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TREATMENT OF EFFLUENT IN TEXTILE WASHING INDUSTRY AND REDESIGNING OF ETP

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DECLARATION OF CANDIDATES

We hereby declare that the project/thesis work under the supervision of Dr. Amimul Ahsan entitled "Treatment of effluent in textile washing industry and redesigning of ETP", has been performed by us and this work has not been submitted elsewhere for reward of any degree or diploma (except for publication).

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ABSTRACT

Due to its complicated composition and high concentrations of pollutants, textile effluent is a significant cause of pollution. Due to its complicated makeup and high concentration of contaminants, it has a number of detrimental effects on the environment. In this study, we sought to establish the ideal ratios of cationic polymer and polyaluminum chloride (PAC) for the coagulation of textile wastewater. We also looked at the possibility of using cactus as a natural coagulant for the purification of wastewater. For jar testing, different dosages of PAC and cationic polymer were used to gauge how well they reduced COD, pH, color, and TSS. The results showed that COD, pH, color, and TSS were all significantly reduced at an optimal dosage of 1.2 mg/L for both PAC and cationic polymer. Furthermore, the ideal dosage for TDS removal was found to be 0.4 mg/L. We can observe that for a dosage of 1.2 mg/L, the removal efficiencies for COD, Color, pH, TSS, and TS were, respectively, 31.11%, 98.15%, 100%, 98%, and 87.17%. TDS, however, is not eliminated. For a dosage of 4 mg/L, the TDS rises by at least 46.17%. Cactus was studied as a natural coagulant for textile wastewater treatment in order to investigate alternate coagulation methods. According to the results of the jar tests, cactus at its ideal dosage of 20 mg/L substantially reduced TDS, TSS, color, COD, and turbidity. For pH, the values are random and ranges from 8.05 to 8.22. So, cactus powder was not effective for pH. For DO, the optimum dosage was 230 mg/l. The dosage with less concentration just reduced DO. Removal efficiencies for TDS, TSS, DO, and color at an optimal dose of 20 mg/L are respectively 29.38%, 57%, 77.5% (DO addition), and 21.01%. However, turbidity and COD rise. The minimum turbidity addition is 20% for dosages under 20 mg/L, while the minimum COD increase is 15% for dosages under 20 mg/L. The pH value that comes closest to 7 is 8.09 at 230 mg/L. The design of various Effluent Treatment Plant (ETP) components for the textile washing industry is covered in this thesis paper. A bar screen, equalization tank, coagulation tank, flocculation tank, primary clarifier, aeration tank, and secondary clarifier are among the components that were designed. Each component is specifically created to solve the special difficulties involved in treating textile wastewater. To attain the target effluent quality, the design integrates the fundamentals of physical, chemical, and biological treatment procedures. The research's conclusions offer a thorough foundation for the development and application of an efficient ETP in the textile washing sectors, eventually promoting environmental sustainability and legal compliance.

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CHAPTER 1: INTRODUCTION

1.1 General

Bangladesh is currently a developing country with a rapid growing economy. Bangladesh's economy greatly benefits from the textile sector, which accounts for more than 77% of exports and employs millions of people [1]. The late 1970s saw the start of Bangladesh's textile sector, which has since expanded quickly. The nation is currently one of the biggest exporters of ready-made clothing in the globe.

Bangladesh has over 5000 textile industries now. Most of them are situated in Dhaka, Narayanganj, Gazipur and Keraniganj districts. More than 4 million of people work in these textile industries [2]. The textile business is primarily made up of knitwear, textiles, and ready-made clothing. After the manufacture of these garments, washing is required for altering the outlook, appearance, comfort, and design of ready-made clothing made from solid color dyed or pigment printed fabric. Although industrial washing is a recent fad in Bangladesh, it has existed for 50 years. Now, washing involves adding various shades, dry processes, dying, and many other processes depending on what the buyer wants. Washing give advantages like starch removal, giving the cloths soft feeling; dirt, oil spots, and stains from the clothes during production are eliminated; accurate sizing; new outlook to the garments etc.

However, the textile industry produces a great amount of wastewater. One of the biggest commercial water consumers in the world, the textile industry produces large amounts of wastewater that is frequently contaminated with a range of contaminants, including dyes, detergents, salts, heavy metals, and organic compounds. Depending on the particular process and the kinds of materials used, the makeup of wastewater from the textile sector varies. High concentrations of organic substances, suspended solids, chemicals that change pH, and heavy metals may be present. In textile washing industry, number of chemicals are used to achieve the desired look and to aid in subsequent washing processes because garment washing is not fixed in a typical washing process like rinse. They mainly use: detergents, sequestering agents, anticreasing agents, desizing agents, enzymes, anti backstainer, neutralizing agents, softening agents, bleaching agents, oxidizing agents, reducing agents, fixing agents, catanizer, wetting agent etc. So, the wastewater from textile washing industry can be complex. If not properly managed, wastewater from the textile sector can have negative effects on the environment and public health.

The treatment of this wastewater consists of an Effluent Treatment Plant or ETP. It is a specialized system made to handle industrial wastewater from different textile industry sources. The ETP is an essential component of textile production that serves to reduce wastewater's negative environmental and public health effects through some processes.

1.2 Background

Effluent Treatment Plant or ETP is a specialized system which is created to clean industrial wastewater before it is released into the atmosphere. An ETP's function is to clean the wastewater of contaminants and pollutants so that it can be safely released into the environment or used again in industrial operations. Pretreatment units, primary treatment units, secondary treatment units, and tertiary treatment units are some of the parts that make up an ETP system. Screening, grit removal, and oil and grease removal are all included in the pretreatment unit. Sedimentation containers and clarifiers are among the main treatment facilities. Activated sludge devices, trickling filters, and biological reactors are some of the secondary treatment components. Sand screens, carbon filters, and reverse osmosis are a few of the tertiary treatment components. The kinds of pollutants present and the characteristics of the wastewater are what determine which treatment procedures are used in an ETP system. Physical, chemical, and biological processes like coagulation-flocculation, sedimentation, activated sludge, oxidation, and decontamination are frequently used in treatment processes. These procedures aim to purge the effluent of nutrients, pathogens, organic matter, suspended solids, and other pollutants.

The development of industrialization and the extreme pollution and environmental harm caused by the discharge of industrial wastewater into water bodies at the beginning of the 20th century are what gave rise to the history of effluent treatment plants (ETPs).

Manchester, England's first wastewater treatment facility was built in 1890 to handle the sewage from the expanding metropolis [3]. As industrialization expanded and more factories started discharging their wastewater into rivers and other bodies of water, the need for wastewater treatment became more and more obvious. Several nations started passing laws and rules in the early 1900s demanding industries to treat their wastewater before releasing it into the environment. The Rivers and Harbors Act of 1899, which forbade the discharge of any material into navigable waterways without a permit, was the first federal law in the United States to regulate wastewater discharges [4].

The creation of synthetic fibers and other materials during World War II increased textile production, which in turn increased the amount of wastewater produced by the textile industry.[5] Activated sludge and other biological treatment techniques were developed in the 1950s and 1960s, which marked the beginning of efforts to handle textile wastewater. As the environmental movement gathered traction in the 1970s, governments all over the world started to enact stricter rules regarding the discharge of industrial wastewater. In this respect, the United States' Clean Water Act of 1972 marked a significant turning point by requiring businesses to acquire permits and adhere to stringent effluent limits for the discharge of their wastewater [6]. Since then, treatment methods, automation, and monitoring have all advanced, contributing to the ongoing evolution of ETP. To treat wastewater and lessen environmental impact, ETPs are now used in a variety of sectors, including textile, food and beverage, chemical, and pharmaceutical.

1.3 Objectives of the Study

The aim of this study is to treat the effluent of textile washing industry of Ananta Apparels Ltd, Narayanganj in Bangladesh. The main objective of this thesis is to investigate and evaluate the efficiency of various effluent treatment methods in the textile washing industry. Specifically, the study aims to:

1. To calculate the ideal coagulant dosage for wastewater treatment employing cationic polymer and polyaluminum chloride as coagulants, consequently increasing the treatment process' effectiveness.
2. To determine the ideal cactus powder dosage needed for effective treatment by conducting independent jar experiments and evaluating the performance of cactus powder as a potential coagulant in wastewater treatment.
3. To design and suggest a thorough effluent treatment plant (ETP) for wastewater from textile washing, taking into account the unique traits and makeup of the wastewater.

In order to promote sustainable wastewater management practices and lessen the environmental impact of the textile manufacturing processes, the study's overall objectives are to improve understanding of coagulant dosage optimization, assess the potential of cactus powder as a coagulant, and propose an improved design for effluent treatment in the textile washing industry.

1.4 Scope of the Study

The following are some of the study's limitations:

- Only a few water and wastewater quality parameters, including pH, TS, TDS, TSS, and COD, were tested in this research.
- In this research, wastewater treatment only used effluent from one textile industry as a raw sample.
- The optimum dosage using PAC and Cationic Polymer can be worked on more.
- The ideal dosage while using Cactus Powder can be worked on.

CHAPTER 2: LITERATURE REVIEW

2.1 General

The design and effectiveness of textile 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 on an industrial basis.

2.2 Wastewater from Textile Industry

There are more than 5000 textile industries in Bangladesh [7]. These industries produce huge amount of wastewater. Most of the textile industries are located in Dhaka, Narayanganj and Gazipur districts. Bangladesh generated about 577,000 tonnes of textile waste in 2019 [8]. Most of the time they are situated near rivers like Buriganga, Turag, Shitalakshya etc. The textile industries dump 2030 million liter wastewater every year into the water bodies of Bangladesh [9]. These rivers are hugely polluted because of the effluent wastewater from these textile industries.

Along the banks of these rivers, there are numerous other large and minor industries in addition to textiles. The majority of them do not have appropriate ETPs (effluent treatment plants) and do not even adhere to the most fundamental river protection laws. They are subject to punishment under the Water Act 2013, River Protection Act 2013, and Environment Conservation Rules 1997, but they evade it due to political corruption, a dearth of leadership from the River Commission, and other factors. The government was ordered by the high court in 2009 to demarcate the riverbank, but this has not yet been done.

2.3 Operations in Textile Washing Industry

Industrial garment cleaning is a technology that alters the look, feel, comfort, and design of ready-made clothes made from solid-colored fabrics that have been dyed or printed with pigments. Denim cloth is specifically subjected to washing. A 2/1 or 3/1 cotton twill cloth (work-wear twill) with a dyed blue warp and a raw white weft is what is known as denim. At times, the weave is colored while being sized. Sizing materials are incorporated into the warp yarn during the weaving process to fortify the strand and increase resistance to mechanical abrasion in looms. In that case, it is necessary to eliminate the size materials in order to make the surface soft and smooth in preparation for additional washing procedures. When washing clothes, various washing techniques are used. It includes both dry and moist processes as well as chemical processes [10].

Dry Process:

Arid process is the name given to a process that is used in an arid environment. This is used on soiled clothing. The sample garment undergoes a variety of mechanical abrasions during this procedure, giving it an aged appearance. Without it, denim clothing does not appear nice, and the majority of the time, it is done manually [11].

Wet Process:

After leaving the dry process area, the raw garment is subjected to wet processes like rinses, enzyme washes, bleach washes, etc. to achieve the desired appearance. The garment goes through several chemical processes in this process to get rid of impurities from various production processes, give it a new appearance, make it soft, and get it ready for the customer [11].

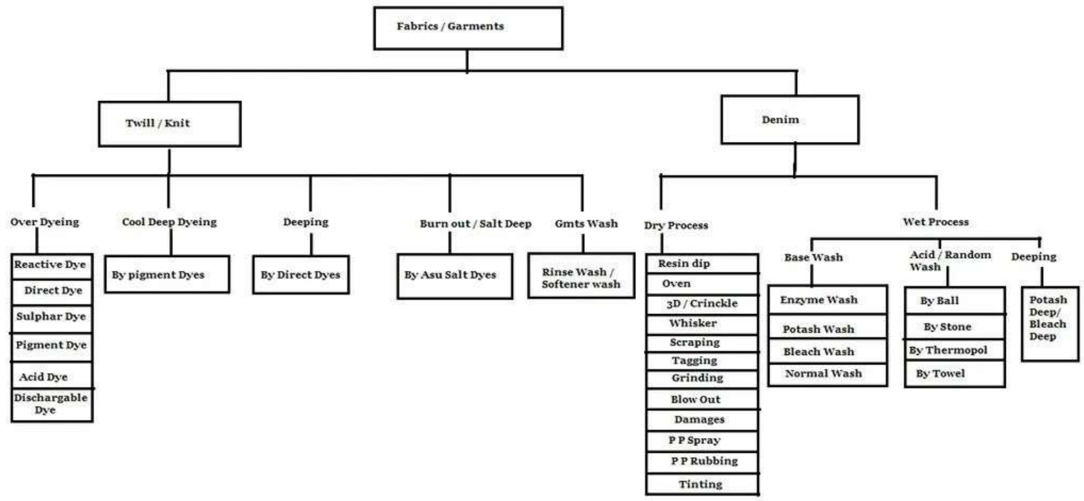

Figure 2.1: Textile Washing Process [11]

2.4 Water Usage in Textile Industry

Throughout the entire textile processing procedure, water is used extensively. Nearly all finishing chemicals, specialty chemicals, and dyes are applied to cloth substrates from water baths. Additionally, aqueous systems are used in the majority of cloth preparation processes like desizing, scouring, bleaching, and mercerizing.

Each step in the cloth production process uses a lot of water, which eventually turns into wastewater. The pretreatment, dyeing, printing, and finishing of textile materials rank among the various process steps' most significant sources of pollution. Water consumption ranges from 12 to 65 L to make one meter of finished cloth. The amount of water used will increase as the processing procedure lengthens [11].

In the textile washing process, for the washing of 1 kg garments, 20 liters of water is required, which is huge. This water is high on temperature and contamination and thus, needs proper treatment before disposal.

2.5 Textile Wastewater Characteristics

From 2.4, we have come to know about the eater amount that is used in textile industry. We have also seen that, textile washing industry consumes a lot of water. Parameters like suspended solids (SS), dissolved solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO) are the primary indicators of composite textile wastewater quality. Table 2.3 lists the typical properties of effluent from the textile sector. The COD values of composite wastewater are exceptionally high in comparison to other characteristics, as shown in Table 2.3. The effluent from composite textiles often has a BOD/COD ratio of 0.25 or below, which indicates that a significant amount of the organic matter is not biodegradable.

Table 2.1: Composite textile wastewater characteristics [12].

SL. No.	**Parameters**	**Values**
1	pH	7.0-9.0
2	Biochemical Oxygen Demand (mg/L)	80-6,000
3	Chemical Oxygen demand (mg/L)	150-12,000
4	Total suspended solids (mg/L)	15-8,000
5	Total dissolved solids (mg/L)	2,900-3,100
6	Chloride (mg/L)	1000-1600
7	Total Kjeldahl Natrogen (mg/L)	70-80
8	Color (Pt-Co)	50-2500

2.6 Treatment Process of Wastewater

2.6.1 Primary Treatment Process

The initial step in treating textile wastewater at an Effluent Treatment Plant (ETP) is primary treatment. During this step of the treatment process, big, solid particles are physically removed from the wastewater using screening, sedimentation, and/or flotation [12]. Prior to further processing in the ETP, primary treatment aims to lower the wastewater's concentration of suspended particles, oils, and grease. Coagulation and flocculation are two common mechanical and chemical techniques used in the initial treatment process to help separate suspended particles from wastewater. Before wastewater is released into the environment, it is essential to pass this stage to ensure that it complies with the necessary discharge criteria. [12]

The primary treatment method has some restrictions and mainly focuses on physical separation and sedimentation. Dissolved contaminants, colloidal particles, or soluble organic matter cannot be removed with this method. Additionally, compared to secondary treatment methods, the removal efficiency for suspended particles is typically lower. Therefore, secondary treatment is frequently used to further cleanse the wastewater after primary treatment, such as biological processes (such as activated sludge, trickling filters) or sophisticated treatment techniques (such as membrane filtering, chemical oxidation) [12].

It's important to keep in mind that the scope and layout of primary treatment may change based on the unique properties of the wastewater, the treatment plant's capacity, and the standards for effluent quality established by regulatory agencies [9].

2.6.2 Secondary Treatment Process

In wastewater treatment plants, secondary treatment is a biological procedure that comes after initial treatment. It focuses on removing nutrients, suspended particles, and organic materials from wastewater. Secondary treatment's main objective is to further clean the wastewater so that it is appropriate for reuse or discharge into receiving bodies of water [10].

Aerobic bacteria may obtain energy and nutrients from organic materials. They convert organic material into CO2 by oxidizing it, and water breaks down nitrogenous organic material into ammonia. Among the aerobic systems utilized in the secondary treatment are activated sludge systems, trickling filters, and aerated lagoons. The main purpose of anaerobic treatment is to stabilize the generated sludge [13].

One of the often employed biological treatment methods is aerated lagoons. The effluent from the primary treatment is aerated for roughly 2–6 days and the produced sludge is then removed in a big storage tank that is lined with rubber or polythene. The elimination of BOD is up to 99% efficient, whereas the removal of phosphorus is 15–25% efficient. It is discovered that aerated lagoons are also where ammonia nitrification takes place. This method's primary drawbacks are the substantial amount of space it requires and the possibility of bacterial contamination in the lagoons [12].

A designed Effluent treatment plant on screening, equalization, aeration and biological sedimentation. With coagulation and flocculation, the efficiency of the designed treatment for COD, BOD, TDS, TSS were 86.6%, 88.59%, 63.86%, and 89.25% respectively [14].

2.7 Turbidity and COD Removal with Natural Coagulants

Locally available natural coagulants can be used as great coagulants to remove turbidity and COD from textile washing wastewater. The jar test was used to examine the ability of cactus to function as a natural macromolecular coagulant. With beginning turbidities ranging from 20 to 200, water with turbidity less than 5 NTU could be obtained thanks to the cactus coagulation's rather strong turbidity reduction effectiveness. The optimum dosage of cactus coagulant was discovered to be similar to that of AlCl36H2O when applied to the same water sample. Additionally, the effects of variables including pH, temperature, and alkalinity on cactus coagulation were investigated. Using cactus solids to cleanse sewage water, potable water supply, and highly murky saltwater led to excellent removal efficiency of turbidity and COD [15].

Because they are less expensive, more readily available locally, and environmentally benign, natural coagulants can be utilized for the same purpose. The commercial adoption of natural coagulants from certain plants is hindered by low manufacturing yields and high operating costs, which is why performance of their composites is being investigated [16].

In a study, the extracted liquid coagulant's pH was 7.05, while its electrical conductivity was 1123 s/cm, and the optimally mixed cactus powder had a bulk density of 590 kg/m^3. 12.25 ml/l, 7.31 pH, and 26.53 minutes were the ideal dosage, pH, and extraction times, respectively. The clearance efficiency for turbidity, TSS, and E. coli were 87.13, 82.15, and 84.02%, respectively. These findings showed that the composite coagulant performed well in the treatment of water, outperforming alum, the most widely used commercial coagulant, by 82–99% [16].

Cactus is effective at removing wastewater's chemical oxygen demand (COD) and coloration, according to some research. Plant-based coagulants have the potential to be efficient in treating wastewater while being environmentally friendly and sustainable. The bio-coagulant shown effectiveness in removing color and turbidity [17].

In another study, the outcomes of jar tests with cactus powder were compared with natural coagulants Moringa Olifera and PolyDADMAC, two chemical coagulants. The waters from the Legedadi and Geffersa reservoirs were used in the Jar test experiment. The efficacy of cactus powder in removing turbidity from raw waters from the Legedadi and Geffersa reservoirs was 99.4% and 95.7%, respectively. Coagulation using cactus powder had no effect on the water's PH. With rising cactus concentrations, total dissolved solids and conductivity steadily rose. For both water samples, the efficacy of cactus in removing turbidity was on par with that of chemical coagulants. When compared to Moringa olifera, cactus shown greater efficacy in removing turbidity [18].

In a different investigation, the results showed that when the dose increased from 0.50 to 3.50 g for both cactus powder and alum, respectively, the percentage of turbidity removed from turbid water samples went from 23.9% to 54% and 28.46% to 58.2%. In comparison to the use of artificial coagulants (Alum), cactus powder also has a negligible impact on pH value (7.33 at 0.50 g, 7.49 at 1.50 g, 7.57 at 2.50 g, and 7.57 at 3.50 g). As the dose of cactus powder grew from 0.50 g to 3.50 g, respectively, the salinity increased from 0.4% to 0.69% and from 0.39% to 0.98% [19].

2.8 Polyaluminum Chloride and Cationic Polymer as Coagulants

Chemical compound polyaluminum chloride (PAC) is frequently employed as a coagulant in water treatment procedures. It is a polymer made of inorganic elements like aluminum chloride. Aluminum is either reacted with another hydroxide source or with hydrochloric acid to create PAC, which is then purified.

In order to remove suspended particulates, organic debris, and specific types of pollutants, polyaluminum chloride is frequently employed in municipal and industrial water treatment systems. In order for them to combine and form larger particles that can be easily removed through sedimentation or filtering, it destabilizes the particles in the water. When it comes to cleaning up polluted water, reducing their concentration, and enhancing overall water quality, PAC is quite successful.

The type of polymers known as cationic polymers has molecules that have a net positive charge. They are frequently employed as coagulants and flocculants in the treatment of wastewater to help remove suspended particles, organic materials, and other impurities. These polymers can cluster and settle more effectively because they are often water soluble and can form complexes with negatively charged particles.

The effectiveness of the commercial polyaluminum chlorides (PAC) and the as-prepared cationic polymer in reducing turbidity in Nile water was assessed. The use of coagulants in the treatment of Nile River water revealed that 0.5 ppm of cationic polymer; DS 0.85 reduced the turbidity brought on by algal biomass to 61.5%. A pre-chlorination step is necessary for the removal of algal cells effectively. With a turbidity removal percentage of 73.1% and a total algal removal percentage of 94.8%, the pre-chlorination/coagulation method utilizing cationic polymer (DS = 0.97) produced the best treatment results [20].

The polyelectrolyte - polyaluminium chloride (PAC), a substitute for alum-based coagulation, is also employed at the Barekese Water Treatment Plant in Ghana. However, nothing is known about the operating parameters necessary to obtain higher performance than alum-based coagulation. The purpose of this study was to establish the ideal coagulant dose, mixing rate, and operational pH for improved water treatment performance. In a pH range of 6.5 to 8.0, the impacts of three different sets of mixing speed pairs—180/40, 180/25, and 150/25 revolutions per minute (fast/slow)—on the treatment process were examined. The best coagulation was produced by mixing at 150/25 rpm and a PAC dose of 15 mg/L, respectively [21].

2.9 Jar Test Operations

The most popular experimental technique for coagulation-flocculation is the jar test. In the trials, a sample of synthetically turbid water was used to coagulate various coagulants using a standard jar text setup. It was conducted as a batch test using a set of six breakers and steel paddles with six spindles. The sample was missing uniformly prior to executing the jar text. The samples should next have their turbidity and coliform count quantified in order to indicate a beginning concentration.

The beakers were filled with a variety of concentrations of coagulants. The entire process described in the jar text was carried out at various speeds of rotation [22].

The beakers were stirred at various mixing times and speeds after the necessary amount of coagulants had been introduced to the suspensions, including rapid mixing, 200-250 rotations per minute (rpm) for 1-3 minutes and 10–15 minutes of gentle mixing (30–40 rpm). A sample was eventually taken with a pipette from the middle of the supernatant following the 20–60 minute agitation period in order to perform physicochemical and bacteriological analyses that indicate the final concentration. All tests were conducted with three different turbidity ranges: higher (90-120 NTU), medium (40-50 NTU), and lower (25-35 NTU) NTU, at an ambient temperature of between 26 and 32°C [23].

In the experiment, mixing duration and the dosage of the coagulant were changed to investigate how they affected flocculation and to determine the ideal value for each parameter.

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 Proportions and Case Study

The Ananta Apparels Ltd. facility in Siddirganj, Narayanganj district, provided the wastewater for collection. It is a washing industry for textiles. Raw Wastewater from different points of the existing Effluent Treatment Plant (ETP) were collected from the textile washing industry and were tested. The total amount of the collected wastewater was 16 liters. Wastewater for jar test with cactus was collected from Apex Textiles Ltd, volume was 2 liters. The volume wastewater taken from different components of the ETP is given below:

Table 3.1: Volume of the Collected Wastewater

Before Equalization Tank	2L
Before Flash Mixer	2L
Before Aeration Tank	2L
Before Secondary Clarifier	2L
Before Filter Feed Tank	2L
Outlet	2L
Jar Test	2L
Jar Test	2L

Figure 3.1: Wastewater Collection

Figure 3.2: Wastewater Collection

3.3 Preparation of Materials and Apparatus

The tools and supplies were ready in accordance with how the case study was to be conducted. This involves using laboratory equipment according to normal practices.

The standard equipment needed to test the characteristics of raw textile wastewater was needed for this investigation. Prior to the experiment, the wastewater was gathered and kept in a secure location. The beakers need to be big enough to hold the required amount of effluent. For raw wastewater test, 6 beakers of 600 ml volume were used. Other apparatus were used from the experiment laboratory as well.

3.3.1 Multiparameter Meter

Multiple electrochemical parameters, like as pH, conductivity, dissolved oxygen, salinity, temperature, and turbidity, can all be measured using a multiparameter meter. Any type of electrochemical measurement requires the use of multiparameter meters. These devices are used by researchers all over the world to simultaneously measure a variety of substances accurately.

The device must first be readied before it can be used. The meter must first be correctly calibrated. Chlorophyll-fluorescence and other sensors are calibrated after temperature, specific electrical conductance, dissolved oxygen, pH, oxidation-reduction potential, turbidity, and ionselective electrodes. The multiparameter meter is used to collect readings of each parameter after the sample has been prepared.

Figure 3.3: Multiparameter Meter (Benchtop Senslor+31; HACh, USA)

3.3.2 Spectrophotometer

An instrument used to evaluate the strength of light beams at various wavelengths is a spectrophotometer. A spectrophotometer uses a monochromator with a diffraction grating (which may be stationary or mobile) to produce the analytical spectrum. A light source is shined into the monochromator of a spectrophotometer, diffracted into a rainbow, split into two beams, and then scanned across the sample and control solutions. The sample and the reference either transmit a portion of the incident wavelengths or reflect a portion of it. The resulting light beam is then directed at the photodetector device, which compares the relative intensities. Relative currents are converted by electronic circuits into linear transmission percentages and measures of concentration or absorbance.

Figure 3.4: Spectrophotometer (DR3900; HACh, USA)

3.3.3 Turbidity Meter

The cloudiness or turbidity of a liquid brought on by suspended solids in the sample is measured using a turbidity meter. Turbidity, which is often referred to as water clarity, is frequently used to gauge the water's hygienic quality and frequently shows when filters are malfunctioning.

Figure 3.5: Turbidity Meter (2100Q; HACh, USA)

3.3.4 COD Reactor

The chemical oxygen demand of a water sample is determined using a laboratory COD (Chemical Oxygen Demand) reactor. A metric known as chemical oxygen demand measures the quantity of oxygen needed to chemically oxidize both organic and inorganic molecules in water.

The COD reactor typically comprises of a water sample-holding glass or metal vessel, also known as a COD digestion tube or reactor. The reactor has a condenser, a temperature controller, and a heating element. During the digesting process, the condenser aids in preventing the loss of volatile components.

Figure 3.6: COD Reactor (DRB200, HACh, USA)

3.3.5 Jar Test Apparatus

A laboratory tool called the Jar Test Apparatus is used to simulate and improve the coagulation and flocculation processes in the treatment of water and wastewater. A flocculator or paddle flocculator are other names for it. The jar test aids in calculating the best coagulant and flocculant dosage needed to effectively clarify or sediment suspended particles in water.

Figure 3.7: Jar Test Apparatus (Wr230-20, HACh, USA)

3.4 Properties of the Wastewater

Depending on a number of variables, including the kind of textile manufacture, the washing procedures, and the chemicals employed, the composition and qualities of textile washing effluent might change. Here are a few typical characteristics of effluent from textile washing, though:

High Organic Load: The wastewater from washing textiles often has a high level of organic molecules. Detergents, surfactants, oils, greases, and other organic materials used in the washing process are mostly to blame for this.

Suspended Solids: Textile-washing wastewater frequently includes suspended solids, including fibers, lint, dye granules, and other solid wastes. These solids may increase the wastewater's turbidity.

Chemicals and Dyes: A variety of chemicals, dyes, and auxiliaries are used in the washing of textiles. The presence of colorants, pH adjusters, bleaching agents, softeners, and other chemical residues might result from these compounds making their way into the effluent.

Alkaline pH: To help remove stains and grime, alkaline agents, such as sodium hydroxide, are frequently used in textile washing operations. The pH of the effluent is hence typically alkaline.

High biochemical oxygen demand (BOD) and chemical oxygen demand (COD): Textile washing effluent has a high organic content, which raises the BOD and COD levels. While COD represents the total organic load, BOD measures the amount of oxygen needed by microorganisms to break down organic waste.

Temperature Variability: The temperature of the wastewater can change depending on the methods used to wash the textiles and the water sources used. It may be heated during the washing process or left at room temperature.

Presence of Heavy Metals: Heavy metals may be present in some of the dyes and chemicals used in the production of textiles, including chromium, cadmium, lead, and copper. These metals may be contaminants in the wastewater.

This effluent is often treated before being released into the closest aquatic body. The effluent has been gathered for the experiment from several ETP components.

3.5 Polyaluminimum Chloride and Cationic Polymer

Chemical compound polyaluminum chloride (PAC) is frequently employed as a coagulant in water treatment procedures. It is a polymer made of inorganic elements like aluminum chloride. Aluminum is either reacted with another hydroxide source or with hydrochloric acid to create PAC, which is then purified.

In order to remove suspended particulates, organic debris, and specific types of pollutants, polyaluminum chloride is frequently employed in municipal and industrial water treatment systems. In order for them to combine and form larger particles that can be easily removed through sedimentation or filtering, it destabilizes the particles in the water. When it comes to cleaning up polluted water, reducing their concentration, and enhancing overall water quality, PAC is quite successful.

The type of polymers known as cationic polymers has molecules that have a net positive charge. They are frequently employed as coagulants and flocculants in the treatment of wastewater to help remove suspended particles, organic materials, and other impurities. These polymers can cluster and settle more effectively because they are often water soluble and can form complexes with negatively charged particles.

There are various advantages to using cationic polymers in wastewater treatment, including: coagulation and flocculation, improved solid-liquid separation, enhanced sludge dewatering etc.

Polyalumium chloride and cationic polymer were provided by Ananta Apparels Ltd.

3.6 Cactus Powder

Natural coagulants are chemicals with coagulation capabilities that can be employed in wastewater treatment procedures since they are sourced from natural sources. In some situations, these plant-based coagulants can work just as well as conventional chemical coagulants. It has been investigated for its possible use in wastewater treatment, particularly as a natural coagulant and flocculant, for Opuntia ficus-indica, also known as the nopal or prickly pear cactus. The Opuntia ficus-indica cactus pads and powder have coagulation capabilities and can help remove pollutants from wastewater.

Cactus powder in made from cactus tree collected from a local tree shop. 6 cactus trees were collected. They were washed with fresh distilled water. Then, they were sliced. The sliced cactus pieces were kept in oven for three hours to make them dry. After this, the cactus substances were powdered with an electric blender. This is how cactus powder was made. This cactus powder was used as a coagulant in jar test to find a proper coagulation ratio.

3.6 Experimental Setup

The required equipment was prepared, and the experiment was then set up appropriately. All the collected wastewater sample of 6 bottles of volume 12 liters were tested to get their different properties. For this, necessary beakers of proper volume were used.

For the jar test, 6 beakers were used. Wastewater sample for jar test was total 4 liters. 6 beakers of 600 ml volume were used for jar test. 500 ml of wastewater was taken to each beaker. Then those 6 beakers were placed on the jar testing flocculation machine. For jar test, two chemical substances were used. They were polyaluminium chloride and cationic polymer. Both of them are provided by the Ananta Apparels Ltd. The optimum coagulant dosage was to be found.

3.7 Sample Preparation

Each beaker was properly cleaned with distilled water (and other cleaning agents if necessary) to prevent the wastewater from reacting negatively to any impurities. 250 ml or so of wastewater were placed in each of the beakers. Then, different dosage of polyaluminuim chloride and cationic polymer were given in each of the beakers. This is how jar test was done with polyaluminuim chloride and cationic polymer.

In another 6 beakers, 100 ml wastewater was taken in each beaker. Then proper dosage of cactus powder were given to each beaker. After this, jar test was done using those 6 beakers.

Figure 3.8: Beaker with Wastewater for Jar Test

3.8 Jar Test

The jar test is a routine laboratory process used in the treatment of water to establish the ideal chemical dosage for flocculation and coagulation. Its name comes from the glass beakers or jars that were used for the test. A representative water sample is divided into multiple smaller containers, usually glass jars, and tested using this method. Different amounts of coagulant, flocculant, or a combination of the two are applied to each jar. The chemicals are gradually put to the jars, typically beginning with lesser quantities and increasing them.

3.8.1 Jar Test with Polyaluminum Chloride and Cationic Polymer

The purpose of this study was to assess the efficiency of cationic polymer and polyaluminum chloride (PAC) as coagulants in the treatment of wastewater. Six beakers, each having a capacity of 600 ml, were used in the jar test, and 250 ml of wastewater was added to each beaker.

3.8.1.1 Experimental Technique

Beaker preparation: For the jar test, six beakers with a total volume of 600 ml that were clean and well labeled were chosen.

Water Sample: Each beaker received an equal amount of the 250 ml of wastewater sample that was properly measured and poured into each one.

Coagulant Addition: A cationic polymer and poly aluminum chloride (PAC) were used as coagulants. These coagulants were introduced to the beakers in small amounts at first and then gradually increased.

Rapid Mixing: To start rapid mixing, the jar test apparatus was set to revolve at 100 rpm for one minute. The goal of this quick mixing phase was to uniformly distribute the coagulants and promote the growth of microflocs.

Slow Mixing and Settling: After the rapid mixing stage, the procedure continued for an additional ten minutes at a speed of 40 rpm. Slow Mixing and Settling. The development of flocs and their eventual settling were made possible by the slower mixing.

Settling and Observation: After the jar test, the beakers were allowed to settle for a certain amount of time before being observed. The supernatant water got clearer and flocs began to settle to the bottom of the beakers.

3.8.2 Jar Test with Cactus Powder

The purpose of this study was to assess the effectiveness of cactus powder as a coagulant in the treatment of wastewater. Six beakers, each with a capacity of 250 ml, were used in the jar test, along with 100 ml of wastewater.

3.8.2.1 Experimental Technique

Beaker preparation: For the jar test, six beakers, each with a volume of 250 ml and being clean and labeled, were chosen.

Wastewater Sample: To ensure that all beakers contained an equal amount of wastewater sample, a total of 100 ml was carefully measured and poured into each one.

Coagulant Inclusion: For this investigation, cactus powder was chosen as the coagulant. Cactus powder was put to the beakers in small amounts at first and then steadily increased.

Rapid Mixing: To start rapid mixing, the jar test apparatus was set to revolve at 100 rpm for one minute. The goal of this quick mixing stage was to equally distribute the cactus powder and encourage the growth of microflocs.

Slow Mixing and Settling: After the rapid mixing stage, the procedure continued for an additional ten minutes at a speed of 40 rpm. Slow Mixing and Settling. The development of flocs and their eventual settling were made possible by the slower mixing.

Settling and Observation: After the jar test, the beakers were allowed to settle for a certain amount of time before being observed. The supernatant water got clearer and flocs began to settle to the bottom of the beakers.

3.9 Testing

3.9.1 RAW Wastewater Properties Testing

Wastewater collected from different components of ETP was tested. All the samples of all points were tested. Information about different properties of the raw wastewater were gathered. The tested properties were:

- COD (Chemical Oxygen Demand)
- pH
- Temperature
- Color
- TDS (Total Dissolved Solid)
- TSS (Total Suspended Solid)

3.9.2 Wastewater Testing After Jar Test with PAC and Cationic Polymer

After conducting the jar test with polyaluminium chloride and cationic polymer as coagulants, all the water samples of 6 beakers were tested to find out the properties of the sample wastewater. The conducted tests were:

- COD (Chemical Oxygen Demand)
- pH
- Temperature
- Color
- TDS (Total Dissolved Solid)
- TSS (Total Suspended Solid)

3.9.3 Wastewater Testing After Jar Test with Cactus Powder

All of the water samples from the 6 beakers were examined following the jar test using cactus powder as a coagulant to determine the characteristics of the sample wastewater. The tests that were run were:

- COD (Chemical Oxygen Demand)
- pH
- Turbidity
- Color
- TDS (Total Dissolved Solid)
- TSS (Total Suspended Solid)
- DO (Dissolved Oxygen)

3.10 Before and After Case Study

It was seen that before the experiment, the color of the wastewater was bluish. The blue color results from the washing of blue colored jeans pants. However, after both of the jar tests, the color and turbidity were cleared from the wastewater and after using filtration, the water got very clear and uncloudy.

3.11 Data Collection of the Effluent Treatment Plant (ETP)

To make a feasible design of an Effluent Treatment Plant (ETP), all the necessary information were collected from the company which needs the ETP, Ananta Apparels Ltd from Siddhirganj of Narayanganj district. Those information included daily inflow volume of wastewater, characteristics of their wastewater, and the layout of the ETP etc.

3.12 Input Parameters of ETP Design

3.12.1 Design of Bar Screen

Standard design values were used to design the bar screen. The design value ranges are:

Table 3.2: Design Value Range for Bar Screen

Inclination Angle (with horizontal)	30-60	°
Bar Thickness Not Less Than	5	mm
Bar Width Not Less Than	25	mm
Bar Spacing	25 - 50	mm
Velocity Through Screen, V_s Equal or Less Than	0.9	m/s

The design inflow rate is 2400 m^3 per day. The input bar screen design data were:

Table 3.3: Input Data for Bar Screen Design

Input Data		Units
Flow Rate (average)	2400	m^3/day
Inclination Angle (with horizontal)	30	°
Bar Thickness	10	mm
Bar Width	50	mm
Bar Spacing	30	mm
Velocity Through Screen, V_s	0.3	m/s
Depth To Width Ratio	1.5	
Freeboard	0.3	m
Roughness Co-efficient	0.013	

3.12.2 Design of Equalization Tank

The inflow rate was 2400 cubic meter per day or 100 cubic meter per hour. Hydraulic retention time is 10.43 hours. We assumed the wastewater flow time from 8:00 am to 8:00 pm in a day. According to Water and Wastewater Engineering book by Mackenzie L. Davis, the equalization tank was designed. The input design was like this:

Table 3.4: Input Data for Equalization Tank

Input Data	
Flow Rate (m^3/h)	100
Hydraulic Retention Time (h)	10.43
Outflow Pumping Δq (m^3)	100
L/W Ratio	1.3
Assume Length, m	21

3.12.3 Design of Coagulation Tank

Standard design values were used to design the Coagulation Tank. Extremely brief mixing periods are not as crucial as they are in adsorption-destabilization when sweep coagulation is the major coagulation mechanism. For sweep coagulation, a conventional totally mixed flow reactor will work well. Rapid mix G values between 600 and 1000 s^{-1} are advised. Radial Flow Turbine Impeller is used for coagulation mixing. The coagulation tank was designed from the book of Water and Wastewater Engineering by Mackenzie L. Davis

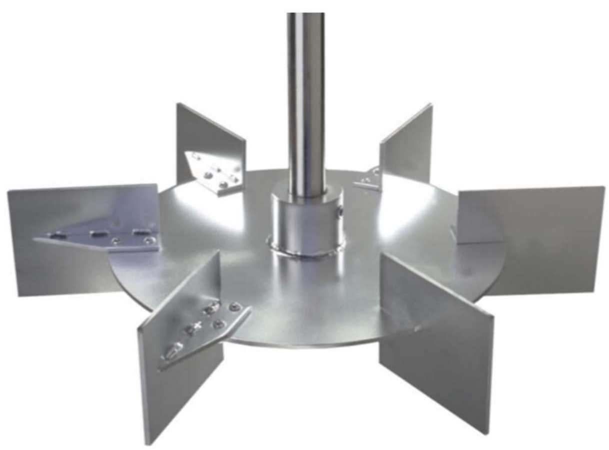

Figure 3.9: Radial Flow Turbine Impeller

Table 3.5: Input Data for Equalization Tank

Input Data		Units
Average Flow Rate	2400	m^3/day
Peak Factor	2	
Detention Time. D_T	8	min
Maximum Flow Rate	4800	m^3/day
Dynamic Viscosity	0.000653	pa-s
Mean Velocity Gradient, G	700	s^{-1}
Tank Depth	2.5	m
Water Temperature	40	
Radial Impeller H/T	2	
Motor Efficiency, η	80	%
Radial Impeller Diameter, D_i	0.400	m
power Number, N_P	5.700	
Water Density, ρ	1000.000	

3.12.4 Design of Flocculation Tank

The flocculation tank was also designed from the book of Water and Wastewater Engineering by Mackenzie L. Davis. The design criteria of flocculation tank goes like this:

Table 3.6: Design Range of Flocculation Tank

Parameters	**Units**	**Range**
Depth of tank	m	3-4.5
Detention time	min	10-40 (normally 30)
Velocity of flow	m/sec	0.2-0.8 (0.4)
Total area of paddle	%	10-25
Peripheral velocity of blades	m/sec	0.2-0.6
Velocity gradient	sec^{-1}	10-75
G.T. factor		10^4-10^5
Power consumption	kW/MLD	10-36
Outlet flow velocity	m/sec	0.15-0.25

The criteria was used and a simple design of flocculation with paddle or impeller was done. The input data for flocculation tank was like this:

Table 3.7: Table: Input Data for Flocculation Tank

Input Data		
Design Flow Rate, Q	2400	m^3/day
Peak Factor	1.5	
Maximum Flow Rate, Q_{max}	3600	m^3/day
Detention Time, td	20	min
Drag Co-efficient, Cd	1.8	
Water Density, ρ	1000	kg/m^3
Velocity of Paddle, V_p	0.4	m/sec
Velocity Gradient, G	40	sec^{-1}
Dynamic Viscosity,	0.00101	N-s/m
Paddle Width	0.3	m
Clear Space Above Paddle	0.3	m
Clear Space Below Paddle	0.3	m
Tank Depth, D	2	m
Freeboard	0.5	m
Length To Width Ratio	2	

3.12.5 Design of Primary Clarifier

The primary clarifier was designed from the book Fundamentals of Wastewater Treatment and Engineering. The design criteria of primary clarifier is given below:

Table 3.8: Design Criteria of Primary Clarifier

Parameter	Unit	Range	Typical value
Detention time	Hour	1.5-2.5	2.0
Overflow rate			
At average flow	$m^3/m^2.d$	32–50	40
At peak hourly flow	$m^3/m^2.d$	78–120	100
Weir loading rate	$m^3/m^2.d$	125–500	260
Rectangular tank			
Length	m	15–90	25–40
Width	m	3–24	5–10
Depth	m	3–5	4.5
Circular tank			
Diameter	m	3–60	12–40
Depth	m	3–5	4.5

We designed the primary clarifier of both circular and rectangular size.

Table 3.9: Input Data of Circular Primary Clarifier Design

Input Data		Units
Average flow rate Q(average)	2400	m^3/day
Number of circular clarifiers used n	1	
Flow in each clarifier Q	2400	m^3/day
Tank Depth	3.5	m
Surface overflow rate v_o	40	m/day
BOD5 Input	485	mg/L
Suspended Solids Input	750	mg/L
BOD removal efficiency	25	%
Solid Removal Efficiency	60	%

3.12.5 Design of Aeration Tank

The aeration tank was designed from standard aeration tank design criteria. A reasonable F/M ratio was assumed. From there, the dimensional values were calculated. From the calculated tank dimensions, hydraulic retention time and solid loading were calculated and checked. These values were within the proper design criteria range. This is how the aeration tank design was finalized. The design criteria for aeration tank is given below:

Table 3.10: Design Range of Aeration Tank

Process Type	**Unit**	**Flow regime (Conventional)**
MLSS	mg/L	1500-3000
MLSS/MLVSS	ratio	0.8
F/M	day^{-1}	0.3-0.4
HRT	h	4-6
θ_c	days	5-8
Q_R/Q	ratio	0.25-0.5
BOD removal	%	85-92

From the table, the input values were like this:

Table 3.11: Input Design Values of Aeration tank

Input Data		
Flow Rate, Q	2400	m^3/day
BOD_5 Input	364	mg/L
Expected BOD_5 Output	30	mg/L
MLSS, x	2500	mg/L
F/M Ratio	0.4	
MLSS in return sludge, x_r	10000	mg/L
θ_c	8	days
Tank Width, W	12	m
Tank Depth, D	4	m
Freeboard	0.5	m

3.12.5 Design of Secondary Clarifier

The secondary clarifier was designed from the book of Fundamentals of Wastewater Treatment and Engineering. The design criteria for secondary clarifier is given below:

Table 3.12: Overflow Rate and Solid Loading for Different Types of Secondary Clarifier

Type of system	**Overflow rate, $m^3/m^2.d$**		**Solids loading, $kg/m^2.h$**		**Depth, m**
	Average	**Peak**	**Average**	**Peak**	
Clarifier following air-activated sludge (excluding extended aeration)	16–32	40–64	4–6	8	3.5–6
Clarifier following oxygen activated sludge	16–32	40–64	5–7	9	3.5–6
Clarifier following extended aeration	8–16	24–32	1–5	7	3.5–6

The input data for secondary clarifier that was used to do the design is given below:

Table 3.13: Input Design Data for Rectangular Secondary Clarifier

Input Data		Units
Flow Rate	2400	m^3/day
SS Input	300	mg/L
Length To Width Ratio	3.3	m
Surface Overflow Rate	20	m^3/m/day
HRT	6	h

Table 3.14: Input Design Data for Circular Secondary Clarifier

Input Data		Units
Flow Rate	2400	m^3/day
SS Input	300	mg/L
Diameter To Height Ratio	2.4	m
Surface Overflow Rate	20	m^3/m/day
HRT	6	h

CHAPTER 4: RESULTS AND DISCUSSION

4.1 General

The findings of the study are discussed and summarized in this chapter. The collected wastewater from different parts of the ETP was tested and their characteristics were found out. Polyaluminum chloride and Cationic Polymer were used to find an optimum dosage for coagulation in ETP. Natural coagulant like cactus was also used to see its efficiency in wastewater treatment. At last, different components of an ETP was designed.

4.2 Characteristics of Wastewater from different parts of ETP of Ananta Apparels Ltd

A total amount of 12 liter water was collected from different parts of ETP. Before Equalization Tank, Before Flash Mixer, Before Aeration Tank, Before Secondary Clarifier, Before Filter Feed Tank, and the Outlet have been chosen for analysis. Total dissolved solids (TDS), total suspended solids (TSS), turbidity, color, and pH are the parameters of interest that were examined. It is possible to improve the effectiveness and performance of the water treatment process by knowing the differences in these characteristics across various components. The results from the tests are given below:

Table 4.1: Wastewater Test Results

SL	Sample Source	pH	COD (mg/L)	Temperature (℃)	Color (Pt-Co)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)
1	Before Equalization Tank	5.83	92	40	913	904	129	1033
2	Before Flash Mixer	5.69	180	40	1028	810	180	990
3	Before Aeration Tank	5.4	220	40	266	886	59	945
4	Before Secondary Clarifier	6.17	29	40	262	1009	36	1045
5	Before Filter Feed Tank	5.96	46	40	325	959	42	1001
6	Outlet	6.42	23	40	264	1001	31	1032

4.3 Characteristics of Wastewater from Different Parts of the ETP of Apex Textiles Ltd

We tested the wastewater collected from Apex Textiles Ltd, Gazipur. The tested properties were pH, COD, Color, TDS, TSS, TS, DO and Turbidity.

Table 4.2: Wastewater Characteristics of Apex Textiles Ltd

Parameters	**Raw WW data**
Dosage (mg/250 mL)	-
pH	5.69
COD (mg/L)	180
Color (Pt-Co)	1028
TDS (mg/L)	810
TSS (mg/L)	180
TS (mg/L)	990
DO (mg/L)	1.49
Turbidity (NTU)	116

4.4 Jar Test with Polyaluminium Chloride and Cationic Polymer

A jar test utilizing polyaluminum chloride and cationic polymer was carried out to ascertain the ideal amount of coagulants for water treatment. The jar test is a typical laboratory technique employed in the water treatment industry to evaluate the performance of various coagulants and establish the best dosages. 6 beakers were put on a jar test device and put through two stages of mixing: first, a quick, rapid mixing at 100 rpm for one minute, then a slow, gradual mixing at 40 rpm for ten minutes. The beakers were allowed to settle after the mixing phase, and samples of the treated water were taken for examination.

The study of the jar test revealed important information on the ideal concentrations of polyaluminum chloride and cationic polymer for treating water. Numerous water quality measures, including COD, TDS, TSS, turbidity, and color, showed a considerable improvement with both coagulants. The outcomes showed that for the majority of the properties examined, coagulant dosage of 0.3 mg/ 250 mL of both the coagulants typically led to better removal efficiencies for COD, pH, Color and TSS. For TDS, the optimum dosage was 0.1 mg/ 250 ml. The test results are given below:

Table 4.3: Properties of Wastewater (before flash mixer) after Jar Test with PAC and Cationic Polymer

SL	Dosage (mg/250 mL)	pH	COD (mg/L)	Color (Pt-Co)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)
Raw WW	0	5.69	180	1028	810	180	990
1	0.1	6.95	146	429	1184	98	1282
2	0.2	6.89	138	274	1569	71	1640
3	0.3	7	127	19	1925	4	1929
4	0.4	7.06	124	123	2630	38	2668
5	0.5	6.69	133	558	2760	43	2803
6	0.6	6.52	143	992	3090	154	3244

4.5 Optimum Dosage for Polyaluminium Chloride and Cationic Polymer

The optimum dosage of Polyaluminium Chloride and Cationic Polymer for which, wastewater gets cleared the most, is discussed here. We conducted the jar test with different dosage and after settling, we tested the properties of the tested wastewater. Then we developed optimum curve of dosage (mg/L vs properties value) to find out the optimum coagulant dosage for each and every parameters. The optimum curves are given below:

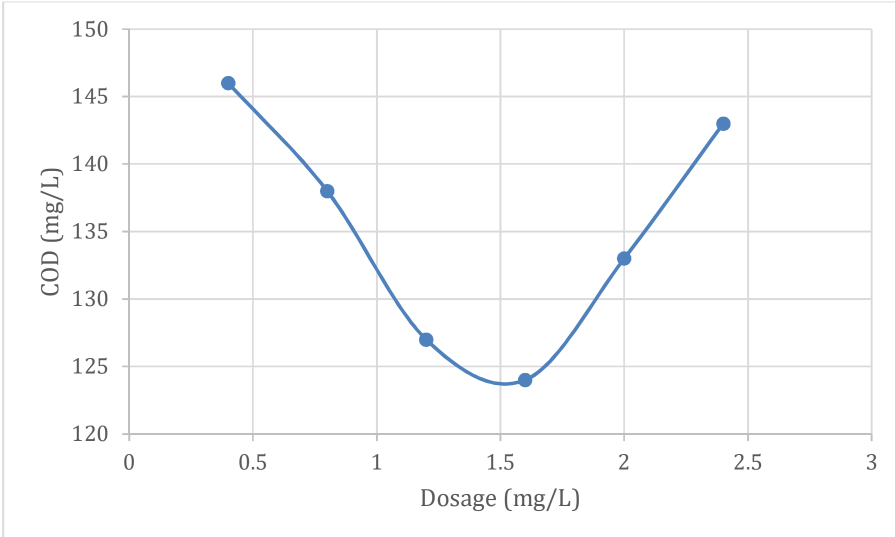

Figure 4.1: COD Optimum Curve with PAC and Cationic Polymer

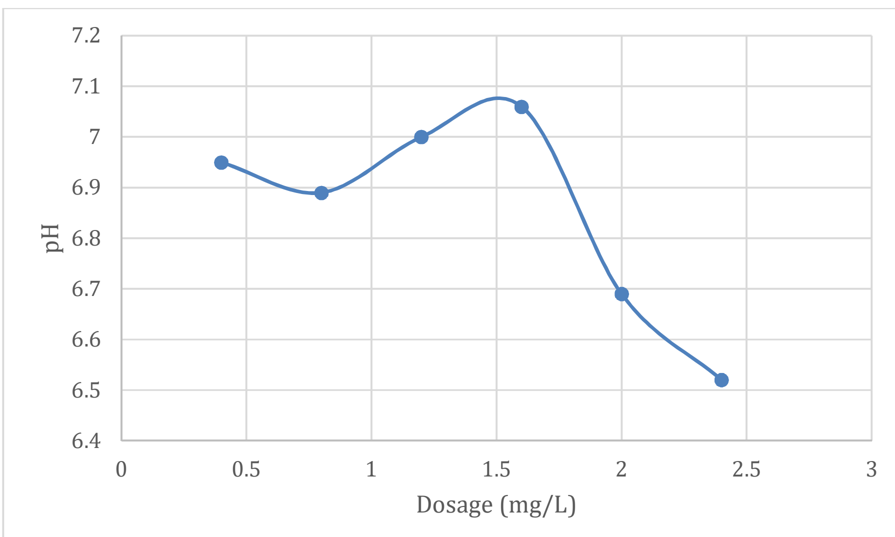

Figure 4.2: pH Optimum Curve with PAC and Cationic Polymer

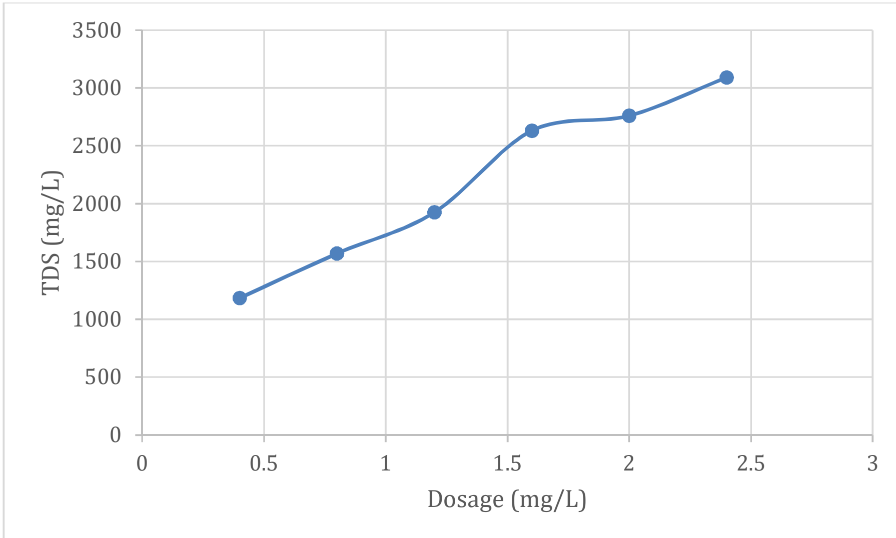

Figure 4.3: TDS Optimum Curve with PAC and Cationic Polymer

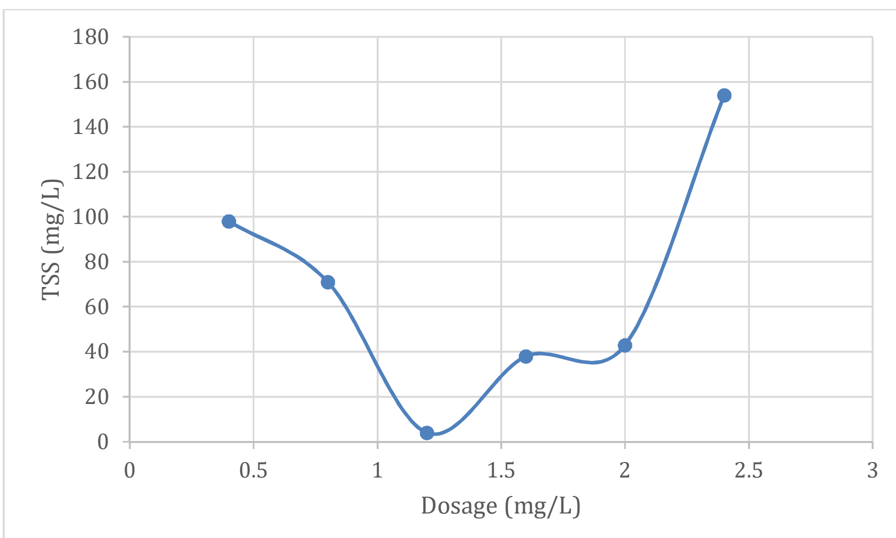

Figure 4.4: TSS Optimum Curve with PAC and Cationic Polymer

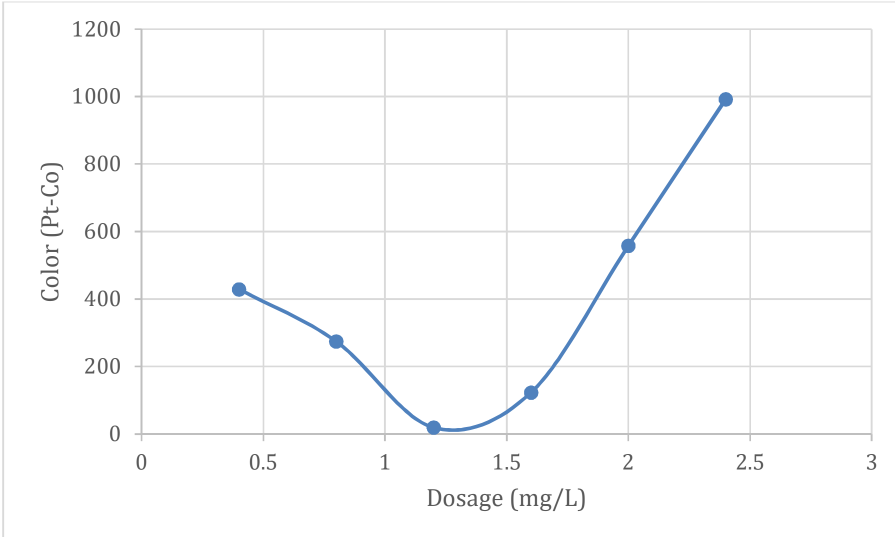

Figure 4.5: Color Optimum Curve with PAC and Cationic Polymer

From the five optimum curves of Color, pH, TDS and TSS, it can be seen that, the COD, pH, Color, and TSS value reaches the most efficient value for the dosage 0.3 mg/250 mL or 1.2 mg/L of both PAC and cationic polymer. On the other hand, for TSS, the optimum dosage was 0.1 mg/ 250 mL or 0.4 mg/L of both PAC and cationic polymer.

4.6 PAC and Cationic Polymer Removal Efficiency

Comparing the previously tested value of before flash mixer point and jar tested wastewater, we obtain the removal efficiencies of certain properties. The removal efficiencies are given below:

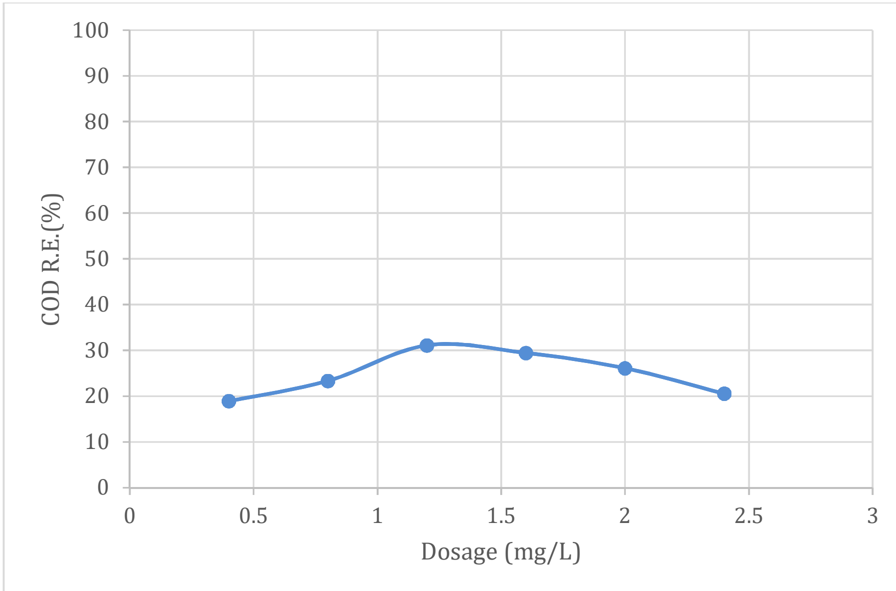

Figure 4.6: COD Removal Efficiencies against Different Dosages

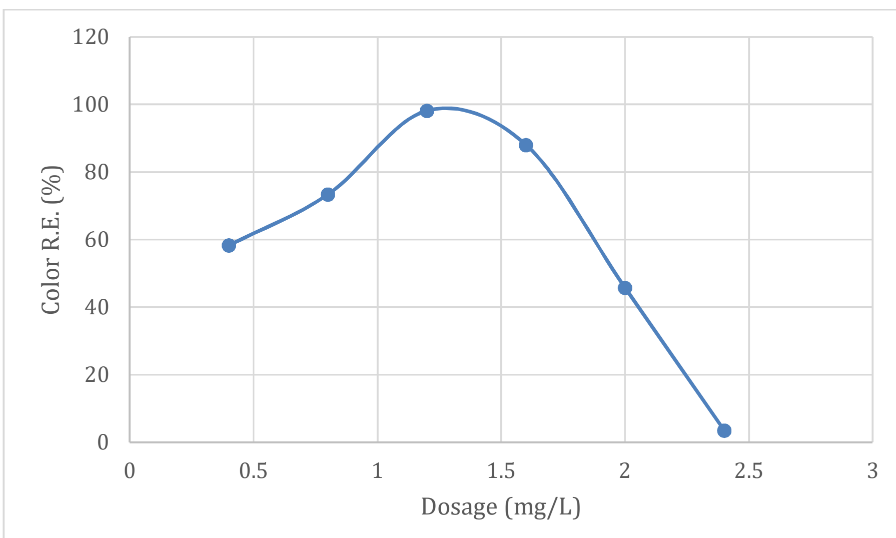

Figure 4.7: Color Removal Efficiencies against Different Dosages

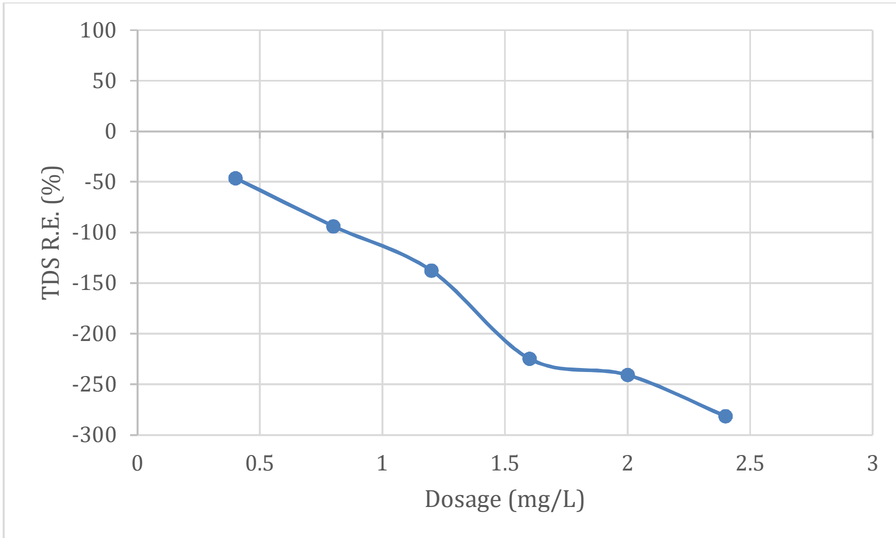

Figure 4.8: TDS Removal Efficiencies against Different Dosages

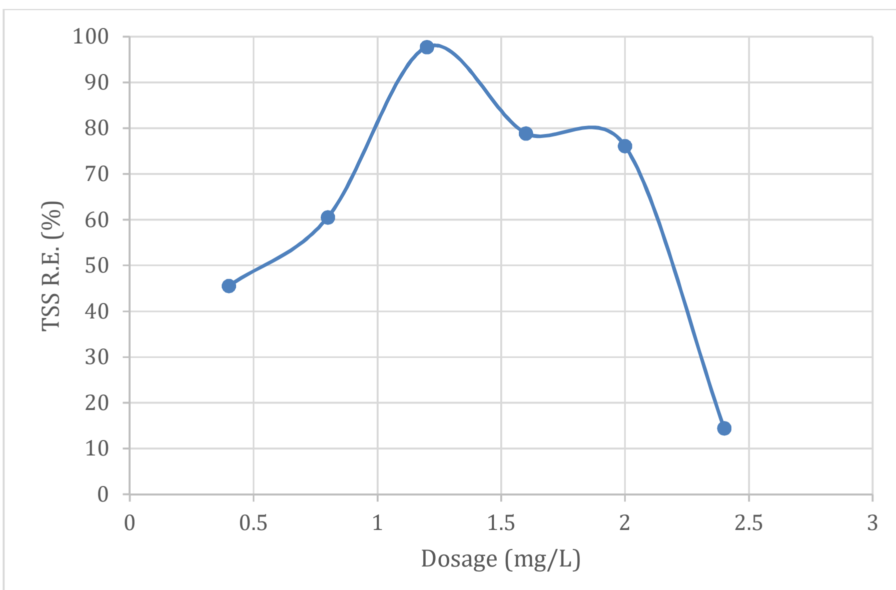

Figure 4.9: TDS Removal Efficiencies against Different Dosages

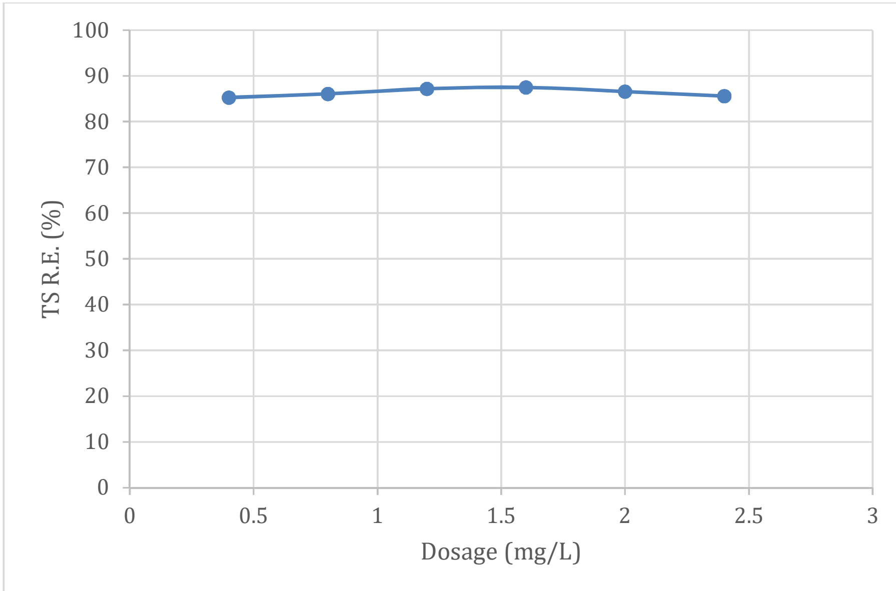

Figure 4.9: TS Removal Efficiencies against Different Dosages

We can see that, for 1.2 mg/L dosage, for COD, Color, pH, TSS, TS the removal efficiencies were: 31.11%, 98.15%, 100%, 98% and 87.17%. But TDS does not get removed. For 4 mg/L dosage, the TDS increases by minimum 46.17%.

4.7 Jar Test with Cactus Powder

To determine the optimal concentration of coagulants for water treatment, a jar test with cactus powder was conducted. The jar test is a common laboratory procedure used in the water treatment sector to assess the effectiveness of different coagulants and determine the appropriate dosages. Six beakers were mounted on a jar testing apparatus and subjected to two stages of mixing: a fast, rapid mixing at 100 rpm for one minute, and a slow, gradual mixing at 40 rpm for ten minutes. After the mixing phase, the beakers were allowed to settle before samples of the treated water were taken for analysis.

The analysis of the jar test produced significant findings regarding the appropriate ratios of cactus powder for treating water. Numerous indicators of the quality of the water, such as COD, TDS, TSS, and color, significantly improved when using this natural coagulant. These test results are provided:

Table 4.3: Properties of Wastewater after Jar Test with Cactus Powder

Sample	Dosage (mg/L)	pH	TDS (mg/L)	TSS (mg/L)	DO (mg/L)	Turbidity (NTU)	Color (Pt-Co)	COD (mg/L)
Raw WW	-	5.69	810	180	1.49	115	1028	180
1	20	8.21	572	78	6.62	138	812	208
2	50	8.36	597	81	2.82	143	872	376
3	100	8.44	662	82	1.61	146	910	400
4	140	8.17	689	93	1.24	153	914	586
5	180	8.05	725	94	1.19	152	924	736
6	230	8.24	750	99	1.23	154	902	584

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4.8 Optimum Dosage for Cactus Powder

This article discusses the ideal ratio of Cactus Powder for maximum wastewater clearance. We performed the jar test with various dosages, and once the effluent settled, we evaluated its characteristics. Then, in order to determine the ideal coagulant dose for each and every parameter, we built an optimal dosage curve (mg/L vs. properties value). The ideal curves are provided below:

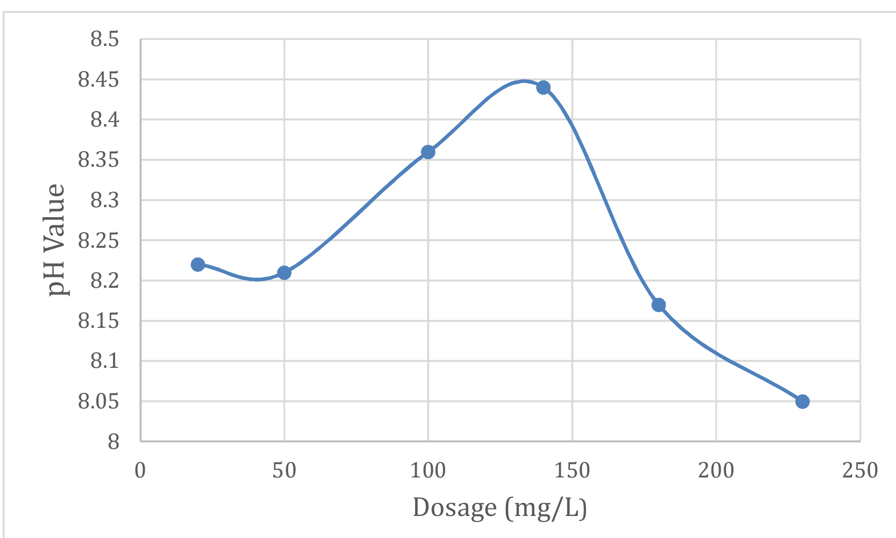

Figure 4.10: pH Optimum Curve with Cactus Powder

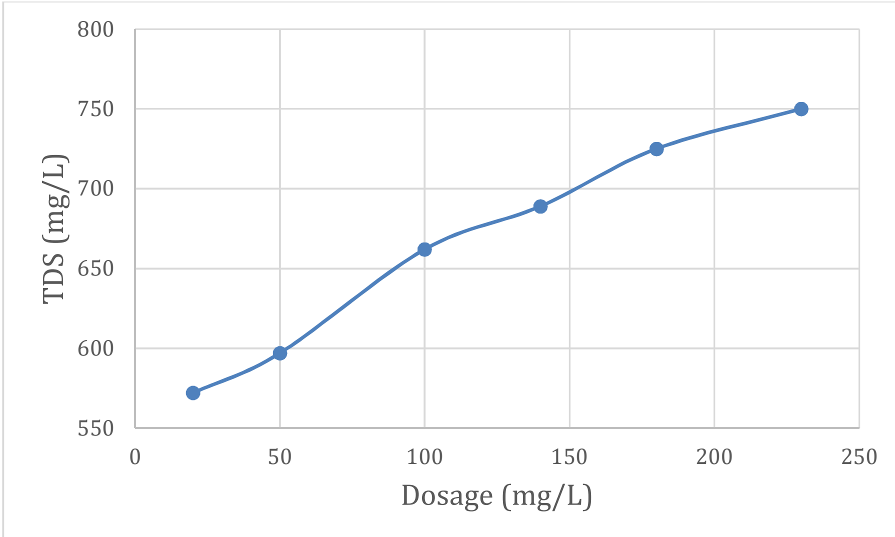

Figure 4.11: TDS Optimum Curve with Cactus Powder

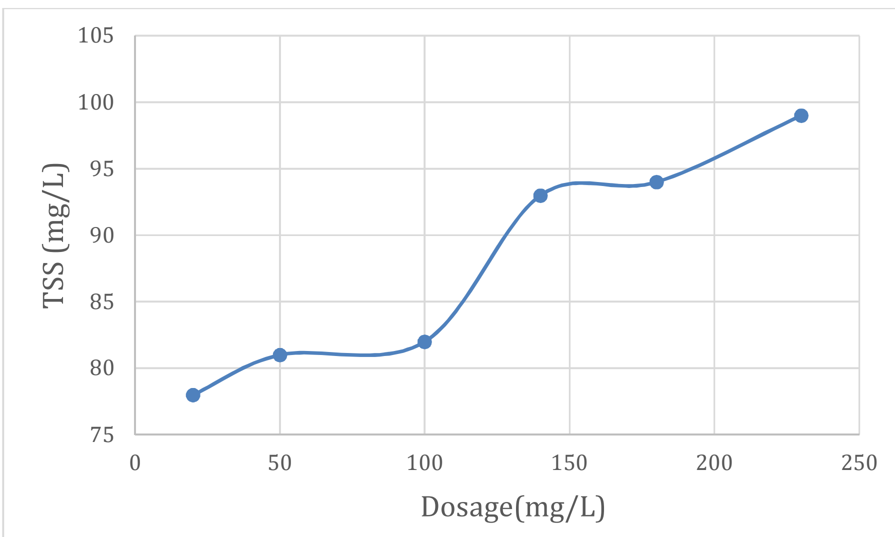

Figure 4.12: TSS Optimum Curve with Cactus Powder

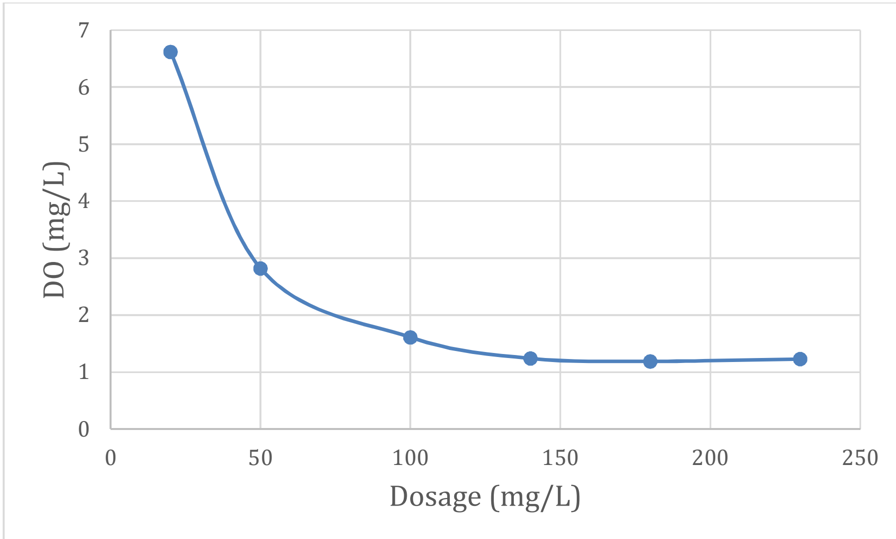

Figure 4.13: DO Optimum Curve with Cactus Powder

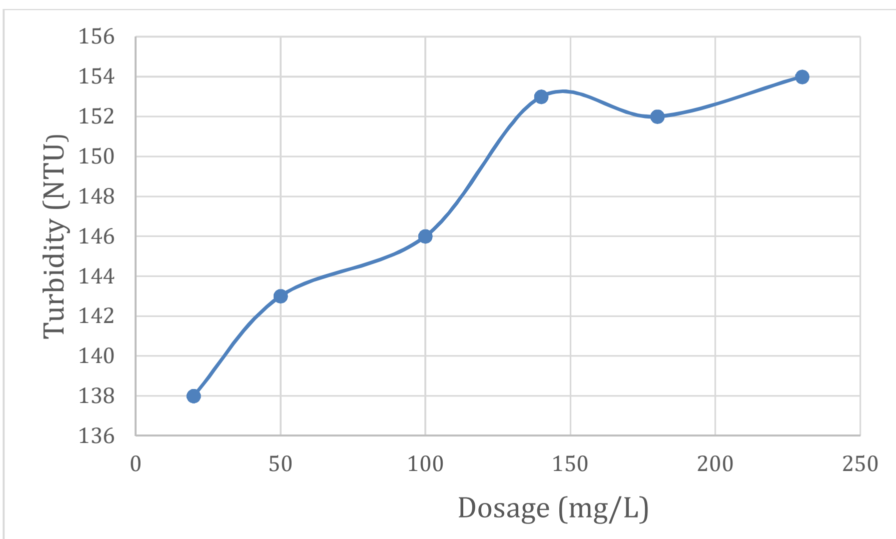

Figure 4.14: Turbidity Optimum Curve with Cactus Powder

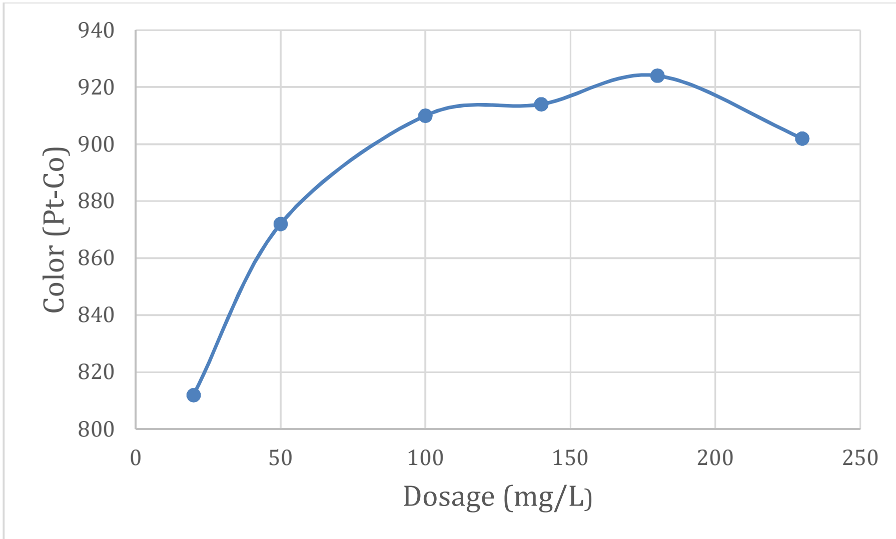

Figure 4.15: Color Optimum Curve with Cactus Powder

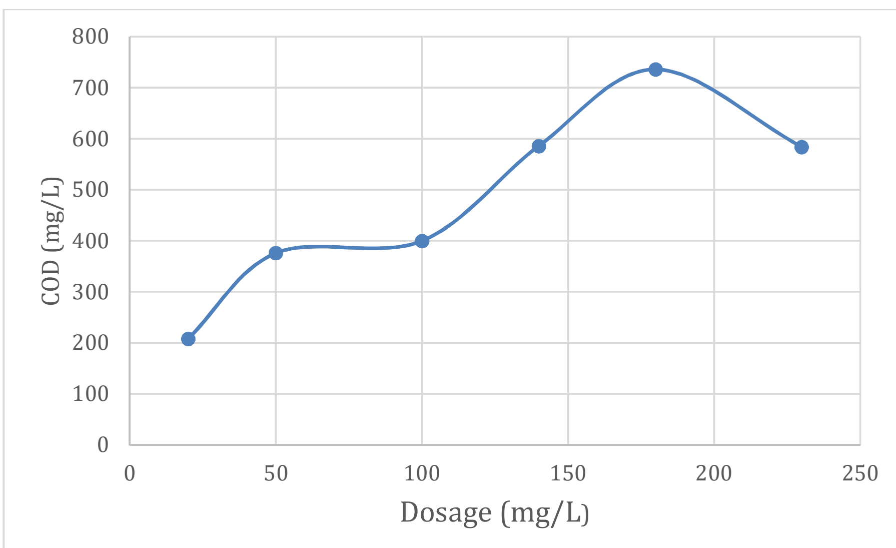

Figure 4.16: COD Optimum Curve with Cactus Powder

From the obtained results and optimum curves, it can be seen that, For TDS, TSS, Color, COD, and Turbidity; the optimum dosage value was 20 mg/L. For pH, the values are random and ranges from 8.05 to 8.22. Cactus powder was not effective to bring pH value to an optimum level. For DO, the optimum dosage was 230 mg/L. The dosage with less concentration just reduced DO.

4.9 Removal Efficiency with Cactus Powder

Comparing the previously tested value of before flash mixer point and jar tested wastewater, we obtain the removal efficiencies of certain properties. The removal efficiencies are given below:

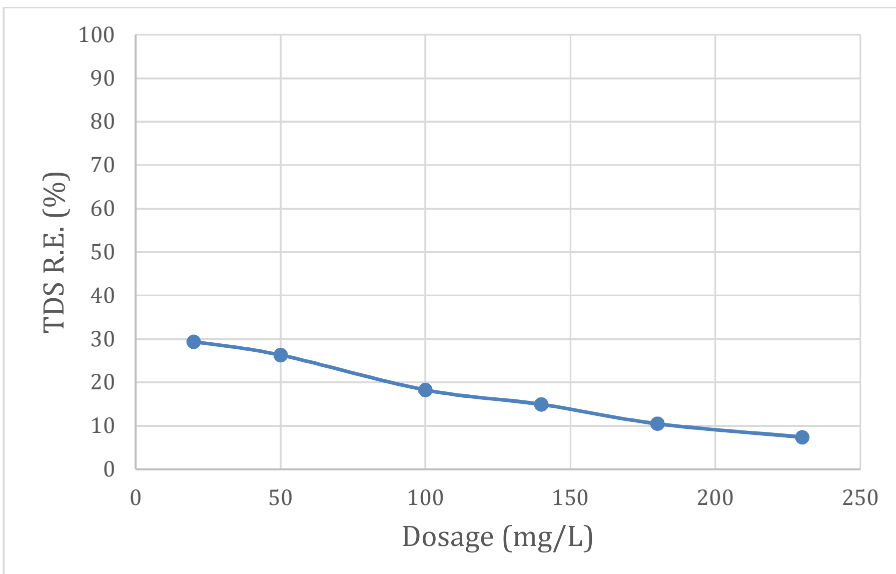

Figure 4.17: TDS Removal Efficiencies against Different Dosages

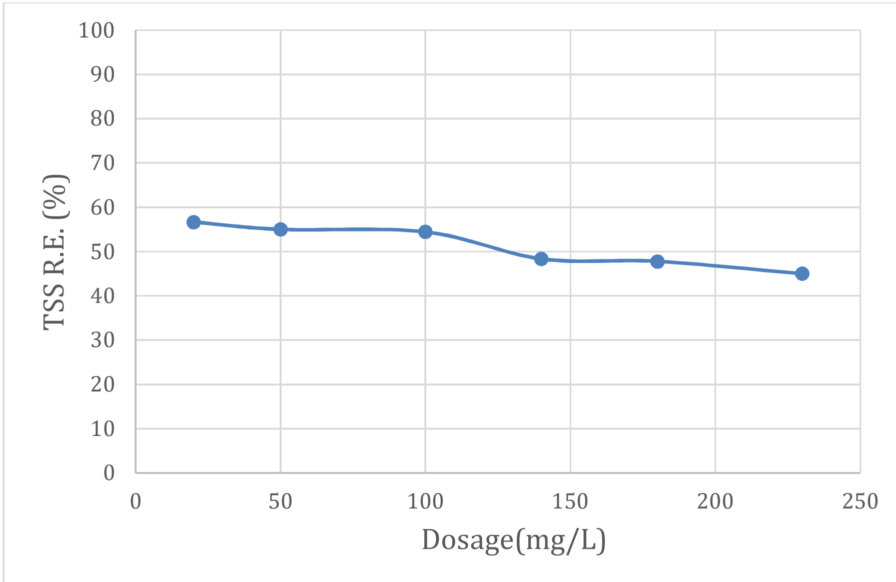

Figure 4.18: TSS Removal Efficiencies against Different Dosages

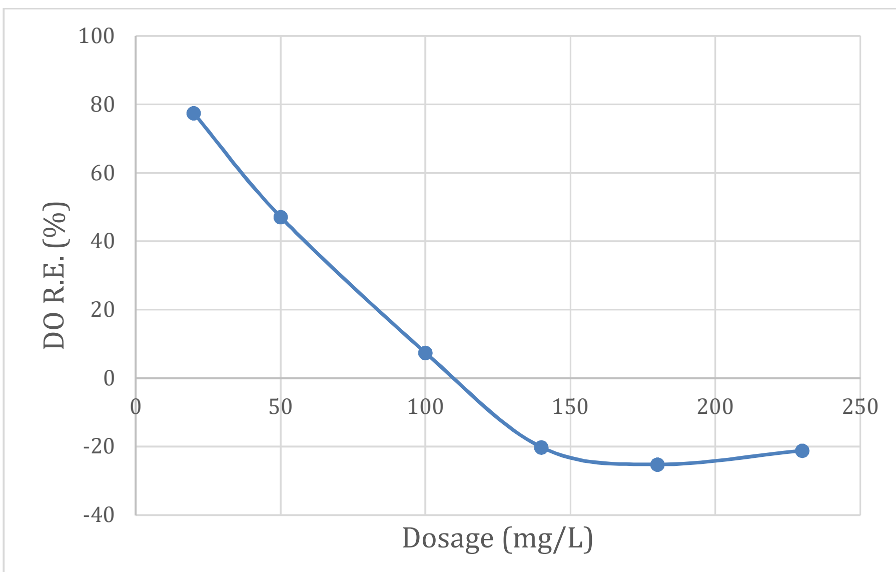

Figure 4.19: DO Removal Efficiencies against Different Dosages

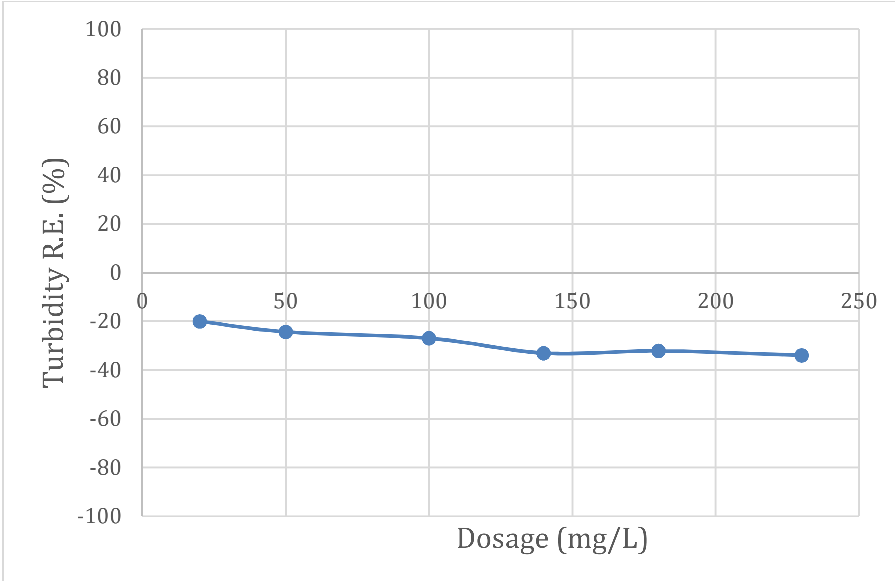

Figure 4.20: Turbidity Removal Efficiencies against Different Dosages

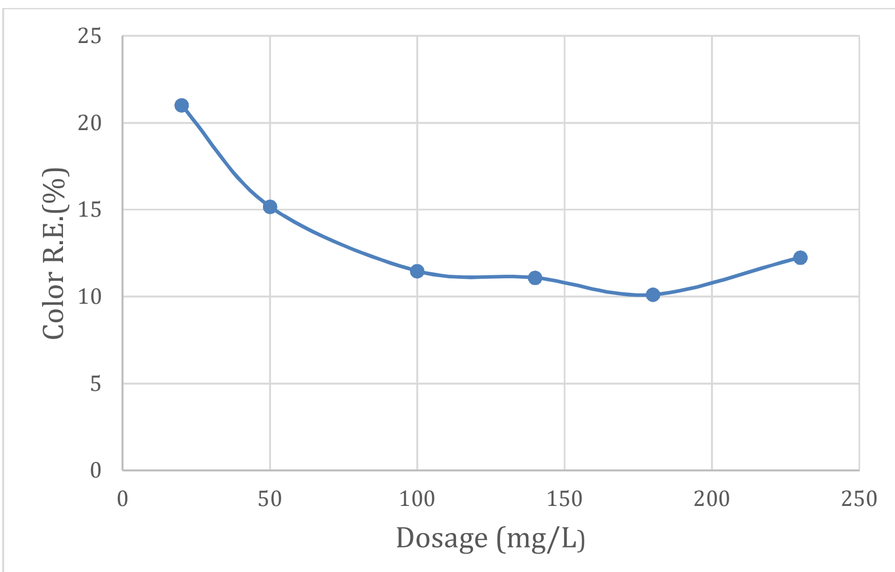

Figure 4.21: Color Removal Efficiencies against Different Dosages

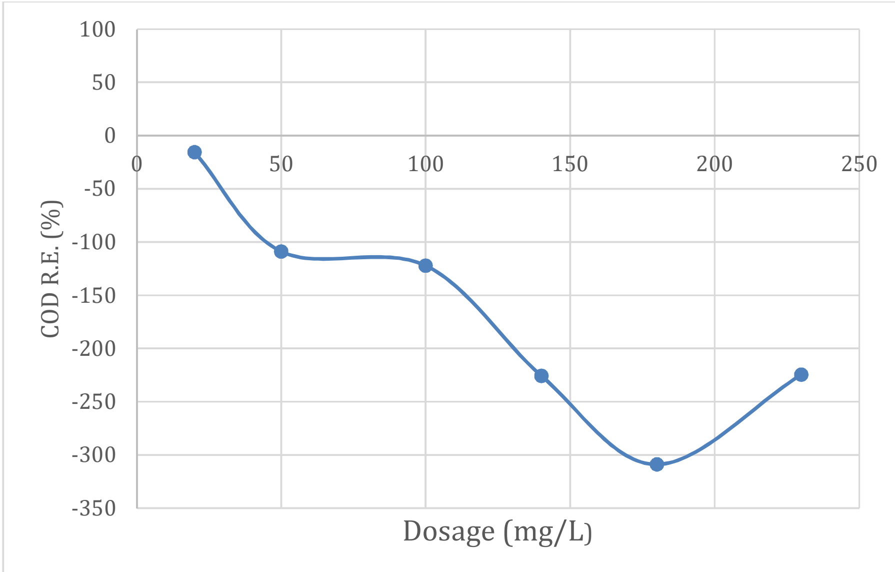

Figure 4.22: COD Removal Efficiencies against Different Dosages

We can see that, for TDS, TSS, DO and color for optimum dose of 20 mg/L, removal efficiencies are: 29.38%, 57%, 77.5% (DO addition) and 21.01%. But, Turbidity and COD increases. The minimum turbidity addition is 20% under 20 mg/L dosage and for COD the minimum COD increase is 15% for 20mg/L dosage. For pH, the closest value to 7 is 8.09 for 230 mg/L dosage.

4.10 Design Output of Effluent Treatment Plant

In order to handle an average flow rate of 2400 cubic meters per day an Effluent Treatment Plant (ETP) components for Ananta Apparels Ltd were designed. The components of the ETP have been carefully chosen and created to efficiently treat the wastewater produced by the textile washing industry, ensuring compliance with environmental laws and encouraging sustainable practices.

4.10.1 Design Output of Bar Screen

The Bar Screen, which serves as the first line of defense against large solid particles and debris in the wastewater, is the initial component of the ETP. The bar screen effectively traps and removes these materials, preventing harm to pumps and subsequent processes. Provided depth was 210 mm and provided width was 310 mm for the bar screen. 6 number of bars have been provided. The output design data were calculated by spreadsheet. The calculated output data are given below:

Table 4.5: Output Design Values of Bar Screen

Output Data		Units	Eqn
Net Submerged Area, Anet (m^2)	0.092593	m^2	$A_{net}= Q/V_s$
% of Open Area	75.000000	%	$S/(S+t_b)$
Gross Submerged Area of Screen, A_s	0.123457	m^2	$A_s=A_{net}/(S/(S+t_b))$
Cross Sectional Area of Chamber, A_c	0.061728	m^2	$A_c= A_s \times \sin(\theta)$
Approach Velocity, V_a (m/s)	0.450000	m/s	$V_a= Q/A_c$
V_a ok or not	OK		
Calculated Width	0.202860	m	
Calculated Depth	0.304290	m	
Number of Bars	6.000000		
Provided Area, A_c'	0.065100	m^2	$A_c'= W \times D$
Provided V_a	0.426694	m/s	$V_a'= Q / A_c'$
Hydraulic Radius, R	0.000078	m	$R= A / P$
Bed Slope, S	3.02827131		$S= ((V_a \times nr)/R)^{0.667})^2$
Head Loss, H_L	0.003742813		$H_L= \beta x(tb/s)^{1.334} x h_v x \sin(\theta)$

4.10.2 Design Output of Equalization Tank

The wastewater then passes through the Bar Screen and into the Equalization Tank. Given that textile washing procedures frequently result in changes in flow and pollutant concentrations throughout the day, this tank helps to homogenize the flow rate and make the incoming wastewater's composition more uniform. The equalization tank offers a stable and regular supply to subsequent operations, assisting in lowering hydraulic and organic shock loads on downstream treatment units. The output design data were calculated by spreadsheet. All the output data are within feasible range:

Table 4.6: Output Design Values of Equalization Tank

Output Data		
Total Flow (m^3)	2400	
Avg Flow Rate (m^3/hr)	100	Qavg= Q / 24
Max Positive Value in Cumulative Difference in Flow	420	
Max Negative Value in Cumulative Difference in Flow	800	
Tank Volume, m^3	1220	V= Qmax (+ve) + Qmax (-ve)
Additional Volume Increase (%)	0	
Final Tank Volume, m^3	1220	
Tank Width, m	16.15384615	W= L / (L/W Ratio)
Tank Height, m	3.596371882	H= V / (L x W)

4.10.3 Design Output of Coagulation Tank

The Coagulation Tank is the next element in the ETP architecture. The wastewater is treated with chemicals to neutralize and destabilize the colloidal particles during the coagulation process, which is made possible by this tank. This process encourages the accumulation of small particles into larger flocs, which facilitates their later clearance. . Spreadsheet calculations were made for the output design data. The produced data are all realistically sized:

Table 4.7: Output Design Values of Coagulation Tank

Output Data		Units	Equations
Tank Volume	26.667	m^3	$Q \times D_T$
Tank Length	3.266	m	$A^{0.5}$
Tank Width	3.266	m	$A^{0.5}$
Equivalent Tank Diameter, T	5.5129	m	$(4V) / 2\pi$
Water Depth, H	11.026	m	2T
Water Depth Below Impeller	3.6753	m	H / 3
Power, P	8.5325	kW	$G^2 \times \mu \times V$
Motor Power, P'	10.666	kW	$P / (\eta /100)$
Rotation Per Minute	340.42	rpm	$(P'/(N_P \times D_i^5 \times \rho))^{0.3333}$

4.10.3 Design Output of Flocculation Tank

The wastewater enters the flocculation tank following coagulation. A light mixing technique is used in this situation to promote the production of larger, settleable flocs. The output design data were calculated by spreadsheet. All the output data are within feasible range:

Table 4.8: Output Design Values of Flocculation Tank

Output Data		
Tank Volume, V	50.000	m^3
Power Required	80.800	watt
Area of Paddle, Ap	3.325	m^2
Paddle length	1.4	m
Area of One Paddle	0.42	m^2
Number of Paddles	8	
Tank Area	25.0000	m^2
Tank Width	3.5355	m
Tank Length	7.0711	m
Total Tank Depth	2.5	m

4.10.4 Design Output of Primary Clarifier

The wastewater next enters the Primary Clarifier, which serves as a settling basin, following flocculation. It enables the flocs to disperse and separate from the cleared effluent as they do so. While the clarified effluent moves on to the next stage, the settled sludge is collected and removed for additional treatment. The output design data were calculated by spreadsheet. All the output data are within feasible range:

Table 4.9: Output Design Values of Rectangular Primary Clarifier

Output Data		Units	Equations
Surface Area	60	m^2	Q / V_O
Tank Volume	210	m^3	A_S x W
Tank Width	3.46410162	m	$(A_S / (L/W\ Ratio))^{0.5}$
Tank Length	17.3205081	m	V / (W x D)
Detention Time	2.1	h	V / Q
Weir Length	6.92820323	m	2 x W
Weir Loading Rate	346.410162		Q / Weir Length
Mass of solid removed	1080	kg/day	Q*SS Conc.
SS to secondary clarifier	300	mg/L	SS*(1-removal Efficiency)
Mass of solid to secondary clarifier	720	kg/day	
Mass of BOD5 removed	291	kg/day	Q*BOD Conc.
BOD5 to secondary clarifier	363.75	mg/L	BOD*(1-removal efficiency)
Mass of BOD5 to secondary clarifier	873	kg/day	

Table 4.10: Output Design Values of Circular Primary Clarifier

Output Data		Units	Equations
Tank Diameter	9	m	$D= \sqrt{(4Q/\pi V_o)}$
Area	63.8199	m^2	(π*D^2)/4
Detention Time	2.2336965	h	(A*H)/Q
Mass of solid removed	1080	kg/day	Q*SS Conc.*η
SS to secondary clarifier	300	mg/l	SS*(1-removal Efficiency)
Mass of solid to secondary clarifier	720	kg/day	
Mass of BOD5 removed	291	kg/day	Q*BOD Conc.*η
BOD5 to secondary clarifier	363.75	mg/l	BOD*(1-removal efficiency)
Mass of BOD5 to secondary clarifier	873	kg/day	
Tank Volume	223.36965		Surface Area x Depth
Weir Diameter	7.000	m	Less Than Tank Diameter
Weir Length	21.9912	m	π x Weir Diameter
Weir Loading	109.134563	m^2/day	Flow Rate / Weir Length

4.10.5 Design Output of Aeration Tank

The Aeration Tank is the next stage in the design of the ETP. The biological breakdown of organic contaminants in wastewater is carried out by aerobic microorganisms, which can thrive and flourish in this tank. By using the organic debris as a food supply, the microbes successfully lower the pollution levels. The F/M ratio was thought to be appropriate. The dimensional values were then computed from there. Hydraulic retention duration and solid loading were computed from the calculated tank size and verified. These values fell within the acceptable range of the design criteria. The aeration tank's design was completed in this manner. The output values were obtained from spreadsheet calculations:

Table 4.11: Output Design Values of Aeration Tank

Output Data		
Tank Volume, V	801.6	m^3
Hydraulic Retention Time, HRT	8.016	h
Volumetric Loading Rate, V_L	1.08982	kg BOD_5/m^3-day
Recirculation Ratio	0.333333	
Oxygen Required	3.312676	kg/day
Total Tank Depth	4.5	m
Tank Width	12	m
Tank Length	16.7	m
Volume With Freeboard	901.8	m^3

4.10.6 Design Output of Secondary Clarifier

The Secondary Clarifier is the last element in the designed ETP architecture. The biomass and suspended particles that were produced during the biological treatment process in the aeration tank can be settled and separated more easily in this tank. Clarified effluent that satisfies the necessary environmental criteria is collected and released as treated wastewater. Both circular and rectangular secondary clarifier were designed by spreadsheet as given below:

Table 4.12: Output Design Values of Rectangular Secondary Clarifier

Output Data		Units	Equations
Mass of SS Input	720	kg/day	Flow Rate x SS Input
Surface Area	120	m^2	Flow Rate / Surfae Overflow Rate
Solid Loading Rate	6	m^3	Mass of SS Input / Surfae Area
Tank Width	6.030	m	Surface Area / Ratio
Tank Length	19.900	m	Surface Area / Tank Width
Weir Length	12.060	m	2 x Tank Width
Tank Volume	600	m^3	Flow Rate x HRT
Tank Depth	5	m	Tank Volume / Surface Area
Weir Loading	199	m^2/day	Flow Rate / Weir Loading

Table 4.13: Output Design Values of Circular Secondary Clarifier

Output Data		Units	Equations
Mass of SS Input	720	kg/day	Flow Rate x SS Input
Surface Area	120	m^2	Flow Rate / Surfae Overflow Rate
Solid Loading Rate	6	m^3	Mass of SS Input / Surfae Area
Tank Volume	600	m^3	Flow Rate x HRT
Tank Depth	5.099	m	$\pi/4 \times D^2 \times H = V$
Tank Diameter	12.240	m	$\pi/4 \times D^2 \times H = V$
Weir Diameter	10.240	m	Less Than Tank Diameter
Weir Length	32.170972	m	π x Weir Diameter
Weir Loading	74.601414	m^2/day	Flow Rate / Weir Loading

4.11 ETP Design Comparison

4.11.1 Bar Screen

The Bar Screen was the main device used in the prior design to remove large solid particles and debris from the wastewater. This element is kept in place in our suggested design since it is essential for shielding downstream machinery from potential harm.

Table 4.14: Design Comparison of Bar Screen

	Calculated Design	Existing Design	Remarks
Bar Thickness	10 mm	-	-
Bar Dimension	10mm×50mm	-	-
Bar Width	210 mm	-	-
Bar Depth	310 mm	-	-

4.11.2 Equalization Tank

The entering wastewater's flow rate and composition were homogenized by an Equalization Tank in the prior configuration. Similar to how we did, we keep this part in our design because it lessens the hydraulic and organic shock loads on downstream treatment units. However, in order to achieve greater flow equalization and increased stability, we have optimized the tank's volume and put advanced control systems into place.

Table 4.15: Design Comparison of Equalization Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	21m×16.153m×3.596m	21.5m×16.5m×3.0m	0.5m more in length and depth
Capacity	1220 m3	1064 m^3	More capacity
HRT	10.43 hr	13.3 Hrs	HRT is less than existing design

4.11.3 Coagulation Tank

The Coagulation Tank, which facilitates the process of coagulation by adding chemicals to the wastewater, is a component of both the prior design and our suggested design. To achieve more effective coagulation and improved removal of colloidal particles and pollutants, we have made improvements in chemical selection and dosing processes.

Table 4.16: Design Comparison of Coagulation Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	3.26m×3.26mX×2.5m	3.05m×3.05m×2.44m	Slightly bigger than existing design
Capacity	26.667 m^3	17 m^3	More capacity than existing design
HRT	8 min	12.75 min	HRT is less

4.11.4 Flocculation Tank

A flocculation tank was used in the earlier design to promote the production of bigger, settleable flocs. Our suggested solution keeps this tank in place, but we have improved the hydraulic design, the mixing intensity, and the retention duration to maximize flocculation and remove as much suspended particles and organic waste as possible.

Table 4.17: Design Comparison of Flocculation Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	7.07m×3.53m×2.5m	3.88m×3.88m×3.04m	Bigger in every dimension than existing design
Capacity	50 m3	45.7 m3	Tank capacity is more than existing design
HRT	20 min	34.3 min	HRT is less than existing design

4.11.5 Primary Clarifier

The Primary Clarifier, which serves as a settling basin for the separation of flocs from the cleared effluent, is a component of both the prior system and our suggested concept. To optimize the settling process and raise the overall clarity efficiency, we have made improvements to the clarifier design, sedimentation rates, and sludge removal techniques.

Table 4.18: Design Comparison of Primary Clarifier

	Calculated Design	Existing Design	Remarks
Tank Dimension	63.82 m^2 × 9m	56 m^2 ×3.96m	Tank is bigger than existing design
Surface Area	63.82 m^2	56 m^2	Surface area is more than existing design
Capacity	223.369 m^3	172.5 m^3	Capacity is more than existing design
HRT	2.23 h	2.15 h	HRT is slightly more than existing design

4.11.6 Aeration Tank

The earlier plan included an aeration tank to promote the development of aerobic bacteria, which aid in the biological breakdown of organic contaminants. The tank is still present in our proposed design, but we have made advancements in the aeration system layout, dissolved oxygen control, and nutrient supplementation to boost the treatment effectiveness and encourage the development of advantageous microorganisms.

Table 4.19: Design Comparison of Aeration Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	16.7m×12m×4.5m	17.04m×21.2m×4.5m	Dimension, specially width is more than existing design
Capacity	901.8 m^3	1625.62 m^3	Tank volume/capacity is less than existing design
HRT	8.016	20.32	HRT is less

4.11.7 Secondary Clarifier

A Secondary Clarifier is used in both the prior design and the design we propose to make it easier to settle and separate the biomass and suspended particles produced during the biological treatment process. To achieve effective separation and generate high-quality treated wastewater, we have concentrated on optimizing the clarifier design, sludge collection systems, and effluent discharge configurations.

Table 4.20: Design Comparison of Secondary Clarifier

	Calculated Design	Existing Design	Remarks
Tank Dimension	20m×6m×5m	14.5m×6.62m×4.5m	Tank length is notably more than existing design
Surface Area	120 m^2	95.99 m^2	Surface area is more than existing design
Capacity	600 m^3	335.89 m^3	Capacity is more than existing design
HRT	6 h	3.56 h	HRT is more than existing design

Although our suggested design and the previously planned ETP components have some similarities, we have also made a number of important enhancements. These improvements cover sludge management, flow equalization, clarifying performance, flocculation and coagulation efficiency, and screen design. Our goal is to improve the efficacy of treatment, the quality of the effluent, and the sustainability of the textile washing sector.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 General

This chapter summarizes the findings and comments of our study, offers advice, and suggests ideas for additional research projects.

5.2 Conclusions

Several experiments were conducted to get the study's findings. These findings allow for the following conclusions to be made:

- The raw wastewater is just like the typical textile washing wastewater and the values are beyond the environmental disposal values.
- After jar test, the optimum value of Polyaluminium Chloride and Cationic Polymer was found for coagulation.
- For COD, pH, Color and TSS; the optimum dosage value was 0.3 mg/ 250 mL or 1.2 mg/L.
- For TDS, optimum dosage value was 0.1 mg/250 ml or 0.4 mg/L.
- We can see that, for 1.2 mg/L dosage, for COD, Color, pH, TSS, TS the removal efficiencies were: 31.11%, 98.15%, 100%, 98% and 87.17%. But TDS does not get removed. For 4 mg/L dosage, the TDS increases by minimum 46.17%.
- Another jar test was conducted with cactus powder. After this jar test, the optimum value of cactus powder was found for coagulation.
- For TDS, TSS, Color, COD, and Turbidity; the optimum dosage value was 20 mg/L.
- For pH, the values were random and ranges from 8.05 to 8.22. Cactus powder was not effective to get optimum result for pH.
- For DO, the optimum dosage was 230 mg/L. The dosage with less concentration just reduced DO.
- We can see that, for TDS, TSS, DO and color for optimum dose of 20 mg/L, removal efficiencies are: 29.38%, 57%, 77.5% (DO addition) and 21.01%. But, Turbidity and

COD increases. The minimum turbidity addition is 20% under 20 mg/L dosage and for COD the minimum COD increase is 15% for 20mg/L dosage. For pH, the closest value to 7 is 8.09 for 230 mg/L dosage.

- A feasible design for ETP's different components were done.
- Dimensions of all the designed components were bigger than the previous design.

This presentation has highlighted the importance of treating effluent in the textile washing industry and the methodology employed to achieve effective wastewater treatment. The jar tests conducted using both the industry's own coagulant and a natural coagulant have helped determine the optimal coagulation ratio. Furthermore, we have attempted to design a feasible Effluent Treatment Plant (ETP) by calculating the dimensions of essential components & comparing them with previous design data to ensure efficiency and effectiveness. The implementation of a well-designed ETP holds significant potential for the textile washing industry to mitigate environmental impacts and comply with regulatory requirements.

5.3 Recommendations and Future Scope of Research

The results of a research study using polyaluminum chloride (PAC), cationic polymer, and cactus powder in jar testing to establish the ideal coagulation ratio are presented in this thesis paper. The study demonstrated the effectiveness of both coagulants in water treatment methods by effectively identifying specific ratios for each. To improve our comprehension and optimize the coagulation process, more research is needed. The main suggestions and the range of upcoming research to expand on the current findings are laid forth in this section.

Future research should investigate the combined use of polyaluminum chloride and cationic polymer, whereas the current study concentrated on identifying the coagulation ratios for separate coagulants. To determine the coagulation ratio of cactus powder, a natural coagulant like cactus powder was also employed separately. The coagulation process, water quality, and coagulation efficiency may all be improved by looking into the synergistic effects of these coagulants in a simultaneous or sequential treatment approach.

It is crucial to look at the underlying mechanics in order to have a thorough understanding of how cactus powder coagulates. Researchers can clarify the coagulation mechanisms and adjust the process parameters by examining the interactions between cactus powder, coagulants, and the aqueous matrix.

To evaluate the robustness and application of the cactus powder-based coagulation method, the study must be expanded to encompass a larger variety of water parameters, such as variable turbidity, pH, organic matter concentration, and hardness. A more thorough knowledge of the coagulant's efficiency and guidance for its practical application will come from evaluating its performance under various water quality scenarios.

Future studies should concentrate on figuring out the ideal dosage of cactus powder, much as the coagulant dosage optimization. The efficacy of using cactus powder as a coagulant will be examined, and various dosage levels and their effects on coagulation efficiency will be examined, in order to improve the therapeutic procedure.

It is essential to look into the long-term stability of cactus powder because of its possible use as a coagulant. It will be possible to better manage the coagulant stock by assessing the stability of cactus powder under various storage circumstances and for lengthy periods of time. This assessment will yield vital information about the powder's shelf life.

Evaluation of the economic viability and environmental impact of using cactus powder as a coagulant is crucial in addition to technical considerations. The viability of the cactus powder-based coagulation technique will be determined by doing a cost analysis and evaluating its sustainability, which will aid in making decisions.

It is advised to carry out pilot-scale or full-scale investigations to validate the results of the jar test experiments and evaluate the practical implementation of the adjusted coagulation ratios. These investigations can assess the efficacy of the cactus powder-based coagulation technique in real-world settings and offer information about how scaleable and successful it is.

The results of a study conducted to design various Effluent Treatment Plant (ETP) components for the textile washing industry are presented in this thesis paper. The bar screen, equalization tank, coagulation tank, flocculation tank, primary clarifier, aeration tank, and secondary clarifier are the planned components that form the basis of a successful wastewater treatment system. To maximize the effectiveness and sustainability of the ETP, additional research and design advancements are required. In order to expand on the existing findings, this section outlines significant recommendations and the next research agenda.

While the current research concentrated on the design of individual components, it is vital to look into how each component in the ETP may be made to work better. To achieve optimum treatment effectiveness, additional research should assess variables including hydraulic residence time, mixing intensity, detention time, and unit sizing. Furthermore, incorporating cutting-edge technology like computational fluid dynamics (CFD) simulations might assist to improve the layout and performance of these parts.

Future studies should examine the use of cutting-edge treatment technologies inside the ETP design in order to improve the efficacy of the treatment. It is possible to evaluate the effectiveness of various technologies for eliminating certain contaminants and meeting strict effluent quality standards, including membrane filtration, activated carbon adsorption, advanced oxidation processes, and biological treatment systems. A sustainable and effective ETP design will be developed by examining the viability and performance of these technologies.

Life cycle analyses (LCAs) should be used in future studies to calculate the environmental impact of operating and maintaining ETP components. This evaluation ought to take into account waste production, chemical use, greenhouse gas emissions, and energy consumption in order to spot chances to reduce the environmental effect.

It is necessary to do an economic analysis and cost optimization study for the ETP components in addition to technical issues. Future studies should look into ways to reduce capital and operating expenses, such as comparing different building materials, enhancing process layouts, and investigating creative financing options. The textile washing industries will be able to make well-informed decisions on whether installing an ETP is practical and profitable.

5.4 Limitations

The BOD determination of raw wastewater and jar tested wastewater were not done because of technical difficulties. BOD is an important metric used to gauge the extent of organic pollution and gauge how well wastewater treatment systems are working. Our ability to compare the initial pollutant load with the treated effluent is constrained because there are no BOD test results for the raw wastewater. As a result, the study's grasp of the overall pollutant removal efficiency attained by the intended treatment approach is incomplete.

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Appendix A
DATA COLLECTION FROM JAR TEST

Table A1: Wastewater Characteristics of Apex Textiles Ltd

Parameters	**Raw WW data**
Dosage (mg/250 mL)	-
pH	5.69
COD (mg/L)	180
Color (Pt-Co)	1028
TDS (mg/L)	810
TSS (mg/L)	180
TS (mg/L)	990
DO (mg/L)	1.49
Turbidity (NTU)	116

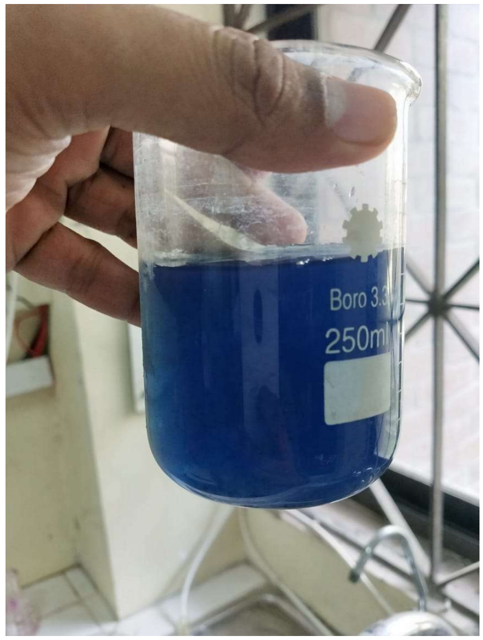
Table A2: Properties of Wastewater (before flash mixer) after Jar Test with PAC and Cationic Polymer:

SL	Dosage (mg/250 mL)	pH	COD (mg/L)	Color (Pt-Co)	TDS (mg/L)	TSS (mg/L)	TS (mg/L)
Raw WW	0	5.69	180	1028	810	180	990
1	0.1	6.95	146	429	1184	98	1282
2	0.2	6.89	138	274	1569	71	1640
3	0.3	7	127	19	1925	4	1929
4	0.4	7.06	124	123	2630	38	2668
5	0.5	6.69	133	558	2760	43	2803
6	0.6	6.52	143	992	3090	154	3244

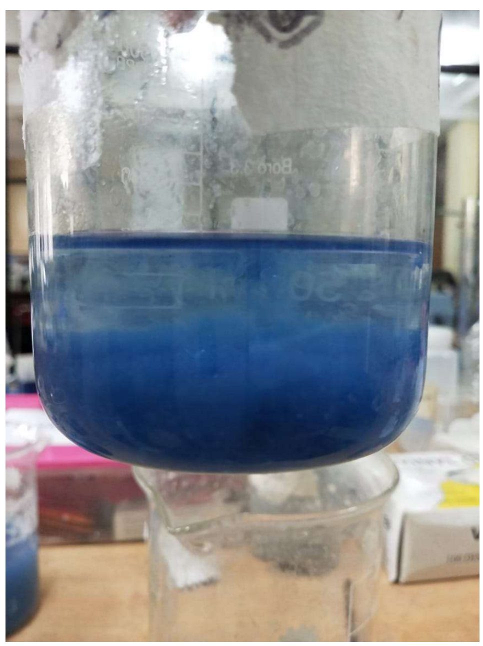
Table A3: Properties of Wastewater after Jar Test with Cactus Powder:

Sample	Dosage (mg/L)	pH	TDS (mg/L)	TSS (mg/L)	DO (mg/L)	Turbidity (NTU)	Color (Pt-Co)	COD (mg/L)
Raw WW	-	5.69	810	180	1.49	115	1028	180
1	20	8.21	572	78	6.62	138	812	208
2	50	8.36	597	81	2.82	143	872	376
3	100	8.44	662	82	1.61	146	910	400
4	140	8.17	689	93	1.24	153	914	586
5	180	8.05	725	94	1.19	152	924	736
6	230	8.24	750	99	1.23	154	902	584

Appendix B
EXPERIMENTAL SETUP



(a)



(b)

(c)

Figure B1: (a) Raw Wastewater Sample (b) Wastewater after Jar Test with PAC and Cationic Polymer (c) Created Flocs after Jar Test with PAC and Cationic Polymer

Appendix C

ETP DESIGN

Table C1: Design Value Range for Bar Screen

Inclination Angle (with horizontal)	30-60	°
Bar Thickness Not Less Than	5	mm
Bar Width Not Less Than	25	mm
Bar Spacing	25 - 50	mm
Velocity Through Screen, V_s Equal or Less Than	0.9	m/s

Table C2: Input Data for Bar Screen Design

Input Data		Units
Flow Rate (average)	2400	m^3/day
Inclination Angle (with horizontal)	30	°
Bar Thickness	10	mm
Bar Width	50	mm
Bar Spacing	30	mm
Velocity Through Screen, V_s	0.3	m/s
Depth To Width Ratio	1.5	
Freeboard	0.3	m
Roughness Co-efficient	0.013	

Table C3: Input Data for Equalization Tank

Input Data	
Flow Rate (m^3/hr)	100
Hydraulic Retention Time (hr)	10.43
Outflow Pumping Δq (m^3)	100
L/W Ratio	1.3
Assume Length, m	21

Table C4: Input Data for Equalization Tank

Input Data		Units
Average Flow Rate	2400	m^3/day
Peak Factor	2	
Detention Time. D_T	8	min
Maximum Flow Rate	4800	m^3/day
Dynamic Viscosity	0.000653	pa-s
Mean Velocity Gradient, G	700	s^{-1}
Tank Depth	2.5	m
Water Temperature	40	
Radial Impeller H/T	2	
Motor Efficiency, η	80	%
Radial Impeller Diameter, D_i	0.400	m
power Number, N_P	5.700	
Water Density, ρ	1000.000	

Table C5: Design Range of Flocculation Tank

Parameters	**Units**	**Range**
Depth of tank	meter	3-4.5
Detention time	minute	10-40 (normally 30)
Velocity of flow	m/sec	0.2-0.8 (0.4)
Total area of paddle	%	10-25
Peripheral velocity of blades	m/sec	0.2-0.6
Velocity gradient	sec^{-1}	10-75
G.T. factor		10^4-10^5
Power consumption	kW/MLD	10-36
Outlet flow velocity	m/sec	0.15-0.25

Table C6: Input Data for Flocculation Tank

Input Data		
Design Flow Rate, Q	2400	m^3/day
Peak Factor	1.5	
Maximum Flow Rate, Q_{max}	3600	m^3/day
Detention Time, td	20	min
Drag Co-efficient, Cd	1.8	
Water Density, ρ	1000	kg/m^3
Velocity of Paddle, V_p	0.4	m/sec
Velocity Gradient, G	40	sec^{-1}
Dynamic Viscosity,	0.00101	N-s/m
Paddle Width	0.3	m
Clear Space Above Paddle	0.3	m
Clear Space Below Paddle	0.3	m
Tank Depth, D	2	m
Freeboard	0.5	m
Length To Width Ratio	2	

Table C7: Input Data of Circular Primary Clarifier Design

Input Data		Units
Average flow rate Q(average)	2400	m^3/day
Number of circular clarifiers used n	1	
Flow in each clarifier Q	2400	m^3/day
Tank Depth	3.5	m
Surface overflow rate v_o	40	m/day
BOD5 Input	485	mg/l
Suspended Solids Input	750	mg/l
BOD removal efficiency	25	%
Solid Removal Efficiency	60	%

Table C8: Input Design Values of Aeration tank

Input Data		
Flow Rate, Q	2400	m^3/day
BOD_5 Input	364	mg/l
Expected BOD_5 Output	30	mg/l
MLSS, x	2500	mg/l
F/M Ratio	0.4	
MLSS in return sludge, x_r	10000	mg/l
θ_c	8	days
Tank Width, W	12	m
Tank Depth, D	4	m
Freeboard	0.5	m

Table C9: Input Design Data for Rectangular Secondary Clarifier

Input Data		Units
Flow Rate	2400	m^3/day
SS Input	300	mg/L
Length To Width Ratio	3.3	m
Surface Overflow Rate	20	m^3/m/day
HRT	6	h

Table C10: Input Design Data for Circular Secondary Clarifier

Input Data		Units
Flow Rate	2400	m^3/day
SS Input	300	mg/L
Diameter To Height Ratio	2.4	m
Surface Overflow Rate	20	m^3/m/day
HRT	6	h

Table C11: Output Design Values of Bar Screen

Output Data		Units	Equations
Net Submerged Area, Anet (m^2)	0.092593	m^2	A_{net}= Q/V_s
% of Open Area	75.000000	%	S/(S+t_b)
Gross Submerged Area of Screen, A_s	0.123457	m^2	A_s=A_{net}/(S/(S+t_b))
Cross Sectional Area of Chamber, A_c	0.061728	m^2	A_c= A_s x sin(θ)
Approach Velocity, V_a (m/s)	0.450000	m/s	V_a= Q/A_c
V_a ok or not	OK		
Calculated Width	0.202860	m	
Calculated Depth	0.304290	m	
Number of Bars	6.000000		
Provided Area, A_c'	0.065100	m^2	A_c'= W x D
Provided V_a	0.426694	m/s	V_a'= Q / A_c'
Hydraulic Radius, R	0.000078	m	R= A / P
Bed Slope, S	3.02827131		$S= ((V_a \times nr)/R)^{0.667})^2$
Head Loss, H_L	0.003742813		$H_L= \beta x(tb/s)^{1.334} x h_v x sin(\theta)$

Table C12: Output Design Values of Equalization Tank

Output Data		
Total Flow (m^3)	2400	
Avg Flow Rate (m^3/hr)	100	Qavg= Q / 24
Max Positive Value in Cumulative Difference in Flow	420	
Max Negative Value in Cumulative Difference in Flow	800	
Tank Volume, m^3	1220	V= Qmax (+ve) + Qmax (-ve)
Additional Volume Increase (%)	0	
Final Tank Volume, m^3	1220	
Tank Width, m	16.15384615	W= L / (L/W Ratio)
Tank Height, m	3.596371882	H= V / (L x W)

Table C13: Output Design Values of Coagulation Tank

Output Data		Units	Equations
Tank Volume	26.667	m^3	$Q \times D_T$
Tank Length	3.266	m	$A^{0.5}$
Tank Width	3.266	m	$A^{0.5}$
Equivalent Tank Dia, T	5.5129	m	$(4V) / 2\pi$
Water Depth, H	11.026	m	2T
Water Depth Below Impeller	3.6753	m	H / 3
Power, P	8.5325	kW	$G^2 \times \mu \times V$
Motor Power, P'	10.666	kW	$P / (\eta /100)$
Rotation Per Minute	340.42	rpm	$(P'/(N_P \times D_i^5 \times \rho)^{0.3333}$

Table C14: Output Design Values of Flocculation Tank

Output Data		
Tank Volume, V	50.000	m^3
Power Required	80.800	watt
Area of Paddle, A_p	3.325	m^2
Paddle length	1.4	m
Area of One Paddle	0.42	m^2
Number of Paddles	8	
Tank Area	25.0000	m^2
Tank Width	3.5355	m
Tank Length	7.0711	m
Total Tank Depth	2.5	m

Table C15: Output Design Values of Rectangular Primary Clarifier

Output Data		Units	Equations
Surface Area	60	m^2	Q / V_O
Tank Volume	210	m^3	A_S x W
Tank Width	3.46410162	m	$(A_S / (L/W\ Ratio))^{0.5}$
Tank Length	17.3205081	m	V / (W x D)
Detention Time	2.1	h	V / Q
Weir Length	6.92820323	m	2 x W
Weir Loading Rate	346.410162		Q / Weir Length
Mass of solid removed	1080	kg/day	Q*SS Conc.
SS to secondary clarifier	300	mg/L	SS*(1-removal Efficiency)
Mass of solid to secondary clarifier	720	kg/day	
Mass of BOD5 removed	291	kg/day	Q*BOD Conc.
BOD5 to secondary clarifier	363.75	mg/L	BOD*(1-removal efficiency)
Mass of BOD5 to secondary clarifier	873	kg/day	

Table C16: Output Design Values of Circular Primary Clarifier

Output Data		Units	Equations
Tank Diameter	9	m	D= $\sqrt{(4Q/\pi V_o)}$
Area	63.8199	m^2	(π*D^2)/4
Detention Time	2.2336965	h	(A*H)/Q
Mass of solid removed	1080	kg/day	Q*SS Conc.*η
SS to secondary clarifier	300	mg/l	SS*(1-removal Efficiency)
Mass of solid to secondary clarifier	720	kg/day	
Mass of BOD5 removed	291	kg/day	Q*BOD Conc.*η
BOD5 to secondary clarifier	363.75	mg/l	BOD*(1-removal efficiency)
Mass of BOD5 to secondary clarifier	873	kg/day	
Tank Volume	223.36965		Surface Area x Depth
Weir Diameter	7.000	m	Less Than Tank Diameter
Weir Length	21.9912	m	π x Weir Diameter
Weir Loading	109.134563	m^2/day	Flow Rate / Weir Length

Table C17: Output Design Values of Aeration Tank

Output Data		
Tank Volume, V	801.6	m^3
Hydraulic Retention Time, HRT	8.016	h
Volumetric Loading Rate, V_L	1.08982	kg BOD_5/m^3-day
Recirculation Ratio	0.333333	
Oxygen Required	3.312676	kg/day
Total Tank Depth	4.5	m
Tank Width	12	m
Tank Length	16.7	m
Volume With Freeboard	901.8	m^3

Table C18: Output Design Values of Rectangular Secondary Clarifier

Output Data		Units	Equations
Mass of SS Input	720	kg/day	Flow Rate x SS Input
Surface Area	120	m^2	Flow Rate / Surfae Overflow Rate
Solid Loading Rate	6	m^3	Mass of SS Input / Surfae Area
Tank Width	6.030	m	Surface Area / Ratio
Tank Length	19.900	m	Surface Area / Tank Width
Weir Length	12.060	m	2 x Tank Width
Tank Volume	600	m^3	Flow Rate x HRT
Tank Depth	5	m	Tank Volume / Surface Area
Weir Loading	199	m^2/day	Flow Rate / Weir Loading

Table C19: Output Design Values of Circular Secondary Clarifier

Output Data		Units	Equations
Mass of SS Input	720	kg/day	Flow Rate x SS Input
Surface Area	120	m^2	Flow Rate / Surfae Overflow Rate
Solid Loading Rate	6	m^3	Mass of SS Input / Surfae Area
Tank Volume	600	m^3	Flow Rate x HRT
Tank Depth	5.099	m	$\pi/4 \times D^2 \times H = V$
Tank Diameter	12.240	m	$\pi/4 \times D^2 \times H = V$
Weir Diameter	10.240	m	Less Than Tank Diameter
Weir Length	32.170972	m	π x Weir Diameter
Weir Loading	74.601414	m^2/day	Flow Rate / Weir Loading

Table C20: Design Comparison of Bar Screen

	Calculated Design	Existing Design	Remarks
Bar Thickness	10 mm	-	-
Bar Dimension	10mm×50mm	-	-
Bar Width	210 mm	-	-
Bar Depth	310 mm	-	-

Table C21: Design Comparison of Equalization Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	21m×16.153m×3.596m	21.5m×16.5m×3.0m	0.5m more in length and depth
Capacity	1220 m^3	1064 m^3	More capacity
HRT	10.43 h	13.3 h	HRT is less than existing design

Table C22: Design Comparison of Coagulation Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	3.26m×3.26mX×2.5m	3.05m×3.05m×2.44m	Slightly bigger than existing design
Capacity	26.667 m^3	17 m^3	More capacity than existing design
HRT	8 min	12.75 min	HRT is less

Table C23: Design Comparison of Flocculation Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	7.07m×3.53m×2.5m	3.88m×3.88m×3.04m	Bigger in every dimension than existing design
Capacity	50 m^3	45.7 m^3	Tank capacity is more than existing design
HRT	20 min	34.3 min	HRT is less than existing design

Table C24: Design Comparison of Primary Clarifier

	Calculated Design	Existing Design	Remarks
Tank Dimension	63.82 m^2 × 9m	56 m^2 ×3.96m	Tank is bigger than existing design
Surface Area	63.82 m^2	56 m^2	Surface area is more than existing design
Capacity	223.369 m^3	172.5 m^3	Capacity is more than existing design
HRT	2.23 h	2.15 h	HRT is slightly more than existing design

Table C25: Design Comparison of Aeration Tank

	Calculated Design	Existing Design	Remarks
Tank Dimension	16.7m×12m×4.5m	17.04m×21.2m×4.5m	Dimension, specially width is more than existing design
Capacity	901.8 m^3	1625.62 m^3	Tank volume/capacity is less than existing design
HRT	8.016 h	20.32 h	HRT is less

Table C26: Design Comparison of Secondary Clarifier

	Calculated Design	Existing Design	Remarks
Tank Dimension	20m×6m×5m	14.5m×6.62m×4.5m	Tank length is notably more than existing design
Surface Area	120 m^2	95.99 m^2	Surface area is more than existing design
Capacity	600 m^3	335.89 m^3	Capacity is more than existing design
HRT	6 h	3.56 h	HRT is more than existing design