EVALUATION OF SURFACE WATER QUALITY AT SELECTED POINTS OF BURIGANGA RIVER AND SEWER LINE

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DECLARATION

The dissertation entitled “Our Thesis Title EVALUATION OF SURFACE WATER QUALITY AT SELECTED POINTS OF BURIGANGA RIVER AND SEWER LINE.” has been performed under the supervision of Md. Masud Alom (Assistant Professor) Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and got permission in partial completion of the requirement for the Bachelor of Science in Civil Engineering. To the best of our knowledge, the thesis contains no materials previously published or written by another individual except where due reference is prepared in the capstone itself.

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ABSTRACT

Buriganga is one of the largest rivers in the southern part of the north-central region of Bangladesh, flowing through the south and west part of Dhaka. The river is one of the most important and heavily polluted waterbodies in Bangladesh. The river receives a significant amount of untreated wastewater from domestic, industrial, and commercial sources, causing severe environmental and health impacts. This paper aims to examine the nature and extent of wastewater pollution in the Buriganga River, its impact on the ecosystem, and the challenges associated with mitigating the problem. The study employs both qualitative and quantitative research methods, including a literature review, field surveys, and water quality analysis. The results show that the Buriganga River is severely contaminated with various pollutants, including heavy metals and organic compounds, exceeding the permissible limits set by national and international standards. This paper examines the water quality of the Buriganga River during the summer and autumn seasons for three different points. Various parameters, including pH, turbidity, dissolved oxygen (DO), electrical conductivity (EC), biological oxygen demand (BOD), chemical oxygen demand (COD), temperature, and total dissolved solids (TDS), as well as heavy metal concentrations (Cd, Cu, Cr, Pb, and Ni), were tested to assess the river's water quality. The results showed that the Buriganga River had poor water quality during both seasons, with several parameters exceeding the permissible limits set by regulatory authority. According to the observation of physicochemical parameters, wastewater coming from sewer lines is more polluted than river water. The study highlights the urgent need for immediate action to improve the water quality of the Buriganga River and protect the health and well-being of the local population and the environment.

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LIST OF ABBREVIATIONS

BIWTA	Bangladesh Inland Water Transport Authority
BOD	Biochemical oxygen demand
BWDB	Bangladesh Water Development Board
BWDB	Bangladesh Water Development Board
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DoE	Department of Environment
DPHE	Department of Public Health Engineering
GPS	Global Positioning System
TDS	Total Dissolved Solids

Chapter I

INTRODUCTION

1.1 Background

Water is the world's most valuable natural resource. It is the most precious and essential resource for survival and any growth endeavor. The river is a source of life, giving sustenance as well as attractiveness to those who appreciate it. The river is a strong natural force that cuts through the terrain like a jagged scar. This is one of the most important natural water sources. People in Bangladesh are either directly or tangentially reliant on surface water.

Dhaka is the metropolis of Bangladesh and one of the world's most crowded cities. The rivers of Buriganga, Turag, Shitalakhya, Balu, Bongshi, and Karnatali encircle the metropolis. The Buriganga River runs through the southwest portion of Dhaka. It meets the Dhaleswari and Shitalakshya waterways and runs into the Bay of Bengal. It is the country's economic and industrial hub, as well as the world's seventh biggest urban region by people. It is home to over 22 million people, making it Bangladesh's biggest and most heavily populated metropolis. This river is also essential for transportation and commerce.

Now, it is also considered one of the most polluted rivers in the world. The river is heavily polluted due to industrial and domestic waste. The increasing urbanization and industrialization of Dhaka influence water quality. Because industrial wastes are dumped into the river without knowing the environmental and ecosystem impacts (BCAS, 2000). Because of the inappropriate sewage disposal system, most of the untreated sewage is dumped into the river. The people who live beside the riverbank, they have not proper sanitation facilities. So, they throw their garbage into the river. Other hand, many factories besides the banks of the river discharge their untreated waste directly. As a result, river pollution has become a major environmental problem today. In addition, pollutants from various polluting sources, such as industrial, agricultural, and domestic wastes also enter the river. These pollutants carry heavy metals, oil, and various chemicals. This pollution is a major cause of a variety of problems for both humans and wildlife, including health problems, habitat destruction, and loss of biodiversity. The river, which was once an important source of water, has now seen its water quality decline significantly over the past few decades.

The river is heavily polluted due to the concern. Untreated municipal trash, industrial waste discharges, runoff from organic and inorganic fertilizers, pesticides, insecticides, and oil emissions nearby could contaminate the Buriganga River (Mostafa et al. 1999). Anthropogenic sources of heavy metal contamination include mining, disposal of untreated and partially treated effluents containing toxic metals, metal chelates from different industries, and indiscriminate use of heavy metal-containing fertilizers and pesticides in agricultural fields (V. Hatje, 1998). The Buriganga River is very important to Dhaka. Launches and country boats provide connections to other parts of

Bangladesh, which is primarily a riverine country. Once, the river was also the city's main source of drinking water. In addition, the high levels of pollution have led to the death of fish and other aquatic life, resulting in a decrease in the biodiversity of the river. To reduce the levels of pollution, the government has implemented several measures such as setting up wastewater treatment plants and creating awareness among the public about the importance of preserving the river.

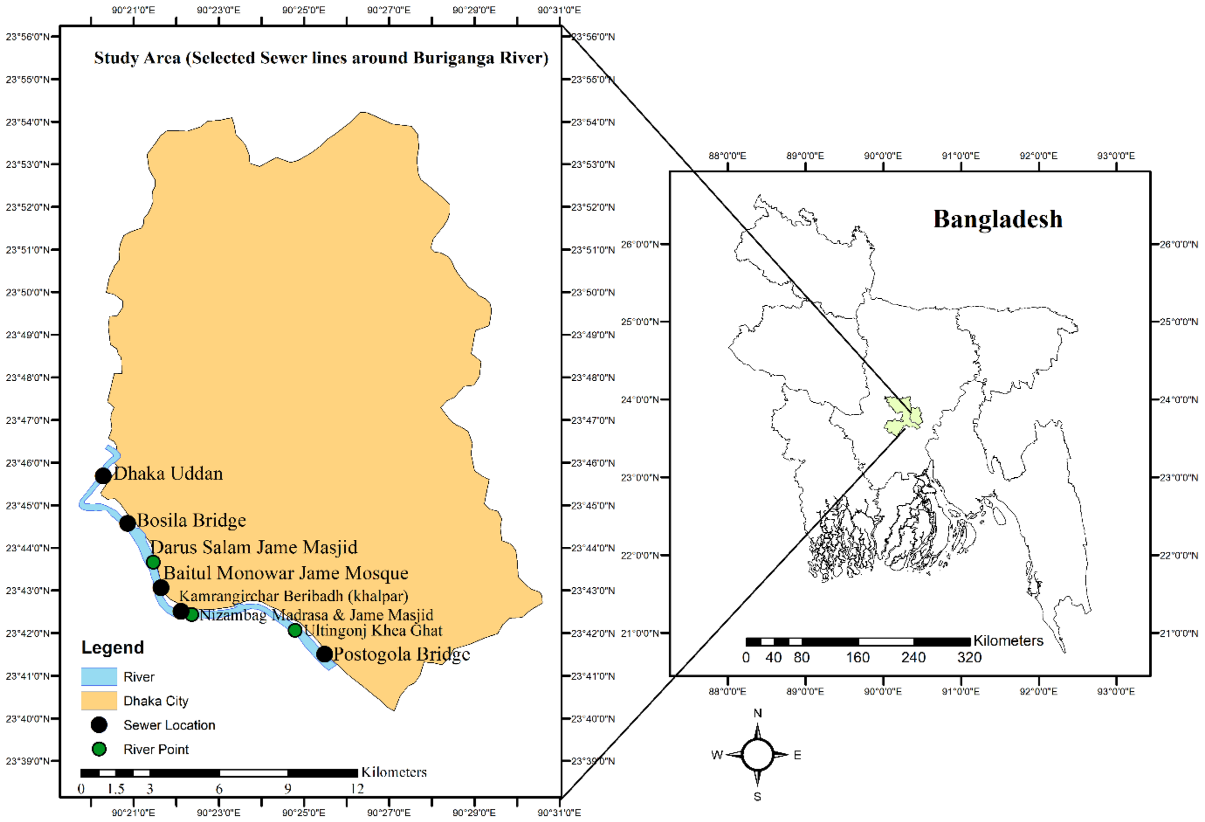


Fig 1. 1: Location map of the study areas

1.2 Importance

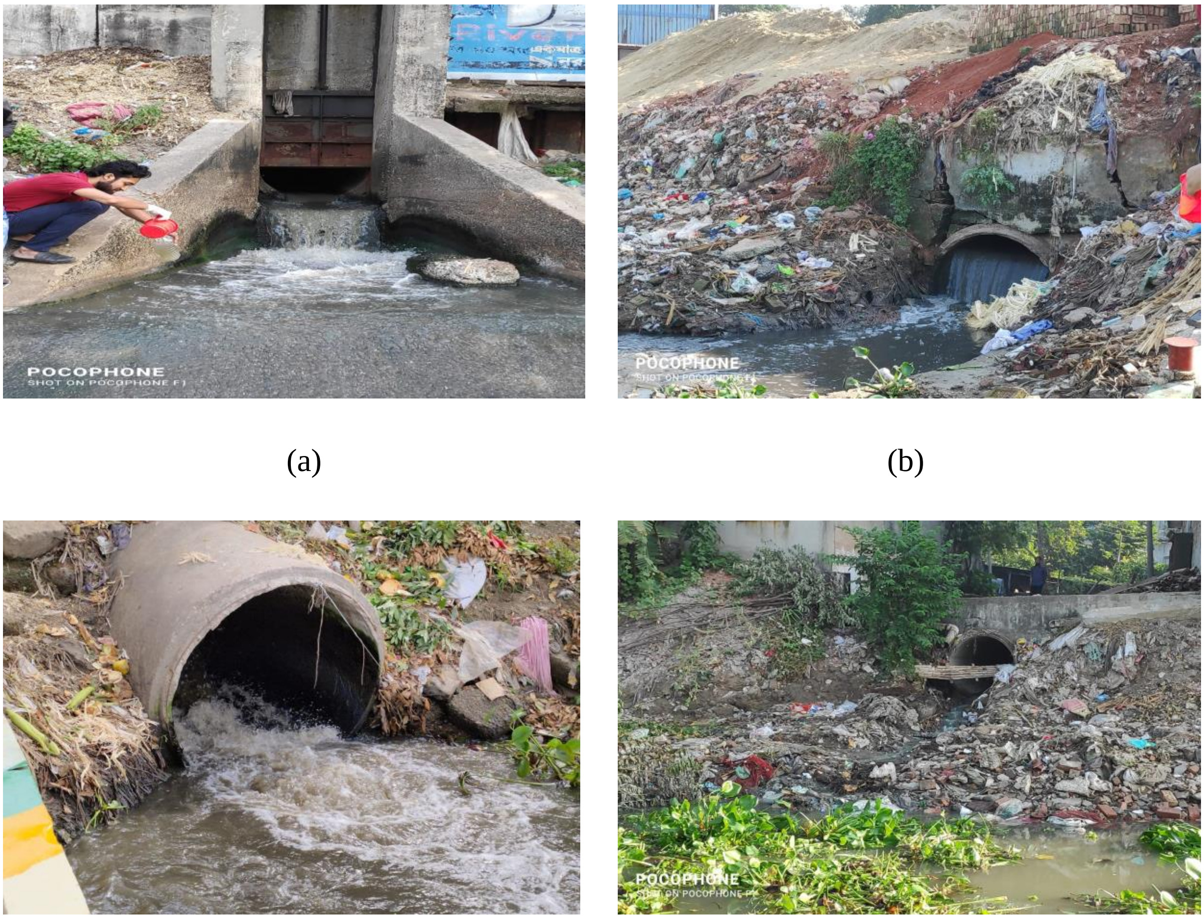
Understanding the origins and effects of waterway pollution requires research. To decrease and manage river pollution, a greater knowledge of the sources of pollution, the impacts of pollutants on aquatic ecosystems, and the efficacy of various pollution control methods is required. It aids in the development of methods for avoiding river contamination and restoring polluted waterways. Scientists, lawmakers, and stakeholders can create more effective methods for reducing and controlling river pollution through study. Analysis can also help to educate public opinion and urge more people to take action to safeguard and maintain our waterways.

The study on Buriganga River pollution is important for several reasons. To begin with, the Buriganga River is an important waterway for Bangladesh and the surrounding region. As such, it is essential to understand the sources and extent of the pollution in the river to take effective measures to mitigate it. Analysis of the sources and extent of Buriganga River pollution will allow us to develop better strategies to protect the river and its resources. Research can then be used to inform decision-makers and policymakers on how best to address the problem. Additionally, this can also help to identify ways of improving water quality and ensuring the sustainability of the river. A study on Buriganga River pollution can also help to raise public awareness in this regard. By increasing public awareness, it may be possible to engage more people in efforts to protect the river and its resources. This will increase support for pollution-reducing efforts, ultimately improving water quality and creating healthier ecosystems. Research aimed to postulate a new management system to control pollution in the Buriganga River based on a recently conducted qualitative and quantitative assessment of river water and wastewater that are discharged into the river (Rahman et al. 2011).

This study deals with the investigation of the water quality of the Buriganga River. For this purpose, samples were collected from three points of the Buriganga River during the summer and late autumn seasons of 2022 to explore the quality of the water on selected parameters.

1.3 River water polluted by connected sewerage source

The river Buriganga is mainly polluted by the industrial and residential wastes that normally fall into the river through sewerage water. Because the wastewater of Dhaka city is not maintained by the wastewater standard. The water quality of the waste is poorer than the standard. For this reason, the quality of the river water is lying down thoroughly. This study was also conducted with some points of the river that are contaminated due to the wastewater of some selected sewerage. A study is done by a team where five different sewage lines that fall into the Buriganga river are tested and analyzed. In that study, the effect of the water of the sewerage line on the river is also described. In this study, a comparison of the water of the three points of the river and five different sewerage line that is allocated around these three river points have been done. To conduct this idea the data on the sewerage line is collected from the group who were involved in the study. The five points of the sewerage are in Dhaka Uddan, Postogola Bridge, Baitul Monowar Mosque, Bosila Bridge, and Kamrangirchar Beribadh area. The samples were collected on the same date when the river water was collected. The sample was also collected in two different seasons to get the variation of data seasonally as our study. Normally this comparison between river water and wastewater has been presented to know how the quality of water of the river is changing day by day due to wastewater that has not matched with the wastewater standard according to ECR. Here it is tried to show that water quality is affected day by day due to untreated sewage water. The parameter tested in the wastewater study was the same as in the river water study. These are dissolved oxygen, temperature, electric conductivity, BOD, COD, the concentration of Pb, Cu, Cr, Ni, and so on. The test was carried out at the laboratory of DPHE.



(a) (b)

(c) (d)

Fig 1. 2: Sewerage line connected with Buriganga.

1.4 Objectives

The major objectives of the present thesis are as follows:

1. To observe the seasonal and spatial change of water quality of Buriganga River.
2. To observe & compare the water quality parameters of selected sewerage line and Buriganga River.

(a) (b)

Fig 1. 3: Buriganga River

1.5 Organization of the Thesis

This thesis comprises five Chapters. Apart from these introductory chapters, the others:

Chapter 2: This Chapter presents a literature review covering background information on the Buriganga River and its environmental significance. The environmental significance of selected water quality parameters has also been inscribed.

Chapter 3: This Chapter presents the methodology of this study and how we did the work, observation, and experiments in the laboratory.

Chapter 4: This Chapter presents water quality data for the Buriganga River. This chapter describes the status of water quality at selected points of the Buriganga River during both Summer and Autumn seasons.

Chapter II

LITERATURE REVIEW

2.1 General

The Buriganga River plays a significant role in the city's culture and economy, but in recent years, it has become severely polluted and degraded. The Buriganga River has a large body of literature, with studies examining a variety of subjects, such as water quality, the causes of pollution, and the effects of human activity on the river's ecosystem.

Untreated industrial effluent is a major source of pollution. Heavy metals and harmful compounds from local leather and textile manufacturers have polluted the river, according to studies. The river's high pollution levels are hazardous to aquatic life as well as human health, particularly fish. Another serious concern is the spread of illegal settlements and unplanned development along the river’s banks. According to studies, these settlements contribute to erosion and sedimentation, which harm the river's water flow and water quality. Settlements also contribute to the loss of vital wetland ecosystems, which are critical for ecosystem functions such as water purification and flood control. Despite these challenges, efforts are underway to restore and protect the river. Studies have suggested a variety of solutions to enhance water quality and lessen pollution, including tighter regulations on industrial discharge and encouraging the use of alternative energy sources. By restoring wetlands and encouraging sustainable land use methods, there are also initiatives to revive the river's ecosystem.

The literature on the Buriganga River emphasizes the numerous difficulties it faces, including habitat loss, water pollution, and urbanization. It also shows that numerous initiatives are being made to strengthen the river's condition and safeguard its ecosystem. Further research is needed to evaluate the effectiveness of these solutions and to identify new strategies to improve the river's water quality and protect its ecosystem.

2.2 Description of Watershed around Buriganga River

The Buriganga River is a tributary of the Dhaleshwari River in central Bangladesh and is one of the main sources of water for the people of Dhaka and surrounding areas. The Buriganga River is a river in Bangladesh that flows past the southwest outskirts of the capital city, Dhaka. Its average depth is 7.6 meters (25 ft) and its maximum depth is 18 meters (58 ft). It ranks among the most polluted rivers in the country (Majumder et al. 2009, Joyce et al. 2015). The Buriganga River Watershed covers an area of about 1,360 square kilometers and is the source of water for over 30 million people. The low-lying, flat landscape of the watershed is notable for its propensity for flooding and water contamination. The watershed is home to a wide variety of animals and fish. The river is also home to a large number of wetlands and freshwater ecosystems, which provide important sources of food and livelihoods for the local population. The Buriganga River Watershed is crucial for providing irrigation and flood protection for the nearby agricultural areas. The watershed is also an important source of sand, gravel, and other building materials for the construction industry in Dhaka.

(a) (b)

Fig 2. 1: River environment nowadays

2.3 Parameters of Concern

This Section describes the significance of some major water quality parameters that are important for describing the overall health of a water body.

2.3.1 pH

Most lakes are basic (alkaline) when they are first formed and become more acidic with time due to the build-up of organic materials. As organic substances decay, carbon dioxide (CO2) forms and combines with water to produce a weak acid, called "carbonic" acid. Large amounts of carbonic acid lower water’s pH. When acidic waters (waters with low pH values) are exposed to certain chemicals and metals, they often make them more toxic than normal. The acidity and alkalinity of a body of water are measured using the pH scale. Typically, the pH scale is displayed as a range. pH scales range from 0 to 14, with pH 7 at 25°C denoting complete neutrality (Ramesh et al. 1996). An aqueous system's pH serves as a gauge for the acid-base equilibrium. It is a sign of both acidities (pH 7) and alkalinity ($pH > 7$) (Hoque et al. 2016).

2.3.2 Turbidity

It is a measure of how cloudy the water in a lake or river is. High turbidity can be caused by silt, mud, algae, and plants wood chips, melted glaciers, sawdust, wood ash, chemicals in the water. The water of rivers is mainly suspended by algae, so soil flows into the water from the banks, by fire or industrial activities such as mining, logging, dredging, etc. During the dry season of 2015, the highest turbidity was measured at 127.45 NTU. The lowest turbidity recorded in 2012, was 1.41 NTU. The lowest during the rainy season was recorded at 0.97 NTU in 2012 and the highest turbidity was recorded in 2014 at 15.4 NTU (Hasan, 2022). Turbidity should ideally be kept below 1 NTU because of the recorded impacts on disinfection.

2.3.3 Temperature

Temperature is an important water quality parameter as it affects many physical, chemical, and biological processes in rivers and other water bodies. It can have significant impacts on the survival and growth of aquatic species, and temperature changes can affect the solubility of gases, the reaction rates of chemical reactions, and the density of water. Water temperature can vary greatly depending on factors such as sunlight, wind, precipitation, and the flow of water. It can also be influenced by human activities such as water withdrawals for irrigation and power generation, discharge from industrial and domestic effluent, and the release of heat from cooling towers. To assess the water quality of a river, the temperature should be measured at multiple points along the river. Temperature is a critical water quality parameter that can have significant impacts on the health and survival of aquatic species, and it should be regularly monitored to ensure that rivers and other water bodies are healthy and suitable for their intended uses.

2.3.4 Dissolved oxygen (DO)

Dissolved oxygen (DO) is oxygen that is dissolved in water. It gets there by diffusion from the surrounding air, aeration of water that has tumbled over falls and rapids, and as a waste product of photosynthesis. Fish and other aquatic life depend on the free oxygen present in water to survive, as well as to prevent odors. DO level is considered the most important indicator of the ability of a water body to support desirable aquatic life. Ample DO in waste-receiving waters is typically ensured by secondary and advanced waste treatment. When sewage or other discharges contain significant amounts of organic matter, bacteria deplete dissolved oxygen. DO is the actual amount of oxygen available in dissolved form in the water. When the DO drops below a certain level, the life forms in that water are unable to continue at a normal rate. The decrease in the oxygen supply in the water harms fish and other aquatic life. Fish killings and the invasion and growth of certain types of weeds can cause dramatic changes in a stream or other body of water.

2.3.5 BOD & COD

The amounts of dissolved oxygen in water are under pressure from the decomposition of organic waste, whether it comes from anthropogenic or natural sources. The biological oxygen demand (BOD), and chemical oxygen demand (COD) work as indicators. Chemical and biochemical oxygen demand (COD and BOD) are terms used to describe how much oxygen is used when a substance deteriorates. The biochemical oxygen demand (BOD) is the quantity of oxygen needed by microorganisms for the aerobic oxidation of organic wastes. The dissolved oxygen requirement for aerobic microorganisms in 1 liter of water over 5 days at 20 degrees Celsius is determined by the BOD parameter. BOD levels were on average 56.8 mg/L. All of the water samples that were taken had BOD levels that ranged from 9.15 to 248. The ideal BOD level for aquaculture, according to Chowdhury (2009), should be less than 6 mg/L. All water samples were outside the permissible range based on measured BOD (Akbor et al. 2017). Another crucial factor for determining river water quality is COD. This calculates the overall oxygen consumption necessary to convert all organic material (including inert) into carbon dioxide and water (Masters et al. 1991).

2.3.6 Cadmium (Cd)

Batteries, alloys, coatings (electroplating), solar cells, plastic stabilizers, and pigments are some common industrial uses for cadmium today. In nuclear reactors, where it serves as a neutron absorber, cadmium is also employed. As we know all these unusable materials are turned into Buriganga from the factory. We have got a quite amount of Cd in the water of the river. Cadmium (Cd) was recorded at 0.1 mg/kg in both rivers during winter and no Cd was recorded in the monsoon and summer periods (Md. Monirul Islam et al. 2014). Many researchers have noted that the river receives domestic and industrial waste from different Lucknow city drains, and has higher concentrations of Cd, Cr, Cu, Ni, Pb, and Zn in the water and sediment during the rainy season than it does during the summer and winter. Because during the rainy season runoff from open polluted areas, agricultural fields, and industries enter the river untreated (Gümgüm et al. 1994).

2.3.7 Electricity Conductivity (EC)

A material's capacity to carry an electric current is measured by its electrical conductivity, also known as specific conductance. The amount of electrical conductivity (EC) is an estimation of the total quantity of dissolved ions in the water, often known as total dissolved salts (TDS). Geology (rock kinds), the size of the watershed (lake basin) concerning the area of the lake, and other sources of ions to lakes are all factors that affect EC. Numerous sources of contaminants exist, and elevated EC may be a symptom of one of these sources. The average, highest, and lowest EC values of all samples taken were 1208 S/cm, 1360 S/cm, and 1171 S/cm, respectively. All the samples taken were over the permissible range for EC, which is 1000 S/cm (ADB, 1994). Thus, aquaculture would not be appropriate for this river. (Akbor et al. 2017).

2.3.8 Lead (Pb)

Lead (Pb) is a soft, pliable metal that is also regarded as a heavy metal. The physicochemical behavior of the environment and the bioavailability of hazardous metals may be dramatically impacted by a contaminant's aqueous form. In an aquatic environment, lead may exist as ions, soluble compounds, or sorbed particles. Lead toxicity varies depending on its chemical form in the environment. Lead is also found in materials used to make printed circuit boards, batteries, ammunition, metals, fillers, heat-transfer agents, lubricants, and additives. conductive agents and production. The busy roads that run alongside the river can be blamed for the high concentration of Pb. Due to heavy gasoline burning, higher Pb concentrations frequently occur in natural streams near highways and large areas (Banat et al. 1998).

2.3.9 Total Dissolved Solids (TDS)

Carbonates, bicarbonates, chlorides, and phosphates make up most of the total dissolved solids in water. As well as organic materials, salt, and other particles, as well as the nitrates of calcium, magnesium, sodium, potassium, and manganese. The average TDS values of Buriganga in three seasons are 426.9 mg/l (pre-monsoon); 169.03 mg/l, (monsoon), and 1015.1 mg/l (post-monsoon). The acceptable standard of TDS for drinking water is 1000 mg/l, industrial water is 1500 mg/l, livestock is 5000 mg/l, and irrigation is 2000 mg/l (ADB, 1994). Except for the post-monsoon season, all measured sample values were within the range that is acceptable for drinking, industrial, and agricultural use (Islam et al. 2015).

2.3.10 Copper (Cu)

Copper is a necessary element for all living things and is widely utilized in electrical wiring, plumbing, and industrial gear. Depending on the proportion of copper in the water, it may have both beneficial and negative effects. Copper can be useful in modest doses since it is a necessary micronutrient for human health and plant and animal growth. In greater concentrations, may be hazardous to aquatic species such as fish and invertebrates and can impair human health if consumed in significant quantities. Copper levels in water can rise because of industrial emissions, mining operations, and inappropriate waste disposal. Copper poisoning can cause gastrointestinal difficulties, liver and kidney damage, and brain diseases over time. According to WHO, EPA, and Bangladesh guidelines, the maximum allowable amount for drinking water is 1500, 1300, and 1000 g/L, respectively (WHO 2004).

2.3.11 Chromium (Cr)

Electroplating, leather tanning, and the textile industry release relatively large amounts of chromium into the river waters. Leaching from topsoil and rocks is the most important natural source of chromium entering water bodies. It cannot be predicted how long the environment can integrate toxic waste. According to WHO and Bangladesh standards, the maximum concentration of chromium in drinking water is 0.05 mg/L (WHO 2004, Hasan et al. 2019). Therefore, concentrations of heavy metals, including chromium, must be determined to evaluate their environmental effects. It is well-known that chromium is essential for leather quality, such as strength, elasticity, and thickness (Grozza, 1984).

2.3.12 Nickel (Ni)

It is mixed into the river water through the industrial waste for manufacturing various products. The present study shows slightly higher concentrations of Cd, Pb, and Cu and slightly lower concentrations of Ni and Cr than the above author. Heavy Metals in Buriganga River Archive of SID. The average Ni concentration was 9.48mg/kg in fish but in baila, during pre-monsoon, the highest (11.21 mg/kg) level was found (Ahmad, 2010). EPA recommends that drinking water levels for nickel should not be more than 0.1 mg/liter (Fay et al. 2005).

2.4 Existing Research on Water Quality of Buriganga River

The first studies of diatoms and river pollution were carried out 60 years ago. The suitability of these microalgae as bioassessment indicators for monitoring river quality was quickly demonstrated (Jones et al. 2013). The use of fluorescence spectrophotometry is being applied to detect sewage pollution in small urban catchments. The results showed a correlation between high tryptophan fluorescence intensity and ammonia during two sewage-related point-pollution events, indicating the summer tryptophan increase does not come from foul sewage. Monitoring of sewage inputs to the river was conducted during summer baseflow (Baker et al. 2003). This review examines the study of diatoms and river pollution from 1999 to 2009. Most of the publications were found in Hydrobiological and were grouped according to the subject. The study found that ecotoxicological studies were limited and that diatom biomonitoring uses the term "species" extensively but rarely addresses taxonomy or phylogeny, which is important for defining accurate indicators of environmental stressors (Rimet et al. 2012). Buriganga is heavily polluted due to the rapid expansion of population and industry, including increased use of fertilizers and agrochemicals. The high population density and lack of sewage treatment facilities have resulted in a rise in untreated wastewater being discharged into the river, leading to poor water quality and a severe threat to the aquatic ecosystem during dry seasons (KAMAL et al. 1999). The Seine basin Water Authority has constructed prospective scenarios to forecast the impact of planned investments and their impact on the river Seine. The

PROSE model was used to simulate the impact of both permanent dry-weather effluents and highly transient Combined Sewer Overflow (CSO). Results showed that the 50 km long reach of the Seine inside Paris was permanently affected by high oxygen consumption accounting for 112% of the flux upstream of the city. The oxygenation of the system is strong due to high phytoplankton activity. The main conclusion is that water quality models should consider the CSOs to be reliable (Even et al. 2007). The Buriganga River has high levels of heavy metals including Pb, Cd, Ni, Cu, and Cr in its water, sediment, and fish found using atomic absorption spectrophotometry. The concentrations vary seasonally and spatially, with some levels higher than recommended, indicating pollution. The results suggest that the river's water, sediment, and fish may not be safe for consumption (Ahmad et al. 2010). The study found that the water quality of the tannery effluent and the Buriganga River was poor, with high levels of pollutants including salinity, TDS, EC, COD, Cr, Cd, Ni, Cu, and Zn. The study also found that these pollutants had a negative correlation with temperature and dissolved oxygen and that Cr posed the highest risk to the ecosystem. The overall conclusion is that the water is not safe for aquatic life (Sarkar et al. 2015). A study by BUET students found the Buriganga River contaminated by tanneries and dying industries' waste. Also, propose a sustainable plan and improve the water quality of the river. Proposals for improving water quality and protecting adjacent areas are presented (Bhowmik et al. 2007). The study on significant health issues results shows increased inflammation and protein synthesis, decreased hemoglobin levels, and elevated levels of creatinine and aminotransferase, indicating kidney and liver damage. The study concludes that the river water is contaminated and unfit for human consumption due to toxic chemicals and microbial entities (Ghosh et al. 2023). A study was done on heavy metal contamination in food items such as vegetables and fish near a tannery campus. Results showed metal concentrations in water and food exceed safe limits, with the highest concentrations of iron, manganese, zinc, copper, and cobalt. The study suggests that long-term consumption of contaminated food could pose potential health risks to consumers (Khan et al. 2014). A study showed that the surface water of the Buriganga River in Dhaka City, Bangladesh has high levels of dissolved oxygen (DO), pH, total coliforms, turbidity, and ammonia. The highest DO concentration was 3.4 mg/l, below the acceptable limit. Due to nearby industrial sites, water quality was worst at Buri 2 (Hazaribagh). Improving water quality is crucial to protect it from pollution and ensure it's safe for consumption and other uses (Pramanik et al. 2013). The study found that the Buriganga river had poor water quality with high turbidity, light brown color in the wet season, and slightly black to black in the dry season. pH was slightly acidic to slightly alkaline and the temperature ranged from 18.2°C to 27.04°C. The study found higher EC, BOD, and TDS in the dry season while DO was higher in the wet season. The mean values of the parameters were higher in the dry season compared to the wet season (Saifullah et al. 2012). The investigation assessed the water quality status of the Buriganga on Temperature and Dissolved Oxygen (DO) of water varied from 22.80 to 31.40 °C and 0.22 to 2.74 mg/L, respectively. But manganese did not vary in different seasons. The results reveal that there were significant differences between sampling seasons (wet and dry) ($p<0.05$) except for temperature and manganese (Fatema et al. 2018). The characterization of water quality from certain selected outfalls discharging wastewater along the river was accomplished as well. The DO level was found noticeably lower during the dry season (1.73 to 2.36 mg/l) than in the wet season (3.27 to 4.68 mg/l). Moreover, Principal Component Analysis identified high ionic distributions during the wet season and more organic pollution during the dry season. Water quality parameters TDS, TSS, EC, and COD were obtained downstream of the river while BOD5 and NH3-N were higher towards the upstream of the river (Alam et al. 2020). A study found that a Floating Constructed Wetland system was effective in treating the polluted water collected from the Buriganga River. It can remove pollutants such as ammoniacal nitrogen, total inorganic nitrogen, phosphorus, biochemical oxygen demand, and chemical oxygen demand at high rates. The system also achieved a significant reduction in Escherichia coli levels. The study also showed the importance of input hydraulics, pollutant loadings, and hanging root maturity for maintaining the system's stability. (Saeed et al. 2016).

2.5 Existing Environmental Condition of the Buriganga River

Human activities such as industrialization, urbanization, and poor waste management are causing serious environmental deterioration in the Buriganga River. Toxic chemical discharge from tanneries is a major contributor to river pollution, posing health hazards and creating ecological damage. Neglect and apathy toward the river's environmental state have resulted in terrible effects and major health concerns for those who live nearby. A result indicated that there were significant environmental health risks and possible ecological disruption of this river and recommended a sustainable policy framework to reduce the pollution (Ali et al. 2008).

Urbanization is a factor in the degradation of the Buriganga River. Over-extraction of groundwater has led to the lowering of the water table and increased salinity, making it unsuitable for drinking and irrigation. The growth of slums along the river has resulted in the direct disposal of sewage waste into the river. Another is facing numerous environmental challenges, including deforestation, land degradation, disposal of untreated sewage and solid waste, and plastic pollution. These issues are affecting the health and livelihoods of the people, as well as the ecosystem of the river, including aquatic life and biodiversity. Deforestation and land degradation in the catchment area resulted in soil erosion, sedimentation, increased turbidity, reduced water flow, and negative impacts on aquatic life, fishing, agriculture, and biodiversity. It is vital to provide crucial services and be surrounded by residents. However, the river has become a dumping ground for plastics. Plastic waste has led to the death of wildlife, reduced biodiversity, and disrupted the food chain.

(a) (b)

Fig 2. 2: River and riverbank condition nowadays

In the end, the degradation of the Buriganga River has serious implications for the health and well-being of the country.

Chapter III

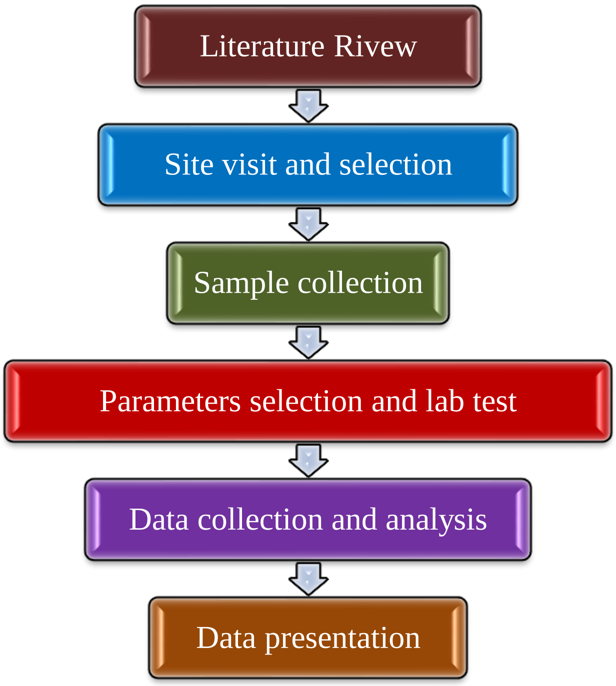
METHODOLOGY

3.1 General

Water is essential for life and is a major component of living things. As the human population has grown, the necessity for producing goods and services is necessary because the population has increased, resulting in greater water use and pollution. Water quality has increased in importance because the quantity of water often cannot be assessed independently of its quality. Water quality is a critical consideration in domestic, agricultural, and industrial purposes, fisheries and aquaculture production & recreation, and the health of ecosystems.

Any physical, chemical, or biological property of water that affects natural ecological systems or influences water use by humans is a water quality variable. There are hundreds of water quality variables, but for a particular water use, only a few variables usually are of interest.

Monitoring is defined by the International Organization for Standardization (ISO) as: “the programmed process of sampling, measurement and subsequent recording or signaling, or both, of various water characteristics, often to assess conformity to specified objectives”. This general definition can be differentiated into three types of monitoring activities that distinguish between long-term, short-term, and continuous monitoring programs as follows: (1) Monitoring is the long-term, standardized measurement and observation of the aquatic environment to define status and trends. (2) Surveys are finite-duration, intensive programs to measure and observe the quality of the aquatic environment for a specific purpose. (3) Surveillance is continuous, specific measurement and observation for water quality management and operational activities (Bartram et al. 1996). The distinction between these specific aspects of monitoring and their principal use in the water quality assessment process is described in the companion guidebook Water Quality Assessments. A Guide to the Use of Biota, Sediments, and Water in Environmental Monitoring, 2nd edition (Chapman et al. 2021).



3.2 Methodology

The systematic, theoretical analysis of the methodologies used in a field of study is referred to as methodology. It is a framework of techniques and principles for conducting research and analysis. The methodology includes the overall research strategy, the guiding principles, the research design, the methods used to collect and analyze data, and other relevant information. It outlines the steps taken and the methods employed to achieve the desired results. The research question and the type of data being gathered and analyzed will influence the methodology choice. In the natural sciences methodologies may include experiments and observational studies.

A single sample taken from a single point is rarely able to accurately represent the water quality of all-natural water bodies because it varies both spatially and temporally. It's important to note that flow can vary geographically and seasonally, which could affect how water quality trends are interpreted. The choice of sampling points, their geographical locations, sample collection, analytical techniques, and the time of sample collection are additional factors influencing the monitoring of water quality trends. This section explains the methodology used to characterize the Buriganga River's water quality.

3.2.1 Characterization of water quality

Monitoring a river's water quality is an important method for figuring out how the river's water affects the quality of the water. The physical, chemical, and biological properties of the water must be evaluated to accomplish this. In this regard, water quality parameters are tested. The summer and autumn seasons were adopted to assess the quality of the river Buriganga.

3.2.1.1 Site visit & selection of sampling points

The selection of the collecting point of water from a water body in any study depends on some Factors. These are possible spatial fluctuation of pollutants, peak pollution detectors, frequency of sample collection, physical limitations of laboratory facilities, etc. Three different points of the Buriganga river are selected to collect samples for testing in selected parameters to check the current condition of the water quality of the river.

The location of a water quality sample site must be carefully chosen to ensure that the data collected is reliable and reflective of the water body or region being evaluated. When choosing a sample location, keep the following criteria in mind:

1. The purpose of the water quality analysis will determine the appropriate location. For example, our goal is to assess the impact of waste at a specific point, the sample is collected from that point.
2. Selected locations are easily accessible for collecting the samples without any safety hazards.
3. Considering the river's physical, chemical, and biological characteristics, the location represents the larger watershed.
4. The selected sampling locations are representative of the average flow of the river.
5. Sampling points have sufficient distance from point sources of contamination, such as sewage, industrial discharges, or agricultural watercourses, to avoid local contamination.
6. Sampling sites are selected for seasonal water quality and flow variability.
7. Locations are easily accessible for future monitoring and maintenance activities.
8. With this possibility, samples are collected at locations with existing data to allow for comparison and analysis over time.

By considering all these criteria we select our sampling location that can represent the water quality of the selected points and provides meaningful data for analysis.

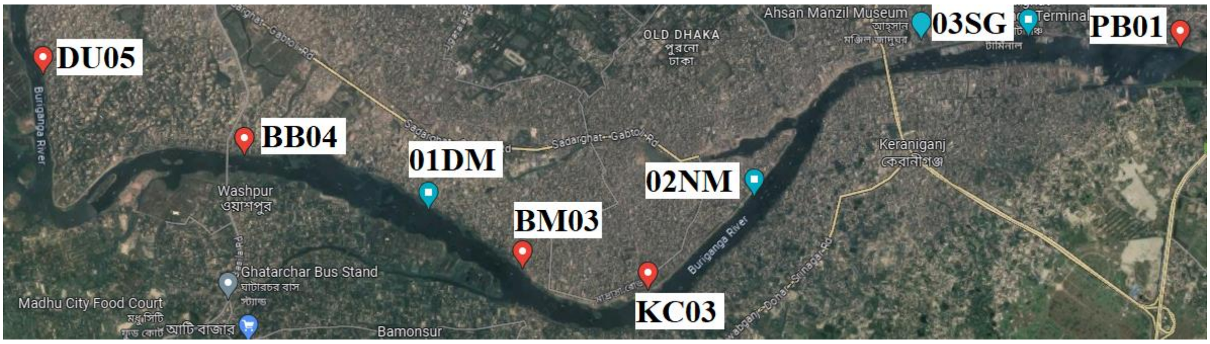


Fig 3. 1: Water Sampling Points in Buriganga River

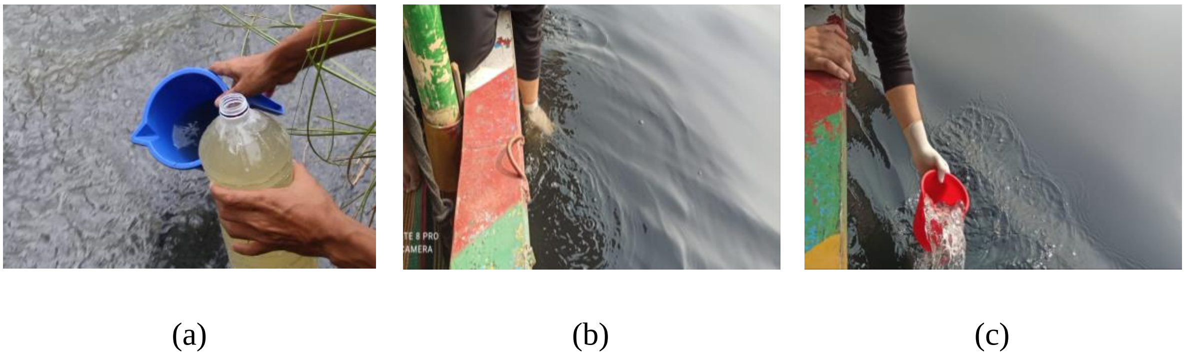
3.2.1.2 Collection of samples

The collection of samples is a crucial step in assessing the pollution status of a river or any other body of water. Samples are typically collected at three different locations along the river, to get a comprehensive understanding of the water quality. The samples are then analyzed in a laboratory to determine the presence and concentration of various pollutants, such as heavy metals, organic matter, and nutrients. The samples were collected by using bucket sampling methods. Use appropriate sampling equipment and techniques to ensure that the samples are representative of the water quality and are not contaminated during the collection process.

Table 3.1: Locations of the water sampling points of Buriganga River

SN	Station Code	Co-ordinates		Station Name
		Latitude	Longitude	
1	01DM	23.717616	90.347674	Darus Salam Jame Masjid
2	02NM	23.707213	90.372717	Nizambag Madrasa & Jame Masjid
3	03SG	23.701037	90.413189	Ultingonj Khea Ghat

At every sampling location, a water sample from approximately two meters away from the bank and one ft depth from the surface was representative of that location. For a fast-flowing river like Buriganga, various chemical components in a water column cannot be in equilibrium at any location. Considering the time and resource constraints, it was decided that water samples would be collected from points nearly two meters away from the bank of the river and at a depth of about one ft (0.3048 meters) from the water surface at all locations. The water samples were collected in a couple of 2-liter pre-labeled plastic bottles from each location. Samples were collected with precaution so that sampling bottles are free from air bubbles. After



(a) (b) (c)

Fig 3. 2: Water sample collection from Buriganga River sampling, the sampling bottles were stored and then carried to the De for analysis. During collection, surface scum was avoided, and a sufficient distance was kept from major sources of pollution. These samples represent the chemical composition at the sampling locations on the day of sampling.

3.2.1.3 Parameter selection for analysis of water samples

The process of analyzing and evaluating water quality is known as water analysis. Various analytical procedures are used to identify the physical, chemical, and biological aspects of water samples. The research is necessary for several purposes, including guaranteeing the safety of drinking water, monitoring the health of aquatic ecosystems, and assessing the quality of industrial and agricultural water usage. Within three hours of sampling, samples were transferred from the field to the laboratory Department of Public Health Engineering (DPHE). The collected water samples were analyzed for pH, Turbidity, Temperature, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Cadmium (Cd), Chemical Oxygen Demand (COD), Copper (Cu), Chromium (Cr), Electrical Conductivity (EC), Lead (Pb), Nickel (Ni), and Total Dissolved solids (TDS) for all samples.

Chapter IV

RESULTS AND DISCUSSIONS

4.1 General

Results and discussions are significant for a thesis paper for showing the findings and conclusions based on the findings. Basically, the results section should present the findings of the research in a clear and concise manner. It should provide a summary of the data collected and the statistical analysis conducted. The results section may include tables, graphs, or other visual aids to help convey the data. On the other hand, the discussion section should provide an interpretation of the results and draw conclusions based on the findings. This section should also include a comparison of the results to the research question or hypothesis.

As mentioned earlier, water samples from Buriganga River were analyzed for pH, Temperature, EC, Turbidity, DO, BOD5, TDS, Cr, Cd, Cu, Pb, and Ni for Summer and Autumn. This Section describes the water quality characteristics of the Buriganga River based on analysis of test results and visual inspections.

4.2 One-way ANOVA

The ANOVA test is an effective statistical method for assessing differences in water quality between river sections. It can help prioritize locations for monitoring and management, identify potential point sources of pollution, and compare water quality data over seasons or years. It is also a valuable tool for assessing water quality data and directing management actions to safeguard and promote river ecosystem health.

Table 4.1: One-way ANOVA test results for both seasons of three locations.

Parameters	Sources of Variation	SS	df	MS	F	P-Value
pH	BG	0.235	1.000	0.235	7.913	0.107
	WG	0.059	2.000	0.030		
Turbidity	BG	198.810	1.000	198.810	51.108	0.019
	WG	7.780	2.000	3.890		
Temperature	BG	6.202	1.000	6.202	465.125	2.734E-05
	WG	0.053	4.000	0.013		
DO	BG	1.153	1.000	1.153	1.851	0.245
	WG	2.491	4.000	0.623		
BOD	BG	1.450	1.000	1.450	0.838	0.412
	WG	6.922	4.000	1.730		
Cd	BG	1.667E-07	1.000	1.667E-07	3.322E-03	0.957
	WG	2.007E-04	4.000	5.017E-05		
COD	BG	266.667	1.000	266.667	22.857	0.009
	WG	46.667	4.000	11.667		
EC	BG	529.000	1.000	529.000	11.756	0.076
	WG	90.000	2.000	45.000		
Ni	BG	0.000	1.000	0.000	29.400	0.006
	WG	0.000	4.000	0.000		
TDS	BG	368.167	1.000	368.167	10.936	0.030
	WG	134.667	4.000	33.667		

The table shows the results of a one-way ANOVA analysis performed on multiple parameters related to wastewater quality. The parameters include pH, turbidity, temperature, dissolved oxygen (DO), biological oxygen demand (BOD), cadmium (Cd), chemical oxygen demand (COD), electrical conductivity (EC), nickel (Ni), and total dissolved solids (TDS).

The table is divided into Sources of Variation, SS (sum of squares), df (degrees of freedom), MS (mean square), F-value, and P-value. The "Sources of Variation" column indicates whether the variation comes from "Between Groups" (BG) or "Within Groups" (WG). The "SS" column shows the sum of squares for each source of variation, and the "df" column shows the corresponding degrees of freedom. The "MS" column shows the mean square for each source of variation, which is calculated by dividing the sum of squares by the degrees of freedom. The "F-value" column shows the calculated F-value, and the "P-value" column shows the corresponding p-value.

The corresponding reference value for our One-way ANOVA, we use 0.05 (Wold et all. 1989). With that reference value the interpretation of the ANOVA results for each parameter is as follows:

- pH: The p-value is 0.107 so we would fail to reject the null hypothesis. This means we don't have sufficient evidence to say that there is a statistically significant difference between the group means.
- Turbidity: the p-value is 0.019 so we would reject the null hypothesis. This concludes that there is a statistically significant difference between the means.
- Temperature: the p-value is 2.734E-05 so we would reject the null hypothesis. This concludes that there is a statistically significant difference between the means.
- DO: The p-value is 0.245 so we would fail to reject the null hypothesis. This means we don't have sufficient evidence to say that there is a statistically significant difference between the group means.
- BOD: The p-value is 0.412 so we would fail to reject the null hypothesis. This means we don't have sufficient evidence to say that there is a statistically significant difference between the group means.
- Cd: The p-value is 0.957 so we would fail to reject the null hypothesis. This means we don't have sufficient evidence to say that there is a statistically significant difference between the group means.
- COD: The p-value is 0.009 so we would reject the null hypothesis. This concludes that there is a statistically significant difference between the means.
- EC: The p-value is 0.076 so we would fail to reject the null hypothesis. This means we don't have sufficient evidence to say that there is a statistically significant difference between the group means.
- Ni: The p-value is 0.006 so we would reject the null hypothesis. This concludes that there is a statistically significant difference between the means.
- TDS: The p-value is 0.030 so we would reject the null hypothesis. This concludes that there is a statistically significant difference between the means.

In an ANOVA, the F-value is determined as the variance between sample means/variation within samples. The greater the F-value in an ANOVA, the greater the difference between sample averages relative to the variation within samples. The greater the F-value, the lower the related p-value. As it is the temperature F-value is the highest, whereas the P-value is the lowest. And Cd's F-value is the lowest, whereas the P-value is the highest. We can understand the cause of pollution, and which affects the most.

4.3 Cohen’s d

Cohen's d is a measure of effect size that aids in assessing the number of differences between two groups or situations. It is determined as the difference between the means of two groups divided by the pooled standard deviation. A Cohen's d value of 0.2 is regarded as a minor impact size, 0.5 as a medium effect size, and 0.8 or above a big effect size (Sawilowsky, S. S. 2009, Cohen, J. 1988).

Table 4.2: Cohen's d-test results for seasonal variation of three locations.

Parameters	**Season**	**Mean**	**SD**	**Count (n)**	**Mean difference**	**Pooled SD**	**Effect Size (d)**
pH	Summer	6.723	0.142	3.00	0.353	0.421	0.8385
	Autumn	7.077	0.397	3.00			
Turbidity	Summer	36.033	2.346	3.00	14.767	2.592	5.698
	Autumn	21.267	1.102	3.00			
Temperature	Summer	29.567	0.058	3.00	2.033	0.163	12.452
	Autumn	27.533	0.153	3.00			
DO	Summer	1.283	0.515	3.00	0.877	1.116	0.786
	Autumn	2.160	0.990	3.00			
BOD	Summer	2.800	1.836	3.00	0.983	1.860	0.529
	Autumn	1.817	0.301	3.00			
Cd	Summer	0.0113	5.774E-04	3.00	3.333E-04	1.002E-02	3.328E-02
	Autumn	0.0110	0.010	3.00			
COD	Summer	26.000	4.583	3.00	13.333	4.830	2.760
	Autumn	12.667	1.528	3.00			
EC	Summer	190.333	6.110	3.00	21.000	8.226	2.553
	Autumn	211.333	5.508	3.00			
Ni	Summer	0.004	0.001	3.00	0.007	0.002	3.130
	Autumn	0.011	0.002	3.00			
TDS	Summer	108.333	6.028	3.00	15.667	8.206	1.909
	Autumn	124.000	5.568	3.00			

Table 4.3: Cohen's d-test results effect size table (Sawilowsky, S. S. 2009, Cohen, J. 1988).

Lebel	**Effect size (d)**
Very small	0.01 < 0.2
Small	0.20 < 0.50
Medium	0.50 < 0.80
Large	0.80 < 1.20
Very large	1.20 < 2.0
Huge	>2.0

Now look at table 4.2 and table 4.3 relatively. From Table 4.3 we can give a label to the effect size of Table 4.2. From Table 4.2 we can find that the effect size of temperature is 12.452, which is the highest value among all of them. This indicates that there is a large variation between the means of the two seasons in comparison. Effect sizes of this scale are generally big and relate to highly significant impacts in seasons. It may be inferred that the difference between the means of the two groups is practically significant and not the result of random chance.

And, if we look at the effect size of Cd, which is 3.328E-02 the lowest one. We can say that it is probably no practical or meaningful difference between the groups being compared. While the statistical test may have found a significant difference between the groups, this difference is so small that it is unlikely to have any real-world significance. As we know, effect sizes smaller than 0.1 are considered very small. This effect size is considered negligible and may not have any practical significance. Therefore, the effect is likely to be statistically significant, but it is not meaningful in practical terms.

Cohen's d values provide helpful information about the effect size of differences in water quality parameters between the summer and autumn seasons. They help us to understand the magnitude of the differences and prioritize management and mitigation efforts accordingly.

4.4 Wastewater Quality Index (WWQI)

The wastewater quality index, which is a comprehensive representation of the said parameters, may be considered a useful tool to provide insight into the degree to which the wastewater is polluted by human activity and the requirements of treatment to meet relevant objectives. The wastewater quality can be defined as a numerical value, which is inherently related to its input constituent parameters. Based on the WWQI, the treatment process can be modified by adjusting the number and duration of cycles and the aeration time can be regulated depending on the predicted organic load or any other constituent parameter (Vijayan et al. 2016).

Table 4.4: WWQI results for seasonal variation of three locations.

Parameters	**Mean**	**Standard value**	**Wi=1/St**	**Qi=100*(Mean/Wi)**	**Wi*Qi**
pH	6.9	7.5	0.133	92.000	12.267
Turbidity (ntu)	28.65	10	0.100	286.500	28.650
Temperature (^{0}C)	28.550	25	0.040	114.200	4.568
DO (mg/L)	1.722	6	0.167	28.694	4.782
BOD (mg/L)	2.308	0.2	5.000	1154.167	5770.833
Cd (mg/L)	0.011	0.005	200.000	223.333	44666.667
COD (mg/L)	19.333	4	0.250	483.333	120.833
Cu (mg/L)	0.007	1	1.000	0.700	0.700
Cr (mg/L)	0.012	0.05	20.000	24.000	480.000
EC (µS/cm)	200.833	700	0.001	28.690	0.041
Pb (mg/L)	0.014	0.05	20.000	28.667	573.333
Ni (mg/L)	0.008	0.1	10.000	7.500	75.000
TDS (mg/L)	116.167	1000	0.001	11.617	0.012
				Total WWQI=	51737.686

Table 4.5: Rating of the wastewater quality for corresponding levels of WWQI (Khudair et al. 2018)

WWQI Value	**Rating of wastewater quality**
<50	Excellent
50 - 100	Good
100 - 200	Poor
200 - 300	Very Poor
300 - 400	Polluted
>400	Very Polluted

Important note is that different countries or regions have different regulations or standards for wastewater discharge, which can affect the interpretation of WWQI scores. Additionally, the weighting factors used to calculate the WWQI score may also vary depending on the specific context and goals of the wastewater treatment plant or regulatory agency. Therefore, it is important to consult the relevant regulatory agency or organization for specific guidelines and criteria regarding the interpretation of WWQI scores.

High levels of BOD, Cd, and COD indicate that the wastewater has a high organic and chemical load. Low levels of dissolved oxygen indicate that the wastewater may not be able to support aquatic life. Some of the parameters are within acceptable limits. But the overall picture is one of very poor wastewater quality.

Our WWQI study shows that wastewater should be treated to remove organic and inorganic pollutants before being discharged into the river to avoid any negative impacts on public health and the ecosystem.

4.5 Principal Component Analysis (PCA)

PCA is a method for decreasing the dimensionality of a collection while retaining as much variation as possible. It restructures the original variables into a new set of variables known as principal components, which encapsulate the most important information in the data. Data visualization, pattern detection, data preparation, and feature extraction can all benefit from PCA.

PCA can be used in water quality studies to detect patterns and connections between various water quality indicators such as temperature, pH, dissolved oxygen, and pollutant concentrations. Principal Component Analysis (PCA) was used to examine the correlation of each factor and to minimize the number of parameters, making it easier to assess water quality at each site. With PCA, it is feasible to find the most relevant factors in explaining the variability in the data and uncover any underlying trends or patterns. This information may be utilized to increase our understanding of water quality and to build strategies for resolving specific water quality challenges.

A PCA graph, sometimes referred to as a PCA plot or biplot, is a graphical display of the outcomes of a PCA analysis. Each point in the scatter plot represents an observation from the data collection and shows how they relate to one another in a reduced-dimensional space. The principal components are represented by the axes in a PCA graph, and the points are plotted according to how well they perform on these components. In the graph, a point's location indicates how similar or distinct it is to other points in the dataset. On the graph, points that are near one another are comparable in terms of the underlying factors, whereas those that are far away are different.

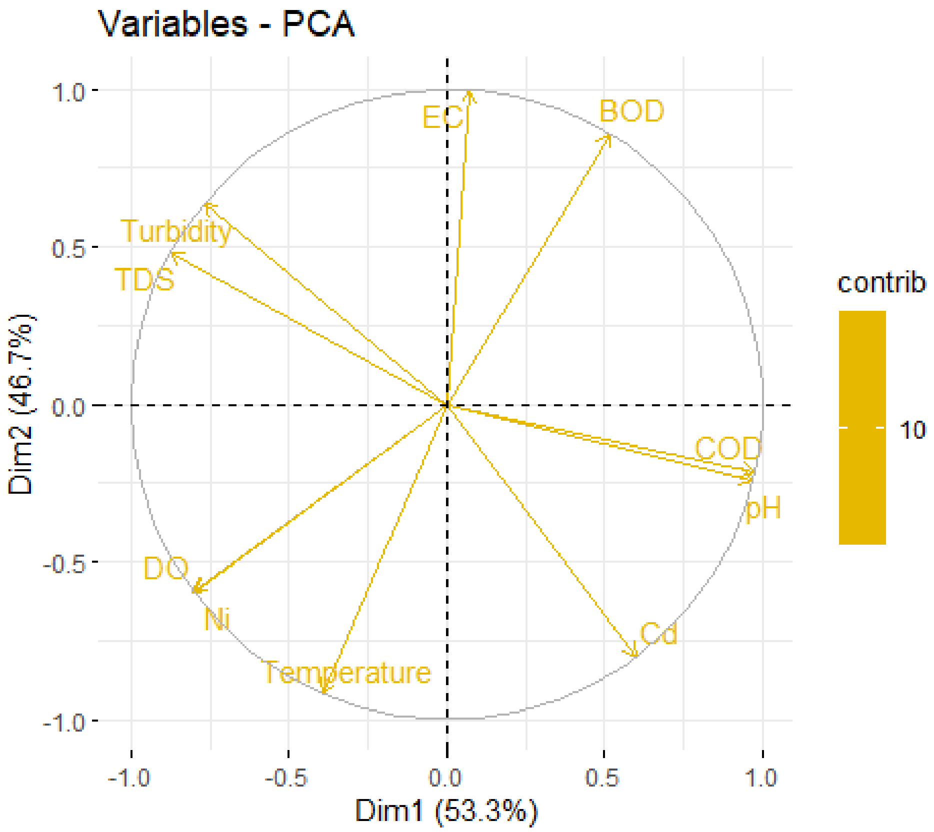


Fig 4. 1: Principal Component Analysis based on the monitored stations for the summer season.

According to the graph on Figure 4.1, there are two lines, one is horizontal and another one is vertical. Now we take the horizontal line as X-axis and Vertical line as Y-axis and the cross point of two line as O point. So, in this PCA plot we will find 4 areas with X and Y for positive and negative.

In the side of X- positive and Y- positive, where all the values have positive relation. We found two parameters which one is EC and another one is BOD. That means the EC and BOD are positively related. Like that in the side of X-negative and Y-negative, where all the values have negative relation. We found three parameters like DO, Ni and Temperature. In other two side where X and Y are related positively or negatively with one another, means that there has a moderate impact. There we can find Turbidity, TDS, COD, pH and Cd.

From the above discussion we come to the point that, for the treatment or good quality of water or maintaining the quality of the river water we need to give an eye on DO, Ni and Temperature. Because they are having a negative impact on the river water quality. Then the parameters which are in the position of positive and negative impact we also need to give an eye on them. Besides them we need to be careful about positive value like EC and BOD. Cause they also may have a relation with others in any way. So, we need to keep an eye so that they don’t change their position.

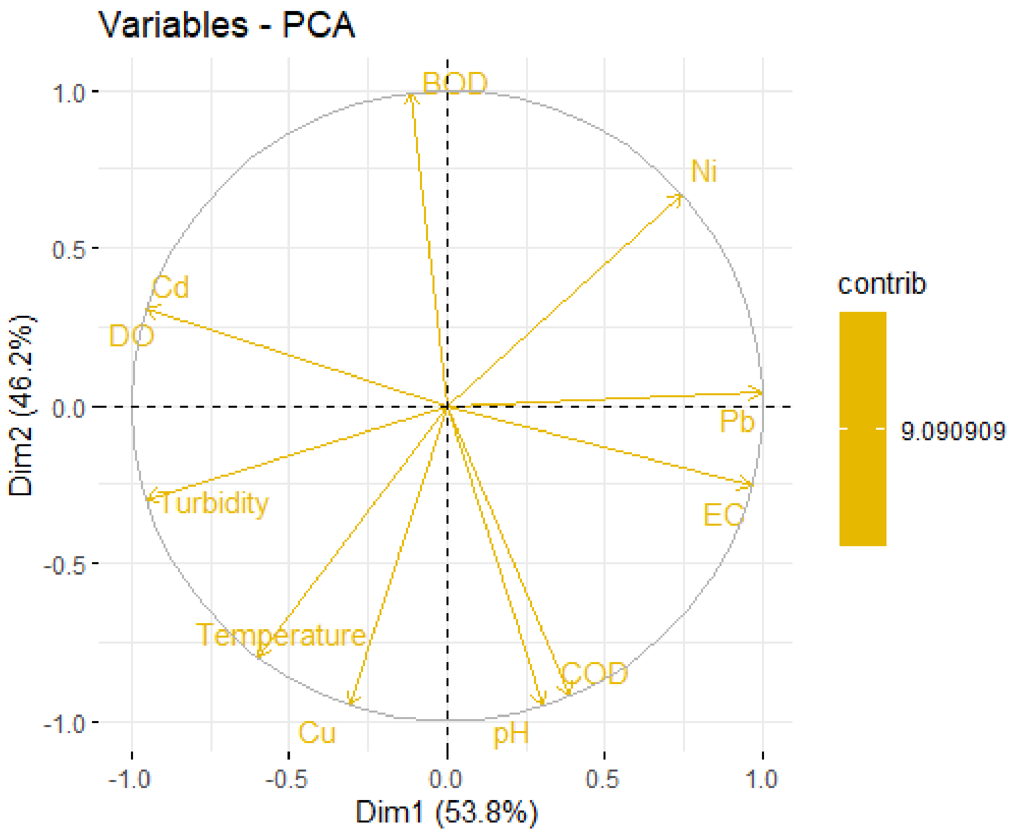


Fig 4. 2: Principal Component Analysis based on the monitored stations for the autumn season.

According to the graph on Figure 4.1, there are two lines, one is horizontal and another one is vertical. Now we take the horizontal line as X-axis and Vertical line as Y-axis and the cross point of two line as O point. So, in this PCA plot we will find 4 areas with X and Y for positive and negative.

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4.6 Correlation Matrix

A correlation matrix is a table showing correlation coefficients between variables. Each cell in the table shows the correlation between two variables. It is also used to summarize data, as input into a more advanced analysis, and as a diagnostic for advanced analyses.

The value of correlations is Between -1 and +1. The correlation value is positive when the tendency for the two variables increases and falls together. And the correlation value is negative when one variable rises while the other is falling. And, if the value is 0, then there is no correlation between the variables.

Table 4.6: Correlation between the parameters of summer season

	pH	**Turbidity (ntu)**	**Temperature (0C)**	**DO (mg/L)**	**BOD (mg/L)**	**Cd (mg/L)**	**COD (mg/L)**	**EC (µS/cm)**	**Ni (mg/L)**	**TDS (mg/L)**
pH	**1**									
Turbidity (ntu)	**-0.9003**	**1**								
Temperature (0C)	**-0.1628**	**-0.2830**	**1**							
DO (mg/L)	**-0.6386**	**0.2399**	**0.8632**	**1**						
BOD (mg/L)	**0.2956**	**0.1498**	**-0.9907**	**-0.9239**	**1**					
Cd (mg/L)	**0.7731**	**-0.9721**	**0.5**	**-0.0056**	**-0.3774**	**1**				
COD (mg/L)	**0.9996**	**-0.8883**	**-0.1890**	**-0.6589**	**0.3210**	**0.7559**	**1**			
EC (µS/cm)	**-0.1692**	**0.5814**	**-0.9449**	**-0.6504**	**0.8915**	**-0.7559**	**-0.1429**	**1**		
Ni (mg/L)	**-0.6343**	**0.2344**	**0.8660**	**0.99998**	**-0.9260**	**0**	**-0.6547**	**-0.6547**	**1**	
TDS (mg/L)	**-0.9665**	**0.9818**	**-0.0958**	**0.4198**	**-0.0407**	**-0.9099**	**-0.9594**	**0.4163**	**0.4148**	**1**

The given correlation matrix shows that the diagonal values are all 1, which makes sense since a variable is perfectly correlated with itself.

A correlation coefficient value near one indicates a positive correlation. It signifies that two variables are directly associated, and when one increases, the other increases as well. A high positive correlation between DO and temperature, for example, is detected in the context of this water quality correlation matrix, with a correlation coefficient of 0.8632. This means that when the temperature of the water rises, so does the amount of dissolved oxygen. Similarly, EC and TDS have a moderate positive association with a correlation coefficient of 0.4163, showing that a rise in electrical conductivity relates to an addition in TDS concentration in the water sample. Positive correlations can be beneficial in discovering relationships between water quality parameters and in accepting predictions about one parameter based on another. But EC and BOD have a high positive correlation with coefficient of 0.8915. Also, TDS has a high positive correlation with Turbidity with coefficient of 0.9818. All the above, pH and COD have the higher positive correlation of 0.9996.

When two variables are negatively linked, it means that when one variable rises, the other tends to fall. Negative correlations may indicate the presence of competing causes or processes that affect the two variables in opposing directions. DO is negatively connected with both BOD and COD in the context of water quality, which makes sense given that organic matter in water can consume dissolved oxygen during the decomposition process. Furthermore, turbidity is negatively associated with pH, which could be owing to large amounts of suspended particles increasing the acidity of water. BOD is also negatively correlated with both Temperature and DO. EC also has a high negative relation with temperature and moderate negative correlation with DO in coefficient of -0.6504.

Table 4.7: Correlation between the parameters of autumn season

	pH	Turbidity (ntu)	Temperature (0C)	DO (mg/L)	BOD (mg/L)	Cd (mg/L)	COD (mg/L)	Cu (mg/L)	EC (µS/cm)	Pb (mg/L)	Ni (mg/L)	TDS (mg/L)
pH	1											
Turbidity (ntu)	-0.0038	1										
Temperature (^{0}C)	0.5802	0.8122	1									
DO (mg/L)	-0.5797	0.8171	0.3273	1								
BOD (mg/L)	-0.9819	-0.1858	-0.7240	0.4148	1							
Cd (mg/L)	-0.5797	0.8171	0.3273	1	0.4148	1						
COD (mg/L)	0.9955	-0.0991	0.5	-0.6547	-0.9594	-0.6547	1					
Cu (mg/L)	0.8149	0.5766	0.9449	1.3E-16	-0.9099	-4.9E-17	0.7559	1				
EC (µS/cm)	0.5362	-0.8462	-0.3764	-0.9986	-0.3665	-0.9986	0.6141	-0.0524	1			
Pb (mg/L)	0.2631	-0.9658	-0.6331	-0.9387	-0.0755	-0.9387	0.3538	-0.3449	0.9554	1		
Ni (mg/L)	-0.4158	-0.9078	-0.9820	-0.5000	0.5807	-0.5	-0.3273	-0.8660	0.5447	0.7680	1	
TDS (mg/L)	0.9981	-0.0652	0.5291	-0.6286	-0.9684	-0.6286	0.9994	0.7777	0.5870	0.3218	-0.3592	1

We can draw numerous conclusions regarding the connections between the various water quality measures that were assessed based on the correlation matrix in Table 4.7. Several important points are as follows:

The given correlation matrix shows that the diagonal values are all 1, which makes sense since a variable is perfectly correlated with itself.

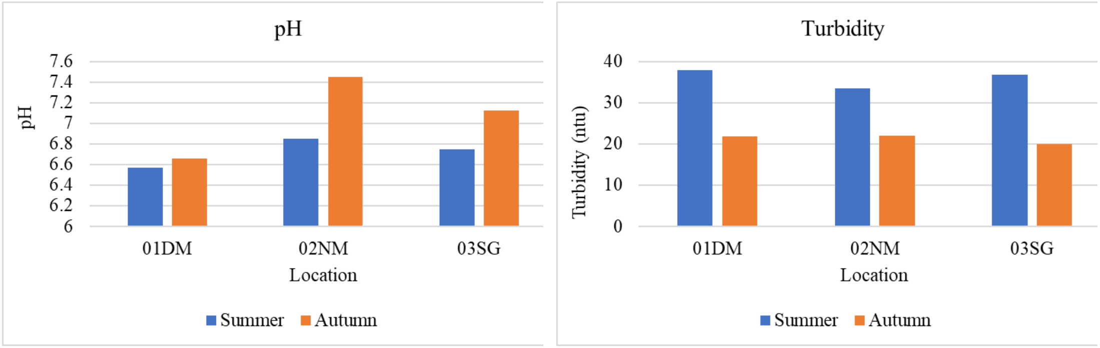
A correlation coefficient value near one indicates a positive correlation. It signifies that two variables are directly associated, and when one increases, the other increases as well. Temperature has a positive correlation with pH and Turbidity, with a correlation coefficient of 0.5802 and 8.122. This means that when the temperature of the water rises, so does the pH and Turbidity. Besides, Turbidity also has a positive relation with OF with coefficient of 0.8171. Similarly, pH and COD have a high positive association with a correlation coefficient of 0.9953, showing that a rise in pH relates to an addition in COD concentration in the water sample. Positive correlations can be beneficial in discovering relationships between water quality parameters and in accepting predictions about one parameter based on another. TDS and pH have a highly positive correlation with a coefficient of 0.9981. Also, TDS has a highly positive correlation with COD with coefficient of 0.9994.

When two variables are negatively linked, it means that when one variable rises, the other tends to fall. Negative correlations may indicate the presence of competing causes or processes that affect the two variables in opposing directions. BOD is negatively connected with both COD and Cu. Furthermore, turbidity is moderately negatively associated with DO. Negative correlations can be beneficial for identifying potential difficulties or stresses in a water system, as well as assessing the efficacy of various water treatment procedures.

4.7 Seasonal and Spatial variation of different parameters

A basic bar chart is a graphical representation of data that employs rectangular bars. This is one of the most prevalent types of charts used in data visualization, particularly when comparing different types of data. The height or length of each bar in a standard bar chart shows the data value being plotted. Vertical or horizontal bars are generally uniformly spaced along an axis representing the compared categories. To aid in identifying between distinct categories or data points, bars might be colored or labeled. Simple bar charts are frequently used to demonstrate changes in data over time, to compare distinct groups or categories, or to depict data distribution over multiple values or ranges. Because they are simple to read and comprehend, they are famous for data visualization in sectors ranging from commerce and finance to science and engineering.

The bar chart's blue bars on the left flank represent the summer parameter values. The orange bars on the right side represent the autumn parameter values. The y-axis represents the corresponding parameter values, and the x-axis represents the locations. The data provided appears to define the parameters for three stations - Darus Salam Jame Masjid (01DM), Nizambag Madrasa & Jame Masjid (02NM), and Ultingonj Kheaghat (03SN) - during the summer and autumn seasons.

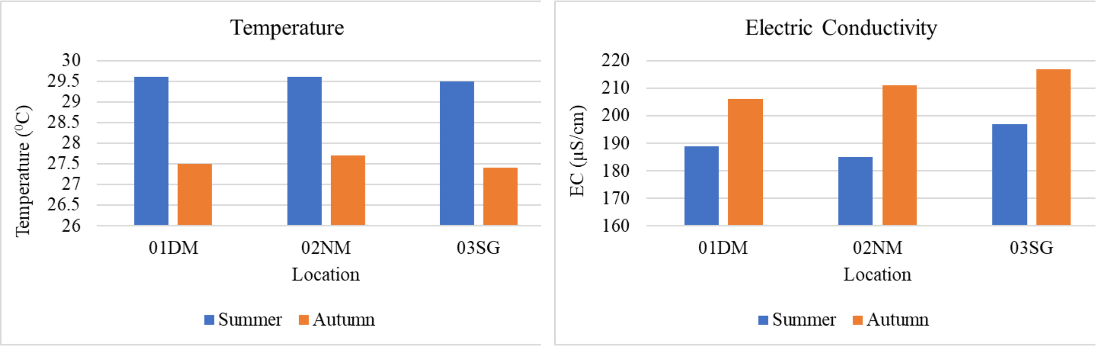


(a) (b)

Fig 4. 3: Seasonal and spatial variation of (a) pH and (b) Turbidity

The graph in Fig 4.3 (a) demonstrates that pH levels in autumn are frequently higher than in summer. The fall pH value near the center (7.45) is significantly higher than any summer reading. The other two pH readings for fall (6.66 and 7.12), on the other hand, are not substantially higher than the analogous values for summer (6.57 and 6.75), indicating that the range of pH values between samples may be greater than the seasonal change. In both summer and autumn seasons, Nizambag Madrasa & Jame Masjid (02NM) has the highest pH level. Also in between both seasons, this place has the highest pH level.

The information appears to represent the turbidity readings (in ntu, or nephelometric turbidity units) for three sites shoes in Fig 4.3 (b). The levels in summer were 33.4 ntu, 37.9 ntu, and 36.8 ntu, respectively. All three sites experienced decreasing turbidity levels in the autumn to 20 ntu, 21.8 ntu, and 22 ntu, respectively. According to this data, all three sites showed lower turbidity levels during the autumn season than during the summer season. Also, Nizambag Madrasa and Jame Masjid had the lowest turbidity levels among the three stations during both seasons. It's important to note that excessive turbidity levels in water can be an indicator of poor water quality, which may be a source of concern for people who depend on these water sources.

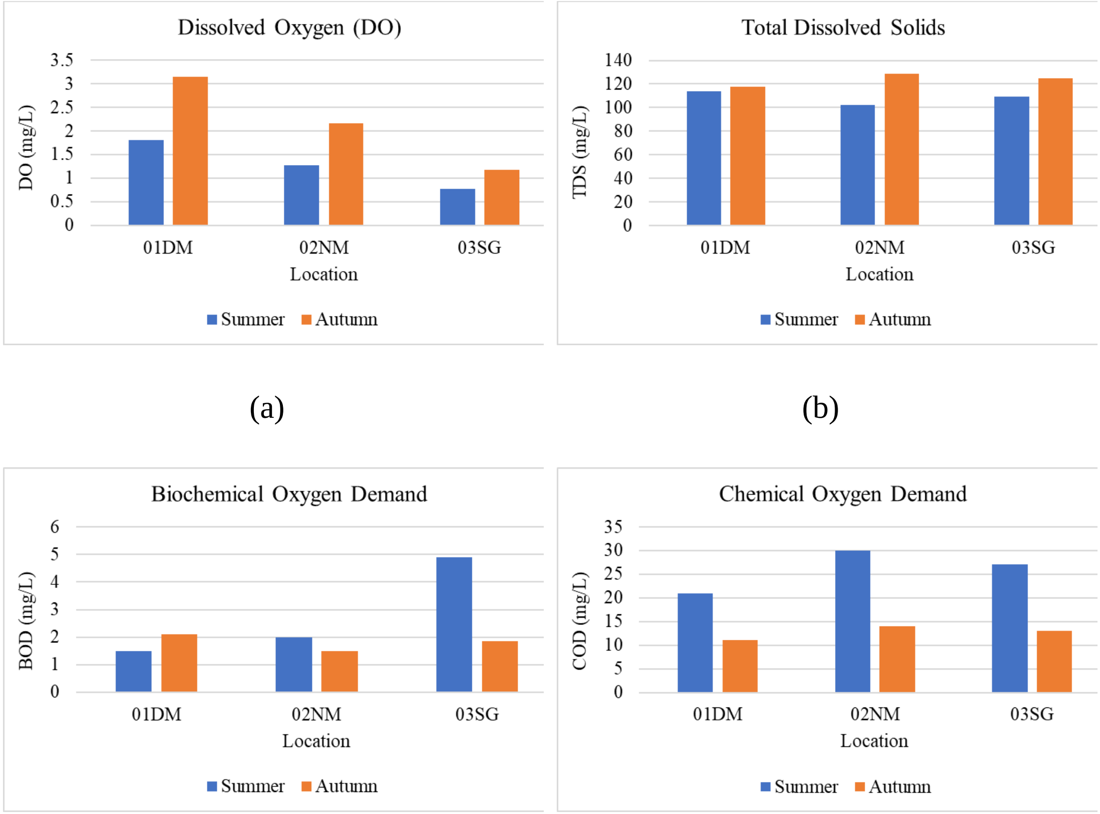


(a) (b)

Fig 4. 4: Seasonal and spatial variation of (a)Temperature and (b)TDS

The presented data appears to Fig 4.4 (a) indicate the water temperature (in degrees Celsius) for three stations. All three locations water temperatures during the summer were comparable. Ultingonj Kheaghat had a slightly lower temperature of 29.5 degrees Celsius than Nizambag Madrasa & Jame Masjid and Darus Salam Jame Masjid, all of which had the same temperature of 29.6 degrees Celsius. All three sites had similar water temperatures during the autumn season. Nizambag Madrasa & Jame Masjid recorded a temperature of 27.7 degrees Celsius, slightly higher than Ultingonj Kheaghat’s 27.4 degrees Celsius, and Darus Salam Jame Masjid's 27.5 degrees Celsius. This information suggests that the water temperatures at the three stations were similar during both seasons, with only minor differences between them. It is important to remember that water temperature can affect the wellbeing and behavior of aquatic species, as well as dissolved oxygen levels and chemical reactions in water, which can have an impact on water quality. The observed temperatures are not, however, within ranges that are suitable for the local ecology or for human usage based only on this data.

The data provided in Figure 4.4 (b) displays the electrical conductivity (EC) of water at three different places during the summer and fall seasons in micro siemens per centimeter (S/cm). For the first location, Darus Salam Jame Masjid, the EC of water during the summer season was 189 µS/cm, and during the autumn season, the EC was slightly higher at 206 µS/cm. For the second location, Nizambag Madrasa & Jame Masjid, the EC of water was 185 µS/cm during the summer season, and slightly higher at 211 µS/cm during the autumn season. For the third location, Ultingonj Kheaghat, the EC of water during the summer season was 197 µS/cm, and during the autumn season, the EC was slightly higher at 217 µS/cm. The electrical conductivity of water varies depending on location and season, with the EC being slightly greater in the fall season compared to the summer season. Electrical conductivity is a measure of water's ability to conduct an electrical current and can be used to determine the amount of dissolved particles or ions in the water. Higher EC values can imply higher dissolved solids levels, which can influence water quality and perhaps aquatic life.



(a) (b)

(c) (d)

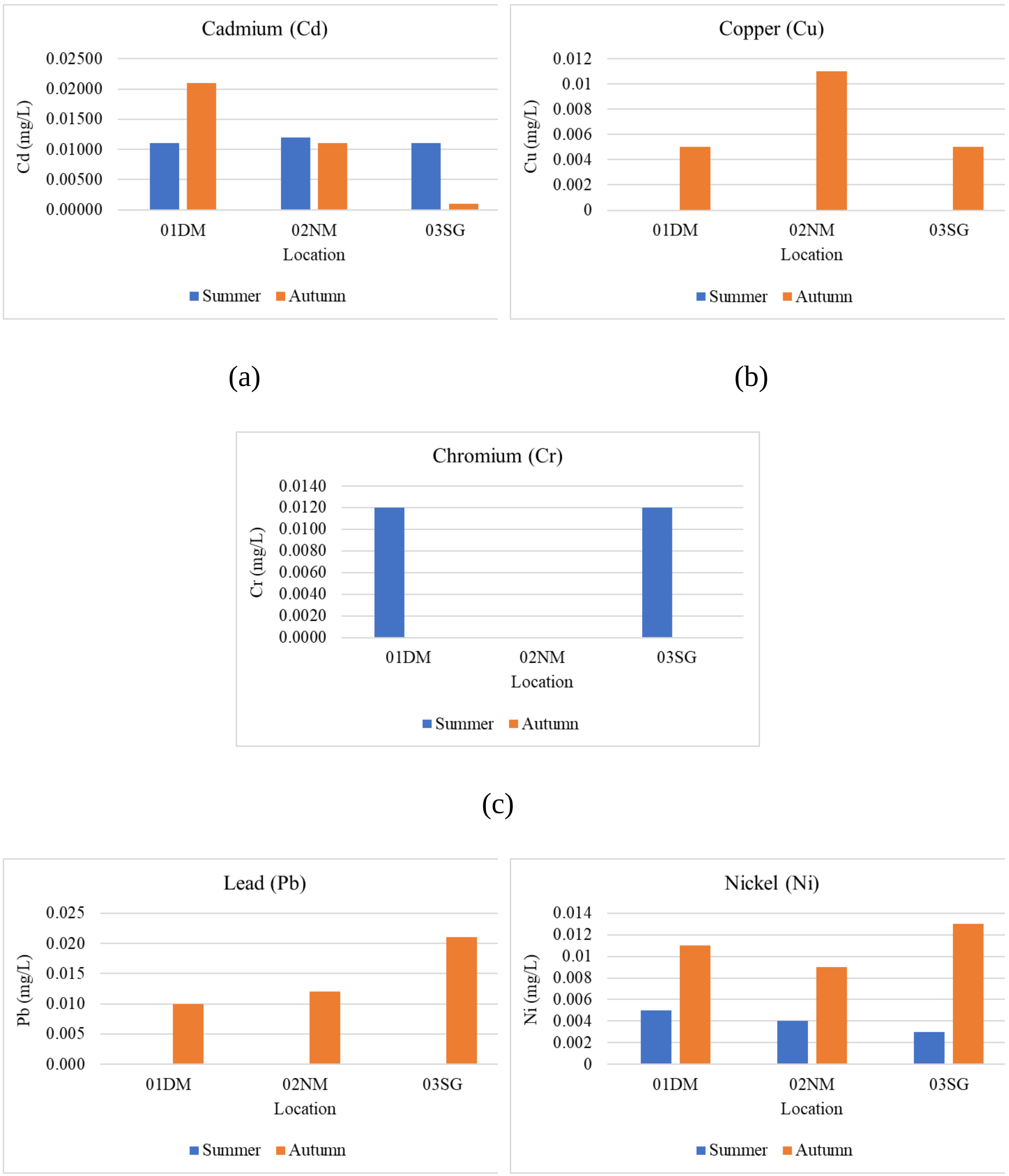
Fig 4. 5: Seasonal and spatial variation of (a)DO, (b)TDS, (c) BOD and (d) COD

The information in Figure 4.5 (a) appears to represent the dissolved oxygen (DO) levels for three stations, which are expressed in milligrams per liter, or mg/L. This information suggests that the DO levels at all three locations were lower in the summer than they were in the fall. Ultingonj Kheaghat had the lowest DO levels compared to Darus Salam Jame Masjid during both seasons. Because it is essential for aquatic creatures' survival, the amount of dissolved oxygen in water is a significant metric for evaluating water quality. Low DO levels can be an indication of poor water quality and may be harmful to or even fatal to aquatic life. To keep aquatic ecosystems healthy, it's crucial to make sure that water DO levels are below safe limits.

Figure 4.5 (b) presented data displays the Total Dissolved Solids (TDS) concentration in milligrams per liter (mg/L) for three separate locations during the summer and fall seasons. The TDS content at the first location, Darus Salam Jame Masjid, was 114 mg/L during the summer season and slightly higher at 118 mg/L during the fall season. The TDS content at the second location, Nizambag Madrasa & Jame Masjid, was 102 mg/L during the summer season and much higher at 129 mg/L during the fall season. The TDS content in the third location, Ultingonj Kheaghat, was 109 mg/L during the summer season and somewhat higher at 125 mg/L during the fall season. TDS concentrations may change between locations and seasons, and TDS concentrations tend to be higher in the autumn season compared to the summer season. The total dissolved solids (TDS) in water are a measure of the total amount of dissolved solids, which might include salts, minerals, and organic stuff. TDS levels above a certain threshold can signify poor water quality and have an influence on aquatic life and human health. As a result, it is critical to monitor and control TDS levels in water to maintain its safety for human consumption and environmental health.

The data provided in Figure 4.5 (c) appears to represent the biological oxygen demand (BOD) levels (measured in milligrams per liter or mg/L) for three locations. According to this data, Ultingonj Kheaghat had the highest BOD levels during both seasons, whereas Darus Salam Jame Masjid had the lowest. BOD levels are a critical criterion for determining the quality of wastewater and surface water. High BOD levels suggest that there is a lot of organic stuff in the water, which can deplete dissolved oxygen levels and endanger aquatic life. To maintain healthy aquatic ecosystems, BOD levels in water must be kept under safe limits. The fall in BOD levels from summer to autumn may be due to a decrease in organic matter inputs throughout the autumn season.

The data provided in Figure 4.5 (d) represents the chemical oxygen demand (COD) levels (measured in milligrams per liter or mg/L) for three locations. COD values estimate the amount of oxygen needed to break down organic matter in water. Higher COD levels indicate higher quantities of organic contaminants, which take more oxygen to break down, resulting in lower oxygen levels in the water and harm to aquatic creatures. These COD levels indicate that there may be higher quantities of organic contaminants in the water throughout the summer, which could be due to increased runoff from agricultural or urban areas, higher temperatures, or other factors. To safeguard the health of aquatic ecosystems and the safety of water resources for human use, COD levels must be monitored, and potential sources of organic contaminants identified.



(a) (b)

(c)

(d) (e)

Fig 4. 6: Seasonal and spatial variation of (a) Cd, (b) Cu, (c) Cr, (d) Pb and (e) Ni.

The data shown in Figure 4.6 (a) reflects cadmium (Cd) levels (measured in milligrams per liter, or mg/L) for three locations. All three stations had reasonably low Cd levels during both seasons. Nizambag Madrasa & Jame Masjid had the highest Cd level during both seasons, with a value of 0.012 mg/L during summer and 0.011 mg/L during autumn. The Cd levels found in this data are typically less than 0.005 mg/L, which is considered safe for surface water. However, excessive Cd concentrations can be hazardous to aquatic creatures, accumulate in the food chain, and pose dangers to human health if consumed in contaminated water or fish. To safeguard the health of aquatic ecosystems and the safety of water resources for human use, Cd levels must be kept within acceptable limits.

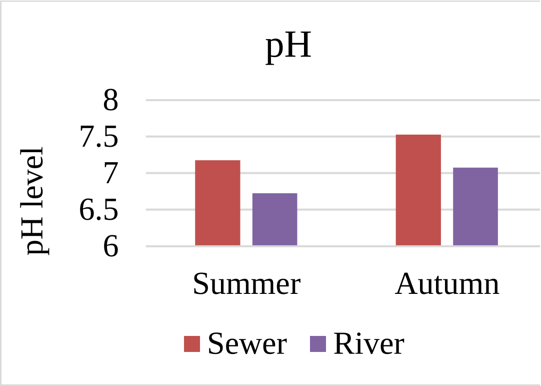
The data provided in Figure 4.6 (b) represents the copper (Cu) levels (measured in milligrams per liter or mg/L) for three locations. The abbreviation "BDL" stands for "below the detection limit," suggesting that the concentration of copper in the water sample was too low to be detected reliably. This could be due to several variables, including the lack of copper sources in the water or the analytical method used to quantify copper concentrations having a detection limit that is higher than the amounts detected in the water samples. Overall, the data indicate that copper levels in water samples were generally low for autumn and below the limits of detection at all three locations during summer. It is critical to continue monitoring copper levels in water resources to ensure that they remain within acceptable limits and to detect any potential sources of copper pollution that could impact aquatic ecosystems or constitute a risk to human health.

The data provided in Figure 4.6 (c) shows the concentration of the pollutant Chromium (Cr) in milligrams per liter (mg/L) for three different locations during the summer and autumn seasons. The concentration of Chromium at the first location, Darus Salam Jame Masjid, was 0.0120 mg/L during the summer season and was below the detection limit during the fall season. (BDL). The concentration of Chromium at the second location, Nizambag Madrasa & Jame Masjid, was BDL for both the summer and fall seasons, indicating that the concentration was below the detection limit for the testing method used. The concentration of Chromium at the third location, Ultingonj Kheaghat, was 0.0120 mg/L during the summer season and below the detection limit during the autumn season. (BDL). Overall, the data suggests that the concentration of Chromium may vary between different locations and seasons, and that some locations may have undetectable levels of Chromium using the testing method used in this study.

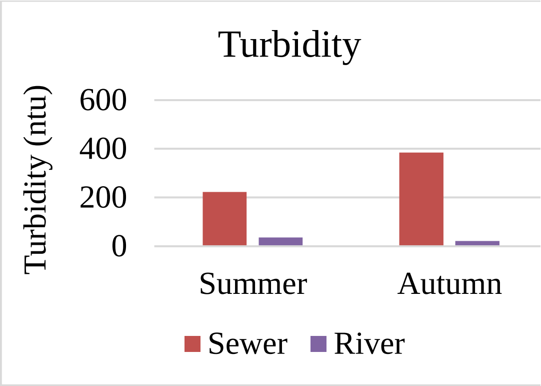
The data provided in Figure 4.6 (d) shows the concentration of the pollutant Lead (Pb) in milligrams per liter (mg/L) for three different locations during the summer and autumn seasons. The concentration of lead was below the detection limit (BDL) in the first location, Darus Salam Jame Masjid, during the summer season, and 0.010 mg/L during the fall season. The concentration of lead at the second location, Nizambag Madrasa & Jame Masjid, was BDL during the summer season and 0.012 mg/L during the fall season. The concentration of lead at the third location, Ultingonj Kheaghat, was BDL during the summer season and 0.021 mg/L during the fall season. Lead concentrations may vary depending on location and season, and some sites may have detectable levels of Lead in the water. Lead is a toxic heavy metal that, at high amounts, can be hazardous to human health and the environment. As a result, it is critical to monitor and control lead levels in water to maintain its safety for human consumption and ecological health.

The data provided in Figure 4.6 (e) displays the pollutant Nickel (Ni) concentrations in milligrams per liter (mg/L) for three separate locations during the summer and fall seasons. The concentration of nickel in the first location, Darus Salam Jame Masjid, was 0.005 mg/L during the summer season and slightly higher at 0.011 mg/L during the autumn season. The concentration of Nickel in the second location, Nizambag Madrasa & Jame Masjid, was 0.004 mg/L during the summer season and slightly higher at 0.009 mg/L during the fall season. The concentration of Nickel at the third location, Ultingonj Kheaghat, was 0.003 mg/L during the summer season and 0.013 mg/L during the fall season. Nickel concentrations may change between locations and seasons, and Nickel concentrations tend to be slightly greater during the fall season compared to the summer season. Nickel is a metallic element that, at high concentrations, can be poisonous to aquatic life and may be hazardous to human health. As a result, it is critical to monitor and control nickel levels in water to maintain its safety for human consumption and ecological health.

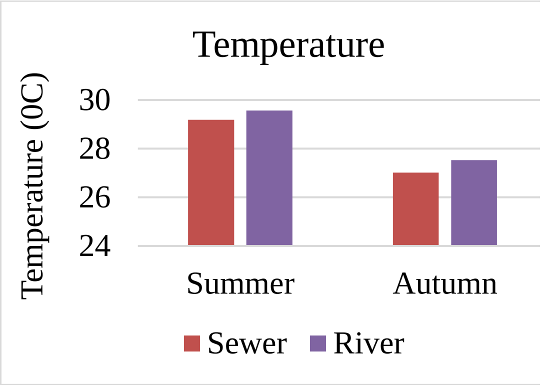
4.8 Difference between sewer and river water quality



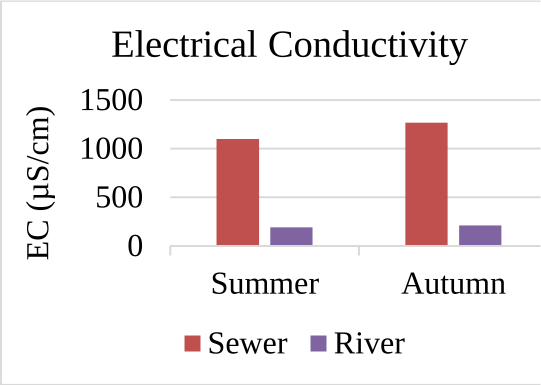
(a)



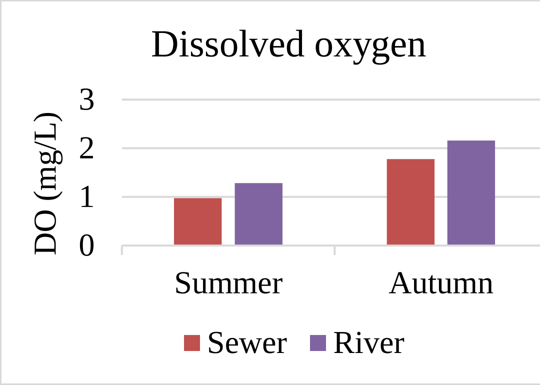
(b)



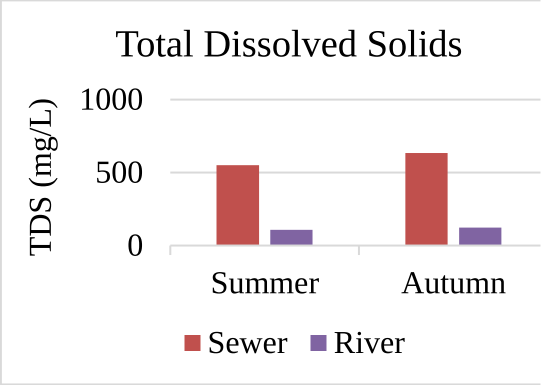
(c)



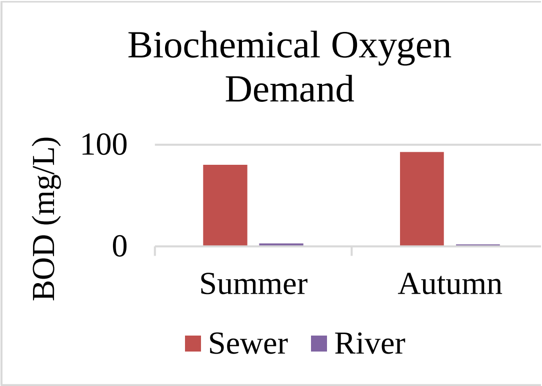
(d)

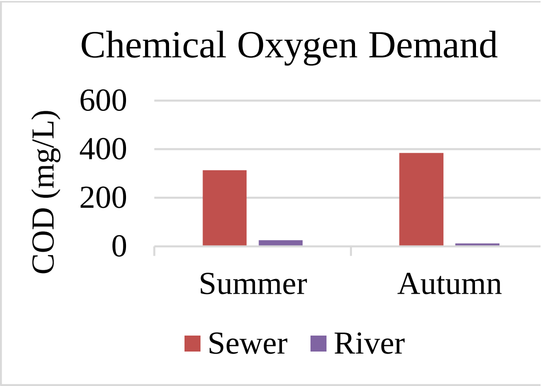


(e)



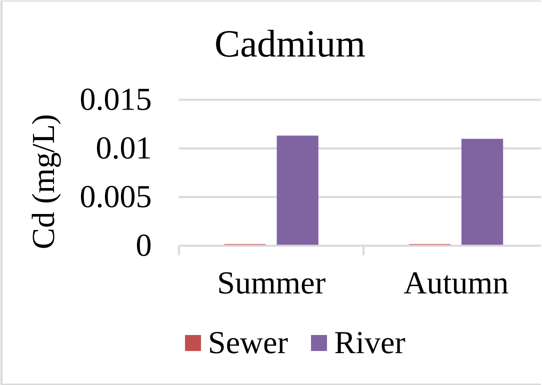
(f)

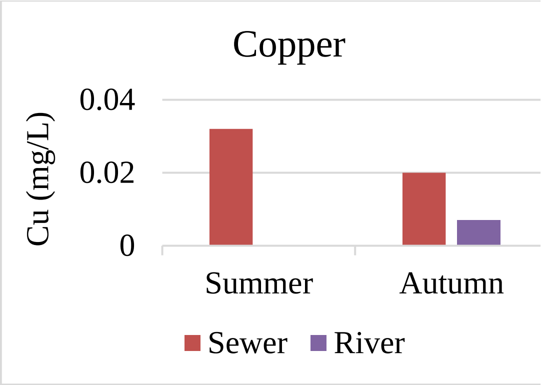

Biochemical Oxygen Demand
BOD (mg/L)
100
0
Summer
Autumn
Sewer
River


Chemical Oxygen Demand
COD (mg/L)
600
400
200
0
Summer
Autumn
Sewer
River

(g)

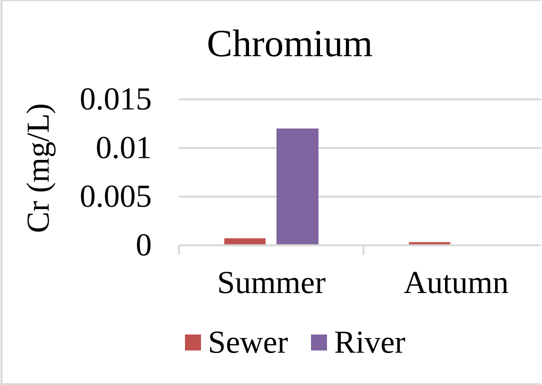
(h)

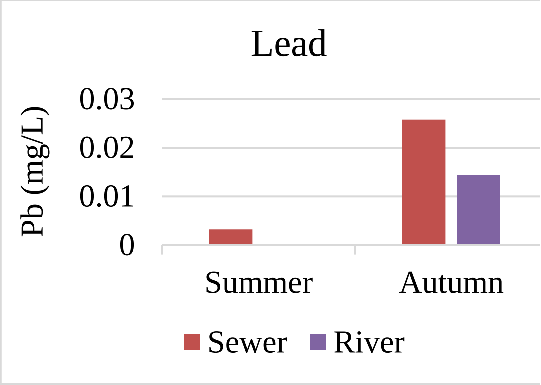

Cadmium
Cd (mg/L)
0.015
0.01
0.005
0
Summer
Autumn
Sewer
River


Copper
Cu (mg/L)
0.04
0.02
0
Summer
Autumn
Sewer
River

(i)

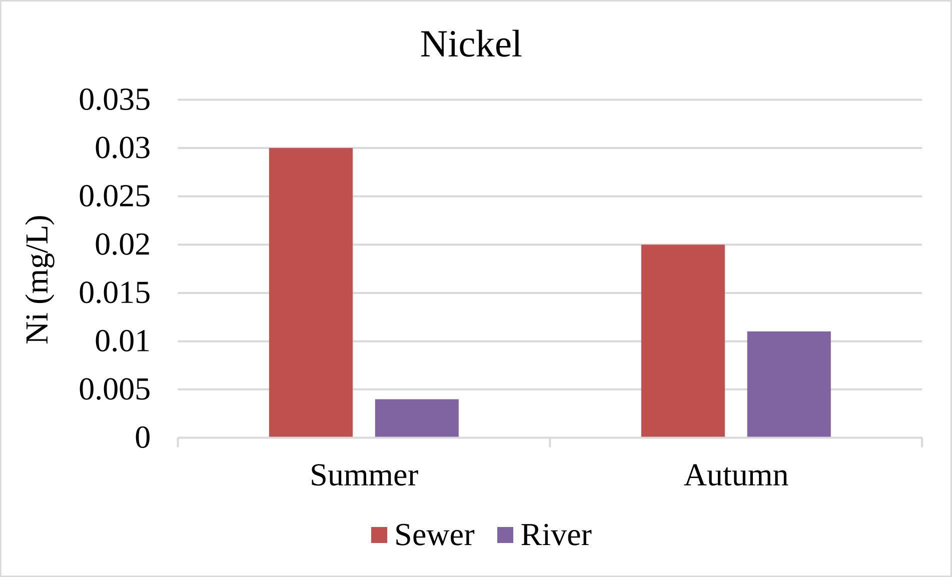
(j)


Chromium
Cr (mg/L)
0.015
0.01
0.005
0
Summer
Autumn
Sewer
River


Lead
Pb (mg/L)
0.03
0.02
0.01
0
Summer
Autumn
Sewer
River

(k)

(l)



(m)

Fig 4. 7: Parameters mean difference between sewer and river for summer and autumn season.

Above Figure 4.7 shows us the mean difference of various water quality parameters measured in a sewer and a river during summer and autumn seasons.

The pH values for both the sewer and river are slightly acidic in summer and autumn, with the river having a slightly lower pH in both seasons. The sewer has significantly higher turbidity values in both summer and autumn compared to the river. The temperature values for both the sewer and river are relatively similar in both seasons. The river has higher DO values than the sewer in both seasons, indicating better water quality. The sewer has much higher BOD values in summer compared to the river, indicating higher organic pollution levels. COD values for both the sewer and river are much higher in summer compared to autumn. The sewer has significantly higher EC values in both summer and autumn compared to the river, indicating higher levels of dissolved ions in the water. The sewer has significantly higher TDS values in both seasons compared to the river, indicating higher levels of dissolved solids in the water. Cd, Cu, Cr, Pb, and Ni These heavy metal concentrations are mostly within acceptable limits. Although some values are missing or beyond limits.

Overall, the data suggests that the sewer has significantly poorer water quality than the river, with higher levels of pollutants such as BOD, COD, and TDS.

Chapter V

CONCLUSION AND RECOMMENDATION

5.1 General

Buriganga River is one of the most significant rivers in Bangladesh and an essential source of livelihood for many people. However, like many other water bodies in Dhaka, the Buriganga River has been facing severe pollution issues due to the discharge of untreated domestic and industrial wastewater. In recent years, the quality of the river water has deteriorated significantly, posing a severe threat to the aquatic ecosystem and public health. To address these concerns, this study was conducted to assess the current water quality of the Buriganga River, including seasonal variations, and to identify major sources of pollution and their impact on the river. The study was conducted in the summer and late autumn seasons in 2022.

5.2 Conclusions

By comparing the value of the test in both seasons, in One-way ANOVA test we found that, the p-value of Cd is higher than standard p-value. So, we cannot conclude that a significant difference exists. In Cohen’s d we found that for seasonal variation, Temperature has the largest effect size and Cd has the lowest. Also, turbidity has a big effect size and rest of the parameters are average (Sawilowsky et all. 2009, Cohen et all. 1988). According to WWQI, Cd, BOD, Pb and Cr have high values that contribute considerably to the overall score. Besides, heavy metals (Cd, Cu, Pb, and Ni) in wastewater have the potential to cause serious health and environmental problems. In PCA for summer season EC and BOD are positively related and DO, Ni and Temperature are highly negatively related. But in autumn season Ni and Pb are highly positively related, and Turbidity, Temperature and Cu are highly negatively related. Here, temperature is negatively related in both seasons.

According to the difference between sewer and river water quality we found some differences between the river and sewer water for summer and autumn season. Most parameters value is higher in sewer than river. The value difference for pH, temperature and DO is not differ very much in between river and sewer. Rest of the parameters like turbidity, BOD, COD, Cd, Cr, Cu, Ni, Pb, EC and TDS have a difference in between sewer and river water quality values in summer and autumn season.

5.3 Recommendations

1. In this study, only 3 points have been selected for testing the water quality, if more locations were selected then more variation would be obtained in the analysis.

2. The study has been done by collecting water for only two seasons. More seasons in a year or several years should give us more information about the selected to get more information about water quality and make a good comparison with each data.

3. We have selected only 13 parameters in this study. Other parameters like color, taste, odor, acidity, alkalinity, chlorine, hardness, etc. can also be tested to get the precise condition of the river and sewerage water.

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