosts.com)

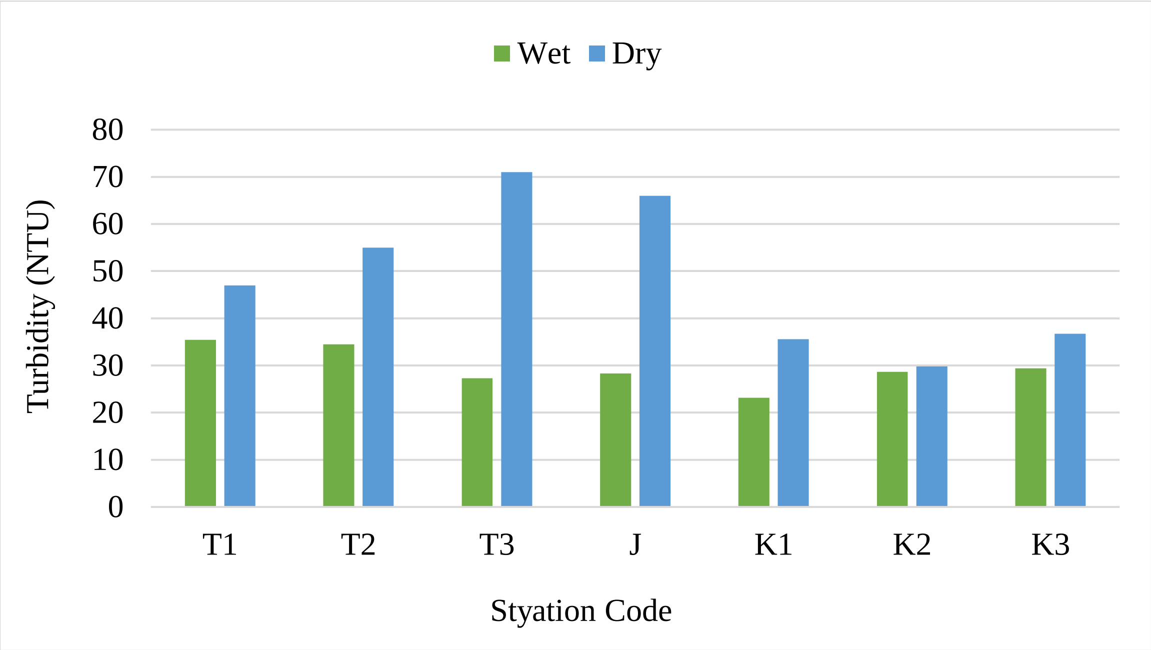


Fig. 4.8 Variation of Turbidity of wet and dry season

4.8.1 Seasonal Variation

Figure 4.8 represent turbidity value variation in different seasons. The X-axis represents the station names and the Y-axis represents the value of turbidity. In the wet season, this value is very low compared to the dry season. At every station, turbidity value is maximum in the dry season. Know that turbidity indicates how much the water is clear and how much light can pass through the water. In the dry season, the water becomes darker due to different elements like silt, mud, algae, plant pieces, melting glaciers, sawdust, wood ashes, or chemicals increases. T1 and T2 station are located in mostly industries area so in these locations more solid type wastes gather made the water darker and a minimum amount of light can able to pass through the water. Stations T3, J, and K1 are located where mostly human wastes are being disposed so these wastes didn’t gather at a place so they travel with the water and make that place a little bit clear so the turbidity value decreases at that location.

In the seasons of dry water flow decreases due to wind speed and wastes get the chance to gather so it make maximum places water darker and increase the value turbidity which is shown in figure 4.8. As station T3 is Diabari Ghat so most people gather at that place of the river which costs the maximum wastes percentage there at this location the turbidity value is maximum in the dry season.

4.8.2 Station Wise variation

Figure 4.8 shows that in the wet season, the turbidity value is maximum at stations T1 and T2 respectively. These locations where water isn’t able to get much light in this season makes life difficult for the fishes and other species living in the water because much oxygen also wasn’t able to pass through the water. The station T3, J, K1, K2, and K3 turbidity values does not have much fluctuation so these locations' water conditions are close to each other.

In the dry season station T3 has the maximum amount of turbidity which makes this place unsuitable for the water species. At junction point (J) Turag and Karnatuli rivers connect with Buriganga so three river wastes gather at that place depending on turbidity that place becomes the second most polluted place between these 7 locations. The chart also represents that the value fluctuates very much in the wet season. Every station value has a large difference between them. After the T3 and J stations in Turag River T1 and T2 have the most amount of turbidity respectively. In Karnatuli River K3 location contain the most amount of turbidity station K1’s location contains close amount of turbidity to the K3 stations. K2 station has the minimum amount of turbidity compared to all other stations of the study.

4.3 Analysis of Water Quality Index

The Water Quality Index (WQI), which takes into account several factors linked to water quality, is a numerical representation that summarizes the general state of the water in a particular location. This index provides decision-makers and the general public with an easy way to receive information on water quality. The process of calculation entails evaluating multiple parameters with assigned weightings, culminating in a single figure that offers a summary of the water quality overall. While methods may differ between locations and organizations, common parameters include chemical characteristics (pH, dissolved oxygen, biochemical oxygen demand, nutrient levels, salinity), biological indicators (presence of coliform bacteria, total coliforms, fecal coliforms), and physical characteristics (temperature, turbidity, color, odor).

The goals of the water quality evaluation and the regional environmental circumstances are taken into consideration while determining the precise characteristics and their corresponding weightings. Values are frequently standardized, given quality ratings, and multiplied by weighting factors after the assessment. The Water Quality Index is the result of adding these numbers together.

Table 4.1 Water quality index (WQI) range, status and possible usage of the water sample (Bouslah et al., 2017)

WQI range	**Water quality status**	**Possible usage**
0-25	Excellent water quality	Drinking, irrigation, and industrial
26-50	Good water quality	Drinking, irrigation, and industrial
51-75	Poor water quality	Irrigation and Industrial
76-100	Very poor water quality	Irrigation
Above 100	Unsuitable for drinking and propagation of fish culture	Proper treatment is required before use

The Water Quality Index is usually broken down into discrete classifications or ranges, such as "Excellent" to "unsuitable for drinking and fish culture" to make it easier to understand (shown in Table 4.1). In general, higher index values signify worse water quality, whereas lower ones imply better quality. Depending on the result of WQI possible use of water is different because all type of water is not habitat able for different types of species. Figure 4.9 also shows the possible use of different qualities of water.

4.3.1 Water Quality Index for Wet season

In the season of wet different water samples is being collected from the Turag and Karnatuli rivers. Then these samples are tested in the lab and depending on those result water quality is been calculated. The table given below represents the total WQI value at different stations. The calculations will be provided in the appendix.

Table 4. 2 Water quality index result in wet season at different stations

Station Code	WQI (Wet Season)	Comment	Possible Uses
T1	278.61	Unsuitable for Drinking, fish culture, and irrigation	Proper Treatment is required for any kind of usage
T2	272.77		
T3	221		
J	229.33		
K1	192		
K2	231.52		
K3	235.67		

The table shows that all the values of WQI are very high at different stations. Figure 4.9 shows that a value above 100 is unsuitable for drinking, fish culture, and irrigation. So in the wet season, all the samples of different locations all are unsuitable for drinking, fish culture, and irrigation because all the sample's value are above 100. T1 station has the maximum value T2 station value is also near the value of the T1 station. From the table also finds that the values of the Turag rivers is high compared to the values of the Karnatuli River. Knows that Turag River contains a high levels of industrial wastes from different type of industries like garments, chemical factories, tannery wastes, etc. Karnatuli River also contains different types of waste but most of them are from household wastes, brick factory wastes, and a few industrial wastes. Due to this wastes, Turag river gets comparatively more polluted than the Karnatuli river. But in the wet season this value is not much less but with the season this difference increases. If this water needs to be used for any purpose first this water needs proper treatment. Without proper treatment use of this water can cause different types of problems depending on the usage of the water.

4.3.2 Water Quality Index for Dry season

Table 4. 3 Water quality index result in dry season at different stations

Station Code	WQI (Dry Season)	Comment	Possible Uses
T1	348.53	Unsuitable for Drinking, fish culture and irrigation	Proper Treatment is required for any kind of usage
T2	388.3		
T3	499.68		
J	469.62		
K1	283.03		
K2	250.5		
K3	285.03		

As knows the value of WQI above 100 is unsuitable for drinking, fish culture, and irrigation. In the dry season WQI value of different seasons is so above 100 even in these seasons all station's value is above 200. At the station K2 has the minimum WQI value. The same the wet season Karnatuli River water quality index is better than the Turag River water quality index. Turag River is more polluted due to number of people live around the river and in the dry season this pollution level increases so the value of the water quality index also increases which indicates the water quality isn’t suitable for any purpose usages.

4.4 One-way ANOVA Test

A statistical method called ANOVA (Analysis of Variance) compares the means of two or more groups to see if there are any statistically significant differences between them. A One-way ANOVA, also known as a single-factor ANOVA, is used when there is only one factor (independent variable) and several levels (groups).

This ANOVA test shows the analysis of the variance between groups. If the P-value is larger than 0.05 there will be a significant variation in the two seasons value or else there will be no significant variations.

Table 4. 4 One-way ANNOVA test value

Parameters	Seasons	Source of Variation	SS	df	MS	F	P-value
pH	Dry	BG	1.56	1	1.56	221.16	4.29E-09
	Wet	WG					
DO (mg/l)	Dry	BG	27.44	1	27.44	91.88	5.65E-07
	Wet	WG					
COD (mg/l)	Dry	BG	7684.57	1	7684.57	71.88	2.06E-06
	Wet	WG					
TDS (mg/l)	Dry	BG	508444.57	1	508444.57	2019.74	9.60E-15
	Wet	WG					
EC (µS/cm)	Dry	BG	169402.20	1	169402.20	593.10	1.38E-11
	Wet	WG					
Temperature (°C)	Dry	BG	372.35	1	372.35	14480.11	7.27E-20
	Wet	WG					
Turbidity (NTU)	Dry	BG	1290.05	1	1290.05	9.56	9.34E-03
	Wet	WG					

Table 4.4 shows the result of the One-way ANOVA test result for parameters in the wet and dry seasons. The source of variation is between groups in the table the column SS represents the sum of squares, the df column represents the degrees of freedom values, the MS column shows the value of the mean square and at the end last column represent the P-value.

A metric known as the p-value, or probability value, is used in statistical hypothesis testing to determine the strength of the result that defies the null hypothesis. It calculates the probability that test results will have any significant differences or that will have no significant differences. As earlier said if the P-value is less than 0.05 that will describe that this parameter has significant variation in the group or if the value is larger then there will be no differences.

The P-value of all parameters is less than 0.05 which means all the parameters have significant variation between groups. The parameters TDS, EC, and Temperature P-value are very close to 0 (zero) indicate the differences between groups is highly significant for these variables.

The parameters pH, DO and COD P-value are close to each other but all values are less than 0.05 which indicates they have significant variation between groups. However these parameters significant variation levels are lower compared to TDS, EC, and Temperature.

The parameter Turbidity has the less significant variation between groups as its value is 0.00094 which is less than 0.05 but it is a closer value compared to other parameters.

4.5 Correlation Matrix

A correlation matrix indicates relation between two parameters. If the two parameters' value increase or decrease parallelly that will be a positive correlation, if one increases while the other decreases that correlation will be negative, or if they don't seem to have any connection so there will be no correlation. Each number in the table represents this relationship, and it helps people understand how different things are connected in data.

4.5.1 Strength of Correlation

The degree of association between two variables is referred to as the correlation's strength. The correlation coefficient, represented by the letter "r," measures the strength of this association. "r" represents the correlation's strength and direction, and its value falls between -1 and 1. Based on the correlation coefficient's absolute value, according to the (Akoglu et al., 2018) following general guidelines can be used to interpret the strength of correlation:

1. **Perfect Positive Correlation ($r = 1$):** When two variables have a perfect positive linear relationship, their correlation coefficient is 1. The other variable increases proportionately to the increase in the first.
2. **Strong Positive Correlation ($0.8 \leq |r| < 1$):** An intensely positive linear relationship is indicated by a correlation coefficient that is near to 1. Though not exactly, the variables generally move in the same direction.
3. **Moderate Positive Correlation ($0.6 \leq |r| < 0.8$):** A moderately positive linear relationship is indicated by a correlation coefficient within this range. Though not as strong as in the case of a strong correlation, there is still a trend that can be seen.
4. **Weak Positive Correlation ($0.2 \leq |r| < 0.6$):** This range of correlation coefficients indicates a weakly positive linear relationship. Although it might not be very noticeable, the trend is there.
5. **No Correlation ($|r| < 0.2$):** There is little to no linear relationship between the variables when the correlation coefficient is near zero.
6. **Weak Negative Correlation ($-0.2 \geq r > -0.6$):** Negatively correlated, similar to a weakly positive correlation. The relationship between the variables is weak and they tend to move in opposite directions.

7. **Moderate Negative Correlation (-0.6 ≥ r > -0.8):** A moderately negative linear relationship is indicated by a correlation coefficient within this range. There is a clear relationship between the variables, even though they move in opposite directions.
8. **Strong Negative Correlation (-1 ≥ r > -0.8):** A strong negative linear relationship is indicated by a correlation coefficient that is near -1. There is a strong inverse movement between the variables.
9. **Perfect Negative Correlation (r = -1):** A correlation coefficient of -1 indicates a perfect negative linear relationship. As one variable increases, the other decreases proportionally.

It's crucial to remember that correlation does not imply causation, and the associations that are shown could be influenced by other variables. The degree to which changes in one variable are related to changes in another can be inferred from the correlation strength. (Schober et al., 2018)

4.5.2 Correlation Matrix of Wet season

Figure 4.9 shows the correlations of the water parameters of Turag and Karnatuli river. It is important to know the correlation between the variables. Here the parameter pH is negatively correlated with dissolved oxygen (mg/l), chemical oxygen demand (mg/l), electroconductivity (µs/cm), Temperature (°C), and Turbidity (NTU). As the strength of correlation describes pH has a weak negative correlation with all the parameters except for the moderate negative correlation with turbidity.

DO has a weak positive correlation with TDS (mg/l), Turbidity (NTU), and strong positive correlation with COD (mg/l). DO doesn't have any correlation with EC and Temperature.

COD correlated with DO, TDS, EC and Turbidity. In between them, it has a strong positive correlation with DO (mg/l), a moderate positive correlation with TDS (mg/l), and weak positive correlation with EC (µs/cm), and Turbidity (NTU). Also, it has a weak negative correlation with pH.

TDS has the has positive correlation with pH, DO (mg/l), COD (mg/l), EC (µs/cm), and Turbidity (NTU) it has a negative correlation with temperature (°C). From them it has a week positive correlation with pH, DO, EC, and Turbidity. Moderate positive correlation with COD it also has a strong negative correlation with the temperature.

Fig. 4.9 Correlation Matrix of wet season

Electroconductivity has positive correlations with the parameters COD (mg/l), TDS (mg/l), and Turbidity (NTU). Has the negative correlations with pH and Temperature (°C). From them, it has weak positive correlations with COD, and TDS. With the turbidity, it has a moderate positive correlation and weak negative correlation with the pH and temperature.

Temperature has a week negative correlation with TDS (mg/l) and Turbidity (NTU). That's means if temperature is trying to increase this two will tends to decrease. Temperature does not correlate with the pH and DO.

Turbidity is week negatively correlated with pH and temperature (0°C) That means if turbidity tries to increases these two will tends to decrease. Turbidity also week positively correlated with DO (mg/l), COD (mg/l), and TDS (mg/l) and moderate positively correlated with EC (µs/cm). That mean if turbidity increases with it these positively correlated parameters also show the tendency to increase.

4.5.3 Correlation Matrix of Dry season

Correlation between different parameters is an important factor that helps to know the relation between every parameter. Figure 4.10 shows the correlation matrix for the dry season of the Turag and Karnatuli rivers.

The parameter pH is negatively correlated with DO, BOD_5, COD, and TDS. Positively correlated with the EC, Temperature, and Turbidity. Between them, it has a weak positive correlation with Turbidity (NTU) and with the EC (µs/cm) and Temperature (0°C), it has a strong positive correlation that means the value of pH increases then the value of EC, turbidity, and temperature will also increase. It has a strong negative correlation with TDS (mg/l) here if the value of pH increases then the value of total dissolved solids value will decrease. The correlation value with DO (mg/l), BOD_5 (g/l), and COD (mg/l) is less than 0.2 so it can consider as having no relations.

Fig. 4.10 Correlation Matrix of dry season

Dissolved Oxygen has Weak negative correlations with pH, BOD_5 (g/l), and Turbidity (NTU) and Weak positive correlations with TDS (mg/l), COD (mg/l) and EC (µs/cm). But here without TDS can be considered that there are no correlations because every correlation value is less than -0.2 or +0.2. The correlation strength depends on the value of each correlation if this value is minimum that means their relation is weak. As an example here if the value of DO increases then the value of COD and EC will increase also but very little because its value is minimum.

Biochemical Oxygen Demand is weak and negatively correlated with EC (µs/cm). That states if the BOD_5 value increases then EC will tend to decrease. Other than electro conductivity BOD_5 is correlated with the pH, COD (mg/l), and Turbidity (NTU), DO (mg/l) but all of their values is less than -0.2 or +0.2 so it does not correlate with each other.

Chemical Oxygen Demand is strongly positively correlated with Turbidity (NTU). Here turbidity will move with the COD. If the COD value increases then the turbidity value will also increase. Same as the BOD_5, COD has few weak correlations with other parameters where all of their values are less than -0.2 or +0.2.

Total Dissolved Solids have Strong negative correlations with pH and EC (µs/cm), Moderate negative correlation with Temperature (°C), and Weak negative correlation with Turbidity (NTU). That means if the value of total dissolved solids decreases then the values of these parameters also decrease according to their correlation strength. Total dissolved solid has a weak positive correlation with dissolved oxygen.

Electro Conductivity has Strong positive correlations with pH and Temperature (°C), a moderate positive correlation with Turbidity (NTU) and a weak positive correlation with DO (mg/l) is less than 0.2. That shows if any of these parameters value increases there all value also will increase. Electro Conductivity also has a moderate negative correlation with BOD_5 (mg/l). That means if the value of EC decreases then the value of BOD_5 also decreases.

Temperature is moderately positively correlated with EC (µs/cm) and Turbidity (NTU), weak positive correlation with pH. It also has a weak negative correlation with TDS (mg/l) and Nearly has no correlation with DO (mg/l), BOD_5 (g/l), and COD (mg/l) because all their value is less than 0.2.

Turbidity is strongly positively correlated with COD (mg/l), weak positively correlated with pH, EC (µs/cm), and Temperature (°C), and weak negative correlations with TDS (mg/L). Nearly do not correlate with DO (mg/l) and BOD_5 (g/l).

These interpretations shed light on how several water quality measures relate to one another throughout the dry season.

CHAPTER-V

CONCLUSION AND RECOMMENDATIONS

5.1 General

This thesis represents the water quality of the Turag and Karnatuli rivers. To understand the water quality samples are collected from 7 stations and after some parameters which help to understand the water quality those are tested. Some of them are tested on the spot and some are tested in the lab. Depending on the results of those tests some analysis are being performed to understand the water quality and its spatial and temporal variations.

5.2 Conclusion

The analysis of physiochemical parameters reveals seasonal variations in the water quality of Turag and Karnatuli rivers. Generally, water quality appears better during the wet season compared to the dry season. Stations such as T1, J, and K1 exhibit higher pollution levels, as indicated by maximum parameter values. During the dry season, parameters including DO, COD, EC, and TDS significantly increase across most stations.

In the wet season among the 7 stations water quality of the T1 station is in the worst condition and the K1 station has the best water condition. In the wet season according to the WQI the water quality condition varies from highest to lowest in Turag river T1>T2> J >T3 and in Karnatuli river K3>K2>J> K1. But in the dry season the water quality of the whole Turag River is worse compare to the Karnatuli River. In WQI Turag River water quality value is almost double that of the Karnatuli River. T3 station has the highest WQI value and K2 station has a minimum WQI value. According to the analysis of variation, all the parameters value has a significant variation between the groups but the significant variation is maximum for temperature and minimum for turbidity.

In the wet season DO is highly positively correlated with COD and temperature is highly negatively correlated with TDS. There are a few more positive and moderate correlations and some weak negative and positive correlations between a few parameters.

In the dry season pH is highly positively correlated with EC and COD is highly positively correlated with Turbidity. pH is also highly negatively correlated with TDS and TDS is highly negatively correlated with EC. Apart from this, there are few more positive and negative correlations between different parameters and their strength is weak or moderated depending on their relation values.

5.3 Recommendations

In this thesis paper, two seasons of water quality are monitored and here only 7 stations are investigated. So depending on this, it is difficult to understand the exact conditions of the whole river. Here are some recommendations for the future:

1. It can be monitors more season's so that result can be better.
2. Can be fix up more stations so that the result of water quality can get more accurate.
3. In this paper no test has been done with heavy metal if we consider some heavy metal parameter than results can be more accurate.

5.4 Limitations

It is important to acknowledge several limitations that may have impacted the results and their interpretation. These limitations, stemming from various constraints, are outlined below:

- Due to a shortage of time, the study could not analyze more seasons. This limitation restricts the understanding of seasonal variations and their impact on the research findings.

- The lab environment was not of the highest standard, which could have led to equipment errors.

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Appendix

Table 1: Full data sheet

Station Code	Coordination		Ph		DO (mg/l)		BOD (mg/l)		COD (mg/l)		TDS (mg/l)		EC (PPM)		EC (µS/cm)		Temperature (ºC)		Turbidity (NTU)	
	Latitude	Longitude	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
T1	23.8358500	90.3378170	6.8	7.53	0.6	4.06		13	4	47	84	446	40	160	85.33	320	30.1	19.9	35.47	47
T2	23.8182910	90.3398180	6.7	7.39	0.8	2.4		14	8	55	87	466	40	150	80	300	30.2	19.9	34.46	55
T3	23.7999990	90.3424870	6.8	7.52	0.6	3.26		21	4	71	85	444	40	150	80	300	30.2	20.1	27.27	71
J	23.7858504	90.3359631	6.8	7.44	0.7	4.09		17	8	66	85	476	40	160	85.33	320	30.3	20.1	28.34	66
K1	23.7945040	90.3294450	6.8	7.3	0.6	3.1		23	4	56	82	492	40	130	69.33	260	30.3	19.8	23.14	35.6
K2	23.8027900	90.3052310	6.8	7.32	0.7	4.49		18	4	39	80	488	40	140	74.67	280	30.6	20	28.65	29.8
K3	23.8058420	90.2949580	6.7	7.58	0.6	2.8		20	4	30	78	437	40	160	85.33	320	30.5	20.2	29.38	36.7

Table 2: Water Quality Index of T1 station in wet season

Parameters	TRP (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.8	8.5	0.12	0.57	1.76	0.21	80.00	16.54
DO (mg/l)	0.6	5	0.20	0.57	1.76	0.35	12.00	4.22
COD (mg/l)	4	100	0.01	0.57	1.76	0.02	4.00	0.07
TDS (mg/l)	84	1000	0.00	0.57	1.76	0.00	8.40	0.01
EC (µS/cm)	85.33	2250	0.00	0.57	1.76	0.00	3.79	0.00
Temperature (ºC)	30.1	25	0.04	0.57	1.76	0.07	120.40	8.46
Turbidity (NTU)	35.47	5	0.20	0.57	1.76	0.35	709.40	249.31
	Total		0.57			1.00		278.62

Table 3: Water Quality Index of T2 station in wet season

Parameters	TRT (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.7	8.5	0.12	0.57	1.76	0.21	78.82	16.30
DO (mg/l)	0.8	5	0.20	0.57	1.76	0.35	16.00	5.62
COD (mg/l)	8	100	0.01	0.57	1.76	0.02	8.00	0.14
TDS (mg/l)	87	1000	0.00	0.57	1.76	0.00	8.70	0.02
EC (µS/cm)	80	2250	0.00	0.57	1.76	0.00	3.56	0.00
Temperature (ºC)	30.2	25	0.04	0.57	1.76	0.07	120.80	8.49
Turbidity (NTU)	34.46	5	0.20	0.57	1.76	0.35	689.20	242.21
	Total		0.57			1.00		272.78

Table 4: Water Quality Index of T3 station in wet season

Parameters	TRD (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.8	8.5	0.12	0.57	1.76	0.21	80.00	16.54
DO (mg/l)	0.6	5	0.20	0.57	1.76	0.35	12.00	4.22
COD (mg/l)	4	100	0.01	0.57	1.76	0.02	4.00	0.07
TDS (mg/l)	85	1000	0.00	0.57	1.76	0.00	8.50	0.01
EC (µS/cm)	80	2250	0.00	0.57	1.76	0.00	3.56	0.00
Temperature (ºC)	30.2	25	0.04	0.57	1.76	0.07	120.80	8.49
Turbidity (NTU)	27.27	5	0.20	0.57	1.76	0.35	545.40	191.67
	Total		0.57			1.00		221.01

Table 5: Water Quality Index of JP station in wet season

Parameters	JP (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.8	8.5	0.12	0.57	1.76	0.21	80.00	16.54
DO (mg/l)	0.7	5	0.20	0.57	1.76	0.35	14.00	4.92
COD (mg/l)	8	100	0.01	0.57	1.76	0.02	8.00	0.14
TDS (mg/l)	85	1000	0.00	0.57	1.76	0.00	8.50	0.01
EC (µS/cm)	85.33	2250	0.00	0.57	1.76	0.00	3.79	0.00
Temperature (ºC)	30.3	25	0.04	0.57	1.76	0.07	121.20	8.52
Turbidity (NTU)	28.34	5	0.20	0.57	1.76	0.35	566.80	199.19
	Total		0.57			1.00		229.33

Table 6: Water Quality Index of K1 station in wet season

Parameters	KRAB (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.8	8.5	0.12	0.57	1.76	0.21	80.00	16.54
DO (mg/l)	0.6	5	0.20	0.57	1.76	0.35	12.00	4.22
COD (mg/l)	4	100	0.01	0.57	1.76	0.02	4.00	0.07
TDS (mg/l)	82	1000	0.00	0.57	1.76	0.00	8.20	0.01
EC (µS/cm)	69.33	2250	0.00	0.57	1.76	0.00	3.08	0.00
Temperature (ºC)	30.3	25	0.04	0.57	1.76	0.07	121.20	8.52
Turbidity (NTU)	23.14	5	0.20	0.57	1.76	0.35	462.80	162.65
	Total		0.57			1.00		192.01

Table 7: Water Quality Index of K2 station in wet season

Parameters	KRBF (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.8	8.5	0.12	0.57	1.76	0.21	80.00	16.54
DO (mg/l)	0.7	5	0.20	0.57	1.76	0.35	14.00	4.92
COD (mg/l)	4	100	0.01	0.57	1.76	0.02	4.00	0.07
TDS (mg/l)	80	1000	0.00	0.57	1.76	0.00	8.00	0.01
EC (µS/cm)		2250	0.00	0.57	1.76	0.00	0.00	0.00
Temperature (ºC)	30.6	25	0.04	0.57	1.76	0.07	122.40	8.60
Turbidity (NTU)	28.65	5	0.20	0.57	1.76	0.35	573.00	201.37
	Total		0.57			1.00		231.52

Table 8: Water Quality Index of K3 station in wet season

Parameters	KRKB (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	6.7	8.5	0.12	0.57	1.76	0.21	78.82	16.30
DO (mg/l)	0.6	5	0.20	0.57	1.76	0.35	12.00	4.22
COD (mg/l)	4	100	0.01	0.57	1.76	0.02	4.00	0.07
TDS (mg/l)	78	1000	0.00	0.57	1.76	0.00	7.80	0.01
EC (µS/cm)	85.33	2250	0.00	0.57	1.76	0.00	3.79	0.00
Temperature (ºC)	30.5	25	0.04	0.57	1.76	0.07	122.00	8.58
Turbidity (NTU)	29.38	5	0.20	0.57	1.76	0.35	587.60	206.50
	Total		0.57			1.00		235.68

Table 9: Water Quality Index of T1 station in dry season

Parameters	TRP (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.53	8.5	0.11765	0.65242	1.53274	0.18032	88.58824	15.97448
DO (mg/l)	4.06	5	0.20000	0.65242	1.53274	0.30655	81.20000	24.89176
BOD (mg/l)	13	12	0.08333	0.65242	1.53274	0.12773	108.33333	13.83727
COD (mg/l)	47	100	0.01000	0.65242	1.53274	0.01533	47.00000	0.72039
TDS (mg/l)	446	1000	0.00100	0.65242	1.53274	0.00153	44.60000	0.06836
EC (µS/cm)	320	2250	0.00044	0.65242	1.53274	0.00068	14.22222	0.00969
Temperature (ºC)	19.9	25	0.04000	0.65242	1.53274	0.06131	79.60000	4.88026
Turbidity (NTU)	47	5	0.20000	0.65242	1.53274	0.30655	940.00000	288.15580
	Total		0.65242			1.00000		348.53799

Table 10: Water Quality Index of T2 station in dry season

Parameters	TRT (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.39	8.5	0.11765	0.65242	1.53274	0.18032	86.94118	15.67747
DO (mg/l)	2.4	5	0.20000	0.65242	1.53274	0.30655	48.00000	14.71434
BOD (mg/l)	14	12	0.08333	0.65242	1.53274	0.12773	116.66667	14.90167
COD (mg/l)	55	100	0.01000	0.65242	1.53274	0.01533	55.00000	0.84301
TDS (mg/l)	466	1000	0.00100	0.65242	1.53274	0.00153	46.60000	0.07143
EC (µS/cm)	300	2250	0.00044	0.65242	1.53274	0.00068	13.33333	0.00908
Temperature (ºC)	19.9	25	0.04000	0.65242	1.53274	0.06131	79.60000	4.88026
Turbidity (NTU)	55	5	0.20000	0.65242	1.53274	0.30655	1100.00000	337.20359
	Total		0.65242			1.00000		388.30085

Table 11: Water Quality Index of T3 station in dry season

Parameters	TRD (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.52	8.5	0.11765	0.65242	1.53274	0.18032	88.47059	15.95326
DO (mg/l)	3.26	5	0.20000	0.65242	1.53274	0.30655	65.20000	19.98698
BOD (mg/l)	21	12	0.08333	0.65242	1.53274	0.12773	175.00000	22.35251
COD (mg/l)	71	100	0.01000	0.65242	1.53274	0.01533	71.00000	1.08825
TDS (mg/l)	444	1000	0.00100	0.65242	1.53274	0.00153	44.40000	0.06805
EC (µS/cm)	300	2250	0.00044	0.65242	1.53274	0.00068	13.33333	0.00908
Temperature (ºC)	20.1	25	0.04000	0.65242	1.53274	0.06131	80.40000	4.92930
Turbidity (NTU)	71	5	0.20000	0.65242	1.53274	0.30655	1420.00000	435.29919
	Total		0.65242			1.00000		499.68662

Table 12: Water Quality Index of JP station in dry season

Parameters	JP (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.44	8.5	0.11765	0.65242	1.53274	0.18032	87.52941	15.78355
DO (mg/l)	4.09	5	0.20000	0.65242	1.53274	0.30655	81.80000	25.07569
BOD (mg/l)	17	12	0.08333	0.65242	1.53274	0.12773	141.66667	18.09489
COD (mg/l)	66	100	0.01000	0.65242	1.53274	0.01533	66.00000	1.01161
TDS (mg/l)	476	1000	0.00100	0.65242	1.53274	0.00153	47.60000	0.07296
EC (µS/cm)	320	2250	0.00044	0.65242	1.53274	0.00068	14.22222	0.00969
Temperature (ºC)	20.1	25	0.04000	0.65242	1.53274	0.06131	80.40000	4.92930
Turbidity (NTU)	66	5	0.20000	0.65242	1.53274	0.30655	1320.00000	404.64431
	Total		0.65242			1.00000		469.62200

Table 13: Water Quality Index of K1 station in dry season

Parameters	KRAB (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.3	8.5	0.11765	0.65242	1.53274	0.18032	85.88235	15.48654
DO (mg/l)	3.1	5	0.20000	0.65242	1.53274	0.30655	62.00000	19.00602
BOD (mg/l)	23	12	0.08333	0.65242	1.53274	0.12773	191.66667	24.48132
COD (mg/l)	56	100	0.01000	0.65242	1.53274	0.01533	56.00000	0.85834
TDS (mg/l)	492	1000	0.00100	0.65242	1.53274	0.00153	49.20000	0.07541
EC (µS/cm)	260	2250	0.00044	0.65242	1.53274	0.00068	11.55556	0.00787
Temperature (ºC)	19.8	25	0.04000	0.65242	1.53274	0.06131	79.20000	4.85573
Turbidity (NTU)	35.6	5	0.20000	0.65242	1.53274	0.30655	712.00000	218.26269
	Total		0.65242			1.00000		283.03393

Table 14: Water Quality Index of K2 station in dry season

Parameters	KRBF (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.32	8.5	0.11765	0.65242	1.53274	0.18032	86.11765	15.52897
DO (mg/l)	4.49	5	0.20000	0.65242	1.53274	0.30655	89.80000	27.52808
BOD (mg/l)	18	12	0.08333	0.65242	1.53274	0.12773	150.00000	19.15930
COD (mg/l)	39	100	0.01000	0.65242	1.53274	0.01533	39.00000	0.59777
TDS (mg/l)	488	1000	0.00100	0.65242	1.53274	0.00153	48.80000	0.07480
EC (µS/cm)	280	2250	0.00044	0.65242	1.53274	0.00068	12.44444	0.00848
Temperature (ºC)	20	25	0.04000	0.65242	1.53274	0.06131	80.00000	4.90478
Turbidity (NTU)	29.8	5	0.20000	0.65242	1.53274	0.30655	596.00000	182.70304
	Total		0.65242			1.00000		250.50521

Table 15: Water Quality Index of K3 station in dry season

Parameters	KRKB (Vn)	ECR Standards (Sn)	1/Sn	Total (1/Sn)	K=1/total (1/Sn)	Wn= K/Sn	Qn=(Vn/Sn)*100	Wn*Qn
Ph	7.58	8.5	0.11765	0.65242	1.53274	0.18032	89.17647	16.08055
DO (mg/l)	2.8	5	0.20000	0.65242	1.53274	0.30655	56.00000	17.16673
BOD (mg/l)	20	12	0.08333	0.65242	1.53274	0.12773	166.66667	21.28811
COD (mg/l)	30	100	0.01000	0.65242	1.53274	0.01533	30.00000	0.45982
TDS (mg/l)	437	1000	0.00100	0.65242	1.53274	0.00153	43.70000	0.06698
EC (µS/cm)	320	2250	0.00044	0.65242	1.53274	0.00068	14.22222	0.00969
Temperature (ºC)	20.2	25	0.04000	0.65242	1.53274	0.06131	80.80000	4.95383
Turbidity (NTU)	36.7	5	0.20000	0.65242	1.53274	0.30655	734.00000	225.00676
	Total		0.65242			1.00000		285.03246