ISLAMIC UNIVERSITY OF TECHNOLOGY

DHAKA, BANGLADESH

ORGANIZATION OF ISLAMIC COOPERATION

Treatment of Pagla Sewage Treatment Plant Effluent by Multimedia Filter and Activated Carbon Filter

Sanim Arefin

Usrat Rifat Shuprova

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING (CEE)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

June 2024

Treatment of Pagla Sewage Treatment Plant Effluent by Multimedia Filter and Activated Carbon Filter

A thesis by

Name of Student	Student ID
SANIM AREFIN	190051131
USRAT RIFAT SHUPROVA	190051133

Supervisor

Dr. Amimul Ahsan
A/Professor

Submitted to the

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING (CEE)

ISLAMIC UNIVERSITY OF TECHNOLOGY

In partial fulfillment of the requirement for the award of the degree of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

June 2024

DECLARATION OF CANDIDATES

We hereby declare that the project/thesis work under the supervision of Dr. Amimul Ahsan entitled "**Treatment of Pagla Sewage Treatment Plant Effluent by Multimedia Filter and Activated Carbon Filter**", has been performed by us. This work has not been submitted elsewhere for the reward of any degree or diploma (except for publication).

Sanim Arefin
Student ID: 190051131

Usrat Rifat Shuprova
Student ID: 190051133

June ,2024

APPROVAL OF SUPERVISOR

This is to certify that the project/thesis submitted by Sanim Arefin (190051131), and Usrat Rifat Shuprova (190051133) have been found satisfactory and accepted as partial fulfillment of the requirement for the Bachelor of Science in Civil Engineering degree.

SUPERVISOR

DR. AMIMUL AHSAN

A/Professor
Department of Civil and Environmental Engineering (CEE)
Islamic University of Technology (IUT)
A subsidiary Organ of the
Organization of Islamic Cooperation (OIC)
Board Bazar, Gazipur, Bangladesh

June, 2024

ACKNOWLEDGEMENTS

Firstly, we would like to express our sincere appreciation to Allah (S.W.T) for his compassion towards us, which has enabled us to finish this study and prepare the project and thesis.

The project/thesis entitled "Treatment of Pagla Sewage Treatment Plant Effluent by Multimedia filter and Activated Carbon Filter" has been conducted in partial fulfillment of the requirement for the degree of Bachelor of Science (B.Sc.) in Civil Engineering. The work is possible with the unconditional cooperation of many people. We are indebted to the supervisor of our project/thesis, Dr Amimul Ahsan, A/Professor, Department of Civil and Environmental Engineering (CEE), Islamic University of Technology (IUT), Bangladesh, who helped us a lot by giving a patient hearing, sufficient time for discussion, continuous suggestion, and guidance for the preparation of this project/thesis.

We want to give thanks to the lab Technicians of the Environment Engineering Lab of the Department of Civil and Environmental Engineering (CEE), Islamic University of Technology (IUT), Bangladesh, who helped with our practical work/test in the laboratory.

We also express our heartiest gratitude to other faculty members of the Department of Civil and Environmental Engineering (CEE), Islamic University of Technology (IUT), Bangladesh, who helped by providing important suggestions.

Abstract

The Pagla Sewage treatment plant is the oldest wastewater treatment plant in Dhaka city, situated in Narayanganj. It was first operational in 1968 and has been in service ever since. The plant aims to treat only domestic wastewater This includes wastewater from sinks, bathrooms, garages etc..It was initially designed for 500,000 citizens, but by 1992, it was rehabilitated by JICA, to treat a capacity of 120,000 m3/day. The plant has been designed considering influent BOD5 of 200mg'l, and effluent BOD5 of 50 mg/l. Although the initial plan was the treatment of domestic wastewater, recent studies reveal a higher amount of pollutants in the influent section, pointing towards possible mixing of industrial waste in the inlet.

The PSTP was not initially designed to handle industrial waste. The industrial waste may include toxic chemicals, heavy metals and other non-treatable substances, that PSTP cannot possibly treat. The lack of efficiency of PSTP needs to be addressed in such a way, that the old treatment plant can keep running at least close to it's initial capacity and goals. Modifications on certain aspects of the plant can significantly increase it's capability. Studies have shown that the 8 lagoons in the PSTP are not able to function at their design capacity. Although immediate cleaning is recommended along with other upgrades, it is an expensive price to pay for an old plant. Due to the building of new plants like Dashenkandhi and Gandharpur Water treatment plants, it may seem uneconomical to spend so much money on PSTP.

The study aims to improve the quality of the effluent of PSTP by the use of a multimedia filter bed, and an activated carbon filter bed, which is a much cheaper alternative to other expensive upgrades. This Study aims to deliver a prospect and possibility to accomplish just that.

In order to better grasp the use of the multimedia and activated carbon filter, the research aims to obtain the filter efficiency. The filter efficiency refers to the removal of a non-desirable parameter in a sample water, by the use of the filters. It provides more information on how effective the filter is, at removing a particular parameter, by running the water through it.

Table of Contents

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

1.1 Background of the study

The expanding demand for water in several industries, including transportation, agriculture, manufacturing, drinking and recreation, highlights how essential it is to human existence. However, increasing demand, together with population expansion and industrial water use, has resulted in a worrying rise in water pollution. The problem has been made worse by the constant availability of xenobiotic compounds brought about by routine activities. Improper wastewater disposal has made surface and groundwater contamination worse. Finding the origins of contamination is still difficult and sometimes doesn't become clear until the water quality declines to an unacceptable degree (Hossain et al. 2018).

Bangladesh, with its dense population and fast urbanization, is confronted with all these urgent challenges related to water management. With the world's densest population in its capital, Dhaka, the city depends on the Pagla Sewage Treatment Plant (PSTP) to handle wastewater. Because the city is flat, wastewater is transported via a gravity-based system. The Buriganga River receives treated effluent from the PST, which is intended to process wastewater according to certain specifications. The treated wastewater includes a variety of household, business, institutional, and industrial waste that, if left untreated, might be harmful to the environment and public health. In light of the growing shortage of fresh water, Bangladesh's water difficulties need to strike a balance between the provision of safe drinking water and effective wastewater treatment. Even if it might be difficult, using wastewater for farming offers chances to maximize the use of water and nutrients while reducing harmful effects on human health. For agriculture, the environment, and public health to effectively manage the many effects of wastewater usage, sound policy decisions and technical interventions are necessary. (Hossain et al. 2018)

1.2 Pagla Sewage Treatment Plant

The Pagla Sewage treatment plant is the oldest wastewater treatment plant in Dhaka city, situated in Narayanganj. It was first operational in 1968 and has been in service ever since. The plant aims to treat only domestic wastewater. This includes wastewater from sinks, bathrooms, garages etc. Initially, it consisted of 4 facultative lagoons, to break down the sewage by germs. The lagoons are 3m in depth. It was initially designed for 500,000 citizens, but by 1992, it was rehabilitated by JICA, to treat a capacity of 120,000 m3/day. The number of lagoons has been doubled to 8 (Hossain et al. 2018).

PSTP is located on the outskirts of Dhaka city, 1km away from the Buriganga River. The plant has been designed considering the influent BOD5 of 200 mg/l, and an effluent of 50 mg/l.

As soon as the water enters the plant through the inlet, it is allowed to pass through the screen, which removes mostly large solids. The water is then pumped by the 4 lift pumps, to the grit chamber. This is where more of the smaller solid particles are allowed to settle down. The primary clarifier is where the final steps of solid removal take place, before biological treatment. PSTP has 4 primary clarifier tanks. The design of the primary clarifier is such that it is capable of removing 90-95% settleable solids, and 40-60% of SS. The sludge that is collected is allowed to dry in a separate sludge lagoon, after which it is treated separately (Hossain et al ,2018.).

The water is then allowed to enter into lagoons A and B. These are rectangular ponds where the water is allowed to stay for an extended period. The bacterial actions, combined with the effect of sunlight, allow for the breakdown of germs in the pond. This is why the color of the ponds is greenish. The light, warmth, and oxygen help in the growth of algae in the water. Algae helps the bacteria break down the sewage. The blowing of wind allows for the evaporation of water and actively prevents any sort of stagnation. In the final stage, the water is mixed with a dosage of chlorine to further remove germs. The effluent is released 1km away, along a pipeline, to the Buriganga River. Thus, the main units of the treatment plant are pretreatment, primary sedimentation tanks, facultative lagoons and sludge stabilization lagoons. This is the process flow diagram of the Pagla Sewage Treatment Plant (Hossain et al, 2018).

.

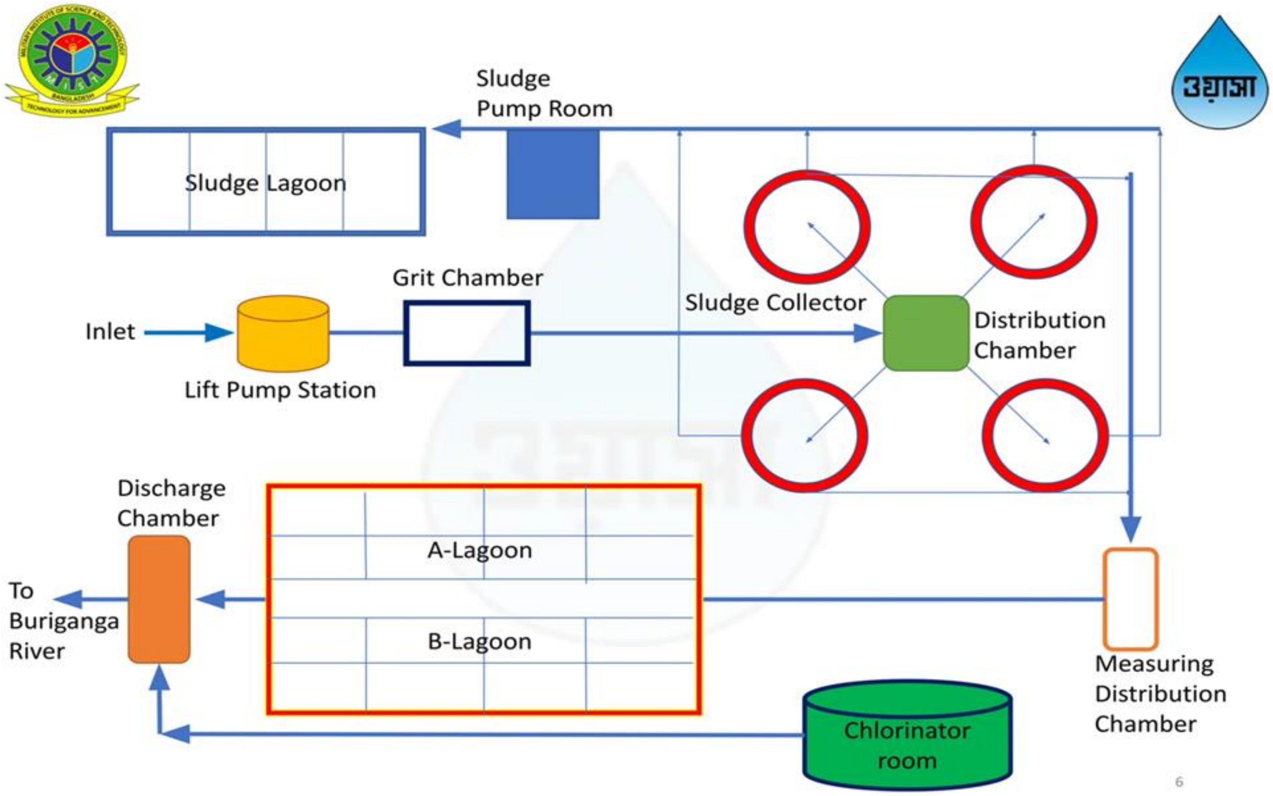

Fig. 1.1: Process Flow Diagram of Pagla Sewage Treatment Plant

(https://www.slideshare.net/slideshow/presentation-on-pagla-sewage-treatment-plant-and-saidabad-water-treatment-plantpdf/265507668)

1.3 Problems in Pagla Sewage Treatment Plant's Effluent

The plant was initially constructed in 1968 with only 4 facultative lagoons. A 120,000 cubic meter per day sewage capacity was added to the Pagla sewage treatment facility in 1992 through renovations. The total area of the treatment plant is 110.5 ha. The present ground level is +1.8m to +6.9m (Hassan et al., 2017).

Table 1.1: Design and existing flow rates of Pagla STP

Flow	Full-scale design (m^3/day)	Existing Facility (m^3/day)
Daily average	146,000	96,000
Daily Maximum	183,000	120,000
Hourly Maximum	232,000	120,000

The PSTP was not initially designed to handle industrial waste. The industrial waste may include toxic chemicals, heavy metals and other non-treatable substances that PSTP cannot possibly treat. Studies have shown that the 8 lagoons in the PSTP are not able to function at their design capacity. Although immediate cleaning is recommended along with other upgrades, it is an expensive price to pay for an old plant. Due to the building of new plants like Dashenkandi and Gandharpur Water treatment plants, it may seem uneconomical to spend so much money on PSTP. The lack of efficiency of PSTP needs to be addressed in such a way that the old treatment plant can keep running at at least close to its initial capacity and goals (Hossain et al. 2018).

1.4 Objectives

The specific objectives of this study are:

i. To determine the efficiency of the multimedia filter and activated carbon filter to treat PSTP.

ii. To determine the combined efficiency of the multimedia filter and activated carbon filter to treat PSTP.

1.5 Scope

i. The study’s scope involves investigating long-term performance, optimization, cost-effectiveness and integration with other treatment technologies.

ii. The study's scope includes laboratory-scale experiments focused on the removal efficiency of heavy metals like Cd, Hg, Pb etc. for advanced effluent treatment methods.

Chapter 2: Literature Review

2.1 Introduction

Pagla Sewage Treatment plant in Narayanganj is such an area where water demand is always very important to fulfill. The quality and effectiveness of Pagla Treatment Plant's effluent, as well as the procedures, activities, and circumstances that lead to such effectiveness, will be covered in more detail in this chapter. It will go into more detail about wastewater treatment and how it is used for domestic, agricultural and irrigation purposes.

2.2 Concerns of Pagla Sewage Treatment Plant's Effluent

Water, a vital resource for the survival of the human species, has the potential to be a destructive force if contaminated significantly. The trend of population immigration towards large cities and rapid economic growth has led to the necessity of modern, well-maintained, centralized water distribution systems. However, ageing of the system, over-stress and poor maintenance of the distribution system led to the degradation of water quality below acceptable levels within the supply network. In Pagla Sewage Treatment Plant, this contamination occurs due to various reasons including but not exclusive to failure to maintain proper disinfectant residual, low pipeline water pressure, intermittent water supply, excessive network leakages, corrosion of parts and inadequate sewage disposal. Now the alarming question is are the consumers getting pure water after distribution from the treatment plant? High levels of Cd, turbidity, TDS, TSS, aesthetically unpleasant water color and odor, and low levels of DO are the main concerns of Pagla Sewage Treatment's Effluent quality (Hossain et al. 2018)

.

2.3 Effluent from Pagla Sewage Treatment Plant

Prior research on Pagla Sewage treatment has been done by many researchers. Reviews have revealed that the treatment facility has been in operation, with decreasing efficiency. The research includes effluent quality investigations and addresses the scarcity of research on sewage wastewater management in urban areas. But the common characteristic of these areas is the lack of accessibility to suitable quantity and quality of water. The water quality of these treatment plants is affected by some contamination which is responsible for waterborne disease along with other disease burdens. This quality deterioration occurs due to various reasons but mainly because of unable function of its design capacity. The health risks due to these problems are causing a large number of diseases every year which degrades the quality of health and sanitation of the area which is one of the main criteria for development. So the present stage of the Pagla sewage treatment plant water quality is in need to asses it’s effluent quality parameters of pH, TSS, TS, DO, COD, Turbidity, Colour, EC, Salinity and heavy metals like Cd, Mn, Pb’s concentration in effluent water and treated water and compare it with ECR 2023 (Hossain et al. 2018).

.

2.4 Conventional Treatment Approaches and Limitations

One of the most notable was the use of effluent for agricultural purposes, drinking purposes, and irrigation purposes. Parameters like suspended solids (SS), dissolved solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO) are the primary indicators of the Pagla treatment plant.

Many researchers point to the lack of efficiency of the plant due to it being old, and having industrial waste getting mixed with the influent. Others point to the microbial aspects of the effluent. A comprehensive analysis of bacteriological, physical, and chemical properties was done extensively. Even though an extensive literature review has been conducted, none worked on trying to improve the effluent quality of PSTP. This is important because the plant is unable to function at its design capacity. Our research focuses on the installation of Activated Carbon beds. This cheap, cost-effective upgrade will allow for the effluent to be much more desirable (Hossain et al, 2018).

.

2.5 Multimedia Filtration as an Advanced Treatment Method

The multimedia filtration system is efficient for targeting suspended solids, organic matter, and certain dissolved pollutants in effluent. Media components like sand, gravel and aggregate have exceptional absorption capacity and removal efficiency (Chowdhury et al. 2021).

.

2.6 Activated Carbon Filtration as an Advanced Treatment Method

Activated carbon filtration is a widely utilized technique that relies on the adsorption of contaminants onto the filter's surface. This method is particularly effective at eliminating certain organic substances such as undesirable tastes and odors, micropollutants, as well as chlorine, fluorine, and radon from both drinking water and wastewater (Reungoat et al, 2012).

.

.

Chapter 3: Methodology

3.1 Introduction

An overview of the study's experimental procedures will be provided in this chapter. It will include the gathering and preparation of wastewater, the characteristics of the wastewater and the equipment used in the experiment, the configuration of the equipment, sample preparation, tests conducted, and the design of the effluent treatment plant’s different components.

3.2 Wastewater preparation

Effluent from Pagla Sewage Treatment Plant (PSTP) was taken directly from the point of release, i.e. the Buriganga River. The Strategy comprises wastewater being collected at the beginning of every month, and tests and treatment being carried out to observe the results for that month. This way, samples were collected and tested for a period of 9 months (August to April). This was done to observe the variation of the contaminants throughout the year.

3.2 Tests

The following are the tests that were carried out, to check the quality of the effluent. The tests were carried out every month, to check the quality variations of the water. The tests were carried out as soon as the water was extracted. The following provides the sequence of how the water was treated and tested:

1. Testing of raw water parameters
2. Raw water being allowed to run through the multimedia filter
3. Test the parameters of the treated water
4. Raw water being allowed to run through the activated carbon filter
5. Test the parameters of the treated water.

3.3 Water Quality Parameters

The quality of any water is determined by how the fundamental parameters of the water measure up. The following are the water quality parameters that were tested for:

Table 3.1: Water quality parameters to be tested in the laboratory.

pH	TDS	TSS
TS	Colour	COD
EC	Salinity	Turbidity
DO	Nitrate (NO_3^-)	Ammonium (NH_4^+)
Manganese (Mn)		

The tests account for whether the water quality coincides with the Bangladesh Environmental Conservation Rules 2023 (ECR’23) for effluent standards.

3.4 Bangladesh Environmental Conservation Rules 2023

ECR is a set of standards that dictate the rules and regulations to save and conserve the environment, in compliance with the Environmental Conservation Act 1995. The use of both the Multimedia filter and the activated carbon filter aims to try and fix the water quality parameters.

Table 3.2: Effluent parameter guidelines in ECR 2023

Parameter	unit	ECR’23
pH	-	6.5-8.5
TDS	mg/l	<1000
TSS	mg/l	10
TS	mg/l	00
Colour	PtCo	<15
COD	mg/l	4
Turbidity	NTU	10
DO	mg/l	>=6
Odour	-	Odourless
Nitrate	mg/l	45
Ammonia	mg/l	7
Manganese	mg/l	0.4

3.5 Filter Preparation

In principle, two types of filters were prepared to treat PSTP effluent. The following provides a detailed overview of the entire procedure.

3.5.1 Multimedia Filter

The multimedia filter is intended to treat the PSTP as a first step. It consists of a proportioned mixture of sand, gravel, pebbles etc. To contain all the materials, a large, commercially available, 20L filter jar was used. The jar comes with a built-in tap, that makes the procedure easier.

The components of the multimedia filter are pebbles, coarse gravel, medium gravel, fine gravel and river sand. The following table provides details of the components in greater depth:

Table 3.3: Details of the multimedia filter components.

Component	Image	Sieve
Pebbles		-
Coarse Gravel		1 inch
Medium Gravel		¾ inch
Fine Gravel		#4 (4.75 mm)

River Sand		#40 (0.425 mm)

The layers of the filter have been carefully arranged into a plastic jar, which is connected to an in-built tap.

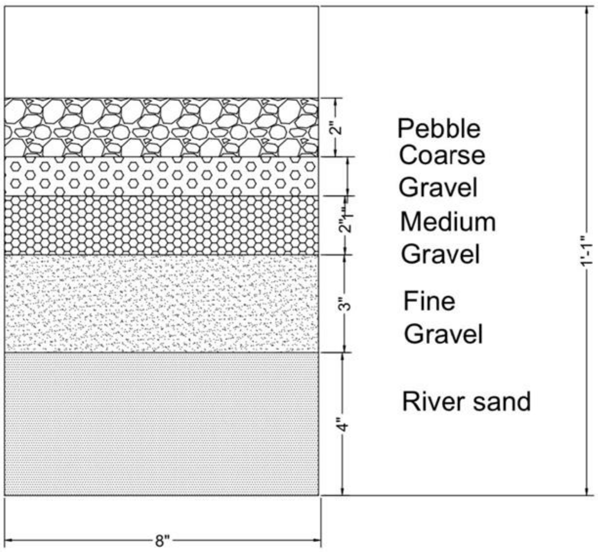

Fig. 3.1: Multimedia filter setup

3.5.2 Activated Carbon Filter

This consists of the same 20L plastic jar, but this time it is filled with activated carbon of diameter 0.2mm. The filter height is 8 inches.

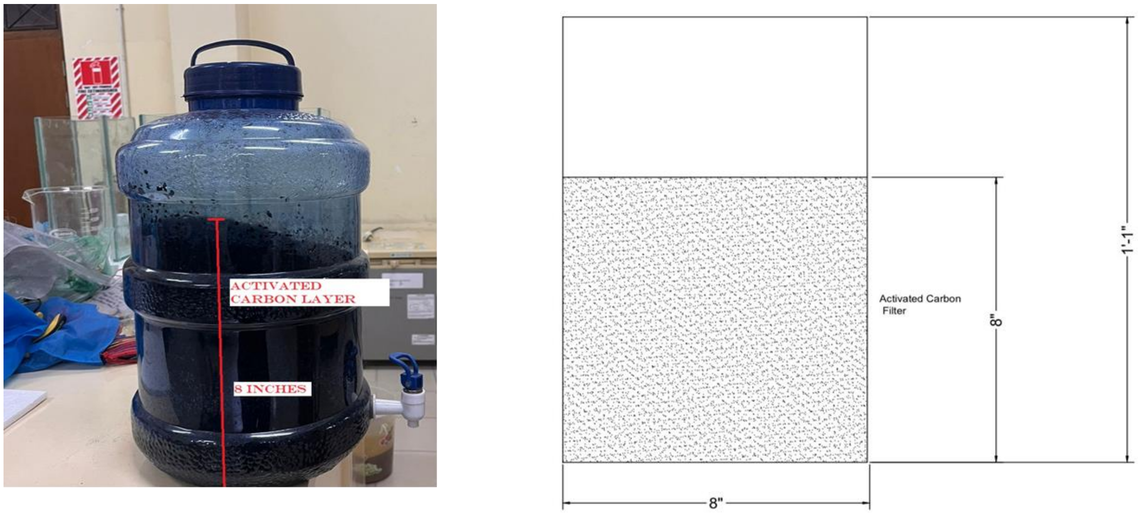

Fig. 3.2: Activated Carbon filter setup

3.5.3 Strainer

The strainer used was a thin metallic strip of 0.1mm holes, rolled into a tube, that would fit into the outlet of the tap of the filter. The material was then poured into the jars, allowing the strainer to firmly rest onto the materials, fixating its position.

Fig. 3.3: Strainer setup in filters

3.6 Preparation of Apparatus

This section deals with the lab apparatus that would be used to determine the water quality parameters previously mentioned.

3.6.2 Spectrophotometer

The majority of the above-mentioned parameters were measured using this device. The HACH DR3900 model was used to measure ammonia concentrations, total suspended solids, total dissolved solids, colour, chemical oxygen demand (COD), dissolved oxygen, nitrate, and manganese.

Fig. 3.4: Spectrophotometer

3.6.3 Turbidity meter

The HACH 2100Q Portable Turbidimeter was used to measure the turbidity of all the samples in this experiment.

Fig. 3.5: Turbidity meter

3.6.4 pH meter

In order to get a reliable pH reading, the HACH HQ411D pH meter was used.

Fig. 3.6: pH meter

3.6.5 COD Reactor Apparatus

Chemical oxygen demand is one of the most important parameters with regard to this experiment. The HACH DRB200 Reactor was used for measurements of COD levels in samples.

Fig. 3.7: COD Reactor apparatus

3.7 Properties of Wastewater

Due to the primitive nature of the PSTP, the plant is not designed to handle the wastewater that comes from plants from the surrounding area. The plant was only made to treat domestic wastewater. The treatment process consists of large lagoons that slow the process down as well. As a result, the effluent that is made is more polluted than initially intended. The following provides more detailed effluent parameters for the month of February 2024.

Table 3.4: PSTP effluent parameter test for February 2024.

Parameter	PSTP Effluent	ECR'23
pH	6.88	6.5-8.5
TDS (mg/l)	726	<1000
TSS (mg/l)	66	10
TS (mg/l)	792	00
Colour (Pt-Co)	454	<15
COD (mg/l)	30	4
EC (S/m)	833	-
Salinity (%)	0.19	-
Turbidity (NTU)	83.7	10
DO (mg/l)	3.1	>=6
Odour	YES	Odourless
Nitrate (mg/l)	5.3	45
Ammonia (mg/l)	5.1	7
Mn (mg/l)	0.23	0.4

It must be noted that the TSS, TDS, turbidity, ammonia and other important parameters do not fall below the recommended ECR'23 guidelines. As a result, ways of improving the parameters are necessary.

3.8 Experimental Procedure

The entire experimental procedure was segregated into smaller portions. After the effluent had been collected from the plant, the water was first tested for the parameters mentioned above.
The water was then allowed to run through the multimedia filter at first, after which the water parameters were tested again. This was done to know whether the multimedia filter had any effect on the quality of the water. The treated water was then run through an activated carbon filter, and

tested for the parameters again. This was done to check whether the activated carbon filter had any effect on the water quality parameters.

Another 5L of raw water was run through the activated carbon filter, and tested for the parameters. This was done to understand the impact of the multimedia filter only, on the raw water. The process flow diagram has been provided below. The entire process was repeated over 6 months, from October 2023 to March 2024. This was done to get more repetitions of data, as well as to see how seasonal variations affect the treatment process.

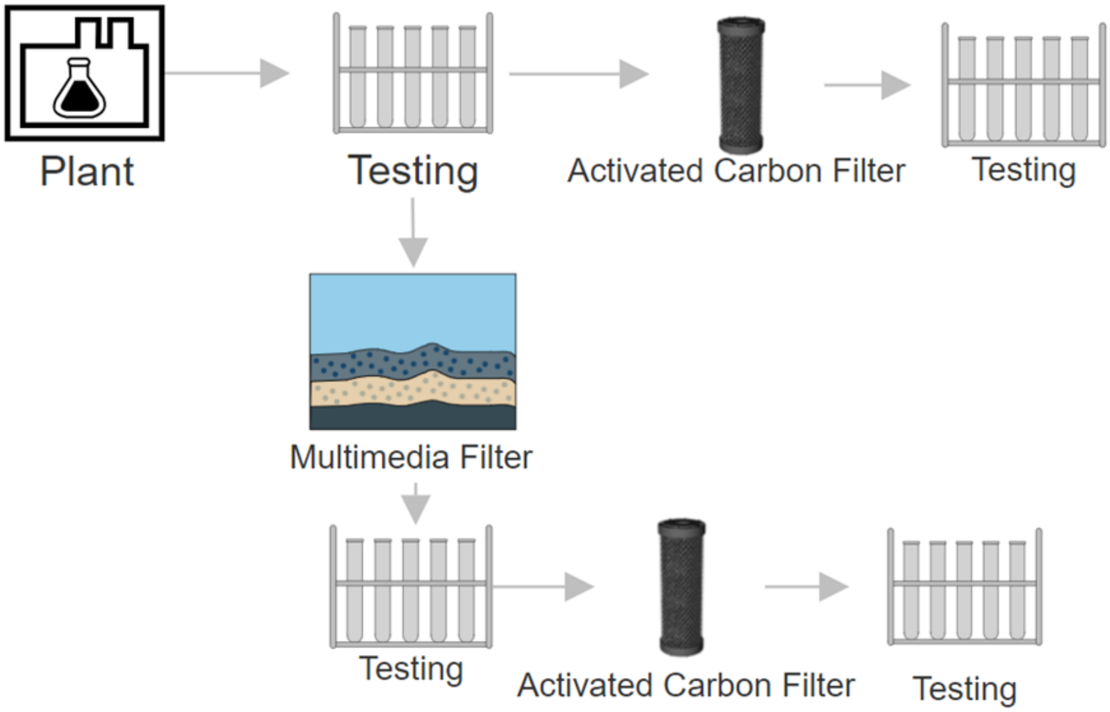

Fig. 3.8: Experimental procedure using Multimedia filter and Activated carbon filter.

Chapter 4: Results and Discussion

4.1 General

The final results of the entire procedure sum up to a lot of data, that is better understood if they are arranged in a tabular and graphical form. The data is then further analyzed to calculate the filter efficiency of the filters that were used.

4.2 Results

The effluent parameters and the filtered parameters were all measured for 6 months. Data has been obtained for all the months and the following illustrates the data.

October 2023

Table 4.1: Wastewater parameter of PSTP effluent & treated effluent in October 2023

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR' 2023
pH	6.73	7.3	7.9	8.4	6.5-8.5
TDS (mg/l)	373	580	576	601	<1000
TSS (mg/l)	37	38	8	5	10
TS (mg/l)	410	618	584	606	1010
Colour (Pt-Co)	500	162	56	30	<15
COD (mg/l)	Too high	102	61	39	4
EC (mS/m)	213	532	701	683	-
Salinity (%)	0.38	0.4	0.71	0.78	-
Turbidity (NTU)	48.7	29.6	6.32	5.78	10
DO (mg/l)	8.29	3.32	4.23	6.1	>=6
Odour	Yes	Yes	Odourless	Odourless	Odourless

November 2023

Table 4.2: Wastewater parameter of PSTP effluent & treated effluent in November 2023

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR' 2023
pH	6.94	6	8.4	8.19	6.5-8.5
TDS (mg/l)	773	701	399	326	<1000
TSS (mg/l)	31	40	10	7	10
TS (mg/l)	804	741	409	333	1010
Colour (Pt-Co)	554	211	32	27	<15
COD (mg/l)	171	180	45	1	4
EC (mS/m)	437	687	1437	1403	
Salinity (%)	0.37	0.33	0.72	0.7	
Turbidity (NTU)	334	34.6	7.23	6.81	10
DO (mg/l)	0.2	3.2	5.73	5.64	>=6
Odour	Yes	Ye	Odourless	Odourless	Odourless

December 2023

Table 4.3: Wastewater parameter of PSTP effluent & treated effluent in December 2023

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR' 2023
pH	7.11	6.88	8.2	8.4	6.5-8.5
TDS (mg/l)	1200	1039	804	805	<1000
TSS (mg/l)	35	41	40	6	10
TS (mg/l)	1235	1080	844	811	1010
Colour (Pt-Co)	603	322	101	56	<15
COD (mg/l)	220	225	92	43	4
EC (mS/m)	599	1001	1010	1512	-
Salinity (%)	0.32	0.33	0.72	0.41	
Turbidity (NTU)	71.6	50.6	82.31	56.3	10
DO (mg/l)	1.1	3.2	4.21	5.31	>=6
Odour	Yes	Yes	Odourless	Odourless	Odourless

January 2024

Table 4.4: Wastewater parameter of PSTP effluent & treated effluent in January 2024

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR' 2023
pH	7.01	7.39	8.35	8.1	6.5-8.5
TDS (mg/l)	805	745	460	289	<1000
TSS (mg/l)	35	38	8	21	10
TS (mg/l)	840	783	468	310	1010
Colour (Pt-Co)	679	455	121	51	<15
COD (mg/l)	237	211	101	32	4
EC (mS/m)	939	687	1437	1123	-
Salinity (%)	0.4	0.33	0.42	0.4	
Turbidity (NTU)	109.5	101.6	7.98	4.32	10
DO (mg/l)	1.5	2.1	5.6	5.75	>=6
Odour	Yes	Yes	Odourless	Odourless	Odourless
Nitrate (mg/l)	-	4.8	2.1	0.3	45
Mn (mg/l)	-	1.32	0.007	0.008	0.4

February 2024

Table 4.5:Wastewater parameter of PSTP effluent & treated effluent in February 2024

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR’ 2023
pH	6.88	6.94	7.02	7.02	6.5-8.5
TDS (mg/l)	726	362	505	580	<1000
TSS (mg/l)	66	39	12	18	10
TS (mg/l)	792	401	517	598	1010
Colour (Pt-Co)	454	751	55	61	<15
COD (mg/l)	30	8	5	6	4
EC (mS/m)	833	742	1025	1172	-
Salinity (%)	0.19	0.36	0.51	0.58	
Turbidity (NTU)	83.7	76.9	11.4	24.4	10
DO (mg/l)	3.1	7.55	7	7.18	>=6
Odour	Yes	Yes	Odourless	Odourless	Odourless
Nitrate (mg/l)	5.3	4.9	1.1	0.5	45
Ammonia (mg/l)	5.1	5.08	4.99	5.03	7
Mn (mg/l)	0.23	0.21	0.0034	0.009	0.4

March 2024

Table 4.6: Wastewater parameter of PSTP effluent & treated effluent in March 2024.

Parameter	PSTP Effluent	Multimedia Filter only	Activated Carbon Filter only	Multimedia+Activated Carbon Filter	ECR' 2023
pH	7.37	7.86	8.4	8.4	6.5-8.5
TDS (mg/l)	773	690	416	335	<1000
TSS (mg/l)	38	38	8	6	10
TS (mg/l)	811	728	424	341	1010
Colour (Pt-Co)	554	162	56	30	<15
COD (mg/l)	9	7	2	1	4
EC (mS/m)	710	687	1437	1403	-
Salinity (%)	0.37	0.33	0.72	0.7	
Turbidity (NTU)	78.4	31.3	6.32	5.78	10
DO (mg/l)	2.72	3.2	5.73	5.64	>=6
Odour	Yes	Yes	Odourless	Odourless	Odourless
Nitrate (mg/l)	3.1	0.2	0.5	0.3	45
Ammonia (mg/l)	7.35	3.45	0	0.13	7
Mn (mg/l)	0.17	1.2	0.007	0.008	0.4

4.3 Graphical Analysis

The results have further been plotted out into bar graphs to better understand how the parameters vary with seasonally, and how the filters affect them.

4.3.1 Total Dissolved Solids

Table 4.7: Data of TDS for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Oct	373	580	576	601
Nov	805	745	460	289
Dec	1200	1039	804	805
Jan	805	745	460	289
Feb	726	362	505	580
Mar	773	690	416	335

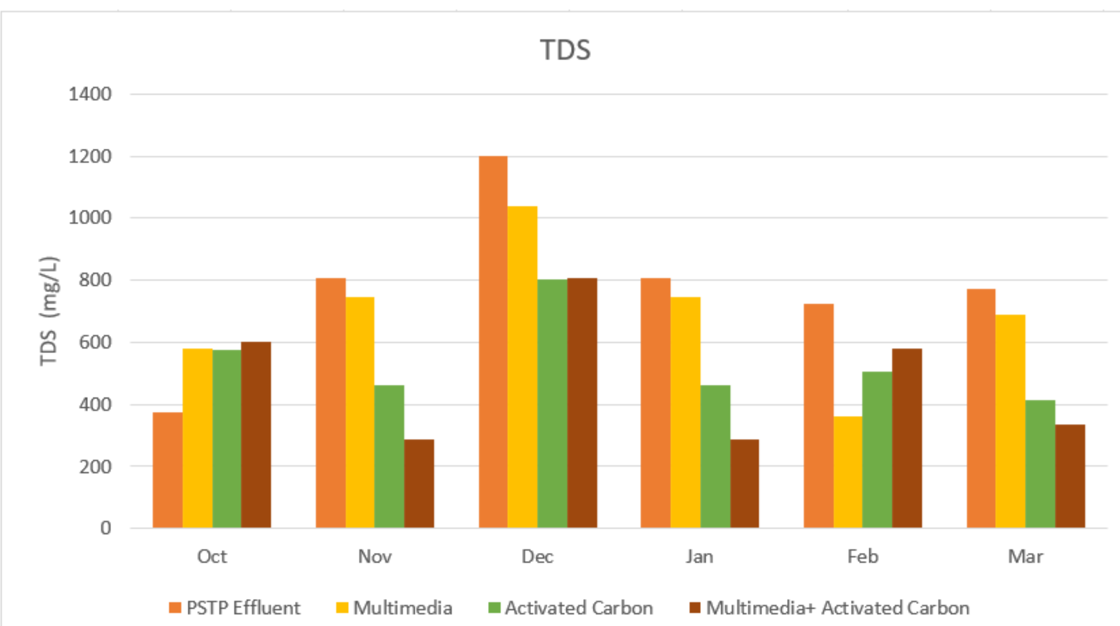

Fig. 4.1: Data of TDS for 6 months.

4.3.2 Total Suspended Solids

Table 4.8: Data of TSS for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Oct	37	38	8	5
Nov	31	40	10	7
Dec	35	41	40	6
Jan	35	38	8	21
Feb	66	39	12	18
Mar	38	38	8	6

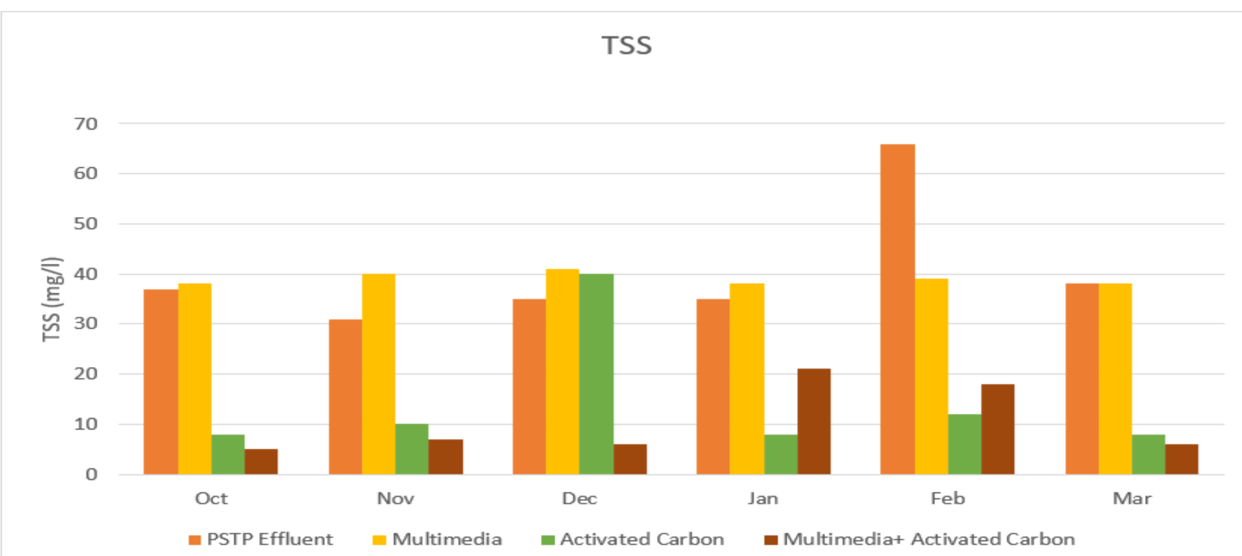

Fig.4.2:Data of TSS for 6 months.

4.3.3 Chemical Oxygen Demand

Table 4.9: Data of COD for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Oct		102	61	39
Nov	171	180	45	1
Dec	220	225	92	43
Jan	237	211	101	32
Feb	30	8	5	6
Mar	9	7	2	1

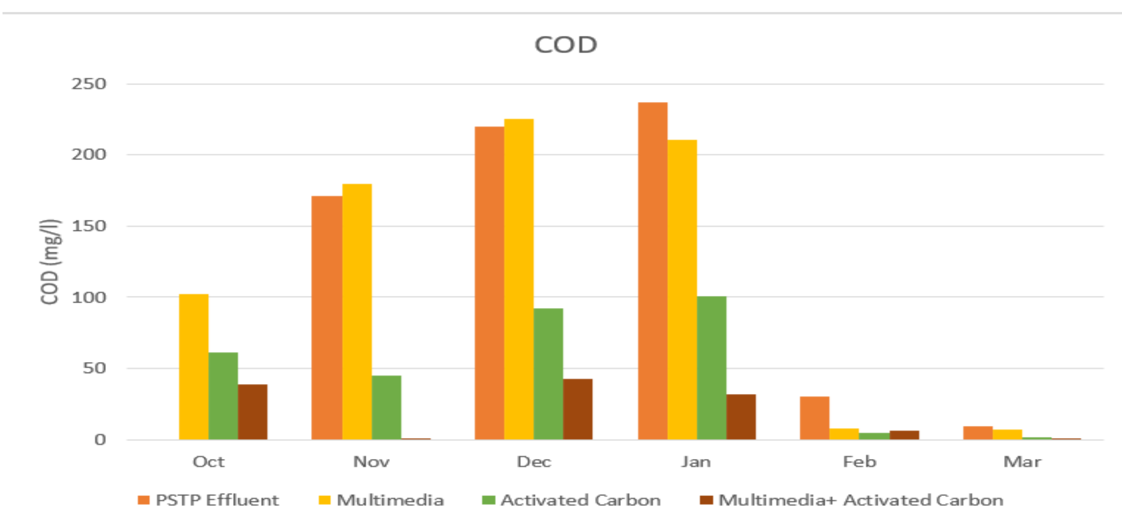

Fig. 4.3: Data of COD for 6 months.

4.3.4 Turbidity

Table 4.10: Data of Turbidity for 6 months.

Month	PSTP Effluent	Multimedia Filter	Activated Carbon Filter only	Multimedia + Activated Carbon Filter
Oct	48.7	29.6	6.32	5.78
Nov	334	34.6	7.23	6.81
Dec	71.6	50.6	82.31	56.3
Jan	109.5	101.6	7.98	4.32
Feb	83.7	76.9	11.4	24.4
Mar	78.4	31.3	6.32	5.78

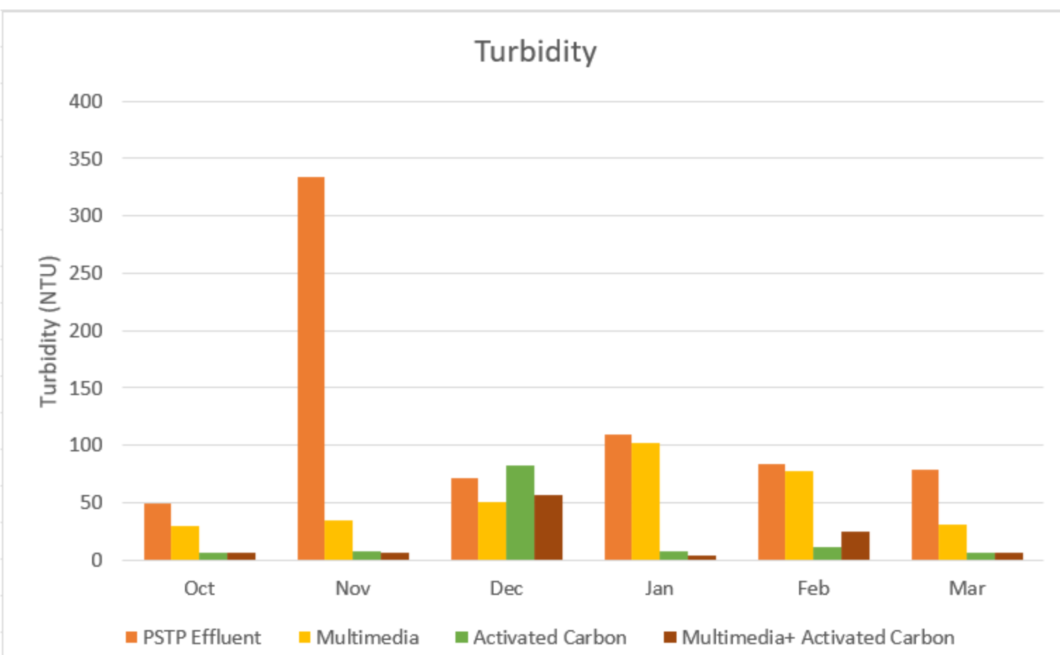

Fig. 4.4: Data of turbidity for 6 months.

4.3.5 Colour

Table 4.11: Data of color for 6 months.

Month	PSTP Effluent	Multimedia Filter	Activated Carbon Filter only	Multimedia + Activated Carbon Filter
Oct	500	162	56	30
Nov	554	211	32	27
Dec	603	322	101	56
Jan	679	455	121	51
Feb	454	751	55	61
Mar	554	162	56	30

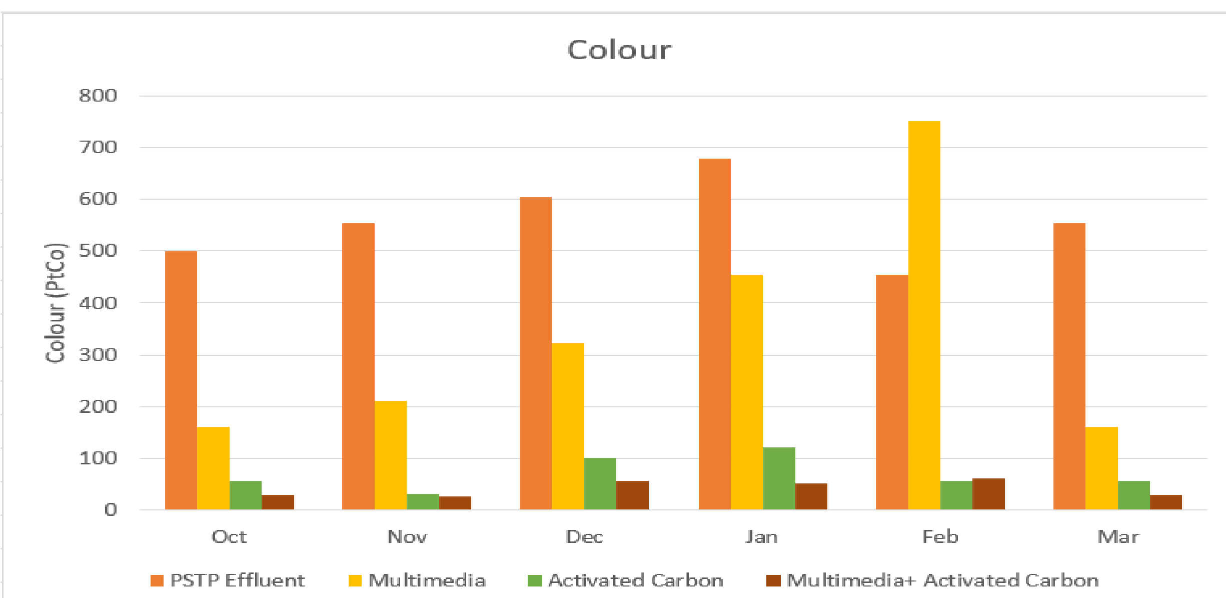

Fig. 4.5: Data of color for 6 months.

4.3.6 Dissolved Oxygen

Table 4.12: Data of DO for 6 months

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Oct	8.29	3.32	4.23	6.1
Nov	34	34.6	7.23	6.81
Dec	1.1	3.2	4.21	5.31
Jan	1.5	2.1	5.6	5.75
Feb	3.1	7.55	7	7.18
Mar	2.72	3.2	5.73	5.64

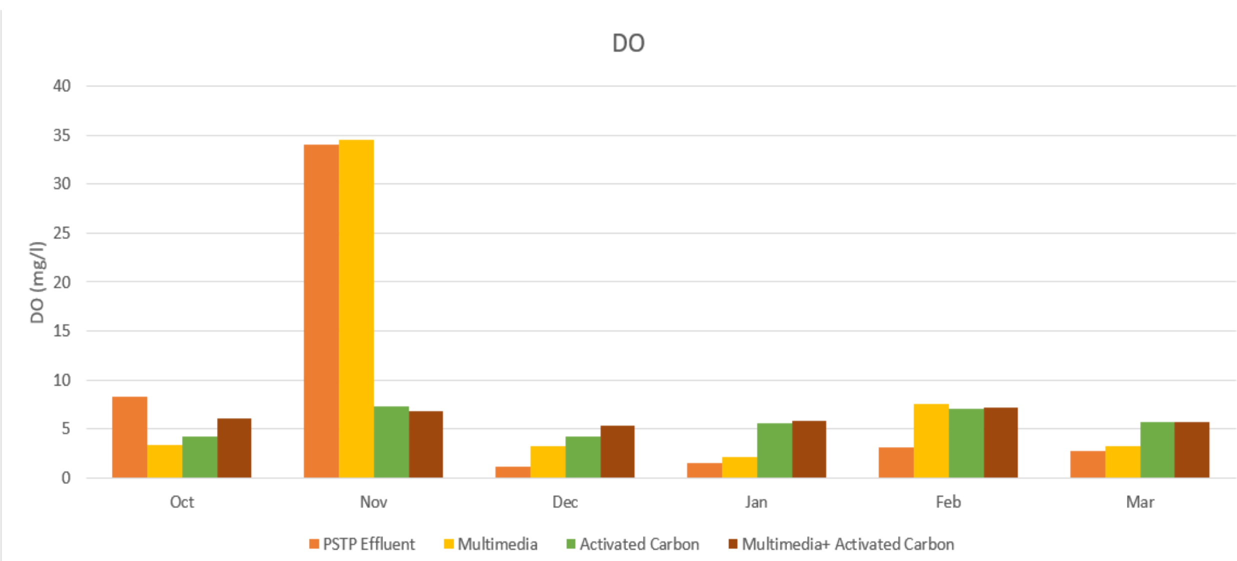

Fig. 4.6: Data of DO for 6 months.

4.3.7 Nitrates

Table 4.13: Data of Nitrates for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Jan		4.8	2.1	0.3
Feb	5.3	4.9	1.1	0.5
Mar	3.1	0.2	0.5	0.3

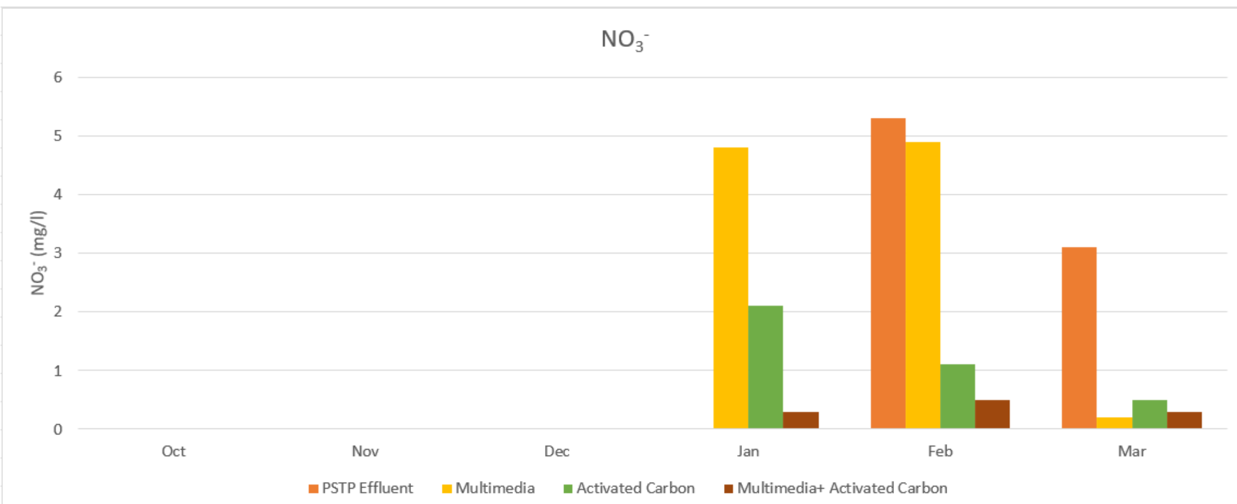

Fig.4.7: Data of Nitrates for 6 months.

4.3.8 Ammonia

Table 4.14: Data of Ammonia for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Jan		2.2	0.4	0.19
Feb	5.1	5.08	4.99	5.03
Mar	7.35	3.45	0	0.13

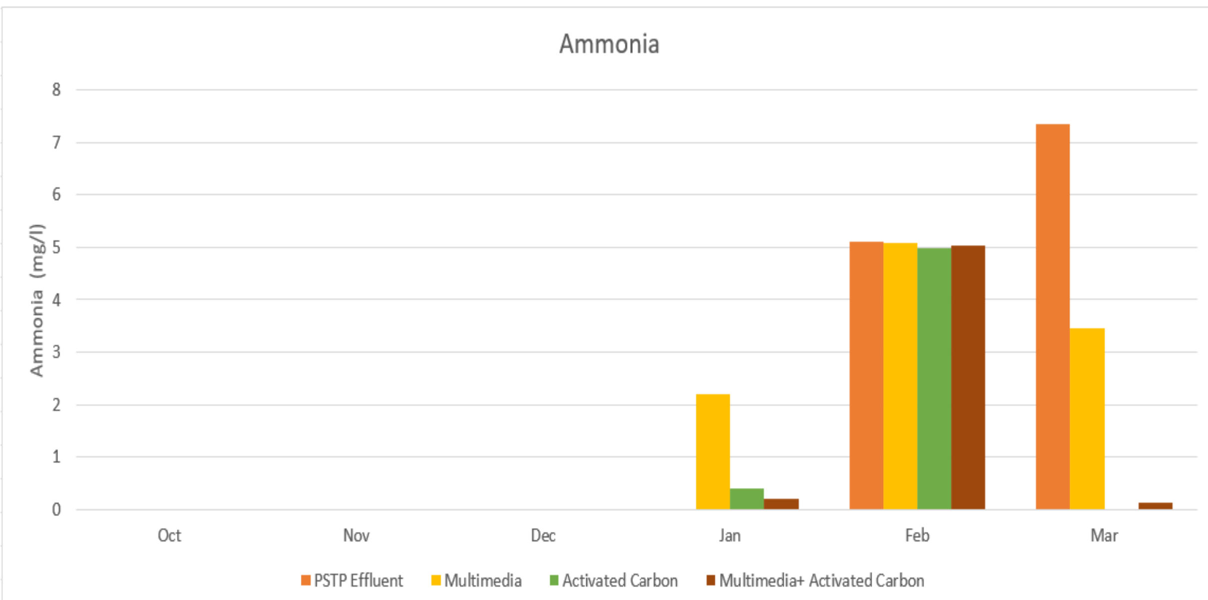

Fig. 4.8: Data of Ammonia for 6 months.

4.3.9 Manganese

Table 4.15: Data of Manganese for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Jan		1.32	0.007	0.008
Feb	0.23	0.21	0.0034	0.009
Mar	0.17	1.2	0.007	0.008

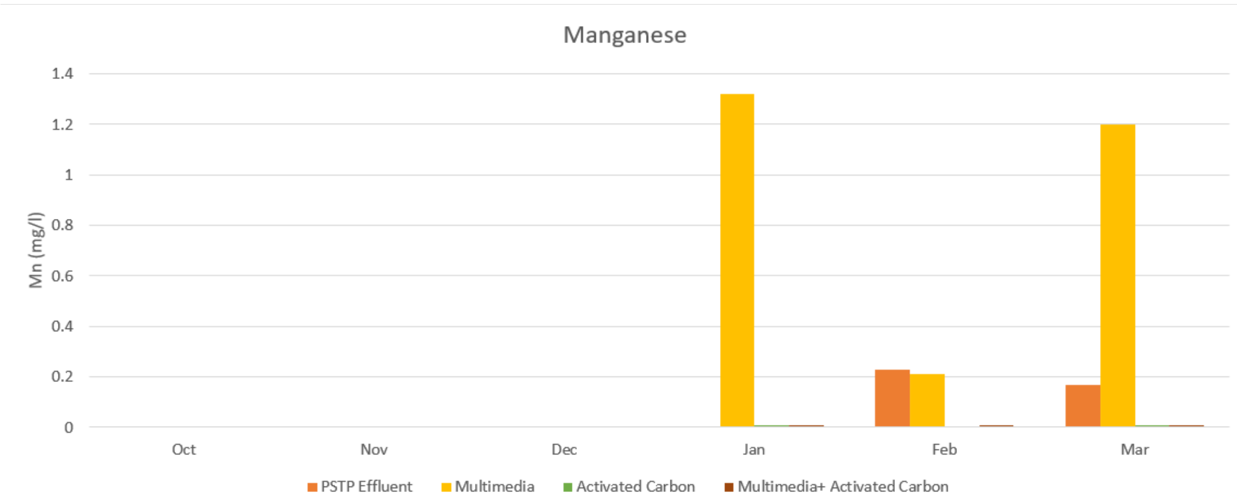

Fig. 4.9: Data of Manganese for 6 months.

4.3.10 Total Solids

Table 4.16: Data of total solids for 6 months.

Month	PSTP Effluent (mg/l)	Multimedia Filter (mg/l)	Activated Carbon Filter only (mg/l)	Multimedia + Activated Carbon Filter (mg/l)
Oct	410	618	584	606
Nov	804	741	409	333
Dec	1235	1080	844	811
Jan	840	783	468	310
Feb	792	401	517	598
Mar	811	728	424	341

Fig. 4.10: Data of TS for 6 months.

4.4.1 Filter Efficiency

Filter Efficiency refers to how well the filter is able to remove a particular parameter.
The efficiency has been calculated using the formula:

$$\text{Efficiency (\%)} = \frac{(Initial)-(Final)}{(Initial)} * 100$$

The efficiency has been calculated for each parameter. This provides a more in-depth understanding of how well each filter behaves with respect to each parameter. The filter efficiency has been provided in the following table.

Table 4.17: Filter efficiency of 3 filtrations.

Parameters	Multimedia (%)	Activated Carbon (%)	Multimedia+Activated Carbon (%)
Turbidity	55.3	83.3	85.8
TDS	11.1	31	38.1
TSS	3.3	64.4	73.9
TS	11	33.6	38.7
Ammonia	31.5	60	58.6
Nitrate	39.3	80.1	90.5
Colour	38.3	87.4	92.4
Mn	0	97.4	95.6
COD	54	63.2	87.6

4.4.2 Filter Efficiency

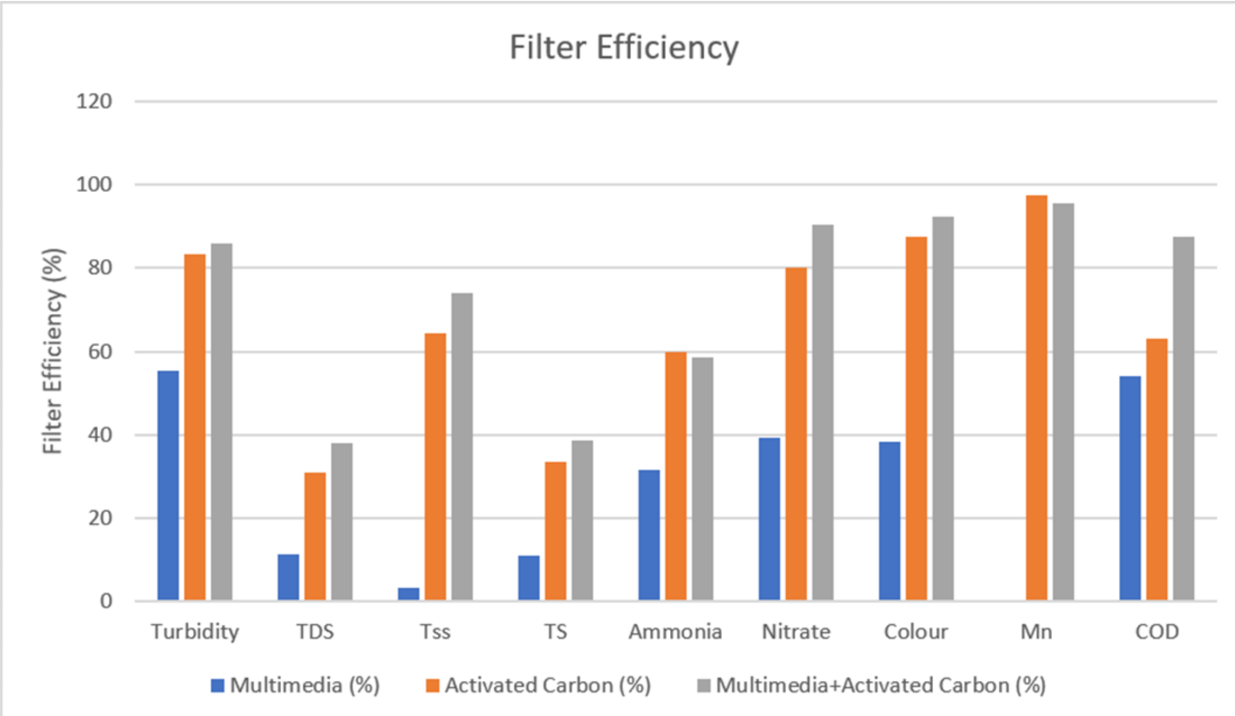

Fig. 4.11: Filter efficiency using multimedia filter, activated carbon filter and multimedia plus activated carbon.

4.5 Discussion

The use of both multimedia filter and activated carbon filter showed significant improvement in the effluent quality. The main parameters that showed promise are TDS, TSS, COD, colour, turbidity, nitrate, ammonium and manganese.

TSS and TDS both showed great improvements in both the filters separately and combined. But TSS showed greater improvement as the undissolved solids were more easily filtered out.
The most significant improvement in water quality parameters was COD. The results show that the combined filter brought down the COD concentration to less than 100 mg/l, well below the ECR guidelines. COD is caused by the accumulation of solid waste, soluble organic compounds, antifreeze, residual food waste, emulsified oils and dying bacterial cells. The layer of activated carbon helped to remove these insoluble matters easily.
As for colour, the visually unpleasant (Fig. A.2) effluent changed colour immediately when it was run through the filters. The multimedia filter did not play a significant role here. It was the intrinsic properties of activated carbon, which absorbed the agents responsible for colour.
The turbidity was shown to have been reduced significantly by the use of the filters, bringing the concentration down to single-digit numbers on average (Table 4.17).
The pH was never expected to change due to the use of filters, and the pH was never beyond the ECR standard in the first place.
The data for nitrate concentrations are limited to 2 months (table 4.13). But even with the data that were collected, the nitrate concentration in the raw effluent was already well below the ECR limit.
However, the use of the filters has significantly brought down the nitrate content (Table 4.17). This goes to show that even if by any chance, any high level of nitrate concentration happens to exist, the filter will be able to deal with it. But to what extent, is another scope of further study.
Ammonia concentration, much like the nitrate and Manganese concentrations, are limited to 2 sets of data (Table 4.14). Ammonia is a very common component of effluents, and it was present in the PSTP samples. However, the concentrations were roughly within the ECR limits. But when run through the filters, it showed a significant reduction in concentration. The activated carbon layer played the main part in absorbing the ammonia into it (Table 4.17).
Manganese is a heavy metal that has strict guidelines in the ECR'23, and the effluent had very low Mn concentrations. But treatment with the filters showed the Mn concentration to reduce to roughly zero mg/l (Fig. 4.9). This finding shows that Mn can also be removed by the filter layers (Table 4.15).
The general conclusion is that the multimedia filter is not by itself effective enough to improve the water quality parameters, but the combined effect with the activated carbon plays a great role in making the water more improved (Table 4.17).

From the filter efficiency calculations, it can be seen that the TSS, TDS, and TS are more effectively removed using the activated carbon filter, or even more effectively, the combined filter of activated carbon and multimedia. The multimedia by itself is only able to remove 11%, 3.3%, and 11% of TDS, TSS, TS respectively (Table 4.17).

The removal of turbidity has shown relatively more effectiveness when only multimedia filter is used alone, i.e. 55%. But the use of an activated carbon filter, or the combination of both filters, has shown that around 86% turbidity can be removed (Fig. 4.11).

The levels of ammonia, nitrates, and colour, has shown to have fairly decreased when the multimedia filter is used alone. But again, the use of activated carbon or the successive filtrations of multimedia filter, followed by activated carbon shows that the levels drop by around 80-90% (Table 4.17)

Manganese is a metal that, if consumed in excess, may lead to manganese toxicity, resulting in permanent neurological disorders, including tremors, and difficulty walking. The ECR'23 guidelines for manganese state that the concentration should be no more than 0.4mg/l. The use of Multimedia filter has shown to be ineffective in dealing with manganese levels. But the activated carbon has been able to reduce the manganese levels significantly. The activated carbon by itself, has shown to be 97% efficient in reducing manganese concentrations.

As for the COD levels, although the multimedia filter has shown a significant efficiency of 54%, successive filtration has been shown to remove 87.6% of COD. The activated carbon layer has played a role in absorbing the chemical contents in the water, which requires oxygen to remove it (Table 4.17).
In conclusion, it can be observed that the multimedia filter by itself is not effective enough to remove the impurities. But with the implementation of the activated carbon filter, or even better, the implementation of the successive filtrations of multimedia and activated carbon filters, the majority of the impurities can be removed.

Chapter 5: Conclusion and Recommendations

5.1 General

The PSTP, being a relatively old plant, with primitive designs, is no longer as efficient as it initially was, mainly due to the increase in overall population density, and the possible mixing of industrial wastewater with the influent. The PSTP, never being designed to deal with industrial wastewater, could use an upgrade, so that the parameters of the treated effluent can be within the range of ECR '23.

5.2 Conclusions

The experiment is based on showing us that the use of a cheap, available filter media can help to further improve the effluent of the PSTP. The use of activated carbon is very helpful in significantly improving the effluent parameters, i.e. TS, turbidity, COD, and ammonium.

- The Efficiency of the Multimedia filter was 40% on average, whereas the efficiency of the activated carbon filter was 83% on average.
- The combined filter efficiency of the filters was much greater than the individual effects of the filters, 93% on average.

5.3 Recommendations and Future Scope of Study

There are only very limited studies done on the PSTP. Understandably, there has been no research found on improving the water quality parameters, upgrading the plant, or studies of how long the plant may be able to run into the future. Studies can be done on the proportion of the domestic wastewater, and the proportion of industrial wastewater that the plant is taking in for treatment.

5.4 Limitations

Although the research was a long, and tedious process of collecting 6 months of data, the research can be extended to collect data for the whole year, i.e. 12 months. As a result, the seasonal variations during the whole year were not recorded.
Also, the effluent was collected once every month. This could be improved to more collections and treatments throughout the month. Increasing the number of collections and testing would provide a more reliable data set of the effluent behaviour for that month.

The testing of raw water was done after the effluent has been collected from Narayanganj(effluent release site) and brought back all the way to IUT laboratory. There is a considerable time gap between collection and testing, for which a few parameters such as COD, DO may have changed slightly. This could be prevented by the use of on-site testing kits, where the water would be tested immediately after collection. This would provide more reliable data.

References

1. Saha, M. L., Alam, A., & Rahman, M. (2016). Bacteriological, physical, and chemical properties of sewage wastewater in Dhaka city, Bangladesh. Dhaka University Journal of Biological Sciences, 21(1), 1–8. https://doi.org/10.3329/dujbs.v21i1.9739

2. Hassan, R. (2020). Sewage wastewater characteristics and its management. Retrieved from https://www.academia.edu/70211684/Sewage_Waste_Water_Characteristics_and_Its_Management

3. Ncube, P., Pidou, M., Stephenson, T., & Jefferson, B. (2018). Consequences of pH change on wastewater depth filtration processes. Water Research, 123, 45–56. https://doi.org/10.1016/j.watres.2017.10.040

4. Fundneider, T., Acevedo Alonso, V., Wick, A., Hollender, J., & Löffler, D. (2021). Implications of biological activated carbon filtration on micropollutants in wastewater treatment. Water Research, 178, 116588. https://doi.org/10.1016/j.watres.2020.116588

5. Reungoat, J., Escher, B. I., Macova, M., & Argaud, F. X. (2012). Ozonation and biological activated carbon filtration for the removal of micropollutants from wastewater. Water Research, 46(3), 863–872. https://doi.org/10.1016/j.watres.2011.11.064

6. ADB (Asian Development Bank), 2013. Khulna Water Supply Project: Project Data Sheet (PDS): Details. http://www.adb.org/projects/42171-013/details

7. M. A., Tuhin, M. A. R., Hossain, M. Z. and Salauddin, M., 2009. Designing an Effective Water Supply Network for Khulna City: A GIS Based Approach. PLAN PLUS, 5. Khulna: Urban and Rural Planning Discipline. pp. 88-101.

8. Gani, M. A., Alfasane, M. A., & Khondker, M. (2014). New records of phytoplankton from wastewater lagoons of Pagla, Bangladesh. Bangladesh Journal of Botany, 43(1), 87–90. https://doi.org/10.3329/bjb.v43i1.19753

9. ECR 2023

10. Bangladesh - Dhaka Sanitation Improvement Project : Environmental Assessment : Environmental and Social Impact Assessment of Pagla STP and Trunk Mains (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/507721559627554397/Environmental-and-Social-Impact-Assessment-of-Pagla-STP-and-Trunk-Main

Appendix

Sample Collections and Appearance

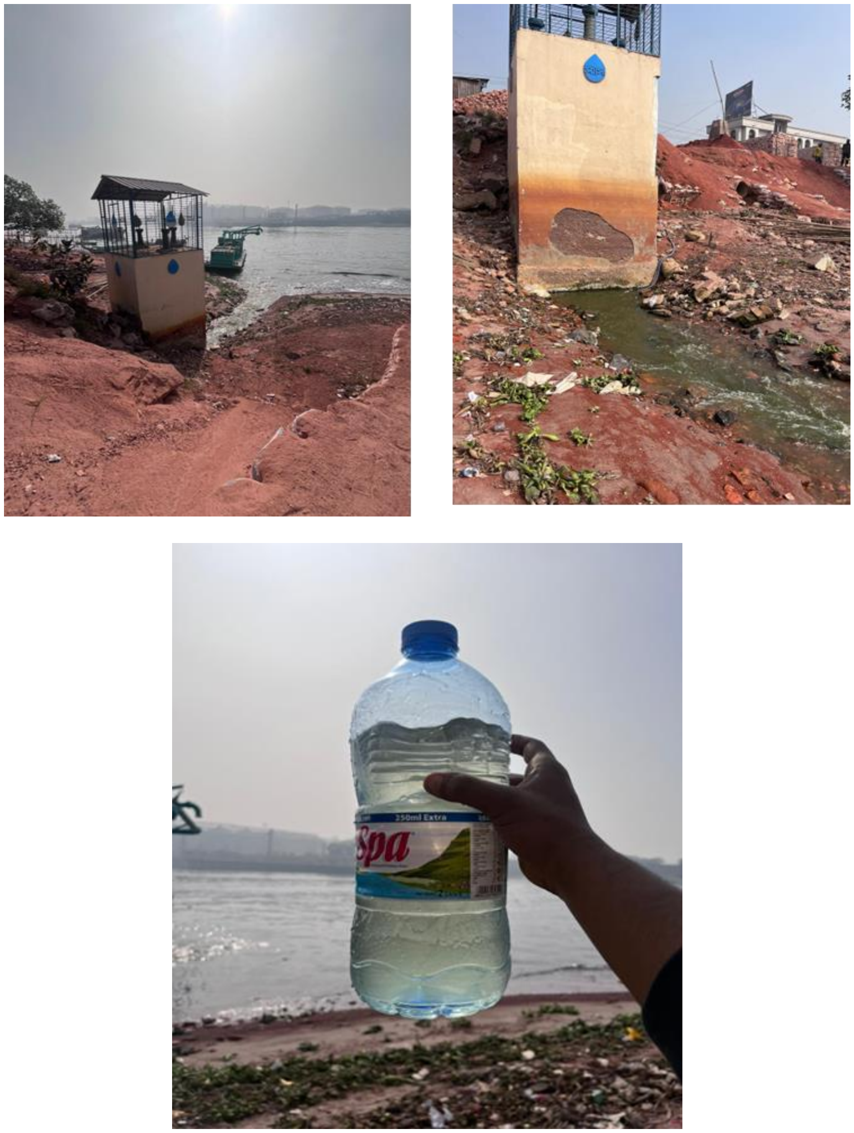

Fig. A.1: Sample collection location.

Fig. A.2: Before and after filtration of effluent.