ASSESSMENT OF WASTEWATER QUALITY OF SELECTED SEWERS CONNECTED TO THE BURIGANGA RIVER

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DECLARATION

The dissertation entitled “Our Thesis Title ASSESSMENT OF WASTEWATER QUALITY OF SELECTED SEWERS CONNECTED TO THE BURIGANGA RIVER.” 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

Sewage systems are essential for modern society, and the main pollutant in the Buriganga River is wastewater from Dhaka City. Unchecked and untreated discharge of waste is having a negative effect on the river's water quality. The main source of pollution is the Hazaribagh tannery, which has been in operation for a while without a treatment facility. Sewage lines are the entire system of pumps, pipelines, and mains used to collect wastewater and each community has its own sewage system. Urban infrastructure must include sewerage systems to safeguard against flooding and the spread of waterborne diseases. It is important to make existing infrastructure more capable and to ensure proper care, as they react to the chemical composition of wastewater, changing it. Here we have studied various parameters of wastewater including pH, temperature, turbidity, TDS, DO, BOD, and COD so on. These parameters are analyzed through some significant analysis and seasonal differences are highlighted.

We obtained a maximum p-value of 1 from a one-way ANOVA analysis, which is the p-value for cadmium. And for temperature, copper, and nickel, the lowest p-value was 0, which was also the case. The pH value, on the other hand, was discovered to be 0.009.

Using Cohen's d, we were able to determine the specifics of the effect size. It appears that temperature has the biggest effect size (Cohen's d), with a value of 4.156; turbidity, DO, and TDS have medium effect sizes, ranging from 0.727 to 0.913; and Cd and Ni have no effect sizes, with values of 0.

From WWQI, EC has a maximum value of 118400 and Cd has the minimum value of 0.0152. Ni, Pb, Cu have excellent water quality. pH, turbidity, temperature, BOD, COD EC, TDS are very polluted. DO is in poor condition. Other parameters are excellent.

pH was higher in autumn than in summer, and turbidity was also similar to pH, but turbidity increased abnormally in Dhaka Uddan during the autumn season. Electrical conductivity was higher in autumn than in summer.DO was higher in autumn but was found to be unusually low at one point compared to summer. Also, TDS in the summer season is less than in the autumn season. As seen in BOD and COD, BOD is always lower than COD. Again, at the Kamrangirchar Beribadh, there is some discrepancy in both cases that is slightly higher in summer than in autumn. Copper is less available in autumn than in summer. Most of the increase in chromium was observed in the summer season but in some cases, it was the same in both seasons. Nickel is high in summer and low in autumn. Reducing the toxicity of waste involves source control, advanced treatment methods, improving sewage treatment processes, promoting public awareness, regular monitoring, separation of hazardous waste, and collaboration between governments, industries, and communities. These steps can help to minimize the toxicity of sewage waste, leading to a cleaner and healthier environment.

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First and foremost, we would like to express and convey our gratitude to the almighty Allah for his blessing approval, protection, mental power, and wisdom in all aspects of our life, and all applause to ALLAH for completing this thesis. The real spirit of achieving a goal is through the way of excellence and austere discipline we would have never succeeded in completing our task with the cooperation, encouragement and help provided by various personalities.

This work would not have been possible without the support and guidance of Md. Masud Alom (Assistant Professor), Department of Civil Engineering, Daffodil International University, Dhaka, who happen to be our research supervisor for his endless patience, scholar guidance continual encouragement, Constant and energetic supervision, constructive criticism, valuable advice, reading inferior drafts and correcting them at all stages have made it possible to complete this research. And we chose this topic and developed the search. Deep Knowledge and keep interest of our supervisor in the field of Engineering and influenced us to carry out of this research.

We would like to express our heartiest gratitude to all our faculty members, Department of Civil Engineering for their king help to finish our thesis and, we would like to thank the staff of the CE department of Daffodil International University. We must be sincere to acknowledge with due respect the constant support and patience of our family members and friends for their helpful and assistance in completing our program.

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CHAPTER I

INTRODUCTION

1.1 Background

Sewerage systems are the backbone of modern society. It keeps waste out of populated areas to keep the population healthy. Dhaka city's wastewater goes directly into the Buriganga river unfiltered, resulting in water pollution. Untreated waste from factories built around the Buriganga river in Dhaka city is destroying our environment and river today. The way in which man-made waste material enters the river and pollutes the river is a matter of discussion. The quality of the water is constantly changing due to uncontrolled and untreated waste being dumped into the river for a long time. Many factories have been built near the river, including cement factories, dyeing industries, the fertilizer industry, workshops for aluminum, steel, and iron, car-repairing facilities, production facilities for batteries, different pharmaceutical materials, hardware manufacturers, leather tanneries, etc.

The lines of these factories' Toxic liquids and hazardous chemicals flow, altering human life and river characteristics. Not only factories, but people are also dumping household waste and municipal sewage into the river. The Hazaribagh Tannery, according to experts, is the primary source of pollution in Buriganga. The tannery has been in operation for 46 years, but no treatment plant has been installed to neutralize the poisonous compounds it produces. (Bhowmik, 2008). Buriganga is one of the world's most polluted rivers, according to the World Health Organization (WHO). This is due to the city dumping 60,000 cubic meters of poisonous trash into its waters every day (Where Is Our River? 2018).

To be a great sewerage system, the system has to be reliable, easy to use, ecofriendly, low in cost, and low in maintenance. Dhaka city sewerage system has most of them, but the biggest issue it has is that it's not eco-friendly and is destroying the nearby eco system and the environment. Buriganga is situated near a lot of industries that directly dump their wastewater into the river, greatly polluting it. The sewerage line is the full network of pumps, pipelines, and mains used to collect wastewater. Each community uses its own sewage system, and the sewage might come from a variety of sources, such as residences or schools.

Domestic and industrial systems are the two basic categories. Both systems are sometimes integrated into one. Domestic sewage systems are used to collect and treat wastewater from individual homes, while industrial sewage systems treat wastewater generated by industries such as factories, refineries, and chemical plants. Sewerage lines are vital components of urban infrastructure that assist in protecting the urban environment from floods and the spread of water-borne illnesses by properly carrying wastewater to wastewater treatment plants and moving rainwater off urban surfaces.

Although sewage systems are useful for disposing of wastewater, they can harm the ecosystem if they are not designed or maintained properly. Sewage water includes several chemicals that might be dangerous to people. Existing sewerage systems are under increasing strain as a result of population growth, urbanization, and climate change. To prevent further strain, it is essential to increase the capacity of existing infrastructure and ensure that wastewater is properly treated.

The rising pressure on sewerage systems presents itself as operational failures leading to flooding events, greater loads on treatment facilities leading to poor water discharge quality, and leaks associated with increased structural degradation due to concrete corrosion. Sewerage lines, although underground and out of sight, are critical components of urban infrastructure for carrying old, polluted water for safe treatment. During the transmission of wastewater via sewerage systems, reactions occur that change the chemical components of the wastewater. These activities are generally carried out by bacteria, with Cd, Cu, Cr, Pb, Ni, Fe, and other elements playing a key role. These components have an influence on sewerage pipes by creating odor. These hazardous chemicals also have an environmental impact by contributing to greenhouse gas emissions and contamination in natural aquatic habitats.

1.2 Study Area

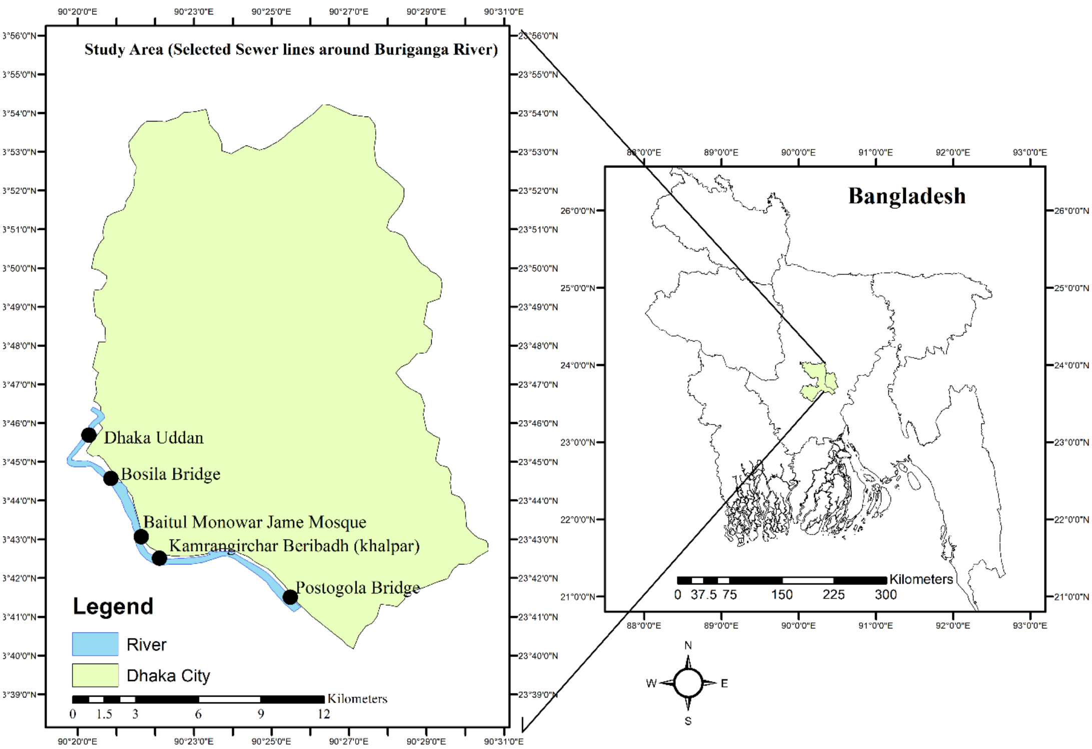


Figure 1.1: Location Map of the study area

1.3 Objective

The major objectives of the present thesis are as follows:

i. To measure the temporal variations of physicochemical properties of wastewater which are entering the Buriganga River through several sewers from diverse zones of Dhaka City.

ii. To find out the possible solution how to minimize the toxicity of the waste.

CHAPTER II

LITERATURE REVIEW

2.1 General

Bangladesh's capital city, Dhaka, depends heavily on the Buriganga River. Long a component of the city's culture and economy, the river has recently suffered from serious pollution and deterioration due to some untreated sewerage lines. The literature on the Buriganga River and its sewage system is vast, with research focused on a variety of themes such as water quality, pollution sources, and the influence of human activity on the river's environment. Untreated industrial effluent is a major cause of pollution in the Buriganga River. According to studies, the river is extensively polluted with harmful chemicals and heavy metals that are discharged through untreated sewage pipes from textile and leather manufacturers located along its banks. As a result, the river's high levels of pollution have a harmful influence on human health as well as the river's fish and other aquatic life. Another big issue with the Buriganga river is the expansion of illegal settlements and unplanned urbanization along its banks, which allows sewage to cheaply into the river, these issues create erosion and sedimentation, which have a negative impact on river flow and quality. Finally, the literature on the Buriganga River and its sewage systems emphasizes the several issues that the river faces, such as water pollution, urbanization, and habitat loss. However, it also shows that numerous attempts are being made to improve the river's health and safeguard its ecology.

More study is needed to assess the efficacy of these treatments and to develop new ways for improving the river's water quality and protecting its environment.

2.2 Parameters of Concern

This section describes the significance of some key water quality parameters that are important in describing the overall health of water bodies.

2.2.1 pH

pH has a direct impact on wastewater treatability since it is a chemical component of the wastewater, regardless of whether the treatment is physical/chemical or biological. Because it is such an essential component of the wastewater's composition, it is vital to treatment. The pH of fresh sewage is greater than 7, indicating that it is alkaline in nature. The pH of septic sewage is less than 7, indicating that it is acidic in nature. The pH of raw sewage varies from 6.8 to 8.0, depending on the quality of the raw water. The pH range of 6.5 to 8.0 is excellent for activated sludge systems. Because nitrifying bacteria are most metabolically effective in this pH range, which optimizes ammonia removal rates, this range has been developed.

2.2.2 Dissolved Oxygen (DO)

When there is an increase in nutrients and organic elements from industrial effluent, sewage discharges, and runoff from the land, the oxygen level of the water will decrease. The amount of dissolved oxygen in a river decreases whenever raw sewage is released into it because microorganisms that utilize the sewage as a food source multiply and breathe. This fast usage of oxygen in the water by respiration can cause fish deaths. In general, dissolved oxygen will balance itself automatically in flowing streams teeming with fish and plant life. Because natural aeration and agitation (wind, animal movement) improve dissolved oxygen levels, if these factors do not exist, such as in a basement hydroponic tank, one should pay particular attention. Temperature, pressure, and salt content are further factors that influence dissolved oxygen (salinity).

DO levels drop when the temperature rises.

DO levels fall when pressure falls.

DO levels decrease with increasing salinity.

2.2.3 Temperature (T)

Temperature is an important parameter to keep track of in any aerobic wastewater treatment system. Bacteria in wastewater treatment systems, like people and many other living species, survive at specific temperatures. Temperature influences the biological activity of bacteria in sewage as well as the solubility of gases in sewage. Moreover, temperature affects sewage viscosity, which affects the sedimentation process in its treatment. Water temperature has a significant impact on biological activity and growth, water chemistry, water quantity measures, and the types of creatures that live in bodies of water.

2.2.4 Turbidity

Turbidity is used to detect the presence of pathogens, bacteria, and other contaminants that are hazardous to aquatic life and human health. Turbidity is measured in drinking water and wastewater systems for this reason. It has the potential to raise the cost of water treatment for drinking and food processing. It has the potential to harm fish and other aquatic species by lowering food supply, deteriorating breeding grounds, and interfering with gill function. Suspended particles, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms, generate turbidity in wastewater. Turbid water has a muddy or hazy look and is unattractive.

2.2.5 Biological Oxygen Demand (BOD)

The BOD is an important measure for determining the quality of water. It is concerned with the amount of oxygen consumed by aerobic living organisms in order to oxidize organic molecules. Sewage with high BOD levels can decrease the oxygen in receiving waters, resulting in the death of some organisms. BOD is a measure of the quantity of oxygen required by microorganisms during the breakdown of organic matter in water bodies. It represents the quantity of organic contamination in an aquatic environment. The higher the BOD, the faster oxygen is reduced in the stream. This means that higher types of aquatic life have less oxygen accessible to them. High BOD levels have the same consequences as low dissolved oxygen levels: aquatic organisms get stressed, suffocate, and die.

2.2.6 Chemical Oxygen Demand (COD)

COD is a water quality measure used not only to determine the amount of biologically active substances such as bacteria but also biologically inactive organic matter in water. It is an important and rapidly measured variable for characterizing water bodies, sewage, industrial wastes, and treatment plant effluents. COD is a measure of the amount of oxygen required to break down organic contaminants in water. A greater COD level in a sample suggests that it includes more oxidizable material. If this is the case, the water will have lower quantities of dissolved oxygen. Higher COD values indicate that there is more oxidizable organic substance in the sample, which reduces dissolved oxygen (DO) amounts. A decrease in DO can result in anaerobic conditions, which are harmful to higher aquatic living organisms.

The Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are both most essential metrics used to describe (measure the level of pollution) wastewater. COD measures all organic matter, whereas BOD only measures biologically decomposed organic matter.

2.2.7 Cadmium (Cd)

Cadmium is a chemical element with the atomic number 48 and the symbol Cd. This soft, silvery-white metal has chemical properties with the two other stable metals in group 12, zinc and mercury. Cadmium is a naturally occurring metal that may be found in trace levels in air, water, soil, and food. Cadmium is found in all soils and rocks, including coal and mineral fertilizers. The major sources of urban wastewater include diffuse sources such as food, detergents, and body-care products, as well as storm water. Cadmium exposure at low levels reduces bone density and alters bone composition. Children are especially susceptible to these consequences since their bones are rapidly expanding. Cadmium is difficult to remove from our cells and tends to accumulate in the kidney. The manufacture of nickel-cadmium (Ni-Cd) rechargeable and the use of cadmium as a sacrificial corrosion-protection covering for steel and iron make cadmium a significant metal for our daily lives. Batteries, solar cells, plastic stabilizers, and pigments are all made with cadmium. As just a sacrificial corrosion-protection coating for both iron and steel, it is also used. Cadmium is still widely used in industry today for solar cells, batteries, alloys, and coatings (electroplating).

2.2.8 Copper (Cu)

Copper has the scientific symbol Cu and the atomic number 29. It is a soft, malleable, ductile metal with excellent electrical and thermal conductivity. A freshly exposed pure copper surface is pinkish orange in color.

Electroplating, paintings and dyeing, petroleum refineries, fertilizers, mining and metallurgy, explosives, pesticides, and the iron and steel industries are the major sources of copper pollution in wastewater. Copper is released into the environment by natural processes such as windblown dusts and decaying flora, as well as through human activities such as municipal solid waste management and fossil fuel combustion. Copper generally adheres to particles (particulate matter) in the air and can travel a long distance from its source.

2.2.9 Chromium (Cr)

The chemical element chromium has the symbol Cr and the atomic number 24. It is the first component of Group 6. It is a steely-grey transition metal that is glossy, hard, and brittle. The metal chromium is prized for its great resistance to corrosion and hardness. The earth's crust has comparatively modest quantities of chromium (Cr). Cr is present in the natural environment in rocks, animals, plants, soil, volcanic dust, and gases. Cr is used in nuclear and high temperature studies, refractories, drilling muds, metal finishing, textiles, fungicides, wood preservatives, smell representatives, leather treatment, industrial water purification, photo-mechanical processing, pigments and dyes catalytic manufacturing, and the manufacture of chromic acid and chemical products. Chrome plating, pigment manufacturing, leather tanning, and wood product preparation are all industrials' sources of chromium. Normally, the presence of chromium species in wastewaters can affect the operation of wastewater treatment facilities, resulting in malfunctions, especially in industrial wastewaters with relatively high chromium concentrations. The skin, eyes, blood, and heart muscle are all negatively impacted. Workers who are exposed to chromium and its compounds may suffer injury.

2.2.10 Electrical Conductivity (EC)

Using electricity, the sophisticated water treatment method known as EC removes toxic metals, mixed solids, and inorganic/organic contaminants from wastewater. (Pan et al., 2016) Compounds of trace minerals, sulfides, chlorides, nitrogen, and phosphorus are examples of inorganic pollutants. Electrical conductivity is important for wastewater systems because it provides information on the total dissolved solids (TDS), chemicals, and minerals that are present in water. Conductivity increases with the number of contaminants in the water.

2.2.11 Lead (Pb)

Chemical element lead has the atomic number 82 and the letter Pb for its symbol. It is a thick hefty metal that is heavier than most everyday materials. Lead (Pb) is pliable and soft, and it also has a low melting point. Lead has a tinge of blue when it is first cut, and it is bright and gray. When exposed to air, it tarnishes to a drab gray tone. Lead, like other heavy metals, can contaminate drinking water and surface water through industrial effluents and corrosion in home plumbing systems, respectively. This makes drinking water dangerous. High levels of lead can cause damage to the brain, kidney and can cause anemia in both adults and children. Pregnant women can experience a miscarriage if exposed to high levels during their pregnancy. Consistent exposure to lead can potentially produce noxious health effects. Sudden lead poisoning, chronic illnesses including nerve damage, paralysis, cancer, colic, poor cognitive function, and infertility, among others, can all be brought on in humans by even minute levels of lead in food or water.

2.2.12 Nickel (Ni)

The chemical element nickel has the atomic number 28 and the symbol Ni. It is a shiny, silvery-white metal with a little hint of gold. A transition metal with ductility and hardness is nickel. Nickel is a poisonous chemical that harms both human and aquatic health. Contact with nickel can have several negative health impacts on people. The chemical is released into the environment by power plants, metal factories and waste incinerators. It is also used in fertilizers and enters groundwater from farm runoff. Contact with nickel can have a number of negative health impacts on people, including allergies, kidney and heart problems, lung fibrosis, and lung and nasal cancer. Nickel is released into the environment by power plants, metal factories and waste incinerators.

2.2.13 Total dissolved solids (TDS)

Total dissolved solids (TDS) are the amount of organic and inorganic components dissolved in a particular volume of water, such as metals, minerals, salts, and ions; TDS is essentially a measurement of anything dissolved in water that is not an H2O molecule. TDS is used to determine drinking water quality because it indicates the quantity of ions present in the water. High TDS concentrations also show the presence of poisonous minerals that are harmful to one's health. Distilled water with very low levels of total dissolved solids (TDS), such as distilled water, will help "cure" arthritis by "washing out" calcium deposits in joints. Drinking "natural" waters with high mineral concentrations are often considered good for human health.

2.3 Case Study

2.3.1 Sedimentary Evidence for Decreased Heavy-Metal inputs to the Chesapeake Bay

Owens and Comwel (1995) conducted a study to see if two decades of environmental laws made a difference in the quantity of trace metal deposited in the Chesapeake Bay.

To estimate the buildup of heavy metals in the system, two assumptions were used in this study:

1. The sediment's age is known.
2. Concentrations of heavy metals.

In Chesapeake Bay, two sample locations were chosen. Anoxia was discovered in mid-bay channel sediments, which reduces the activity of bioturbating organisms. The sediment samples were then ground. Both the Constant Initial Contraction model (CIC) and the Constant Rate of Supply model (CRS) were used to compute sedimentation rates (CRS). Chesapeake Bay cores reveal a pattern of metal contamination in Chesapeake Bay's main stem.

Lead concentrations peaked in both Cores in the mid-1970s before dropping sharply to the present. The maximal concentration of zinc occurs several years before that of lead. Great progress has been achieved in reducing trace metal contamination across the bay.

2.3.2 Trace metal speciation ill the Yamaska and St. Francois rivers (Quebec)

In 1979, Tessier, Campbel, and Bisson conducted this study. Analysis of the results obtained in this study indicates that total soluble and particulate trace metal concentrations present great spatial and temporal variations as do levels of suspended solids.

The mean concentrations of dissolved copper in the Yamaska and St. Francois River basins were 1.2 and 8.6 ug/l respectively.

The sequential extraction process of the present study highlights areas where anomalously high concentrations of particulate trace metals may adversely affect water quality and biota.

2.3.3 Water Quality Modeling (Speciation Modeling of Copper) in South San Francisco Bay

The study in South San Francisco Bay, California was conducted by Kevin J. Novo Gradac and P.F. Wang in 1984 because of increased concentration of metal and, thus an increased bioavailability to Bay organisms. A scheme for estimating the distribution of copper 29 among dissolved and adsorbed phases as well as the process controlling the partitioning of copper using geochemical speciation model MINTQA2 was used. The diffuse-layer methodology and constants from Dzombak (1987) had shown to yield excellent results when modeling copper sorption to an amorphous iron oxyhydroxide phase. The percentage of dissolved copper was predicted by MINTEQUAA2 for three scenarios of amorphous iron content in the suspended sediments. The values were reported for a total of 20 different samples that varied specially and temporally. Several parameters were held constant including constant pH of 7.9 and the solution was assumed to be in equilibrium with carbon dioxide in the atmosphere. The predicted values are within 1% of the actual values which indicates errors in predicted percentages of dissolved copper are small enough to adequately model the distribution of copper. The percentage of dissolved copper was predicted by MINTEQA2 for three scenarios of amorphous iron content (3.15, 4.15, 8.3 g Felkg) in the suspended sediments compared to measurements published by Kuwabara et al. (1986).

2.4 Other Studies

(a) Sylva (1976) studied the copper speciation in aquatic systems by considering inorganic and organic complexation, adsorption, and precipitation processes. The author investigated a given aquatic system with fairly known chemical composition and equilibria collected from literature. Analytically, the equilibrium condition was achieved by simultaneously solving the equilibrium mass balance equations using a modified version of computer program COMICS.

Sylva's (1976) major findings are that in the absence of organic complexing agents, hydrolysis and precipitation are the reactions dominating the chemistry of copper in the pH range of the natural aquatic system. According to the author, the major process of removal in this case was precipitation of malachite which was affected by the pH of the system. The chemistry of a system changes to a greater extent depending on the presence of organic substances.

(b) Kuwabara et. al. (1989) studied the seasonal and spatial distribution of copper, zinc and cadmium for south San Francisco Bay. According to their study copper levels in water were related to the inherent dissolved organic carbon and is controlled by complexation. They also observed a reverse correlation between dissolved copper and salinity and concluded that the level of dissolved copper concentration is directly related to the sorption process.

(c) Bradford and Luoma (1980) studied the concentration of copper, zinc, amorphous iron, and organic carbon in oxidized surface sediments of the South Bay. According to their report, the southernmost region of south bay was most heavily contaminated with copper and zinc. The area was identified to have the slowest circulation.

CHAPTER III

METHODOLOGY

3.1 General

Water quality varies both spatially and temporally, and so cannot be accurately represented by a single sample obtained from a single site. It is important to note that sewage flow varies seasonally and spatially.

This may have an impact on how water quality trends are interpreted. Other elements influencing water quality trend monitoring include the selection of sampling points, their geographic locations, sample collection schedules, sample collection techniques, sample processing procedures, analytical methodologies, and sample collecting duration.

Here we will discuss different seasons and different spatial zones and how the sewerage lines are affecting Buriganga river water and try to detail the water quality of sewerage lines and the impact of the lines and our working process.

3.2 Characterization of water quality

An important tool for figuring out how the environment affects water quality and detecting new issues is water quality monitoring in a natural water body. To do this, the water and sediment in the sewerage lines must have their physical, chemical, and biological properties evaluated. Consequently, monitoring.

To describe the water and sediment quality of sewerage lines connected to the Buriganga River, a program covering two separate seasons was adopted.

3.2.1 Selection of sampling points

The number of sampling locations in a water body during a study depends on a variety of factors, including potential spatial variation in pollutants, the ability to identify pollution peaks, and the frequency of sample collection. Samples were taken at different locations across the Buriganga area. selected for sampling water samples were taken on five different sewerage lines falling on the river.

Water quality varies both spatially and temporally, and so cannot be accurately represented by a single sample obtained from a single site. It is important to note that sewage flow varies seasonally and spatially.

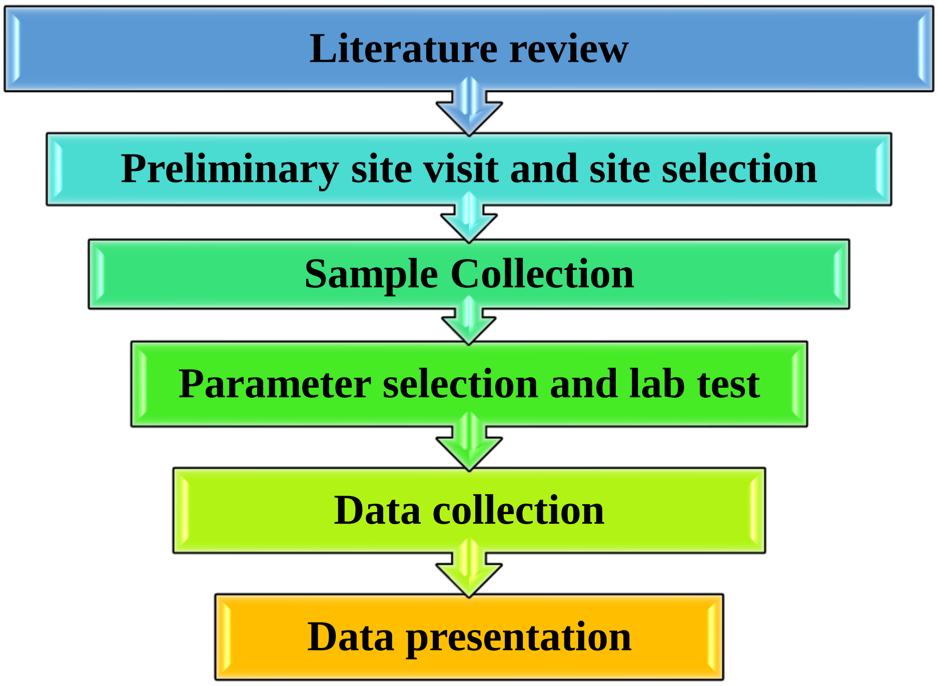
(a) (b) (c) (d) (e)

Fig 3.1: Various sewers point which are connected to the river (a) Postogola Bridge (b) Kamrangirchar Beribadh (khalpar) (c) Baitul Monowar Jame Mosque (d) Bosila Bridge (e) Dhaka Udaan

This may have an impact on how water quality trends are interpreted. Other elements influencing water quality trend monitoring include the selection of sampling points, their geographic locations, sample collection schedules, sample collection techniques, sample processing procedures, analytical methodologies, and sample collecting duration.

Here we will discuss different seasons and different spatial zones and how the sewerage lines are affecting Buriganga river water and try to detail the water quality of sewerage lines and the impact of the lines and our working process.

To simplify our analysis, a special flow chart has been created where we can easily visualize how we have done the processing.



Samples were collected with precaution so that sampling bottles are free from air bubbles. After sampling, the sampling bottles were stored and then carried to the De for analysis. During collection, surface scum was avoided, and sufficient distance was kept from major sources of pollution. These samples represent the chemical composition at the sampling locations on the day of sampling.

3.2.2 Literature review

When we think about collecting these samples and thinking about which lines to select, we start studying the previous papers. Because we believe that this kind of literature evaluation is typically done to gauge how much is known about a certain subject. It can be used, for instance, to develop research agendas, find research gaps, or simply to discuss a certain topic. Our team very efficiently studied 30 papers that were based on river and sewerage lines from different parts of the world. After studying various papers, we select some important parameters which are highly harmful to our environment.

3.2.3 Preliminary Site Investigation and Site Selection

During the site investigation we tried to use the knowledge of previous literature review to avoid any problems later. First, we divided the entire area into several zones, and then we categorized the sites accordingly. This was the main step in our investigation. Because we wanted our samples to be from different sources.

After investigation of the sites, we selected the sites based on few factors. Such as-

1. Point sources will vary from one another. For example, in the case: commercial, residential, etc.
2. Availability of water in all seasons - During our investigation we found that it is impossible to collect water in some seasons because the collection points are submerged under water during the rainy season and dry up again during the hot season. So, we try to take the collection points in such a way that samples are available in all seasons.
3. The location must be safe and simple to reach to collect the samples.
4. Considering the physical, chemical, and biological traits of the river, the location should be representative of the larger water body. It is important to choose sampling sites that accurately reflect the river's mean flow.
5. Sites for sampling were chosen based on seasonal variations in the flow and quality of the water.
6. Future monitoring and maintenance procedures should be simple to complete at the location. The samples were collected in a couple of 2-liter pre-labeled plastic bottles from each location.

3.2.4 Collection of Sample

We collected samples from places where our water collection was easy and where the wastewater was coming from different sources before being discharged into the river. The presence and concentration of various pollutants, including heavy metals, organic matter, and nutrients, are then assessed in a laboratory using the samples. The number of sampling locations in a water body during a study depends on a variety of factors, including potential spatial variation in pollutants, the ability to identify pollution peaks, and the frequency of sample collection. Samples were taken at different locations across the Buriganga area. selected for sampling water samples were taken on five different sewerage lines falling on the river. The samples were obtained through the use of bucket sampling techniques. Utilize the proper sampling tools and procedures to guarantee that the samples are accurate representations of the water quality and were not contaminated during collection.

Table 3.1: Locations of the water sampling points of connected sewerage to Buriganga River

SN	**Station Code**	**Station Location**		**Station Name**
		Latitude	**Longitude**	
1.	PB01	23.691784	90.424781	Postogola Bridge
2.	KC02	23.708513	90.368537	Kamrangirchar Beribadh (khalpar)
3.	BM03	23.717783	90.360663	Baitul Monowar Jame Mosque
4.	BB04	23.742889	90.347648	Bosila Bridge
5.	DU05	23.761452	90.338131	Dhaka Uddan

At each sampling point, wastewater is collected before it enters the river from the pipe so that only the lines can be easily analyzed for water quality. Since our goal is to evaluate how much pollution is entering the river and how much of the toxic parameter is flowing into the line, we carefully collect samples. Before taking the sample, the sample bottle was properly cleaned 3 times with water. In 2-liter plastic bottles with labels already on them, water samples were taken at each location. To make sure there were no air bubbles in the sample bottles, samples were carefully collected.

(a) (b) (c) (d) (e)

Fig 3.2: Sample Collection Point (a) Postogola Bridge (b) Kamrangirchar Beribadh (Khalpar) (c) Baitul Monowar Jame Mosque (d) Bosila Bridge (e) Dhaka Uddan

The sample bottles were stored after sampling, and they were later taken for analysis. Surface dirt was avoided during collection, and significant sources of contamination were kept far enough away.

3.3 Parameter selection and Test

Water analysis is the process of evaluating and analyzing the quality of water. In order to determine the physical, chemical, and biological characteristics of water samples, various analytical techniques are used. The study is required for several reasons, including ensuring the security of drinking water, keeping track of the well-being of aquatic ecosystems, and evaluating the effectiveness of industrial and agricultural water use. 3 hours after sampling, samples were Department of Public Health Engineering moved from the field to the lab (DPHE).

pH, turbidity, temperature, total dissolved solids (TDS), 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 dissolved oxygen (DO) were all measured in the water samples that were collected.

Some tests are done in the field because temperature and weather can change their properties. So, we measured pH, turbidity and temperature in the field.

(a) (b)

Figure 3.3: On site sample testing on pH, turbidity, and temperature

CHAPTER IV

RESULT AND DISCUSSION

4.1 General

The most important part of a paper is the result and discussion; here the output of the whole work is discussed. It is discussed what has been worked on, what kind of results have come through the tests, what are the remedies, why it happened, etc. Many frequently asked topics are discussed here. That's why we must be careful while working on this matter so that no wrong information comes out.

Result and discussion for wastewater sewers the results of the study showed that the wastewater sewers had high levels of pollutants, including organic matter and heavy metals. These findings highlight the need for improved wastewater treatment and management practices to protect human health and the environment. In this paper, we will do some analysis and try to explain the results.

4.2 One-way ANOVA

One-way ANOVA (Analysis of Variance) is a statistical test used to compare the means of three or more groups. It tests the null hypothesis that all group means are equal against the alternative hypothesis that at least one group mean is different.

The test works by analyzing the variance between groups and the variance within groups. If the variance between groups is significantly larger than the variance within groups, then it can be concluded that there is a significant difference in means between at least two of the groups.

Table 4.1: One-way ANOVA test values

Parameters	Sources of Variation	SS	df	MS	F	P-Value
pH	BG	0.310	1	0.310	11.932	0.009
	WG	0.208	8	0.026		
Turbidity	BG	66259.600	1	66259.600	1.464	0.261
	WG	362158	8	45269.750		
Temperature	BG	11.794	1	11.794	43.176	0
	WG	2.185	8	0.273		
DO	BG	1.606	1	1.606	2.083	0.187
	WG	6.167	8	0.771		
BOD	BG	384.400	1	384.400	4.036	0.079
	WG	762.000	8	95.250		
Cd	BG	0	1	0	0	1
	WG	0	8	0		
COD	BG	12390.400	1	12390.400	7.526	0.025
	WG	13171.200	8	1646.400		
Cu	BG	0	1	0	36.000	0
	WG	0	8	0		
Cr	BG	0	1	0	4.658	0.063
	WG	0	8	0		
EC	BG	70560	1	70560	1.321	0.284
	WG	427280	8	53410		
Pb	BG	0.001	1	0.001	5.197	0.052
	WG	0.002	8	0		
Ni	BG	0	1	0	65535	0
	WG	0	8	0		
TDS	BG	17640	1	17640	1.321	0.284
	WG	106820	8	13352.500		

The table displays the results of a one-way ANOVA study of several wastewater quality-related factors. Some of the factors (TDS) are 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 various elements of the table include Sources of Variation, SS (sum of squares), df (degrees of freedom), MS (mean square), F-value, and P-value. The "Sources of Variation" column (WG) indicates whether a variation comes from "Between Groups" (BG) or "Within Groups." The "SS" column represents the sum of squares for each source of variation, and the "df" column displays the associated degrees of freedom.

The relevant p-value is shown in the "P-value" column, while the computed F-value is shown in the "F-value" column.

The interpretation of ANOVA results for some important parameters is as follows:

The P-value is a statistical measure that helps to determine the probability of obtaining the observed results in a hypothesis test, assuming that the null hypothesis is true. In the context of ANOVA, it refers to the probability of obtaining the observed variation in the dependent variable (response variable) among different groups (independent variables) by chance, assuming that there is no significant difference between the groups.

Looking at the provided P-values, it seems that the null hypothesis can be rejected for some variables, while for others, it cannot.

Specifically, the pH and BOD variables have P-values less than 0.1, suggesting that the difference between groups for these variables is statistically significant at the 90% confidence level. On the other hand, the Cd and EC variables have P-values greater than 0.1, indicating that there is no significant difference between groups for these variables.

The Temperature, Cu, and Ni variables have P-values of 0 or very close to 0, indicating that the difference between groups is highly significant for these variables.

Finally, for the Turbidity, DO, Cr, Pb, and TDS variables, the P-values are greater than 0.1, suggesting that there is no significant difference between groups for these variables.

4.3 Cohen's d

Cohen's d is a measure of effect size in statistics that indicates the standardized difference between two means. It is commonly used in hypothesis testing to evaluate the magnitude of the difference between two groups.

Table 4.2: Cohen's d test values for two seasons

Parameters	**Season**	**Mean**	**SD**	**Count (n)**	**Mean difference**	**Pooled SD**	**Effect Size(d)**
pH	Summer	7.178	0.171	5.000	0.352	0.161	2.185
	Autumn	7.530	0.151	5.000			
Turbidity	Summer	222.400	84.097	5.000	162.800	212.767	0.765
	Autumn	385.200	288.907	5.000			
Temperature	Summer	29.192	0.273	5.000	2.172	0.523	4.156
	Autumn	27.020	0.687	5.000			
DO	Summer	0.976	0.472	5.000	0.801	0.878	0.913
	Autumn	1.777	1.148	5.000			
BOD	Summer	80.400	12.992	5.000	12.400	9.760	1.271
	Autumn	92.800	4.658	5.000			
Cd	Summer	0	0	5.000	0	0	0
	Autumn	0	0	5.000			
COD	Summer	313.600	53.561	5.000	70.400	40.576	1.735
	Autumn	384	20.591	5.000			
Cu	Summer	0.032	0.004	5.000	0.012	0.003	3.795
	Autumn	0.020	0.000	5.000			
Cr	Summer	0.001	0.000	5.000	0	0	1.365
	Autumn	0.000	0.000	5.000			
EC	Summer	1100	238.223	5.000	168	231.106	0.727
	Autumn	1268	223.763	5.000			
Pb	Summer	0.003	0.001	5.000	0.023	0.016	1.442
	Autumn	0.026	0.022	5.000			
Ni	Summer	0.030	0.000	5.000	0.010	0	0
	Autumn	0.020	0.000	5.000			
TDS	Summer	550	119.111	5.000	84	115.553	0.727
	Autumn	634	111.882	5.000			

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

The interpretation of Cohen's d

The provided values of Cohen's d for each variable indicate the effect size of the difference between two groups for that variable. Specifically, a larger Cohen's d indicates a larger difference between the means of the two groups being compared. The interpretation of Cohen's d as indicating small, medium, and large effect sizes is based on the following guidelines:

Based on these guidelines, we can interpret the effect sizes for each variable as follows:

Based on the effect sizes provided, it seems that temperature has the largest effect size with a value of 4.156, which indicates a very large impact on the outcome of interest. Copper (Cu) also has a very large effect size of 3.795, which suggests a substantial impact on the outcome. Other factors such as BOD, COD, Pb, and Cr also have large effect sizes ranging from 1.271 to 1.735.

Turbidity, DO, and TDS have medium effect sizes ranging from 0.727 to 0.913, which suggests a moderate impact on the outcome.

PH also has a large effect size of 2.185, indicating a significant impact on the outcome.

Finally, Cd and Ni have no effect size with values of 0, which suggests that these factors may not have any impact on the outcome.

It is important to note that Cohen's d is dependent on the standard deviation of the groups being compared, and its interpretation can be affected by outliers or non-normal distributions. Additionally, Cohen's d is typically only used to compare two groups and may not be as useful for comparing more than two groups.

4.4 Wastewater Quality Index (WWQI)

The WWQI takes into account several water quality parameters, including pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), ammonia nitrogen, total nitrogen, total phosphorus, and fecal coliform bacteria. The values of these parameters are measured in the influent and effluent of a wastewater treatment plant and then combined using a weighted formula to generate a single score that reflects the overall quality of the wastewater.

Table 4.4: Wastewater Quality Index test values

Parameters	**Mean Value**	**St**	**Wi=1/St**	**Qi=100*(Mean/Wi)**	**Wi*Qi**
pH	7.354	7.5	0.1333	5515.5	735.4
Turbidity (ntu)	303.8	10	0.1	303800	30380
Temperature (0C)	28.106	25	0.04	70265	2810.6
DO (mg/L)	1.3767	6	0.1667	826.02	137.67
BOD (mg/L)	86.6	0.2	5	1732	8660
Cd (mg/L)	0.000152	0.005	200	0.000076	0.0152
COD (mg/L)	348.8	4	0.25	139520	34880
Cu (mg/L)	0.026	1	1	2.6	2.6
Cr (mg/L)	0.00053	0.05	20	0.00265	0.053
EC (µS/cm)	1184	700	0.001429	82880000	118400
Pb (mg/L)	0.0145	0.05	20	0.0725	1.450
Ni (mg/L)	0.025	0.1	10	0.25	2.5
TDS (mg/L)	592	1000	0.001	59200000	59200
				WWQI =	255210.288

Table 4.5: Water Quality Index based on WWQI value (Khudair et al. 2018)

WWQI Value	**Wastewater Quality**
<50	Excellent
50 - 100	Good
100 - 200	Poor
200 - 300	Very Poor
300 - 400	Polluted
>400	Very Polluted

It is important to note that different countries or regions may 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.

According to Table 4.5 EC has a maximum value of 118400 and Cd has the minimum value of 0.0152. Ni, Pb, Cu have excellent water quality. pH, turbidity, temperature, BOD, COD EC, TDS are very polluted. Do is in poor condition. Other parameters are excellent.

4.5 Principal Component Analysis (PCA)

Principal component analysis (PCA) is a statistical method used to keep as many of the original variables as possible while reducing the dimensionality of a dataset with many variables. Finding principal components – linear combinations of the original variables—that capture the most variance in the data is how the technique operates.

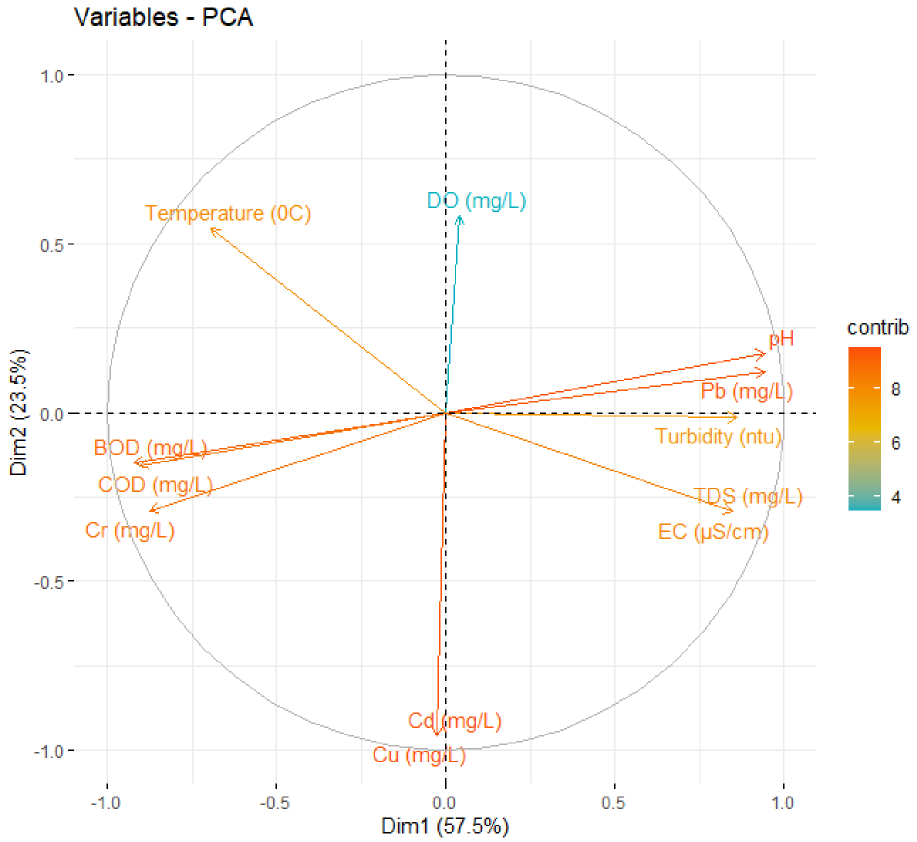


Figure 4.1: Principal Component Analysis based on the monitored stations for the summer season.

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 DO, pH and Pb in the side of all positive. Here DO has small impact than pH and Pb. Like that in the side of X-negative and Y-negative, where all the values have negative relation. We found three parameters like BOD, COD, Cr, Cd and Cu. 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 Temperature, Turbidity, TDS and EC.

From the above discussion we come to the point that, for the treatment or good quality of water or maintaining the quality of the sewage water we need to give an eye on BOD, COD, Cr, Cd and Cu. Because they are having a negative impact on the sewage 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 DO, pH and Pb. Cause they also have a relation with other parameters in another way. So, we need to keep an eye on them, so that they don't change their position.

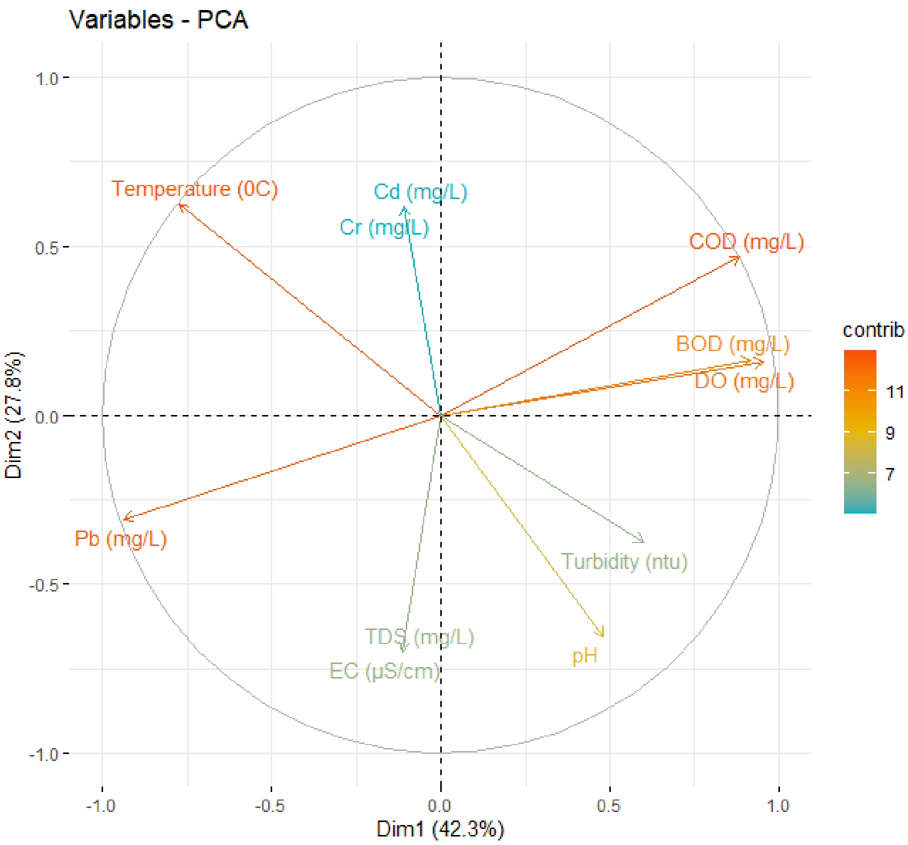


Figure 4.2: Principal Component Analysis based on the monitored stations for the autumn season.

According to the graph on Figure 4.2, 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. According to the graph in Figure 4.2, COD>DO>BOD. They are all highly positive and lie along the X axis.

On the other hand, temperature> Cd > Cr. Here temperature values are highest, and cadmium and chromium are relatively low and they are located very close to Y axis.

In the 3rd section it can be seen that there are also 3 parameters, their order is Pb>EC>TDS. Pb has the highest value and the other two are located near the Y axis. In the last section, pH and turbidity and pH value is slightly higher than turbidity.

Note that here BOD, COD and DO all lie on the positive axis of X and Y and pH and turbidity lie on the negative side of the X and Y axis.

4.6 Correlation Matrix

A table displaying correlation coefficients between variables is called a correlation matrix. The correlation between two variables is displayed in each cell of the table. The correlation matrix aids in forecasting how the relationships between the variables will change over time. You can get a broad overview of the more or less significant association between various variables using the correlation matrix.

Table 4.6: Correlation between the parameters in summer

	pH	*Turbidity (ntu)*	*Temperature (^0C)*	*EC (µS/cm)*	*DO (mg/L)*	*TDS (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Cd (mg/L)*	*Cu (mg/L)*	*Cr (mg/L)*	*Pb (mg/L)*
pH	**1**											
Turbidity (ntu)	**0.855**	**1**										
Temperature (^0C)	**-0.686**	**-0.732**	**1**									
EC (µS/cm)	**0.634**	**0.711**	**-0.560**	**1**								
DO (mg/L)	**0.358**	**0.075**	**-0.059**	**-0.494**	**1**							
TDS (mg/L)	**0.634**	**0.711**	**-0.560**	**1**	**-0.494**	**1**						
BOD (mg/L)	**-0.964**	**-0.703**	**0.636**	**-0.614**	**-0.354**	**-0.614**	**1**					
COD (mg/L)	**-0.953**	**-0.672**	**0.622**	**-0.590**	**-0.372**	**-0.590**	**0.999**	**1**				
Cd (mg/L)	**-0.124**	**-0.043**	**-0.599**	**0.141**	**-0.339**	**0.141**	**0.069**	**0.067**	**1**			
Cu (mg/L)	**-0.124**	**-0.043**	**-0.599**	**0.141**	**-0.339**	**0.141**	**0.069**	**0.067**	**1**	**1**		
Cr (mg/L)	**-0.786**	**-0.772**	**0.308**	**-0.824**	**0.099**	**-0.824**	**0.731**	**0.709**	**0.408**	**0.408**	**1**	
Pb (mg/L)	**0.878**	**0.663**	**-0.495**	**0.803**	**0.040**	**0.803**	**-0.929**	**-0.924**	**-0.134**	**-0.134**	**-0.873**	**1**

The correlation matrix displays the correlation values, which quantify how closely each pair of variables is related linearly. The correlation coefficients have a range of -1 to +1. The correlation value is positive if the two variables tend to rise and fall together. The correlation value is negative if one variable rises while the other falls.

Looking at the matrix in Table 4.6, we can see that the pH values have a strong positive correlation with the turbidity (ntu) values, which suggests that as pH increases, turbidity also tends to increase. There is also a strong negative correlation between temperature and EC (µS/cm), indicating that as the temperature increases, the electrical conductivity of the water tends to decrease. There is a high positive correlation between EC (µS/cm) and TDS (mg/L), indicating that as the electrical conductivity of the water increases, the total dissolved solids tend to increase as well. There is also a moderate positive correlation between Pb (mg/L) and TDS (mg/L), which suggests that higher levels of lead are often associated with higher levels of total dissolved solids.

The BOD and COD values have a strong negative correlation with pH, which suggests that as pH increases, the BOD and COD levels tend to decrease. The Pb also has a strong negative correlation with BOD and COD, which also suggests that as Pb increases, the BOD and COD levels tend to decrease. Similarly, there is a moderate negative correlation between Cu and TDS, indicating that as the total dissolved solids increase, the copper levels tend to decrease.

Table 4.7: Correlation between the parameters in autumn

	pH	*Turbidity (ntu)*	*Temperature (^{0}C)*	*EC (μS/cm)*	*DO (mg/L)*	*TDS (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Cd (mg/L)*	*Cr (mg/L)*	*Pb (mg/L)*
pH	**1**										
Turbidity (ntu)	**0.123**	**1**									
Temperature (^{0}C)	**-0.777**	**-0.706**	**1**								
EC (μS/cm)	**0.211**	**0.443**	**-0.418**	**1**							
DO (mg/L)	**0.291**	**0.585**	**-0.616**	**-0.327**	**1**						
TDS (mg/L)	**0.211**	**0.443**	**-0.418**	**1**	**-0.327**	**1**					
BOD (mg/L)	**0.331**	**0.499**	**-0.647**	**0.012**	**0.814**	**0.012**	**1**				
COD (mg/L)	**0.106**	**0.369**	**-0.396**	**-0.402**	**0.911**	**-0.402**	**0.897**	**1**			
Cd (mg/L)	**-0.630**	**-0.072**	**0.391**	**0.130**	**-0.145**	**0.130**	**0.264**	**0.217**	**1**		
Cr (mg/L)	**-0.630**	**-0.072**	**0.391**	**0.130**	**-0.145**	**0.130**	**0.264**	**0.217**	**1**	**1**	
Pb (mg/L)	**-0.333**	**-0.346**	**0.541**	**0.323**	**-0.909**	**0.323**	**-0.936**	**-0.971**	**-0.096**	**-0.096**	**1**

The correlation matrix displays the correlation values, which quantify how closely each pair of variables is related linearly. The correlation coefficients have a range of -1 to +1. The correlation value is positive if the two variables tend to rise and fall together. The correlation value is negative if one variable rises while the other falls.

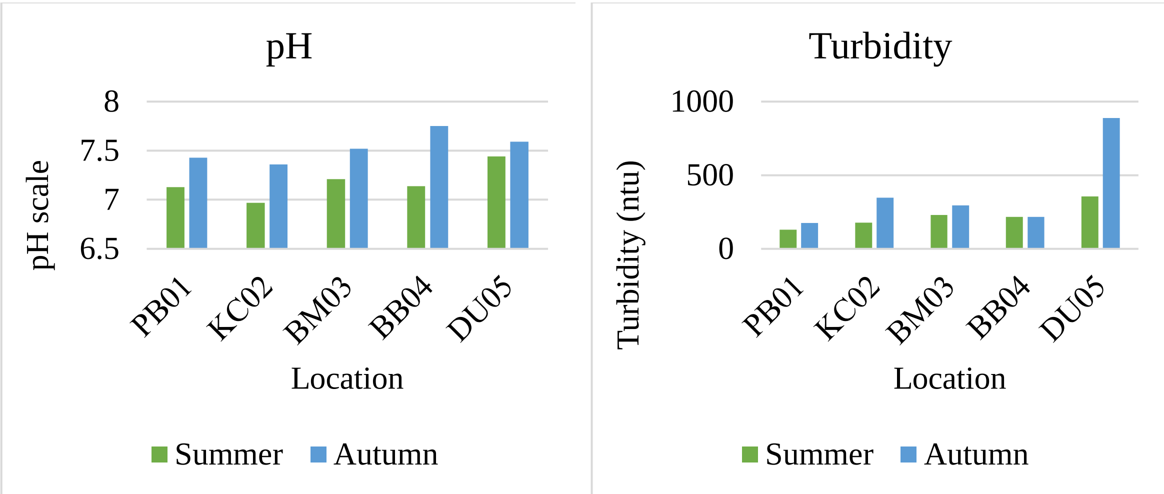
For positive values, we can see that there is a positive correlation between Turbidity and EC, and a moderate positive correlation between DO and turbidity, TDS and pH, and EC and pH. There is also a weak positive correlation between temperature and turbidity. There is a strong positive correlation between TDS and EC and BOD and COD also has a strong positive correlation with DO and COD with BOD also.

For negative values, we can see that there is a strong negative correlation between temperature and pH and temperature and turbidity. Also, a moderate negative correlation between temperature with DO and BOD. There is also a weak negative correlation between TDS and DO, EC and temperature, and DO and EC. There is also a strong negative correlation between Pb with DO, BOD, and COD.

4.8 Seasonal and spatial variation of different parameters

A simple bar chart is a graphical display of data that makes use of rectangular bars to show the values of various categories. The bars are typically plotted along a horizontal or vertical axis, with the height or length of each bar being proportional to the value or frequency it represents.

For presenting and comparing data that is discrete or categorical in nature, such as the difference between seasonal variation in sewerage line's chemical parameters, and the amount of rain that falls throughout the year, simple bar charts are helpful. They can quickly convey crucial information about the data being presented and are simple to read and understand.



(a) (b)

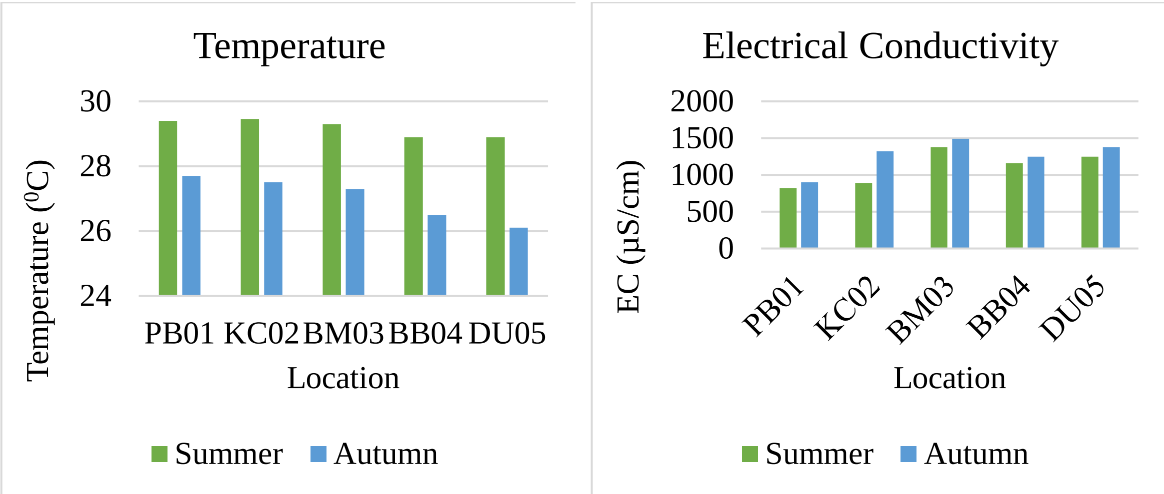
Figure 4.3: Seasonal and spatial variation of (a) pH and (b) Turbidity

(a) We can see here that the autumn season pH is higher than in the summer season. All our selected points have values above 7 in autumn. But in summer some values are above 7 and some below 7 like KC02.

In the case, it’s possible that during the summer season, higher temperatures could cause a decrease in dissolved oxygen levels in the water, which could lead to an increase in pH levels. Additionally, agricultural practices and other human activities that involve the use of fertilizers or other chemicals could also lead to increased pH levels in the sewage. On the other hand, during the autumn season, cooler temperatures and increased rainfall could dilute the concentration of pollutants in the sewage, which could potentially result in lower pH levels.

(b) Here the volatility of the summer season is relatively less than that of the autumn season. Because in the autumn season, various impurities are accumulated through rain, the amount of muddy soil increases, the water is cloudy, etc. That is why the water in the autumn season has more turbidity than in the summer season.

The only exception is the excessive turbidity in the autumn season of Dhaka Uddan (DU05). The reason can be seen here is that in the autumn season, household waste along with other sewage water falls directly into the sewage line through the sewage pipe along with the rain.



(c) (d)

Figure 4.4: Seasonal and spatial variation of (c)Temperature and (d) EC

(c) The temperature is high in summer season because the sun is hot during that time. In this the temperature of the water does not decrease but increases because the temperature of the water increases as the amount of water on the surface increases when the sun heats up in summer. Besides, the rainfall is again less in the summer season, which if not due to reduction in water content, the temperature rises.

On the other hand, the temperature is lower in the autumn season because it is cooler and there is more rainfall which increases the amount of water which reduces the temperature. In addition, because of that time, various substances are mixed in the water, which controls the temperature of the water.

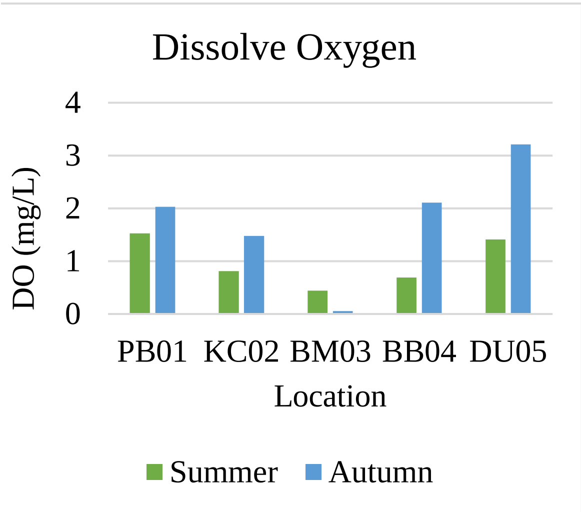
So, the water temperature is high in summer season and the temperature is low in autumn season.

(d) The electrical conductivity of sewage water can vary during the summer and autumn season depending on various factors such as temperature, dissolved solids, and organic matter content. Typically, higher temperatures during the summer season can increase the electrical conductivity of water due to the increase in the ionization of dissolved solids. Additionally, the organic matter content and the presence of dissolved solids can also affect the electrical conductivity of sewage water.

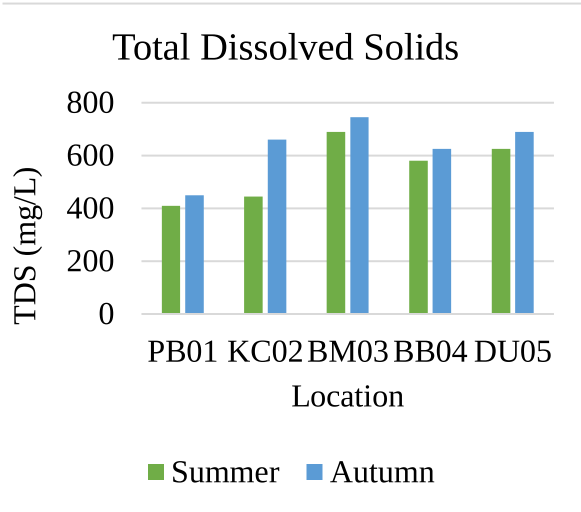
In general, sewage water has a higher electrical conductivity than clean water due to the presence of dissolved salts, metals, and other ions. However, the exact value of electrical conductivity can vary depending on the specific characteristics of the sewage and the surrounding environment.

In that case, the increase in electrical conductivity in sewage lines during the autumn season can be caused by several factors. One of the main factors is the increase in the number of dissolved ions in sewage water due to the decomposition of organic matter. During the autumn season, there is often an increase in the amount of organic matter in sewage water due to the falling of leaves and other plant matter. As the organic matter decomposes, it releases ions such as nitrogen, phosphorus, and potassium, which can increase the electrical conductivity of the water.

In addition, the increase in electrical conductivity can also be caused by the presence of inorganic salts in the sewage water. These salts can come from a variety of sources, including runoff from roads and sidewalks, fertilizers used on lawns and gardens, and industrial processes that release salts into the environment. During the autumn season, there may be an increase in the use of fertilizers and other chemicals, which can lead to an increase in the number of salts in the sewage water and thus an increase in electrical conductivity.



(e)



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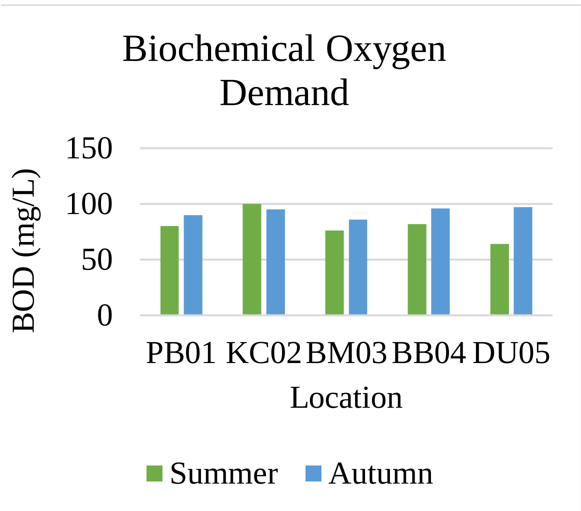
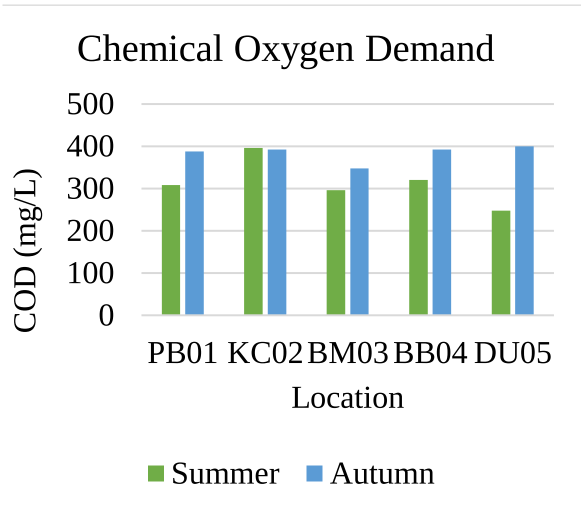


(g)



(h)

Figure 4.5: Seasonal and spatial variation of (e) DO, (f) TDS, (g) BOD and (h) COD

(e) During the summer season water may have less dissolved oxygen because the water temperature is higher during that time. Low and high temperatures attract dissolved oxygen from the water, and low and high temperatures can shorten the lifespan of organisms and cause their death. Also, the temperature and level of water can vary from second to second, and the above problems can be exacerbated if the number of organisms in an environment increases.

On the other hand, water may have more dissolved oxygen during the fall season because the water temperature is lower at that time. During this time the water can have a higher level of dissolved oxygen than the water and preserve the life of the animals.

Another difference is observed in the case of Baitul Monowar Jame Mosque (BM03), where DO value is very low compared to summer. Sometimes the dissolved oxygen of the water can be low in the autumn season because of the movement of water, temperature and due to the increase in the number of animals due to various reasons; the above problems can be seen in both seasons.

(f) The Total Dissolved Solids (TDS) in sewage water can vary depending on several factors such as the amount and type of wastewater generated, the efficiency of the treatment plant, and the dilution of the treated wastewater. In general, TDS is a measure of the concentration of dissolved inorganic and organic substances in water, and it includes minerals, salts, metals, and other substances.

During the summer season, the TDS in sewage water may be higher due to increased water demand and usage, which can result in more wastewaters being generated. Additionally, higher temperatures during the summer can cause more rapid microbial growth, which can increase the concentration of organic matter in the wastewater and thus increase TDS.

During the autumn season, the TDS in sewage water may also be affected by factors such as changes in water usage and temperature. However, the effects of these factors on TDS can be less pronounced than during the summer season.

In this case, there can be various reasons for the abnormal increase in TDS (Total Dissolved Solids) in sewage lines during the autumn season. One possible reason could be the reduction in the flow rate of sewage due to lower rainfall and water levels in rivers, which can lead to an increase in the concentration of dissolved solids in the water. Another reason could be the increased discharge of industrial effluents during the autumn season, which may contain high levels of dissolved solids such as salts, minerals, and metals. Additionally, the use of fertilizers and pesticides during the harvest season can also contribute to the increase in TDS levels in the sewage water.

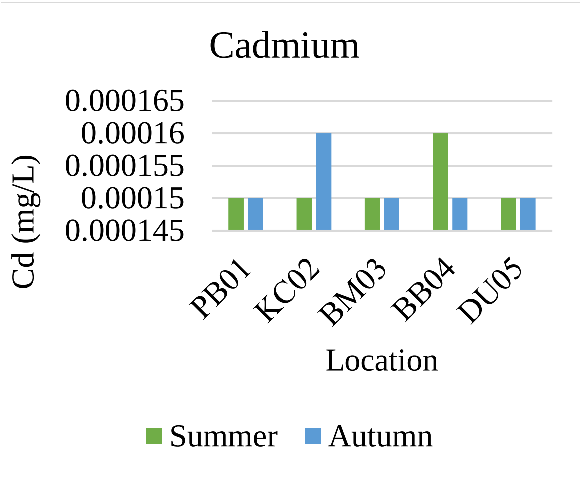
(g) Generally, the BOD level of sewage water can be higher during the summer season because chemicals and organic matter are more present in the water during this time. Warmer water and warmer temperatures should have less oxygen, but BOD levels can be higher due to warmer temperatures in summer.

On the other hand, BOD levels of sewage water may be lower during the autumn season because the water is cooler than in winter and the water contains more oxygen. Also, BOD levels of sewage water may be lower during the autumn season because the organic and inorganic content of sewage water is lower during this period.

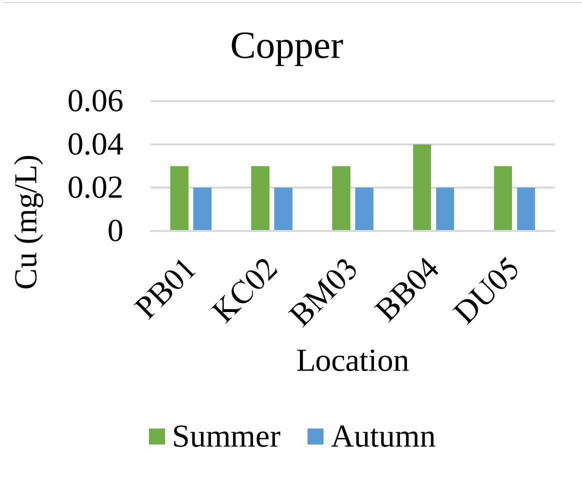
Sometimes sewage water may have low BOD levels during the autumn season because of fluctuating water temperature or warmth or oxygen levels. The BOD levels can be higher or lower than expected due to factors such as pollution from industrial or agricultural sources, sewage discharge, or natural disasters such as floods or droughts.

(h) The COD (Chemical Oxygen Demand) of sewage water can vary in summer and autumn seasons due to several factors such as changes in the temperature of the water, the inflow of different types of pollutants, and variations in the composition of the sewage. Generally, higher temperatures in summer can increase the rate of biological activity in the sewage, leading to an increase in the COD levels. On the other hand, in autumn, the inflow of pollutants such as leaves, and other organic matter can increase the COD levels. However, the COD levels can also depend on the treatment processes that are applied to the sewage before it is discharged into the environment. Proper treatment processes such as biological treatment, chemical treatment, and physical treatment can help to minimize the COD levels in sewage water, regardless of the season.

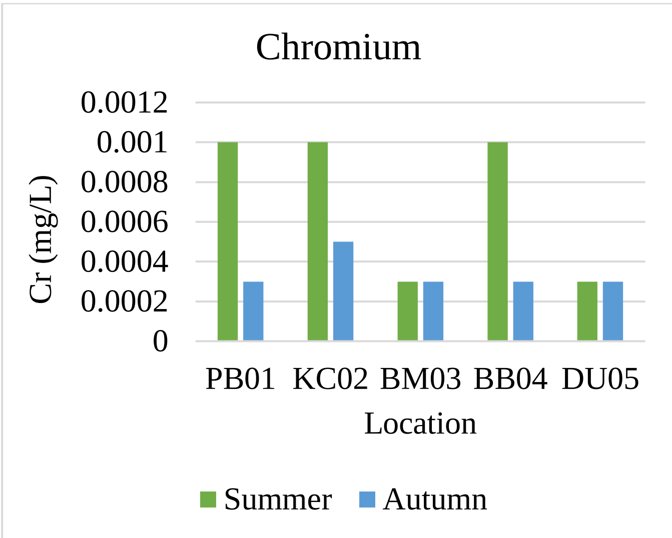
In our study we found that COD in autumn season is slightly higher than in summer.



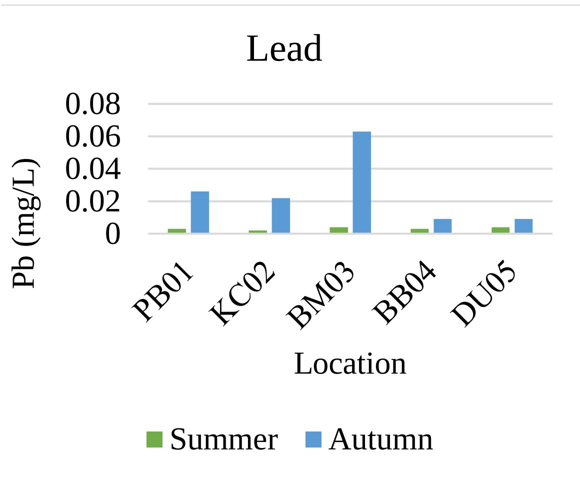
(i)



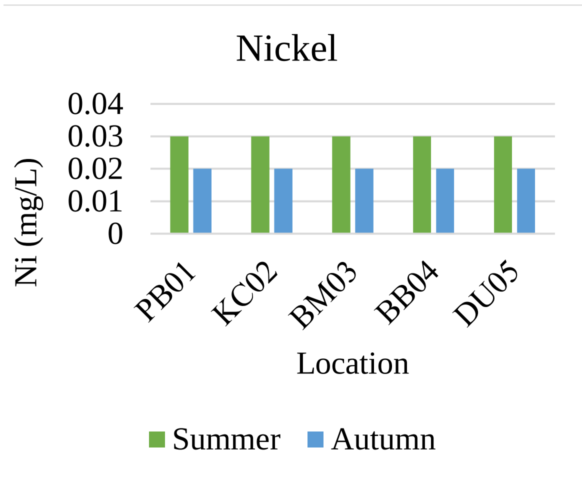
(j)



(k)



(l)



(m)

Figure 4.6: Seasonal and spatial variation of (i) Cd, (j) Cu, (k) Cr, (l) Pb and (m) Ni

(i) The concentration of cadmium in sewage water can depend on various factors such as human activities, industrial discharge, weather conditions, and geological factors. However, it is possible that the concentration of cadmium in sewage water remains mostly the same during the summer and autumn seasons in a particular location due to several reasons.

Firstly, the source of cadmium contamination might be consistent throughout the year, such as an industrial discharge point, which continues to release cadmium into the sewage water at a relatively constant rate.

Secondly, the flow rate and water level of the sewage might not change significantly between the summer and autumn seasons, which can lead to the mixing and dilution of cadmium being consistent throughout the year.

Thirdly, the adsorption and desorption of cadmium on the sewage bed sediments might be relatively stable and consistent throughout the year, which can also contribute to the similar levels of cadmium in sewage water during the summer and autumn seasons.

Overall, it is possible that a combination of these factors and others could result in the levels of cadmium in sewage water being mostly the same during the summer and autumn seasons in a particular location.

Also, the potential for cadmium may be higher in the autumn season because there may be more used water that cadmium can easily leach into. Similarly, water temperatures may be high during the summer season and at the same time, limited space may be used, which may create a different equilibrium environment for cadmium.

That's why KC02 autumn and BB06 summer season values look exceptional.

(j) The concentration of copper in sewage water can vary depending on several factors such as the sources of wastewater, the type of plumbing materials used in buildings, and industrial discharges. However, in general, the concentration of copper in sewage water is not significantly influenced by seasonal changes. The level of copper in sewage water is more likely to be affected by industrial activities and the types of plumbing materials used in buildings. Therefore, it is important to regularly monitor and control the sources of wastewater discharge and the types of plumbing materials used to minimize the concentration of copper in sewage water.

(k) The concentration of Chromium in sewage water can vary depending on several factors such as the source of the wastewater, industrial discharges, and the treatment process.

However, some studies have shown that the concentration of chromium in sewage water tends to be higher in the summer and autumn seasons compared to other seasons. This can be attributed to factors such as increased industrial activity during these seasons, which can lead to the discharge of untreated or poorly treated wastewater containing high concentrations of chromium into the sewage system.

In addition, high temperatures during the summer season can also lead to an increase in the solubility of chromium in water, which can contribute to higher concentrations of the metal in sewage water.

There can be several factors that can cause an abnormal increase in chromium in sewage lines during the summer season. Some possible reasons are:

Increased industrial activity: During the summer season, industries tend to operate at full capacity due to favorable weather conditions, resulting in an increase in industrial wastewater discharge. If industries are discharging wastewater that contains chromium, it can increase the chromium concentration in the sewage lines.

Decreased water flow: During the summer season, the water flow in the sewage lines can decrease due to low rainfall and high evaporation rates. This decreased flow can cause the chromium to accumulate and increase in concentration.

Sewage line corrosion: Sewage lines can be made of different materials, and some of these materials, such as iron, can corrode over time. Corrosion can release chromium from the pipe material and increase the chromium concentration in the sewage lines.

Agricultural activities: During the summer season, agricultural activities like the use of fertilizers and pesticides can increase the chromium concentration in the soil, which can eventually make its way into the sewage lines through groundwater contamination.

(l) The concentration of Pb (Lead) in sewage water can vary depending on various factors such as industrial discharges, sewage inflow, and runoff from urban areas. However, generally, the concentration of Pb in sewage water can be higher in the summer season compared to the autumn season. This is because, during the summer season, there is a higher amount of runoff from urban areas due to increased rainfall, which can contribute to a higher concentration of Pb in the sewage water. Additionally, industrial discharges and sewage inflow can also contribute to higher levels of Pb in the sewage water during the summer season. However, it is important to note that the concentration of Pb in sewage water can vary depending on the location.

Among our selected points, station BM03 (Baitul Monowar Jame Mosque) shows an unusual increase in Pb during the autumn season. There could be several reasons for an abnormal increase in Pb (Lead) in sewage lines during the autumn season. Some possible factors are:

Industrial activities: Autumn is a time when many industries start production after the summer break. If any of these industries release wastewater containing lead into the sewage lines, it can cause an increase in lead levels.

Weather conditions: Autumn is a transitional period from summer to winter, and it is characterized by changes in temperature, humidity, and rainfall. These changes can affect the flow and composition of wastewater in sewage lines, which can increase the concentration of lead.

Human behavior: During the autumn season, people tend to engage in activities such as hunting, fishing, and home repairs. These activities can lead to the generation of lead-containing waste, such as spent ammunition, fishing sinkers, and paint chips, which can end up in the sewage lines.

Infrastructure maintenance: In many places, autumn is a time when infrastructure maintenance work, such as road repairs, takes place. This can lead to the disturbance of soil and sediment, which can contain lead, and this can ultimately end up in the sewage lines.

(m) Nickel is relatively stable in the environment and does not undergo significant changes or reactions in sewage lines. Therefore, its concentration remains relatively constant throughout the year and does not show significant seasonal variations. However, it is important to note that excessive levels of nickel in sewage can still be harmful to the environment and human health.

4.9 The possible solution how to minimize the toxicity of the waste:

Reducing the toxicity of waste can involve several steps, including:

Implementing source control: This involves reducing the number of toxic substances being released into the sewage system in the first place. Industries and businesses can be required to use less toxic chemicals or switch to non-toxic alternatives.

Advanced treatment methods: Advanced wastewater treatment methods, such as membrane filtration, activated carbon filtration, or ozonation, can be used to remove toxic substances from sewage.

Improving sewage treatment processes: The performance of sewage treatment plants can be improved by optimizing operational parameters, such as pH, temperature, and aeration, to ensure maximum removal of toxic substances.

Promoting public awareness: Educating the public about the harmful effects of toxic substances in sewage waste can encourage them to adopt environmentally friendly practices, such as disposing of hazardous waste properly.

Regular monitoring: Regular monitoring of the sewage system and effluent can detect any changes in toxicity levels and help in identifying the sources of toxic substances.

Separating hazardous waste: Separating hazardous waste at the source before it enters the sewage system can prevent toxic substances from entering the wastewater treatment process.

Collaboration: Collaboration between governments, industries, and communities can lead to more effective solutions and the development of new technologies to reduce the toxicity of sewage waste.

Implementing these steps can help to minimize the toxicity of sewage waste, leading to a cleaner and healthier environment.

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 General

Sewerage lines are an essential component of modern infrastructure that enables the safe and efficient disposal of wastewater and sewage from residential, commercial, and industrial areas. The proper design, construction, and maintenance of sewerage lines are critical to prevent blockages, backups, and environmental contamination. Regular inspections and cleaning are necessary to ensure the optimal performance of sewerage lines, and repairs should be made promptly to prevent further damage. The proper disposal of wastewater through sewerage lines is critical for protecting public health and the environment. Wastewater contains various pollutants, including organic matter, nutrients, pathogens, and chemicals, which can cause water pollution and health hazards if not treated appropriately. Sewerage lines play a crucial role in safely transporting wastewater from homes, businesses, and communities to treatment facilities, where it can be treated and discharged into the environment. To ensure the safe and efficient operation of sewerage lines, regular maintenance and management are necessary, including inspections, cleaning, and repairs. Moreover, the use of advanced technologies, such as smart sensors and data analytics, can improve the monitoring and management of sewerage systems and prevent failures or disruptions. Proper wastewater management through sewerage lines is essential for protecting public health, preserving natural resources, and ensuring sustainable development. To address these concerns, this study was carried out to assess the current water quality of selected sewers associated with the Buriganga River. Including seasonal variations and identifying major sources of pollution and their impacts on the line. The study was conducted during the summer and late fall seasons in 2022.

5.2 Conclusion

According to Table 4.5: Water Quality Index based on WWQI value (Khudair et al. 2018) the range of pollution is greater than 400, which indicates that the obtained result 255210.288 is very polluted. As per the analysis of the provided effect sizes, it appears that temperature has the biggest effect size, with a value of 4.156, indicating a very significant impact with season. Turbidity, DO, and TDS have medium effect sizes ranging from 0.727 to 0.913, which suggests a moderate impact with season. Cd and Ni have no effect size with values of 0, which suggests that these factors may not have any impact with season.

According to simple bar chart DU05 is the most toxic site than others. On the hand PB01 is the lowest toxic site in the investigation. The level of toxicity vary from highest toxic place to lowest toxic place is (DU05>BM03>BB04>KC02>PB01).

To minimize the toxicity of waste, solutions may be implementing waste reduction and recycling of wastages, proper waste disposal, would be mandatory to set up wastewater treatment systems in the industries, create awareness to the general people about proper handling and disposal of hazardous waste.

Simple oxidation, ozone hypochlorite treatment, hydrogen peroxide, bioreactors, biological activated sludge (bas), microbiological treatments, enzymatic decomposition and lagoon cleaning, etc. traditional methods can be used for the treatment of polluted industrial wastewater.

5.3 Recommendations

1. Only 2 seasons were studied in this paper, but if more seasons were studied in the future, more information would be available.

2. Only 5 locations have been investigated in this paper, but if more locations are studied, more results will be available.

3. In this thesis paper, 13 parameters have been worked, but if more parameters are worked on in the future, more information will be obtained.

4. Industries should be used advanced wastewater treatment methods, such as membrane filtration, activated carbon filtration, or ozonation to reduce toxic substances from sewage.

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