

AN EVALUATION STUDY ON THE TREATMENT PERFORMANCE OF DASHERKANDI SEWAGE TREATMENT PLANT IN DHAKA CITY

Abid Hossain Niaz¹, Sadia Sarmin² and Nehreen Majed³

¹Student, University of Asia Pacific, Bangladesh, e-mail: 19205010@uap-bd.edu

²Student, University of Asia Pacific, Bangladesh, e-mail: 19205029@uap-bd.edu

³Professor, University of Asia Pacific, Bangladesh, e-mail: nehreen-ce@uap-bd.edu

ABSTRACT

The Dasherikandi Sewage Treatment Plant (DSTP) is Bangladesh's largest and most modern facility for sludge drying and incineration. It covers 24 hectares and handles an amazing 560 tons of sludge every day, treating wastewater for about five million people in Dhaka. The treated water is discharged into the Gazaria Canal, which finally drains into the Balu and Buriganga rivers. The purpose of this study was to assess the DSTP's efficiency and performance, as well as its environmental effect, in order to determine the sustainability of the wastewater management option. Samples were collected from five treatment stages of the plant. Inlet and outlet samples assessed treatment efficiency, while Gazaria canal samples evaluated environmental impact. Water quality parameters were tested at the University of Asia Pacific, following standard protocols and compared with ECR'23 discharge and surface water standards. Despite some challenges, the plant positively impacts aquatic life, local businesses, and recreational opportunities.

INTRODUCTION

Sewage is essentially a mixture of organic and inorganic components, as well as intact biological organisms (bacteria and viruses), which combine to form a highly complicated cocktail. (M. Mudge & S. Ball, 1964). Sewage is the waste and wastewater produced by residential, commercial, and industrial activities containing suspended and dissolved organic solids like human excreta, water from washing, bathing, and cleaning, along with other waste like food scraps, chemicals, and debris. It also includes inorganic solids such as metals, and pathogenic viruses and bacteria (Hassan, et al., 2017).

In the Asia and Pacific region, there is a growing competition for scarce freshwater resources, leading to significant challenges. Alarmingly, around 80-90% of the wastewater generated in this region is discharged without any treatment, resulting in the pollution of groundwater, surface water, and coastal ecosystems. To tackle these issues and ensure the provision of safe water for everyone, it is imperative for governments, local organizations, and communities to collaborate and take action to address water and sanitation concerns (Molla, 2017). According to the United Nations World Water Development Report 2017, on an average, high-income countries treat about 70 percent of the municipal and industrial wastewater they generate. That ratio drops to 38 percent in upper middle-income countries and to 28 percent in lower middle-income countries. In low-income countries, only 8 percent undergoes treatment of any kind. Globally over 80 percent of all wastewater is discharged without treatment. In India, land discharge of wastewater has been practiced since the second quarter of this century, and associated problems have been connected to the amount of sewage treatment, dilution, hydrological and nutrient loadings, and crops (Pescod & Arar, 1985). Israel is the world leader in wastewater recycling. Nearly 90% of wastewater in Israel is treated for reuse, most of it in agricultural irrigation. While Israel reuses almost all of its wastewater, Europe recycles merely 60%. The future goal is, naturally, to recycle the entire volume. UN's and Utrecht University's findings suggest that 52% of global wastewater is treated in the WWTPs. So, the percentage is higher than previously expected (Hydrotech, 2021).

Bangladesh, a developing country with a high population density, faces significant challenges in providing access to safe water and sanitation. However, in recent years, there has been considerable progress in reducing the incidence of water-borne diseases through increased awareness and efforts by local and international organizations. UNICEF reports that 38.3% of Bangladeshis drink water polluted by bacterial sources, and the country treats only 17% of its wastewater, according to the United Nations World Water Development Report 2017. Rivers like the Buriganga and Karnaphuli are heavily polluted by untreated sewage containing microplastics, antibiotics, and other contaminants. This is

greatly harming the aquatic ecosystems, contributing to antibiotic resistance (Mongabay, 2023).

The population of Dhaka city is growing fast, and the present sewage infrastructure is unable to meet the constantly increasing demand from the expanding population (Noor Mohammed, 1988). According to the Dhaka Water Supply and Sewerage Authority (DWASA) in 2021, Dhaka generates approximately 2.3 million cubic meters of sewage per day. Unfortunately, the existing sewage treatment plants can only process around 35% of this amount, which is roughly 800,000 cubic meters per day. That means that about 65% of the sewage remains untreated and is discharged into the environment, leading to significant environmental and health risks. The city has a sewer line network that spans 881 kilometers, but outside of Dhaka, there is no existing sewerage system in place in any other areas of the city (Siddiqui & Islam, 2021). Additionally, there aren't enough STPs to adequately treat all the sewage. Dhaka relies on storm sewage lines due to the absence of a ground storage system for sewage waste, but unfortunately, these lines are also largely dysfunctional. This results in the release of untreated sewage into the water (Sakib, 2022).

The Pagla Sewage Treatment Plant (STP) is the oldest STP in Bangladesh, located on the bank of the Buriganga River in Dhaka. It was established in 1989 and has a capacity of treating 36 million liters of sewage per day (Alam, 2015). As per the World Bank report, the Pagla Sewage Treatment Plant (STP) receives approximately 27 million liters of sewage each day, which accounts for only about 25% of the total sewage generated in Dhaka. Despite its large capacity, the Pagla STP has faced several challenges over the years, including inadequate funding for maintenance and repair, lack of skilled personnel, and a high level of contamination in the incoming sewage due to the presence of industrial waste. As a result, the STP is not operating at full capacity, and a significant amount of untreated sewage is still being discharged into the Buriganga River, causing severe environmental pollution (Alam, 2015). The Dasherbandi Sewage Treatment Plant is set to be Bangladesh's largest modern sewage treatment plant, the largest sewage treatment plant in South Asia, and the modern sludge drying incineration in Bangladesh (Islam, 2022). WASA will then build four more sewage treatment plants at Rayerbazar, Uttara, Mirpur, and Narayanganj's Fatullah. WASA plans to convert the Rayerbazar sewage treatment plant into an underground treatment plant. It has the potential to treat sewage for roughly 5 million people in Dhaka every day (Islam, 2022). This additional treatment plants aim to reach full coverage by 2030 (Dhaka Tribune, 2023)

Performance evaluation of existing treatment plants is necessary to analyze effluent quality and determine if the treatment plant is capable of handling higher hydraulic and organic loadings. Frequent and accurate sampling and laboratory analysis are essential tools for effective process control. Poor sewage system conditions, plant design weaknesses, and organizational issues might prevent treatment plants from meeting effluent standards. Also, the poor performance of wastewater treatment plants can be caused by factors such as population growth, increased water demand, and discharge of trade effluents (KUMAR, Pitta, & Babu M, 2010).

Objectives of the Study:

1. To study the efficiency and performance of the Dasherbandi Sewage Treatment Plant.
2. To monitor the removal of contaminants across different phases of the plant.
3. To assess the environmental impact of this treatment plant on the surroundings.

METHODOLOGY

To find out the treatment performance of Dasherbandi Sewage Treatment Plant in Dhaka city, the research needed to accomplish several stepwise activities. The steps of this research are summarized in figure 1.

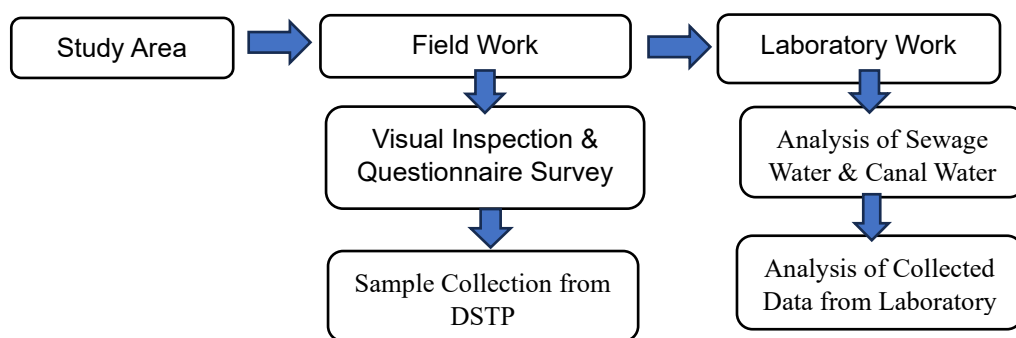


Figure 1 Methodological framework for Steps involved in this research

Study Area

The Dasherikandi Sewage Treatment Plant is set to be Bangladesh's largest modern sewage treatment plant, the largest sewage treatment plant in South Asia, and the modern sludge drying incineration in Bangladesh. (Islam, 2022). The Dasherikandi Treatment Plant, which falls under Khilgaon Police Station, is close to Aftabnagar and will treat sewage from multiple areas of the city, including Gulshan, Banani, DOHS, Aftabnagar, Badda, Magbazar, Niketan, Kalabagan, Dhanmondi (part), and Hatirjheel.

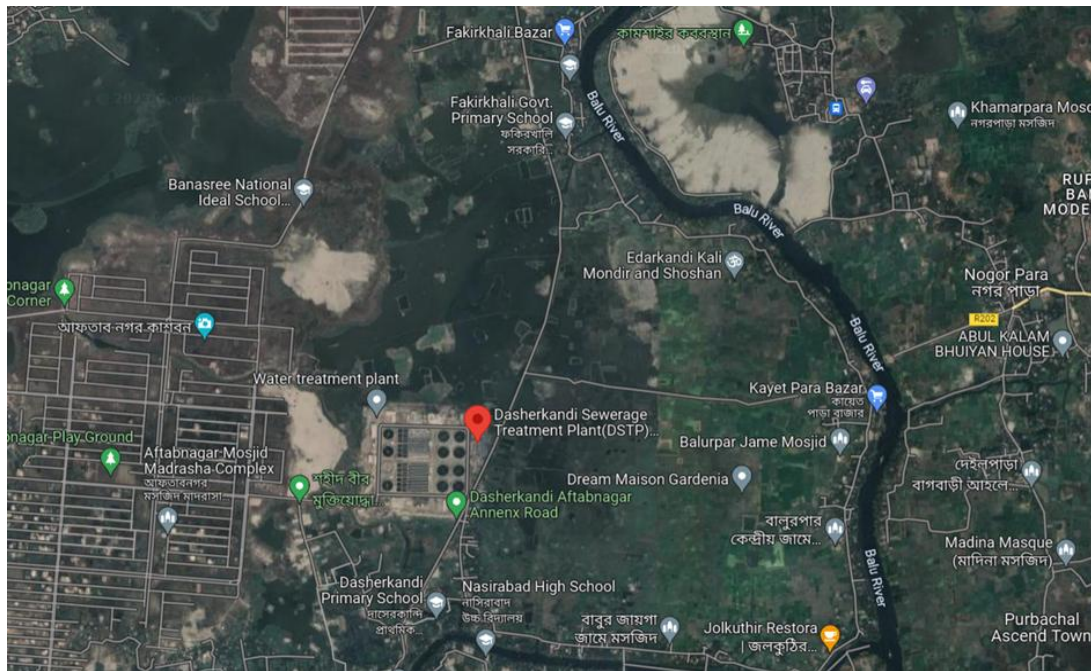


Figure 2 Location of Dasherikandi Sewage Treatment Plant (Google Map)

Collection

Samples were collected in different phases of DSTP. For efficiency evaluation, samples were collected from the Inlet and Outlet was disposed of treated water. A total of six samples were collected for performance evaluation. Figure 3 shows the different phases of DSTP in a flow chart in which, yellow boxes indicate sampling points such as Inlet, primary sedimentation tank (PST), Anaerobic Anoxic Oxic (AAO) tank, secondary sedimentation tank (SST), outlet and Gazaria canal.

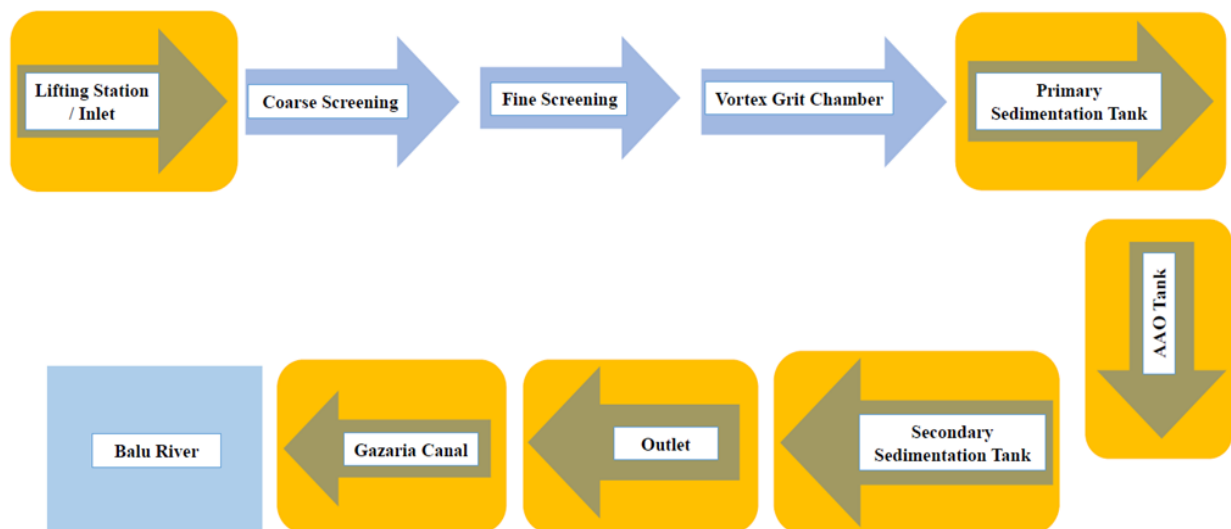


Figure 3 Flow Chart of Different Phases of DSTP (Yellow Boxes are Stand for the Phases from Where Sample are collected)

Data Analysis Procedure

This study was conducted in several stages. Firstly, the samples were collected and analyzed in the laboratory for dissolved oxygen (DO), total suspended solids (TSS), total dissolved solids (TDS), Ammonia (NH₃-N), Nitrite (NO₂-N), Nitrate (NO₃-N), Biochemical Oxygen Demand (BOD₅), Chemical Oxygen Demand (COD) etc. After obtaining results of various parameters from laboratory tests, these were averaged and then compared to the regulatory standard ECR'23. The performance of the DSTP was evaluated by comparing the concentrations of the contaminants of raw with those of the effluent data, while also comparing with the percentage removal of the contaminants. The data was then compared to the outfall discharge quality standards. To assess the environmental impact of DSTP, canal water was also collected and tested for different water quality parameters. Finally, the results were compared to surface water discharge standards.

Social Impact Assessment

A questionnaire survey was conducted in this research to gather data on the social impact of the DSTP.

Interview with Local Households

Primary data on impact was collected through interviewing the household and local people. The interview was conducted in 30 houses. The study's goal was to evaluate the efficiency and environmental impact of wastewater treatment. This will help with decision-making about environmental impact analysis. A semi-structured interview was an appropriate strategy for the study because questions not included in the questionnaire were asked, and new questions were raised as ideas emerged. Each interview lasted 5 to 10 minutes on average. The interview questions covered a broader range of perspectives on the establishment of DSTP and its influence.

Interview with Local Workers

Primary data was also collected by visiting the area of DSTP and the people who are involved in various work. The key informant interviewed the local workers about the sewage wastewater effluent and the impact of the effluent on their field. The study was conducted following a variety of methodologies, techniques, and tools to obtain appropriate and authentic information.

RESULT AND DISCUSSION

This chapter describes the water quality parameters of DSTP with respect to various water quality parameter analysis to understand the current water quality of DSTP. This section includes a brief description of sample testing as well as a comparison of the results.

Evaluation of DSTP Dissolved Oxygen (DO)

From Figure 4, it can be shown that the Inlet, PST, and AAO have the lowest DO below 5 mg/L, which means BOD₅ is high in those stages, and the value is increased in the SST and Outlet, which are above 5 mg/L. Water that has a DO value of 5 mg/L or above means the water is usable by fisheries, various processing and cooling industries, and also for irrigation. The figure shows the variation of DO concentration in different phases.

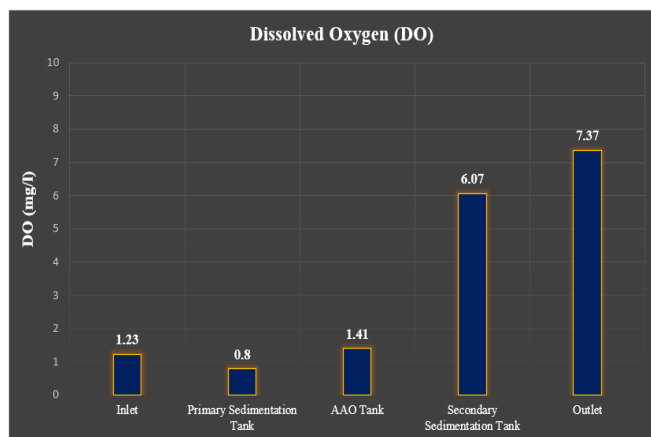


Figure 4 DO concentration along different phases of DSTP

Total Suspended Solids (TSS)

As with municipal wastewater, suspended solids analysis is important to measure the strength of industrial wastewater and the effectiveness of industrial wastewater treatment. The figure shows the variation of TSS concentration in different phases. Figure 5 shows that AAO has the highest TSS concentration and SST has the minimum concentration, which means DSTP has good efficiency in treating waste water.

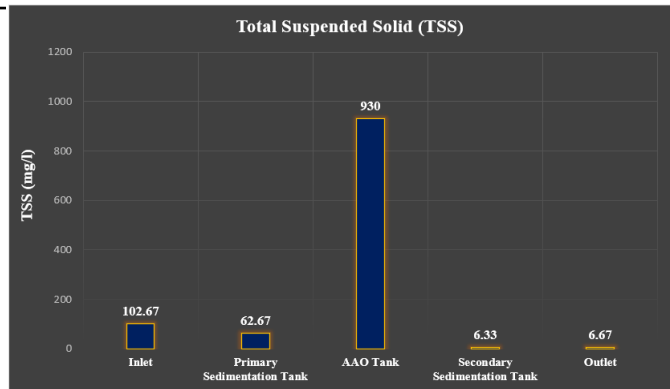


Figure 5 TSS concentration along different phases of DSTP

Total Dissolved Solids (TDS)

It indicates the sum of all organic and inorganic components detected in the wastewater. The total dissolved solids (TDS) in drinking water shall not exceed 1000 mg/L, according to Bangladesh Environment Conservation Rules (2023). The result shows the lowest concentration of TDS in the SST and the highest concentration in the Inlet. It means SST has good efficiency for this parameter. Figure 6 shows the variation of TDS concentration in different stages.

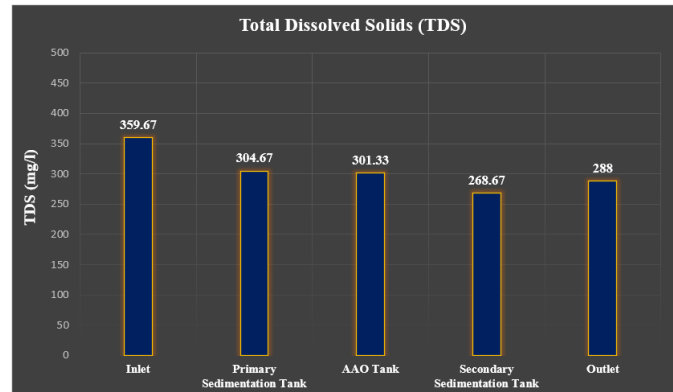


Figure 6 TDS concentration along different phases of DSTP

Ammonia (NH₃-N)

Figure 7 shows the variation of NH₃-N concentrations in different phases. The inlet has the highest amount of Ammonia. However, the outlet has a small amount of ammonia present.

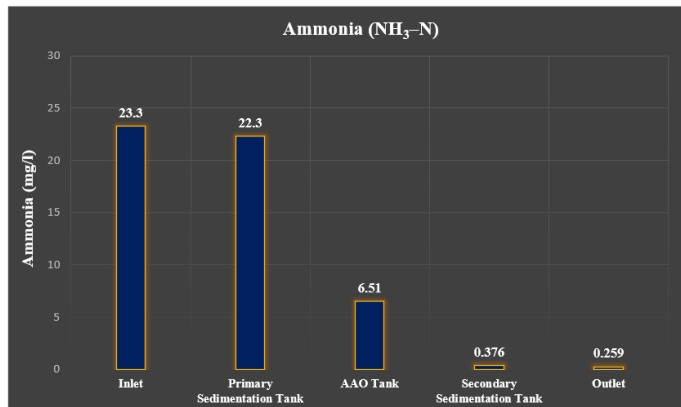


Figure 7 Ammonia (NH₃-N) concentration along different phases of DSTP

Nitrate (NO₃-N)

Figure 8 shows the variation of NO₃-N concentration in different phases. From the figure, it is shown that AAO has the highest NO₃-N concentration and SST has the minimum concentration. Denitrification is the process of removing nitrogen from activated sludge. It is a bacterial process.

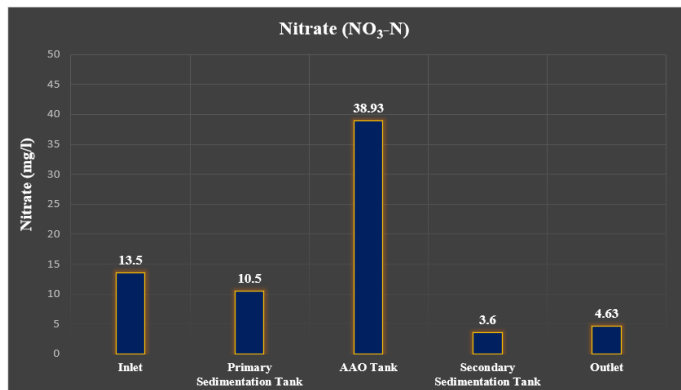


Figure 8 Nitrate (NO₃-N) concentration along different phases of DSTP

Nitrite (NO₂-N)

There is a little variation in the concentration of NO₂-N. Figure 9 shows the variation of NO₂ concentration in different phases.

Phosphate (PO₄)

Figure 10 shows the variation of Phosphate concentration in different phases. The AAO tank has the maximum Phosphate concentration, and SST has the lowest Phosphate. Phosphorus removal is achieved through biological routes, utilizing phosphate-accumulating organisms (PAO) in sequential anaerobic and aerobic environments.

Biochemical Oxygen Demand (BOD₅)

The BOD₅ of water is the quantity of oxygen necessary for the biological decomposition of dissolved organic matter to occur under normal conditions at a standard time and temperature. Typically, the period is considered to be 5 days, and the temperature is 20°C. From the result, inlet and AAO BOD₅ are high, but outlet BOD₅ is less than 6 mg/L. The water is usable by fisheries, various processing and cooling industries, and also useable for irrigation. Figure 11 shows the variation of BOD₅ concentration in different phases.

Chemical Oxygen Demand (COD):

COD is the measurement of the oxygen demand of the waste in terms of the total quantity of oxygen required for the oxidation of the waste to carbon dioxide and water. Figure 12 shows the variation of COD concentration in different phases. It indicates the efficiency of the treatment process. From the result, inlet and AAO tank COD are high, but outlet COD is minimal.

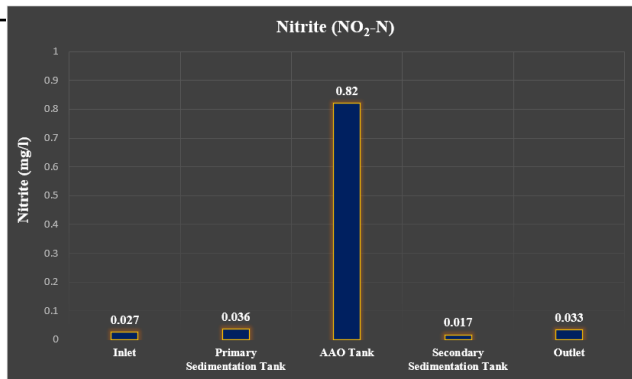


Figure 9 Nitrite (NO₂-N) concentration along different phases of DSTP

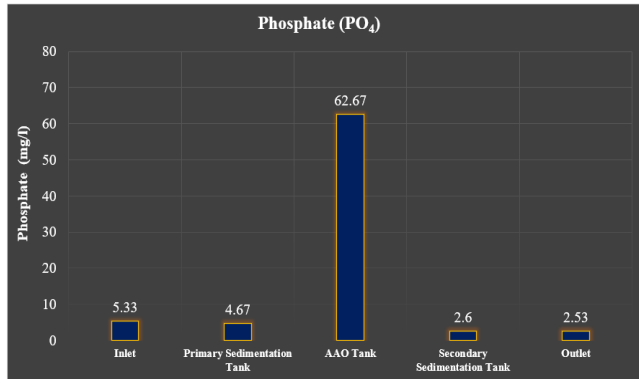


Figure 10 Phosphate (PO₄) concentration along different phases of DSTP

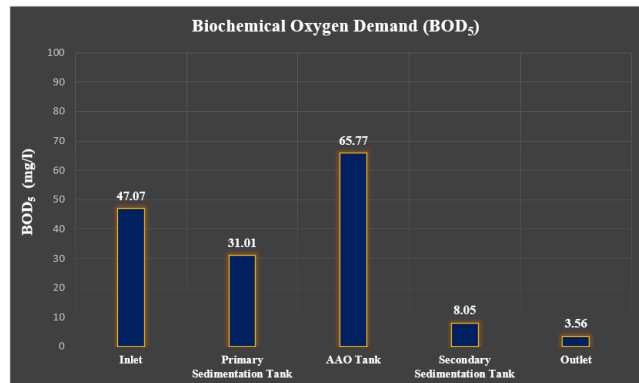


Figure 11: BOD₅ concentration along different phases of DSTP

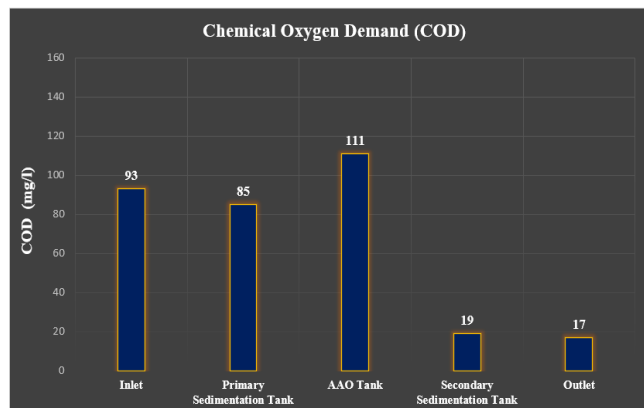


Figure 12 COD concentration along different phases of DSTP

Table 2 shows the percentage removal of different contaminants.

Table 2 Percentages removal of tested parameters

Types of Water Quality Parameters	TSS (mg/L)	TDS (mg/L)	Ammonia (NH ₃ -N) (mg/L)	NO ₂ -N (mg/L)	NO ₃ -N (mg/L)	COD (mg/L)	BOD ₅ (mg/L)	Phosphate (PO ₄) (mg/L)
% Removal	93.50 %	19.93 %	98.89%	0%	65.73 %	81.72 %	92.44 %	52.53%

Impact on Water Quality

The treatment plant's effluent is discharged into the Gazaria Canal, which eventually goes into the Balu River. To analyze the environmental impact, samples were taken from different points (50 m, 100 m, and 150 m) throughout the canal. Then the average surface water quality parameters of the Gazaria Canal along with standard deviations among measurement points (shown in error bars) are shown in the bar chart in Figure 13. The bar chart illustrates the average values and the variability (uncertainty) for water quality parameters. Each bar shows the average measurement of the parameter, while the error bars indicate the variability or standard deviation around these averages. Table 3 shows the comparison of surface water of Gazaria Canal with surface water quality standards for Bangladesh as per ECR'2023. This evaluation provides valuable insights into the canal's water quality as well as assessment of environmental impact.

Dissolved Oxygen (DO)

Dissolved Oxygen is one of the most commonly used parameters to determine the quality of water. As the DO decreases, the quantity of aquatic life forms also reduces. In figure 13 Dissolved Oxygen (DO) exhibited an average value of 7.8 mg/l, with moderately sized error bars (0.95), reflecting some variability. DO levels indicated moderately healthy water for aquatic ecosystems but need monitoring to prevent depletion.

Total Suspended Solids (TSS)

Figure 13 shows that Total Suspended Solids (TSS) has an average value of 9.3 mg/l, with wide error bars (4.54) indicating significant variability in the data. The average value of TSS concentration is 9.33 mg/l which meets the surface water quality standards for Bangladesh as per ECR'2023 means the water is usable by fisheries, various processing and cooling industries, and for irrigation purposes.

Total Dissolved Solids (TDS)

Total Dissolved Solids is the concentration of all substances dissolved in water and is an important parameter of surface water quality. The average values of TDS are 225.5mg/l which demonstrate that the water has a great aesthetic value and less chemical contaminants.

Nitrite (NO₂-N)

Figure 13 shows Nitrite (NO₂) has a mean value of 0.1 mg/l, with minimum error bars of 0.06, indicating high consistency and precision in this set of data. This meets the standard criteria for surface water quality parameters as per ECR'2023 which is usable by fisheries, various processing and cooling industries, and also for irrigation.

Nitrate (NO₃)

Nitrate (NO₃) showed an average value of 3.92 mg/l with small error bars of 0.39, which represents low variability. The average value of NO₃-N is 3.92 mg/l suggested limited nitrogen-based pollution. It meets the standard criteria for surface water quality parameters as per ECR'2023.

Phosphate (PO₄)

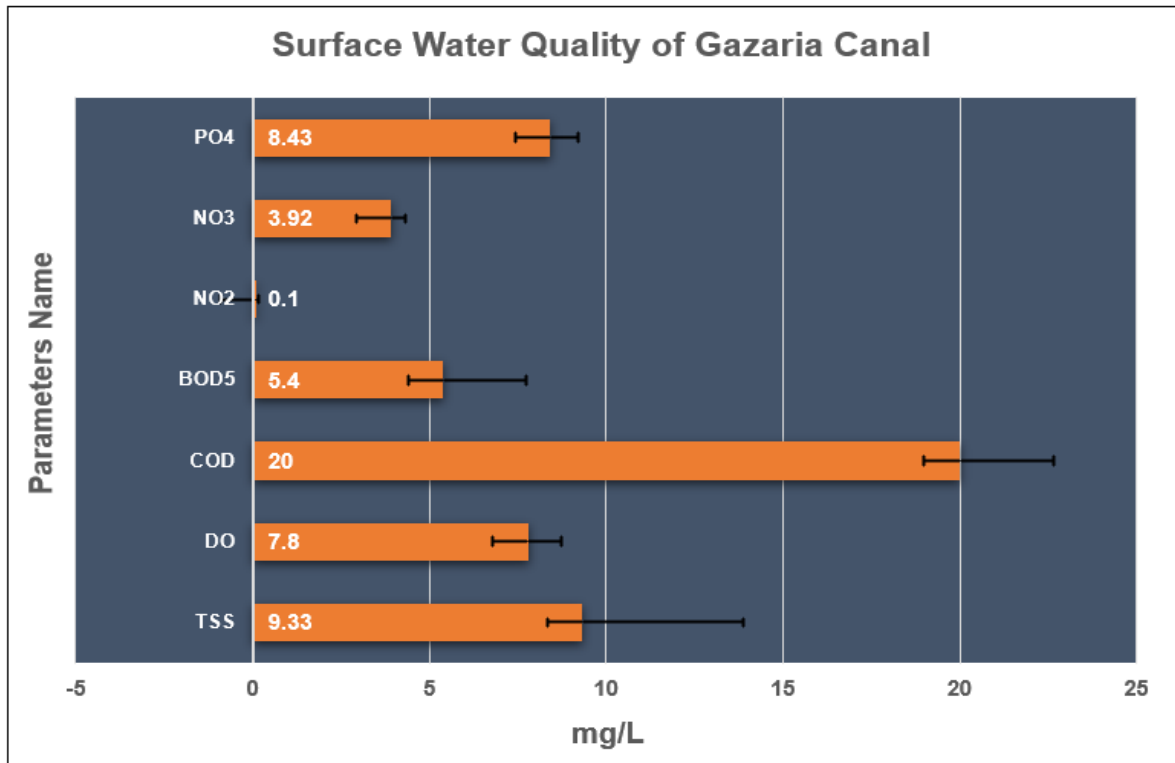
Phosphate is an important water quality parameter for measuring phosphorus. Figure 13 shows the average concentration of PO₄ in surface water in canal Phosphate (PO₄) provides an average value of 8.4 mg/l, with moderate error bars of 0.78, indicating some degree of variation in the readings. The value exceeds the standard values of surface water quality parameters as per ECR'2023. Controlling phosphate is critical to avert long-term ecological damage to the canal ecosystem.

Biochemical Oxygen Demand (BOD₅)

BOD₅ is a measure to see how much oxygen is consumed by bacteria at 20°C for 5 days while the decomposition of organic matter takes place under aerobic conditions. BOD₅ recorded an average value of 5.4 mg/l, with small to moderate error bars of 2.33, indicating consistent data with minor variation. High concentration of BOD₅ which causes more oxygen to decompose. The BOD₅ concentration is higher than the drinking water standard (2 mg/L).

Chemical Oxygen Demand (COD)

COD is another important parameter for measuring the river water quality. It is used to measure the quantity of oxygen needed to oxidize the organic waste into carbon dioxide and water. Figure 13 shows the Chemical Oxygen Demand (COD) is 20 mg/l with relatively large error bars (2.65), implying notable variability highlighting significant organic and particulate pollution in the canal that requires priority in treatment.



Parameter Name	Unit	Standard for Fisheries	Standard for Irrigation	Standard for Drinking Water	Surface Water Quality of Gazaria Canal			Remarks
					50 m	100 m	150 m	
pH	-	6.5–9	6.5–8.5	6.5–8.5	8.17	7.6	7.49	Safe for drinking
TDS	mg/L	1000	1000	1000	230	230.5	216.8	Safe for drinking
TSS	mg/L	-	-	10	7.5	14.5	6	Higher than standard in 100 m
BOD ₅	mg/L	<6	<12	<2	7.96	4.94	3.37	Unsafe for drinking

COD	mg/L	50	100	10	23	19	18	Unsafe for drinking
Nitrate (NO₃-N)	mg/L	7	5	7	3.6	4.35	3.8	Safe
Nitrite (NO₂-N)	mg/L	-	-	1	0.03	0.13	0.13	Safe
Phosphate (PO₄)	mg/L	0.5	2	0.1	9.15	8.55	7.6	Unsafe
Dissolve Oxygen	mg/L	>5	-	>6	8.86	7.55	7.01	Safe

Social Impact of DSTP:

Several questions were asked of the respondents about various impacts of DSTP, such as occupation, age, livelihood, infrastructure development, recreational opportunities.

Owing to DSTP, the mobility of people increased, and that's why their business increased. During the construction of DSTP, many people got jobs here, but many people lost their land and damaged their houses, crops, land.

Many infrastructures have been developed in the zone of DSTP, such as road connectivity, building construction, residential area development, and 95% of people have positive responses and others have no response.

Recreational Opportunity gradually increased around the DSTP that have several positive effects on the community or an individual's quality of life. People can spend their free time in this area. Figure 14 summarizes the respondents' feedback on the social impact of DSTP.

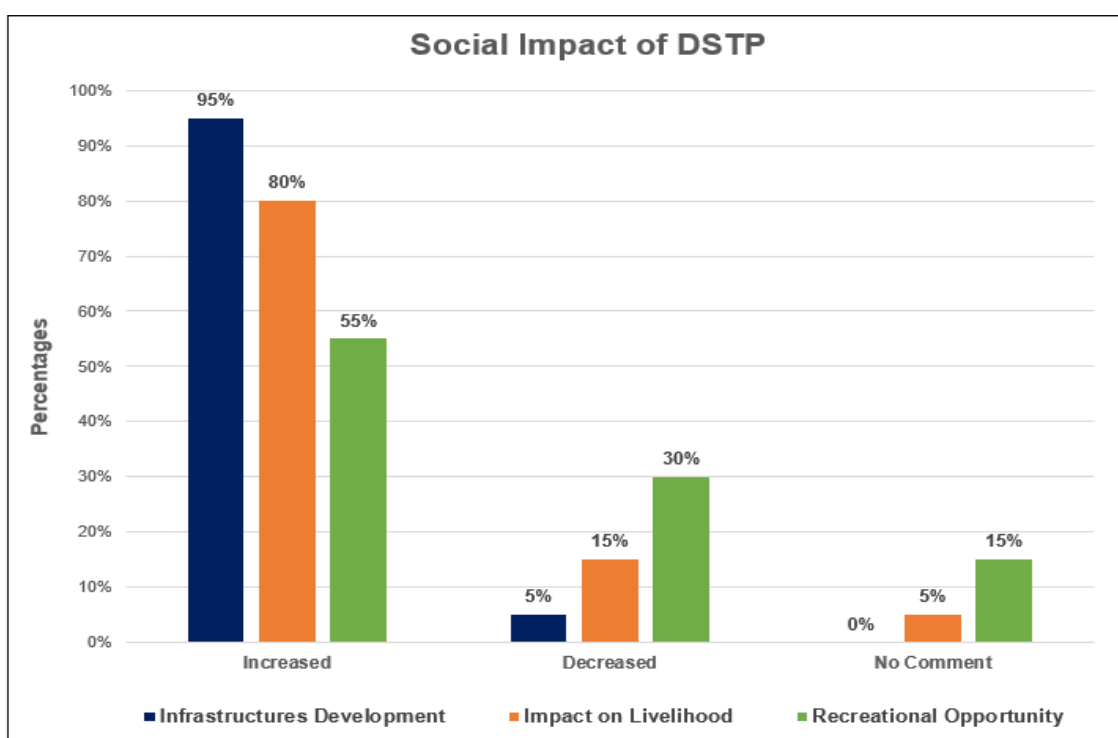


Figure 14 Respondent's opinion about the Social Impact of DSTP

DISCUSSION

For monitoring the different phases of the treatment plant, different water quality parameters were tested individually for the Inlet, PST, AAO, SST, and Outlet. After obtaining results of various parameters from laboratory tests, these were averaged and then compared to the regulatory standard ECR'23. From the result analysis and necessary graph, it was found that each stage of the treatment plant is working effectively.

The performance of DSTP was evaluated by comparing the water quality parameters of raw water and effluent water. The maximum water quality parameters are consistent, which indicates the good efficiency of the treatment plant. The phase-by-phase significant removal is observed so each unit is working properly. The percentage removal of Total Suspended Solids (TSS) was obtained at 93.50%, Total Dissolved Solids (TDS) at 19.93%, Ammonia at 98.89%, Chemical Oxygen Demand (COD) at 81.72%, 5-Day Biochemical Oxygen Demand (BOD₅) at 92.44%. According to ECR'23, effluents met the desired standard for the parameters. However, nitrate (NO³⁻) and (PO₄³⁻) removal were at 66% and 53% with effluents containing 4.63 mg/L and 2.53 mg/L respectively.

In order to understand the environmental impacts, it is important to compare the analyzed results of the Gazaria Canal with Bangladesh standards for discharge, fisheries, irrigation, drinking water, etc. The concentration of BOD₅ in canal water was found to be safe for fisheries and irrigation. In the canal, the concentration of BOD₅ ranged from 3.37 mg/L to 7.97 mg/L, which is higher than the drinking water standard (2 mg/L). The concentration of COD ranged from 18 mg/L to 23 mg/L, which is higher than the drinking water standard (10 mg/L). In the canal, the concentration of phosphate ranged from 7.6 to 9.15, which is higher than the standard value (0.1 mg/L). The DO level ranged from 7 mg/L to 8.87 mg/L in the canal, which meets the standard for being safer for aquatic life. Except for the parameters pH, TDS, Nitrate, Nitrite, and DO, all the water quality parameters were found to be above the drinking water standard.

A questionnaire survey was conducted to assess the surrounding impact of the treatment plant. It was found that the treatment plant has a positive social impact such as livelihood, infrastructure development, recreational opportunities. Also, the existing environment is developing day by day.

CONCLUSION

Based on the data analysis, it has been determined that each stage of the treatment plant operates effectively within its design capacity. The plant successfully removes a significant number of contaminants, indicating that all units are functioning properly. In general, the TSS, COD, and BOD₅ were removed significantly, which are the most important water quality parameters. In treated water, the level of dissolved oxygen increased, which is good for aquatic life. The performance of DSTP is found consistent with respect to water quality parameters based on comparison to the ECR'23 discharge standard.

The analysis shows that most water quality parameters in the canal, where treated water is discharged, exceed drinking water standards but are suitable for fisheries, certain industrial processes, cooling, and irrigation. In the canal water, it was found that BOD₅, COD, and Phosphate concentrations are unsafe. So, there is much risk to the water body, which is ultimately translated into polluting the river water. But the BOD₅ concentration of canal water is safe for fisheries and irrigation. DO is an important water quality parameter for aquatic life, and the value is found to be greater than the surface water quality standard, which is safer for aquatic life's survival.

This Treatment plant has an overall positive social impact, such as increasing the scope of livelihood, infrastructure development, recreational opportunities, and the existing environment, which is developing day by day. The other environmental impact is air pollution caused by the releasing of smoke when sludge is drying, which spreads out along with the surrounding air.

The analysis suggests that the Dasherbandi Sewage Treatment Plant lacks chemical and tertiary treatment processes. To improve the quality of the effluent, advanced treatment methods should be implemented to effectively remove residual pollutants and pathogens. For producing drinking water, the effluent must be disinfected and comply with regulatory standards. Chlorination can help remove remaining bacteria and viruses, while ozone serves as a powerful oxidizing agent and disinfectant. Moreover, during the dry season, the plant's capacity is underutilized due to low sewage concentration, which is not economical; therefore, increasing sewage connections is advisable. Lastly, the absence of a return sludge treatment process suggests that its inclusion could further enhance the plant's performance.

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