PERFORMANCE OF NATURAL COAGULANTS FOR WASTEWATER TREATMENT WITH RESPECT TO INDUSTRIAL COAGULANTS

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: 19C+19E

Semester: Fall-2023

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The thesis titled **"PERFORMANCE OF NATURAL COAGULANTS FOR WASTEWATER TREATMENT WITH RESPECT TO INDUSTRIAL COAGULANTS"** submitted by Md Faysal Bhuiyan (BCE2001019092), Abdul Hamid (BCE2001019087), Md Arman Hossain (BCE2001019075), Md Sobuj Ali (BCE2001019084), Md Nahid Hasan (BCE2001019079), has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on 19th January 2024.

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DECLARATION

It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

to

"Our Parents"

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ABSTRACT

The main objective of this research was to compare the effectiveness of natural coagulants with that of a commonly used chemical coagulant in treating leather wastewater. We aimed to identify a more sustainable and eco-friendly alternative to chemical coagulants for wastewater treatment in the leather industry.

Corn powder outperformed all other coagulants in TDS removal by 80.89% at a dosage of 40 mg/L, demonstrating an efficient and potentially eco-friendly alternative for treating wastewater. Moringa seed and tamarind seed followed closely in their ability to remove 68.75% and 72.50%, respectively. Neem leaf and PAC showed the least effectiveness in reducing TDS, with a percentage of 60.98% and 40.89%, respectively. At a dosage of 40 gm/L, coagulants demonstrate good performance in reducing TDS.

Neem leaf proved most effective in BOD removal, with a percentage of 91.67% at a 40 gm/L dosage. At higher dosages, Moringa Oleifera takes the lead in BOD reduction, followed by polyaluminium chloride (PAC).

Corn powder shows the comparatively best conductivity removal at an 80 gm/L dosage. Tamarind seed powder, Moringa oleifera seed powder, Neem leaf powder, and PAC show increasing conductivity.

Tamarind seed powder and Moringa oleifera powder show good performance in pH adjustment.

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CHAPTER 1

INTRODUCTION

1.1 General

Wastewater may be defined as a combination of liquid or water-carried waste removed from residences, institutions, and commercial and industrial establishments, together with ground water, surface water and storm water(Sonune & Ghate, 2004). Waste water typically contains a variety of high load substance such as oxygen demanding wastes, pathogenic or disease-causing agents, organic materials, nutrients that stimulate plant growth, inorganic chemicals, minerals sediments and also contain toxic compounds, which can have detrimental environmental and public health effect (*Metcalf_and_Eddy_Wastewater_Engineering*, 2004; Sonune & Ghate, 2004).Wastewater can be categorized into four main types such as

(1) Domestic Wastewater: wastewater discharged from homes, residential areas, and commercial establishments, restaurants and shops.

(2) Industrial Wastewater: discharges from industrial processes.

(3) Infiltration/Inflow: Infiltration refers to groundwater seeping into sewer pipes through cracks or leaks, while inflow refers to water entering the system through improper connections or from sources like stormwater runoff.

(4) storm water: runoff resulting from flooding due to heavy rainfall. Industrials wastewater is a major threat to eco system and water.

Industrial wastewater characteristics, depend on composition, strength, flow, and volume, and the industry or manufacturing process in the area and the discharges of industries can contain high-oxygen-demand organic wastewaters and harmful chemicals damaging infrastructure and natural water resources (Crini & Lichtfouse, 2019; Sonune & Ghate, 2004). Industrial discharges may include non-biodegradable compounds and toxic elements that disrupt wastewater treatment plant operations. Actually, water pollution by chemicals has become a major source of concern and a priority for both society and public authorities, but more importantly, for the whole industrial world (Crini & Lichtfouse, 2019; Muralimohan & Palanisamy, 2014; Sonune & Ghate, 2004).

Tannery industries use significant water in their processes and leading to substantial tanned and untanned waste, along with liquid effluents rich in organics, salts, and chromium, often releasing 40-25,000 mg/L of chromium in their discharges(Florescu et al., 2016; Ram Bharose & Singh, 2017; Song et al., 2004). Tanneries generate wastewater in the range of 30 - 35 L/kg with variable pH and high concentrations of suspended solids, BOD, COD and the major problems are due to wastewater containing heavy metals, toxic chemicals, chloride, lime with high dissolved and suspended salts and other pollutants (Chan et al., 2009; Islam et al., 2014; Kazi & Virupakshi, 2007; Manivasagan et al., 2011). In the tanning process, a wide range of chemicals, including acids, alkalis, chromium salts, tannins, sulphates, phenolics, surfactants, dyes, auxiliaries, sulphonated oils, and biocides, are used to transform the semi-soluble protein collagen in hides/skins into durable leather. Unfortunately, these chemicals are not entirely retained by the hides/skins and often end up in wastewater, contributing to environmental concerns (Kumar et al., 2008; Mannucci et al., 2010; Saxena et al., 2017; Tigini et al., 2011).

Heavy metals are hazardous pollutants that do not naturally degrade like organic pollutants and accumulate in different parts of the food chain. These metals, including Hg, Cd, Pb, and As, have no biological function and are toxic to all living organisms. Industrial activities are the main source of these metals in wastegates (Cyanobacteria for Bioremediation of Wastewaters, n.d.). In many countries those wastewater discharge directly in swage or river which is caused highly polluted in term of biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), nitrogen, conductivity, sulphate and chromium (Ayangunna et al., n.d.). Dissolved organic contents consume a large amount of oxygen and increase BOD level which leads to anaerobic fermentation and produces organic acids and hydrolysis of these organic acids causes the decrease in pH values. High TDS, BOD and COD content cause decrease in DO of the water system creating stress condition to the aquatic living organisms. Degradation of dissolved organic contents generates cations and anions and changes in the ionic composition of water which can also exclude some species while promoting population growth of others. have also exclude some species while promoting population growth of others. have also reported a higher amount of TDS, BOD, COD, EC, salinity, alkalinity, hardness and lower amount of DO in effulent (Karnatoli et al., 2018; Ram Bharose & Singh, 2017) .

Figure 1.1: wastewater Discharge

1.2 Problem Statement on Environment:

Industries discharges generation of significant amounts of chemical sludge(Saxena et al., 2017). Tannery wastewater is significant contributor for water and soil pollution and its dark brown color obstructs the penetration of sunlight, resulting in reduced photosynthetic activity and decreased oxygen levels in the receiving water bodies which threat to aquatic life and ecosystem(Mwinyihija, 2010). Those waste reduce the dissolved oxygen levels that increase the development of anaerobic conditions, which can produce emission of foul odors from the water(Rai et al., 2005; Verma et al., 2008).

Industries wastewater contaminate river, lake groundwater(Ho et al., n.d.).Using contaminate in field may reduce the yielding of crops and plant growth. Contaminated metals like lead (Pb) and iron (Fe), Zine (Zn), cobalt (Cu), Nickel (Ni) can indeed cause toxic or hazardous situations in water. Industrials discharges carry heavy metals into soil and water sources, which can harm ecosystems and human health(Abu Bakar & Halim, 2013; El-Gohary et al., 1995; Ho et al., n.d.).

1.3 Research Objectives and Overview

The objectives of the study are:

- Evaluate the effectiveness of natural coagulant Moringa Oleifera, Tamarind seed, Neam leaf, Corn for tannery wastewater treatment.
- Compare the performance of natural coagulant which chemical coagulant.
- Determine the optimal dosages of natural coagulant for effective wastewater treatment.

1.4 Organization of the thesis

Chapter 1: Introduction and Objective. This chapter provides the background and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

Chapter 2: Literature Review. This chapter reviews the related works in the wastewater treatment field with a special focus on natural coagulation techniques.

Chapter 3: Methodology. This chapter includes the research methodology of this study.

Chapter 4: Result and Discussion. This chapter provides an overview of the obtained result and discusses in detail the data.

Chapter 5: Conclusion and Future works. This chapter concludes the whole study and suggests some future works.

CHAPTER 2

Literature Review

2.1 Introduction

Common wastewater treatment methods include biological processes like nitrification, denitrification, and phosphorus removal, as well as physico-chemical processes such as adsorption, ion exchange, precipitation(Kurniawan et al., 2006), reverse osmosis(Qdais & Moussa, 2004),coagulation, and electro-coagulation (Ayangunna et al., n.d.; Fu & Wang, 2011; Song et al., 2004; Wang et al., 2009).Over the past three decades, wide range of wastewater technology have been developed, physical, chemical and biological methods. Those method includes flotation, precipitation, oxidation, solvent extraction, evaporation, carbon adsorption, ion exchange, membrane filtration, electrochemistry, biodegradation for wastewater treatment (Crini, 2005; Crini & Lichtfouse, 2019; Rathoure & Dhatwalia, 2016). Five successive purification steps as described:

(1) preliminary treatment or pre-treatment (physical and mechanical process);

(2) primary treatment (involving physicochemical and chemical method);

(3) secondary treatment or purification (chemical and biological);

(4) tertiary or final treatment (physical and chemical); and

(5) treatment of the sludge formed (supervised tipping, recycling or incineration).

In general, the first two steps are gathered under the notion of pre-treatment or preliminary step, depending on the situation (Crini & Lichtfouse, 2019).

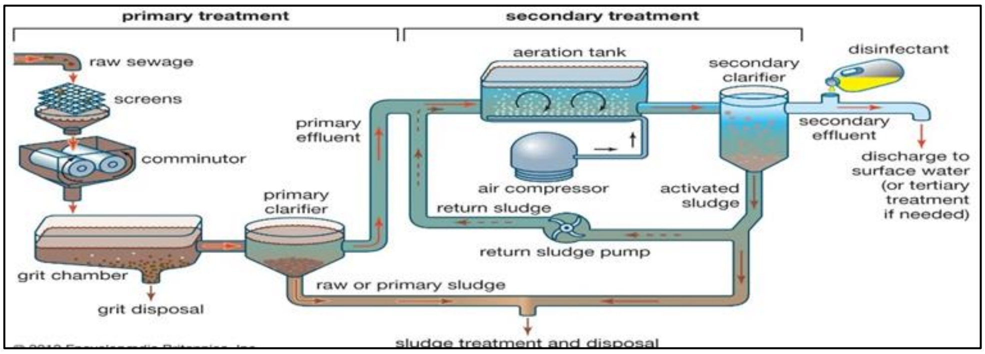

Figure 2.1:Wastewater Treatment Process

2.2 Aerobic Treatment process:

In aerobic treatment process, the waste decomposition occurs rapidly, and this method do not associate with unpleasant odours. But this process generates a significant amount of sludge(Ramteke et al., 2010). Several studies have explored the aerobic treatment of tannery wastewater (TWW) using Activated Sludge Process (ASP) (Ramteke et al., 2010; Saxena et al., 2017). In aerobic decomposition process involves dissolved oxygen by microorganisms (aerobes) for the conversion of organic wastes into biomass. During the process organic wastes are transformed into microbial biomass through metabolic pathways that require oxygen and This results in the conversion of organic matter into new microbial cells and the release of carbon dioxide (CO2) as a metabolic by product (Annachhatre, 1996; Chan et al., 2009; Seghezzo et al., 1998). Aerobic system is suitable for low strength or polluted water where COD concentration less than 1000mg/L (Chan et al., 2009).

2.3 Anaerobic treatment process:

In anaerobic decomposition process microorganisms breaks down into organic matter without oxygen(Chan et al., 2009). There are three steps such hydrolysis, acidogenesis and methanogenesis (Annachhatre, 1996; Saxena et al., 2017; Seghezzo et al., 1998). Anaerobic process is suitable for high concentration pollutant water, where COD concentration over 4000mg/L. Anaerobic process requires less energy, provides potential for bioenergy and nutrient recovery, and is cost-effective. Aerobic treatment good in removing soluble biodegradable organic matter and generates well-flocculated biomass, leading to lower effluent suspended solids. Based on wastewater characteristics and goals the treatment methods should be selected.

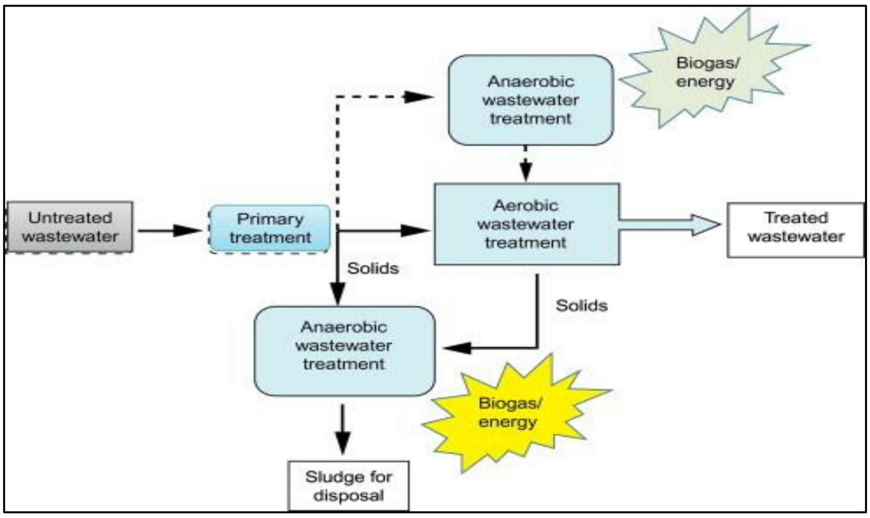

Figure 2.2: Aerobic and Anaerobic treatment process

2.4 Coagulation and flocculation:

The most used water treatment process includes aeration, coagulation, flocculation, sedimentation, filtration and disinfection. Coagulation-flocculation is a common and efficient physico-chemical method for wastewater treatment and is widely used to treat wastewater(Abu Bakar & Halim, 2013).In this process, neutralize the negative charge into tiny particles in water with the positively charge substance which is created during hydrolysis. This neutralization allows the particles to come together and form larger aggregates, effectively removing impurities from the water(Abu Bakar & Halim, 2013; Bahrodin et al., 2021; Duan & Gregory, 2003; Katubi et al., 2021). When particles are slow to settle or are non-settling, the process is speeded up by coagulation and flocculation through the addition of certain chemicals known as coagulants. These processes are effective remove fine suspended particles that can hold bacteria and viruses(Gowda et al., 2017; Muhammed & Jiya, 2019).Polymeric coagulants can be either cationic, anionic, or non-ionic, with cationic and anionic types collectively called polyelectrolytes. Natural coagulants are often polysaccharides or proteins. Even so-called non-ionic polymers can have charged interactions due to partially charged groups like -OH along their chain, especially in solution environments (Bolto & Gregory, 2007; Katubi et al., 2021; Muralimohan & Palanisamy, 2014; Saxena et al., 2017; Yin, 2010). Coagulation in particle aggregation involves four mechanisms:

(1) double layer compression, (2) sweep flocculation,

(3) adsorption and charge neutralization, (4) adsorption & inter-particle bridging

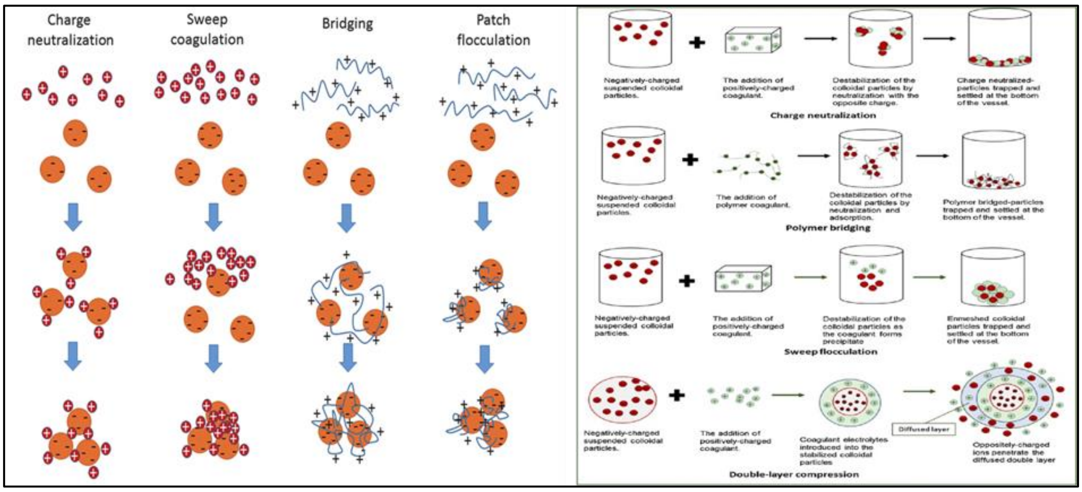

Figure 2.3: Coagulation and Flocculation Process

Coagulation destabilizes colloids and suspended matter by adding coagulants, making them easier to remove. Different mechanisms like charge neutralization, adsorption, and sweep flocculation can remove organic particles and compounds based on coagulant concentration and water properties(Alazaiza et al., 2022; EH et al., 2018; Muhammed & Jiya, 2019; Yin, 2010).Coagulation-flocculation is used either as a pre-treatment phase or post-treatment step, depending on the nature of the waste water being treated. The coagulation-flocculation treatment process can be separated into two step treatments. The first step coagulation, which destabilized the mechanism of colloidal suspension or solution. Second process, called flocculation, involves incorporation of destabilizing particles to come together and form a large agglomerate for easily separated by settling gravity. Coagulation is a quick process, but flocculation takes 20–45 minutes for destabilized particles(Alazaiza et al., 2022; Ayangunna et al., n.d.; Desta & Bote, 2021; Mahudeswaran et al., 2017). Coagulation and flocculation are important physicochemical operations of wastewater treatment used for the removal of turbidity particles and natural organic matter(*Cyanobacteria for Bioremediation of Wastewaters*, n.d.).Coagulation is most essential step in treating industrial wastewaters(Muralimohan & Palanisamy, 2014). Coagulation-flocculation is most used physicochemical treatment in industrial wastewater treatment, reducing suspended and colloidal materials responsible for wastewater turbidity and also decreasing organic matter contributing to BOD and COD levels(Alazaiza et al., 2022; Kazi & Virupakshi, 2007; Sarkar et al., 2006).The effectiveness of coagulation and flocculation process depend on some factors such as dose of coagulant, pH, mixing speed and time. The effect of coagulant dosage on pollutant removal can be depend under three conditions: underdosage, optimum dosage, and overdosage (Bahrodin et al., 2021).

2.5 Chemical coagulant use:

The aluminium sulphate (Alum) and ferric chloride were used for chemical coagulation for decades(Song et al., 2004). Later poly aluminium chloride was used as an effective coagulant than alum and ferric chloride. At present most of the industries are using anionic polymers and cationic polymers for coagulation. These polymers 1 millilitre is equal to 1 kilogram alum. The aim of this study is to replace the chemical coagulants with natural eco-friendly coagulants (Hamdan et al., 2019).Aluminium causes chronic effects. Long-term aluminium exposure can cause intestinal constipation, loss of memory, convulsions, abdominal colic's, loss of energy and learning difficulties, brain and bone effects. Aluminium, once allowed to penetrate the bloodstream, is a neurotoxic agent. The sludge generated after treatment is voluminous and not biodegradable and therefore poses problems with disposal, which leads to increased treatment costs. The cost of these chemicals for imported chemicals has increased at an alarming rate for foreign exchange problems in developing countries(Desta & Bote, 2021; J et al., 2017).Moreover, recent studies have pointed out the health threats arising from the consumption of residual aluminium present in water, such as Alzheimer's diseases, neurological diseases that affects the nervous system, Carcinogenic and cognitive & intellectual deterioration leading to memory loss(*Cyanobacteria for Bioremediation of Wastewaters*, n.d.; Kazi & Virupakshi, 2007; Kimura et al., 2013; Muhammad et al., 2015; Muhammed & Jiya, 2019; Suhaili et al., n.d.; Sulaiman et al., 2019; Tsamo et al., 2021; Vijayaraghavan et al., n.d.; Yin, 2010).It is well-documented that chromium (VI) is a potent carcinogen, posing risks to humans, animals, plants, and even microbes. It can enter cells through surface transport systems and undergo reduction to chromium (III) form, leading to various genotoxic effects(Saxena et al., 2017).

2.6 Natural coagulant:

Natural coagulant has numerous advantages as they are eco-friendly, sustainable, cost effective and simple process. In the process, the pH of raw water has no harm to human health or the environment, with no negative impact on microorganisms. Additionally, natural coagulants can substantially reduce wastewater alkalinity, surpassing the performance of chemical alternatives. Natural coagulants are cost-effective(Alazaiza et al., 2022; Desta & Bote, 2021; Owodunni & Ismail, 2021; Thesni et al., n.d.). Natural polyelectrolytes from plants have been utilized for centuries in developing countries to clarify cloudy water(Chaudhuri et al., n.d.). Natural coagulants are popular due to their availability, cost effective, biodegradable, non-toxic, renewable and for production of less sludge(Muralimohan & Palanisamy, 2014; Yin, 2010). Natural plant-based coagulants as POU water treatment offer several key benefits: they are cost-effective, don't tend to alter the water's pH significantly, and are highly biodegrade(Vijayaraghavan et al., n.d.; Yin, 2010). Bio coagulants or natural coagulants are highly abundant and cost-effective and have a significant removal opportunity compare with chemical coagulants in water treatment.

This lowers the risk of secondary contamination and also minimizes water treatment costs. Moreover, bio coagulants' ease of recycling helps to protect the environment(Tsamo et al., 2021).

The advantages of natural coagulant are:

- Environmental Friendliness
- Non- toxic
- Antibacterial and antifungal properties
- Produce low volume of sludge
- Sludge can serve as effective fertilizer for crops
- Reduce alkalinity of wastewater

2.7 Background Study:

Here will explain earlier studies and research on Moringa oleifera, Tamarind seed, Neem leaf, corn, PAC powder. The effectiveness of both chemical coagulants and natural coagulants for wastewater treatment will be discussed.

2.7.1 Use of Moringa Oleifera as natural coagulant:

(Raju et al., n.d.) This study evaluates the effectiveness of the chemical coagulant Alum in comparison to natural coagulants Moringa Oleifera and tamarind seed powder. The pH, alkalinity, acidity, and total chloride removal efficiencies at the optimum dosage were determined from the sample water. As chemical coagulant Alum causes harmful effect on human and aquatic animals(Muhammed & Jiya, 2019; Sulaiman et al., 2019) ,so the study aims to create an alternative to chemical coagulant using natural coagulant Moringa oleifera and tamarind seed powder. From a conventional treatment plan, varying amounts of 100 mg/l, 150 mg/l, 200 mg/l, 250 mg/l, 300 mg/l, and 350 mg/l coagulant dosages were added to the flocculation tank, followed by variations in pH and settling time. The apparatus was switched on at the speed of the paddles for rapid mixing for about 1–2 minutes. After rapid mixing, the speeds of the paddles were reduced to about 100 rpm, followed by mixing for 60 minutes. After mixing, the apparatus was switched off and the samples were allowed to settle for 10 - 60 minutes. The maximum Reduction Efficiencies of Coagulants dosages was 350mg/l. The reduction efficiencies of pH of 350mg/l dosage were for Alum (18.18%), Moringa Oleifera (18.18%), tamarind seed powder (18.18%). Maximum turbidity removal efficiencies of coagulants were for Alum (97.5%) using dosage of 300mg/l, moringa oleifera (98.12%) dosage of 25mg/l and tamarind seed powder (98.12%) for 300mg/l dosage. Maximum alkalinity reduction efficiencies of coagulants alum 54.05%. moringa oleifera 63.84%, tamarind seed powder (60.46). The combined use of moringa oleifera and tamarind seed powder result was impressive. The combined use of moringa oleifera and tamarind seed powder reduction efficiencies of pH, turbidity, alkalinity, chloride, acidity with the optimum dosage found 19.31%, 98.75%, 66.70%, 50.23%, 80%. Combined use of natural coagulant is more effective than chemical coagulant.

(Muralimohan et al., 2014) In this study investigate the blended natural coagulants Moringa Oliefera and Chemical coagulant Alum ($Al_2(SO_4)_3$) to the treatment of textile wastewater. Natural coagulant Moringa oleifera and Chemical Coagulant Alum of 10mL, 20mL, 40mL, 60mL and 80 mL dosages were used and post treated textile wastewaters was collected to test with coagulants were considered to evaluate the percentage removal efficiency on the major pollutants in textile effluent such as turbidity, TSS, TDS, COD and BOD. Coagulants and raw effluent were collected from the local area and preserved at 4ºC the laboratory incubator. Mixed 2 grams of Moringa oleifera powder with 100 mL of tap water (it gives 2% of Moringa suspension). A magnetic stirrer used to shake the mixture vigorously for 30 minutes. Then four beakers 500mL textile wastewater was dosed with 10mL, 20mL, 40mL, 60mL and 80 mL of natural coagulants were stirred rapidly for 10 min at 180 rpm, followed by 10 min slow stirring for flocculation. After settling, 30mL samples were taken from each dosage. The textile wastewater before treatment the value of total dissolved solids (TDS) was 2800 mg/L. After using natural coagulant moringa Oliefera powder and alum in the ratio of 50:50 TDS removal (%) of the dosage 23.07%,29.21%,36.86%,45.29%,47.82% and 60.04% was achieved respectively by 100:0,90:10, 80:20, 70:30, 60:40 and 50:50 dosage ratio. The maximum removal found ratio of 50:50. The highest BOD and COD removal (%) was found to be 80.67% and 66.73% at 50:50 dosage ratio of MO: Alum respectively. Therefore, Moringa oleifera seed powder has the similar effectiveness to alum in the removal of TDS, COD, and BOD.

(Desta & Bote, 2021) Wastewater discharges from various origin are causing a significant environmental threat to water sources. To mitigate this issue, coagulation-flocculation is commonly used as a pre-treatment method. While coagulation is a rapid process, usually concluding within seconds, flocculation necessitates 20–45 minutes to effectively destabilize particles and facilitate their settling this investigation, Moringa seed powder was used as it is widely availability. Moringa oleifera seed as a coagulant for the direct filtration of turbid surface water resulted in significant enhancements in both its appearance and microbiological quality(Chaudhuri et al., n.d.). Crushed seeds from the Moringa oleifera tree offer a practical alternative as a coagulant, replacing commercial chemicals like aluminium sulphate (alum), especially in developing countries(Sutherland et al., n.d.). The research demonstrated the remarkable efficacy of Moringa seed powder in removal of color, turbidity, and COD. Various doses of Moringa seed powder, ranging from 0.1g, 0.2g, 0.3g, 0.4g, 0.5g, 0.6 g were used in 500 ml of wastewater to achieve optimal results. For the test wastewater was collected carefully and keep the sample at 4ºC temperature Morinaga seed was oven dry at 107ºC for 7 hours after that sieve within 710 size sieves. The impact varying amounts of Moringa seed on the elimination of pollutants (color, turbidity, and COD) from wastewater was investigated. An effective removal in color was observed at pH 9 and pH3, specifically within the dosage range of 0.1, 0.2, 0.3 g/500 ml. Modest improvements were noted in turbidity and COD removal efficiencies under similar dosage and pH conditions. Beyond a dosage of 0.4 g/500 ml of Moringa seed powder, there was a decrease in color and turbidity removal efficiencies. Conversely, COD removal efficiency exhibited a linear increase, reaching its peak at the maximum dosage of Moringa seed powder (0.6 g/500 ml). This indicates that higher dosage is necessary to achieve optimal COD removal efficiency. The highest removal of color and turbidity was attained at a dosage of 0.4 g per 500 ml of the wastewater sample. However, adding more Moringa seed powder than 0.4 g led to a decrease in color and turbidity, which was explained by floc-restabilization. Moringa seed powder dose of 4 mg/L at pH 3, COD witnessed a reduction of 56.34%, color decreased by 91.56%, and turbidity showed a substantial reduction of 98.02%. Increasing the dosage may have the potential to enhance the removal efficiency of COD.

(J et al., 2017) This research explores the employing plant-based coagulants in the coagulation-flocculation process for wastewater treatment to reduce turbidity. The primary objectives of the experiment are evaluating the potential of natural coagulants as alternatives to conventional synthetic coagulants or chemical coagulants like aluminum sulfate. The natural coagulants are *Dolichas lablab*, *Azadirachta Indica*, Moringa Oleifera, and *Hibiscus Rosa Sinensis* and Alum used in this experiment are collected from local area. Various doses of coagulants are used for the tests. The water was collected from a local small paper mill. For *Azadirachta Indica*, commonly known as neem, the initial turbidity of the wastewater was 26.5 NTU. The optimal dosage was 6.5 grams, resulting in a turbidity removal efficiency of 63.01%. For Moringa Oleifera, the initial turbidity of wastewater was 44.8 NTU. The optimal dosage was 3 grams, resulting in a turbidity removal efficiency of 31.47%. The test demonstrates that Moringa Oleifera and *Azadirachta Indica* possess the capability to substitute chemical coagulants.

(Maya Saphira Radin Mohamed et al., 2017) In this report, Moringa Oleifera and *Cicer arietinum* are employed as natural coagulants for wastewater treatment, with a focus on their potential for commercial use as alternatives to chemical coagulants. In the rapidly increasing global population, water pollution has become a mass issue, Various pollutants contribute to altering the physical and chemical characteristics of water. To mitigate the issue physical-chemical treatment methods are applied in wastewater treatment. The coagulation-flocculation process is employed to enhance effluent quality, involving the addition of coagulants to wastewater, selecting high-quality coagulants is an importance in this process. While there are two types of coagulants—chemical and natural, chemical coagulants present numerous disadvantages and adverse environmental effects. Therefore, prioritizing the use of natural coagulants is imperative for a safer environmental impact. Among all the natural coagulants, Moringa Oleifera stands out as the most commonly used due to its widespread availability. Utilizing Moringa Oleifera in the treatment of tannery wastewater, efficacy at a mixing speed of 100 rpm for 60 seconds and 30 rpm for 10 minutes, coupled with a settling time of 20 minutes. The success of this method was achieved 83.33% removal of COD and 82.02% reduction in turbidity. This showcases Moringa Oleifera's potential for sustainable water treatments and it is eco-friendly and affordable.

(Muhammed & Jiya, 2019) This study is about the efficacy of natural coagulant Moringa oleifera and watermelon, in comparison to a chemical coagulant (alum), as primary coagulants. Natural coagulants are environmentally friendly and effective wastewater treatment process due to the drawbacks of conventional coagulants. Plant-based coagulant agents contain proteins with the ability to tightly bind with other molecules. It’s called flocculation. The Moringa oleifera seed has a high protein content of 44.7%. It also has high levels of moisture, carbohydrate, fiber, and ash, with corresponding values of 26.2%, 10%, 10.4%, and 8.8.%. Natural coagulant and chemical coagulant and other equipment are collected from the local area. The initial condition of collected raw water is pH 7.30, TDS 48.7 mg/L, Conductivity 60.9 µS/cm, Turbidity 21.8 NTU. Using 1 g/L coagulant dose of moringa Oleifera seed powder as solo coagulant pH become 7.07, TDS 120mg/ L, Conductivity 150 µS/cm, Turbidity 1.54 NTU. In this experiment they mainly focus on using natural coagulant as aid to another natural coagulant in compared to chemical coagulant alum for better result. When watermelon and Moringa oleifera were used together as an aid coagulant, they achieved the best results. The effectiveness was seen in various aspects, such as the dosage of the combined natural coagulant, the stirring speed during coagulation, and the performance of watermelon and Moringa oleifera when used with alum. The turbidity reduction levels were 94.5%, 94.9%, 96.9%, and 95% respectively.

(Hamdan et al., 2019)Wastewater from industries contains a variety of contaminants. The amount and type of pollutants depend on the industry's processes and capacity. This study aims to evaluate the effectiveness of eco-friendly coagulants can treat wastewater from the different industries. The study followed some parameters like pH, total suspended solids (TDS), chemical oxygen demand (COD), nitrate, phosphate, and oil and grease. The used natural coagulants are Moringa oleifera seeds and *Ocimum sanctum* (Tulsi) powder. The coagulants are gathered from nearby areas and sun-dried for two weeks. The seeds dried in an oven at 35˚C for 5 hours to ensure complete moisture removal. Afterward, they are finely ground into powder for a particle size of approximately 600 µm. 1g of Moringa oleifera seeds and *Ocimum sanctum* (Tulsi) leaves each were combined with 100 mL of distilled water. The mixture was rapidly stirred for 20 minutes using a magnetic stirrer to facilitate the extraction of coagulant proteins into the water. The number of coagulant dosages prepared for the test were 10 mL, 15 mL, 20 mL, 25 mL, 30 mL, 35 mL, 40 mL, 45mL and 50 mL. Moringa and Tulsi coagulant shown and effective result in removal of pH 25.3%. Impressive results were observed in COD removal at doses of 45 mL, 55 mL, 65 mL, 75 mL, 85 mL, and 95 mL. Particularly in the 95 mL dose, which demonstrated a remarkable COD removal efficiency of 93.9%. The best amount of coagulant solution was found to be 95 mL, made up of 50 mL of natural coagulant and 45 mL of solvent.

(Kazi & Virupakshi, 2007) The tanning industry is one of the oldest and complicated waste generate industry. It produces a lot of pollutants like BOD, COD, TDS, TSS, chloride, and chromium. To handle these discharges in an eco-friendly manner, natural coagulants play a crucial role. In this study the effectiveness of natural coagulant *Cicer arietinum* (Chickpea), Moringa oleifera, and Cactus comparing the perform in treating wastewater. The coagulants are gathered, dried under the sun, then ground into smaller particles and those particles obtain sizes around 600 μm. Various doses of natural coagulant, such as 0.05, 0.1, 0.2, 0.3, 0.4, and 0.5 grams, are prepared. These doses are then mixed with 500 ml of tannery wastewater. Then jar test conduct the sample keep to mixing in 100rpm for 1 minute and slow mixing in 30 rpm for 10 minutes and kept 20 minutes for settle. The optimum dosage of moringa oleifera was carried out 0.3gm/500ml and decrease the pH level 5.5 to 4.5. The maximum turbidity reduction was 77.38% and COD removal was 18,000mg/L of 83.33%. Among the three coagulants, Moringa oleifera has proven most effective in removing turbidity. Additionally, it shows a relatively good reduction in other parameters.

2.7.2 Use of Tamarind seed as natural coagulant:

(Zainol & Nasuha Mohd Fadli, 2020) In this study, the effectiveness of natural coagulant, the ability of tamarind seed is being evaluated as a coagulant to measure the highest percentage removal of turbidity and chemical oxygen demand (COD) in the surface water. Different doses of seed extracts were added into the beakers and start the jar test for 1 minute at 120 rpm. The mixing speed was reduced to 30 rpm and kept for 20 minutes. After that the suspensions were left for sedimentation. After 1 hour of sedimentation, clarified samples were collected from the top of the beaker and the samples were analyzed. When distilled water is used as the extraction solution, 99.2% and 77.2% are achieved for the percentage removal of turbidity and COD respectively. The optimum condition achieved for coagulant dosage at 30 mg/L and pH 5.0. In comparison, the used of NaCI at optimum dosage of 30 mg/L and optimum pH of 3.0 gives 99.4% and 73.8% for the highest percentage removal achieved for both turbidity and COD. Here the distilled water of 1M of NaCl solutions turbidity and COD removal is almost similar. Therefore, in future tamarind seeds solvent can be proposed as effective natural coagulants that are safe to use without causing serious health effect to the environment.

(Thesni et al., n.d.) This paper evaluates the comparative effectiveness in the reduction of turbidity, COD, BOD, Total dissolved solids (TDS) and Total suspended solids (TSS) of natural coagulants such as Tamarindus indica seed powder and carica papaya seed powder for the treatment of Municipal wastewater. The initial value of the water for different parameter turbidity, COD, Total dissolved solids (TDS) and Total suspended solids (TSS) was 200NTU,7.4,750mg/l,1230mg/l,1082mg/l respectively. Dosages used 0.1g,0.3g,0.5g,0.7g,0.9g,1.1g. Effective removal of tamarind seed powder were turbidity (63%), total dissolved solids (TDS) (78%), TSS (83%), TS (81%), COD (77%). And 1.1g dosage of tamarind seed powder gave the optimum reduction value. The tamarind seed powder is more effective in removing turbidity and COD. The locally available natural coagulants can also be used in the treatment of textile industry water, tannery waste water etc, because the natural coagulants are cost effective and safe method for the water treatment.

(Syed Zainal et al., 2018) In this study, a coagulation–flocculation process using the combination of polyaluminum chloride (PAC) as coagulant and *Tamarindus indica* seed (TiS) as coagulant aid was used in treating the landfill leachate. In this report the optimum operational conditions determined based on the pH and dosage of the coagulant aid, which considered on parameters, such as suspended solids (SS), and COD. PACI coagulant at pH 6 and concentration of 5,000 mg/l used its suspended solids (SS), and COD removal was SS (99.5%) and COD (73.6%). when Tamarindus indica seed (TiS) as coagulant used where pH 4 and concentration was 5000mg/l and SS removal was 5.9%. when the combination of PAC as primary coagulant and Tamarindus indica seed (TiS) as flocculant was applied. usage of PAC was reduced to 2,750 mg/L with the aid of 2,000 mg/L of TiS. Finally, the removal efficiencies were suspended solids (SS)99.3%, color 97.3%, and COD 67.4%.

(Ayangunna et al., n.d.) The research work showed the effectiveness of tamarind seed powder in coagulation -flocculation treatment of industrial wastewater. They used three parameter pH, turbidity and COD removal and explored their variation multiple mixing times and coagulant dosages. A constant pH of 7.25 and mixing time of 140 rpm for 3 minutes and 40 rpm for 15 minutes were used while the coagulant dosage was varied from 100 to 3800 mg/L. It was observed that the highest COD removal occurred when the dosage was 400 mg/L. Increasing the coagulant dosages resulted in a significant enhancement of turbidity reduction and COD removal efficiency.

2.7.3 Use of Neem leaf powder as natural coagulant:

(Rashid et al., 2016) *Azadirachta indica*, a species of flowering plant in the Meliaceae family, is commonly known as Neem and Indian Lilac. Around the world, this plant grows in tropical, subtropical, and mildly temperate climates area. It is well known for its medicinal properties, particularly in the treatment of diabetes. Neem leaves improve biological functions like strengthen the immune system, support lung health, boost digestive well-being, and help the liver remove toxins from the bloodstream. The wood of neem tree is strong and termite resistance and suitable for use as firewood and charcoal production(Mohan et al., 2019). Neem tree powder serves as a disinfectant and effectively eliminates various types of germs. Neem powder shows potential as an alternative to chlorine, which is used as a sterilizer. Neem leaf powder can enhance water conductivity, with an increase in water salinity. This implementation of neem leaves might provide a safe and environmentally beneficial substitute for chemicals that have negative impacts on the environment.

(Mohan et al., 2019) in this report discuss the effectiveness and potential benefits of using Neem leaves powder as a natural coagulant. Neem leaf powder plays a major role in the removal of physiochemical parameters such as PH, Total solids, TDS, TSS, EC, turbidity, T. Alkalinity, Bi-Carbonate Alkalinity, Total Hardness, Ch. Hardness, Mg. Hardness, Calcium, Magnesium, Carbonate Hardness, non-carbonate Hardness, Chloride, Sulphate, MLVSS, Iron, Silica COD, BOD, Copper and Chromium. Take 250ml of sample in four beakers and keep in jar test apparatus. Switch on the motor and adjust the speed of the paddles. Allow flash mix rapidly for 1 minute. Reduce the speed of the paddles and continue it for 10 minutes. Switch off the motor and allow the solution to settle for 20 minutes. Before treatment value of pH, TDS, COD, BOD was respectively 9.2,5770 mg/l, 1173mg/l ,282.6mg/l after using neem powder coagulant those value become 7.7, 4516mg/l, 601 mg/l, 206 mg/l. pH removal 16.3%, TDS removal 21.73%, COD removal 48.765 and BOD removal for 3 days 27.1%. The BOD3/COD ratio of the effluent was improved to 0.19.

(R & Kumar, 2021) This study aims to evaluate the effectiveness of natural coagulants in removing turbidity and adjusting pH in wastewater. And the efficiency of a combination of orange peel and neem leaf powder at various ratios for treating dairy wastewater. Three combinations of neem leaf and orange peel powder were used with the ratios of 1:1, 3:1, and 1:3. Various dosages of the coagulant were applied, ranging from 0.2 g ,0.4g, 0.6g, 0.8g to 1 g. The samples are put in the jar test where the paddles were rotated at a speed of 80 to 100 rpm for 2 minutes and slowdown 40 rpm for 20 minutes. Neem leaf and orange peel powder ratio of 1:1 shows 86% maximum turbidity removal efficiency. Ratio of 1:3 and 3:1 shows 88% and 87% removal efficiency. Among the three ratio's dosages, 0.8g dosage show a favorable response in changing the pH value of the wastewater.

2.7.4 Use of Zea Mays or Corn powder as natural coagulant:

(Patel & Vashi, 2015) The study aims to treat dyeing mill wastewater using natural coagulants Moringa Oliefera locally known Sajina seed powder (SSP), *Zea Mays* or corn powder or maize seed powder (MSP), and chitosan to remove COD, BOD, and color. It investigates parameters like coagulant dosage, flocculation time, and temperature. The dried seeds are crushed and powdered, sieved through 200 mm nylon sieves. The coagulant is prepared in different dosages: 5.0 g/L, 10.0 g/L, 15 g/L, 20.0 g/L, 25.0 g/L, 30.0 g/L, and 35.0 g/L of each coagulant for a constant flocculation time (120 min) and a constant temperature for 15-150 minutes. To investigate the effect of temperature, 20.0 g/L coagulant for a constant floc-culation time (120 min) at various temperatures (298, 303, 308, 313, 318,323, and 328 K) are kept. The effects of coagulant doses (5-30 g/L) at a temperature of 300 K on the removal of COD, BOD and color from dyeing mill wastewater. Based on the report the continuous removal with increases in coagulant doses up to 30.0 g/L. The optimum dose is found 25.0 g/L all coagulants removal value of COD, BOD. The highest removal of COD, BOD, and color is found 70.3%, 67.9%, and 62.8%, respectively, using SSP. 68.8%, 58.9%, and 47.0%, respectively, using MSP; and 64.7%, 55.7%, and 42.8%, respectively, using chitosan. The optimum flocculation time is found to be 120 min. The highest removal of COD, BOD, and color is found to be 75.6%, 66.1%, and52.8%, respectively, using SSP; 74.7%, 62.9%, and 48.9%, respectively, using MSP; and 69.6%, 60.1%, and 42.8%, respectively, using chitosan. The optimum temperature is attained at 323 K for all coagulants. The highest removal of COD, BOD, and color is found to be 74.9%, 71.1%, and 67.1%, respectively, when SSP is used;72.6%, 68.1%, and 58.5%, respectively, when MSP is used; and 69.6%,64.6%, and 47.3%, respectively, when chitosan is used. Higher temperatures result in improved removal percentages, likely because increased temperature promotes more effective floc settling. Therefore, based on those result the is found to be MSP >SSP >chitosan.

2.7.5 Use of Chemical coagulant PAC:

(Farajnezhad & Gharbani, 2012) In this study the use of instead of ferric chloride in petrochemical wastewater treatment has been investigated. And the poly aluminum chloride is more efficiency and the flocculated formed by poly aluminum chloride is larger than flocculated formed by ferric chloride and so separation is desirable. The analyzing parameters are color, pH, TSS and COD. To create solution 10g of each substance added in distilled water and the solution volumes were increased to 1 liter. Each 1 ml of these stock solutions was equivalent to 20 mg/L when added to 500 mL of wastewater. Three dosages of solution 10, 20, and 30 mg/L were prepared. After that the solution is kept at different maxing time and speed. A consist of rapid mixing (150 rpm) for 1 minutes and slow mixing (30 rpm) for 10 minutes to coagulation. After that the solution was kept settle for 20 minutes. PAC has more efficiency for removal of color (86-88%) than ferric chloride (74-79%). The removal of COD by ferric chloride and PAC as coagulant PAC (48-72%) reduced the COD more than ferric chloride (44-67%). Using PAC improved the removal of TSS 78-81%. Coagulant dose of 10 mg/L was the optimum dosage.

(Abu Bakar & Halim, 2013) In this study, compared the effectiveness of PAC, alum and FeCl3 in treating automotive wastewater, specifically evaluating their performance in removing COD, TSS, and heavy metals. Overall, PAC was selected as the most effective coagulant among the three coagulants used. The alum and ferric chloride are used in powder form with the formula Al2(SO4)3·18H2O (M= 666.42 g/mol, pH2.5–4) and FeCl3·6H2O (M=270.33 g/mol, pH1.8). the sample pH was adjusted. Then, the coagulant was added with dosage varying from zero to 110 mg/L for PAC, nil to 500 mg/L for alum and nil to 250 mg/L for ferric chloride to get the optimum amount of coagulant dosage each. The mixing constant speed of 200 rpm for 2 minutes followed by a slow stirring at 40 rpm for 10 minutes and 30 minutes for settlement time. For 100mg/L coagulant dose pH varied within range of 4-9. The TSS and COD removal efficiencies increase with the increase of PAC dosage at the optimum pH of 7, until it reaches its highest value. The optimum dosage achieved was approximately 70 mg/L aided by 2 mg/L of anionic polyacrylamide, which produced 72% of COD removal and 98% of TSS removal. The removal of COD and TSS started to decrease as the dose of 90 mg/L was applied. At lower dosages, PAC exhibits characteristics like those of alum salts. Therefore, PAC aided by anionic polyacrylamide produced higher removal.

CHAPTER 3

Methodology

3.1 Introduction:

In this chapter, a comprehensive overview of the study area, the materials used, and the software utilized for the research is provided. Furthermore, the experimental and analytic methods employed in laboratory experiments are discussed. All measurement methods for the study were conducted with the standards for water and wastewater experiments at the Sonargaon University laboratory.

3.2 Water Collection:

The wastewater for this study was collected from the Central Effluent Treatment Plant (CETP) located in Savar, Dhaka, Bangladesh. Specifically, the effluent discharged from the treatment plant at CETP was collected for analysis. In the area of Savar, wastewater from tanneries is directed to the CETP for treatment. After the treatment process, the treated effluent is released into the Dhaleshwari River, a distributary of the Jamuna River.

Figure 3.1: Tannery Wastewater Collection

3.3 Materials Collection and Extraction:

The materials used in this study as natural coagulant include Moringa oleifera seeds, Tamarind seeds, Neem leaves, Corn and Polyaluminum chloride (PAC). The method of collecting and extracting coagulants is explained.

3.3.1 Collection and processing of Moringa Oleifera seed:

The plant Moringa oleifera is well known for its many applications and possible health advantages. It is known locally as the Sajian tree or Drumstick tree. Moringa oleifera is a remarkable source of nutritional energy boosters and also a bioactive compound(Leone et al., 2015). Good-quality Moringa oleifera seeds were collected from nearby local trees, and the mature pods of Moringa oleifera were collected. These pods' appearance was brown and dry. Then we extracted the seeds from the pods and collected the triangular segments of seeds. Once the seeds were separated, they underwent a drying process exposed to sunlight for about four days to ensure the complete removal of moisture. After the drying phase, the seeds were finely ground into powder using a blender.

Figure 3.2: Moringa Oleifera collection and seed extraction

3.3.2 Collection and processing of Tamarind seeds:

Tamarind seed powder is derived from the seeds of the tamarind fruit (*Tamarindus indica*), a tropical tree native to Africa and Asia that is extensively grown around the world. Tamarind seed powder has found various applications. Tamarind seed is biodegradable and has potential as a natural coagulant; its efficacy may vary depending on several variables, including the type of water used and the conditions under which it is treated. We select tamarind for its coagulant properties. Tamarind seeds were gathered from local trees and obtained from fully grown tamarind pods. The separation of seeds from the tamarind pods was a manual process, involving the breaking open of the pods and careful extraction of the seeds. After that, the seeds underwent a sun-drying period lasting one week to ensure the thorough removal of moisture. Finally, the dried seeds were finely ground into a powder using a Blander.

Figure 3.3: Tamarind seed powder

3.3.3 Collection and processing of Neem leaves:

Neem leaf powder is extracted from the leaves of the neem tree (*Azadirachta indica*). Neem leaf powder has the potential as a natural coagulant in wastewater treatment. It is widespread in many tropical and subtropical areas; the neem tree is native to the Indian subcontinent. Neem leaf powder contains bioactive compounds, including tannins, which may contribute to its coagulation properties.

The Neem leaves were collected from local trees. The leaves were separated from Neem branches and sun-dried for 6 to 7 days. Then, the dried leaves were ground into fine powders using blender.

Figure 3.4: Neem leaf collection and extraction

3.3.4 Collection and processing of Corn:

Corn powder extracted from corn or maize. Corn powder has the ability to remove pollutants and clarifying water. Corn-based materials is biodegradable and environment friendly. Many studies have demonstrated the potential of corn powder as a natural coagulant, although its recognition remains limited. Corn was collected from the local market, ensuring good quality. The collected corn underwent a drying period of 3 days for ensuring complete removal of moisture. Following the drying process, the corn was finely blended using blender to obtain a fine corn powder.

Figure 3.5: Corn powder

3.3.5 Collection of PAC:

Polyaluminum chloride (PAC) is a versatile chemical coagulant widely used in wastewater treatment processes. PAC speeds up the aggregation of particles in during the flocculation and coagulation process. It is widely used for various wastewater types such tannery industrial and municipal streams. PAC shows the ability to adjust to a wide pH range during treatment. Effectiveness in settling suspended solids (SS) results in clarified water with lower sludge production. The chemical coagulant PAC was collected from a chemical store.

Figure 3.6: Poly Aluminum Chloride (PAC)

3.4 Machinery and Equipment:

Testing wastewater for various parameters requires a range of equipment and machinery to accurately analyze and measure different types of water quality. For the research work, we used existing laboratory machinery and equipment. Those are:

3.4.1 Digital Multi-Parameter:

The Hach HQ40D model, a dual-input digital multi-parameter instrument, is employed for conducting tests on pH, conductivity, and dissolved oxygen (LDO). Using this single device, we conducted tests for pH, conductivity, and LDO on our wastewater for the research.

Figure 3.7: Digital Multimeter

3.4.2 TDS Meter:

Measures for the total amount of dissolved solids (TDS) in the water, including salts, minerals, and other impurities we used TDS meter. The TDS-3 Handheld TDS Meter from HM Digital is utilized for the test. This meter comes factory-calibrated and includes a built-in thermometer.

Figure 3.8: TDS Meter

3.5 Laboratory tests process/ preparation of coagulant:

Initially, all the coagulants were individually weighed and divided into three doses of 4g, 8g, and 16g using a digital weighing machine.

Figure 3.9: Digital Weight Machine

After segregating the coagulants into three doses (4gm, 8gm, and 16gm), each was added to 400ml of wastewater. In this experiment, we used three variant dosages in equal amounts of wastewater. The duration for each coagulant and water mixing was set at 5 minutes.

Figure 3.10: Coagulate dosages separation.

Figure 3.10: Coagulants mixed with wastewater in different dosages.

Figure 3.11: Testing Parameter

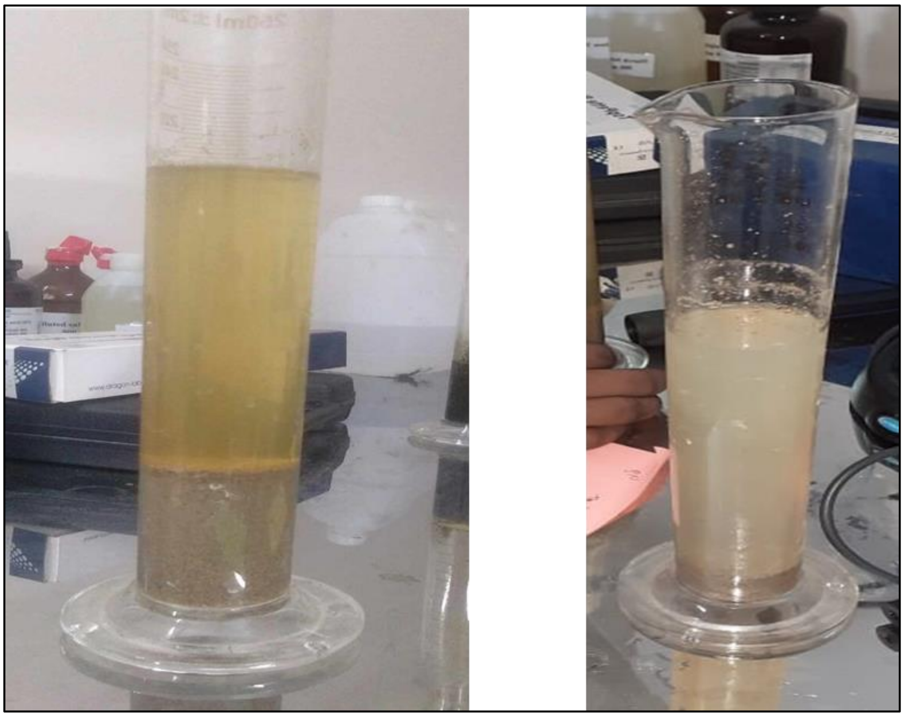

Figure 3.12: After 2 hours settling time.

After mixing, allow them to settle for 2 hours. Then took readings at both the first two hours and the 24th hour. All measurements (pH, Conductivity, LDO, TDS) were taken carefully to ensure that the settled coagulant did not become mixed. We measured LDO of both the wastewater and coagulant-mixed wastewater on the initial day and after a 5-day interval for the measurement of BOD.

Removal efficiency calculation:

The Total Dissolved Solid (TDS), Conductivity and pH removal was taken using this formula:

Effective removal percentages = $(L_o - L)/L_o * 100\%$

Where,

L_o= Initial Condition

L= Final Condition

For BOD measurement=$(L_o - L_5)/L_o$

Where, L_o= First day LDO and L_5 = 5 days later LDO

3.6 Methodology Overview

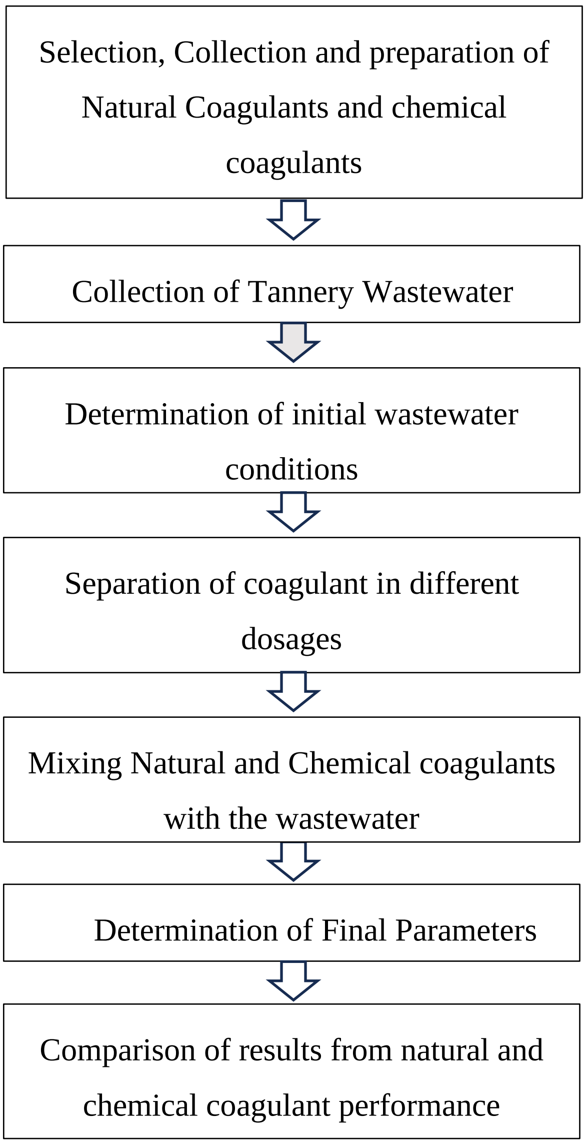

Figure 3.13: Flowchart of Methodology

CHAPTER 4

Results and Discussion

4.1 Introduction

This chapter presents the findings of the research. The discussion on the results can be presented in this chapter also. The discussion of results can also be presented in a separate chapter. If the findings are distinct enough, the results can be presented in more than one chapter also.

4.2 Wastewater initial condition parameters:

Following the collection of wastewaters, the raw wastewater samples analysis for various physical parameters, including pH, conductivity, TDS, dissolved oxygen (DO), and Biological Oxygen Demand (BOD).

Table 4.1: Condition of initial water sample

Parameters	Ranges and units
Conductivity	2.38 mS/cm
TDS	1120 ppm
LDO	0.42 mg/L
BOD	0.12 mg/L
pH	7.57

4.3 pH removal condition:

4.3.1 Effectiveness pH removal using 20gm/L dosage:

Table 4.2: pH removal percentage (%) using dosage of 20gm/L

Dosage (20gm/L)	**PH**	**Initial**	**Differ**	**Perc**
Tamarind seed	7.16	7.57	-0.41	-5.42%
Moringa seed	6.09	7.57	-1.48	-19.55%
Corn powder	6.04	7.57	-1.53	-20.21%

Neem leaf	8.04	7.57	0.47	6.21%
PAC	4.71	7.57	-2.86	-37.78%

The table above shows the difference in pH of wastewater after using different dosages of tamarind seed, moringa oleifera seed, Corn, Neem leaf and PAC coagulants powder. In general, coagulation is most effective at a pH between 6 and 8.

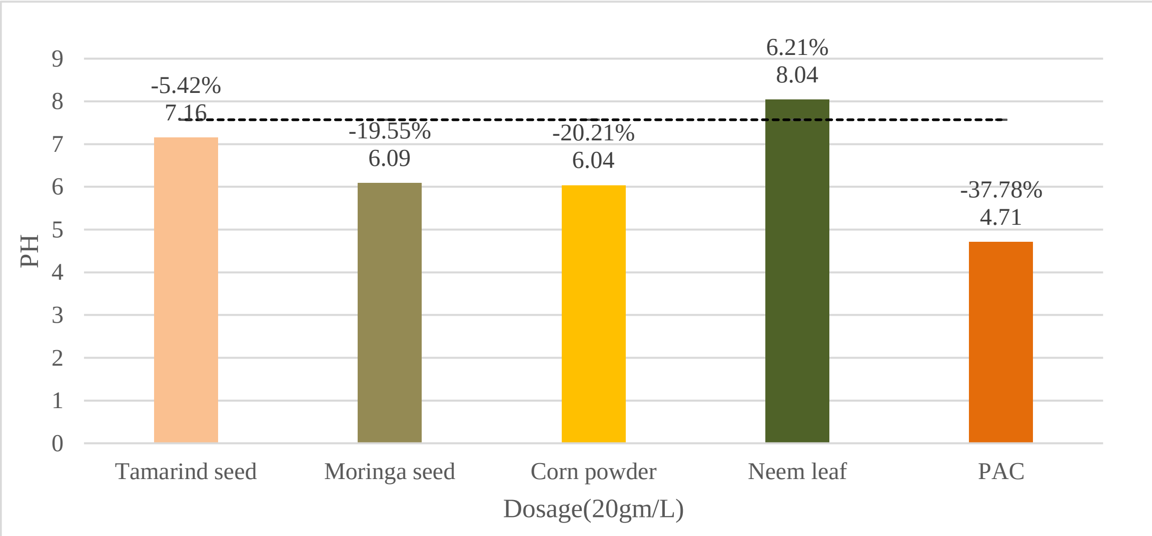

Figure 4.1: pH conditions using 20gm/L dosage

All of the coagulants tested decreased the pH of the wastewater, but PAC was the most effective, decreasing the pH by 37.78%. Tamarind was the least effective, with a decrease in pH of only 5.42%. Moringa seed, and corn powder exhibit significant contributing to a reduction in pH. But Neem leaf demonstrates a negative effect. Here it is seen that all the natural coagulants were able to hold up pH between 6 and 8, where PAC reduced pH to less than 5.

4.3.2 Effective pH removal using 40gm/L dosage:

Table 4.3:pH removal percentage (%) using 40gm/L dosage

Dosage (40gm/L)	PH	Initial	Differ	Perc
Tamarind seed	6.55	7.57	-1.02	-13.47%
Moringa seed	5.52	7.57	-2.05	-27.08%
Corn powder	5.2	7.57	-2.37	-31.31%
Neem leaf	8.31	7.57	0.74	9.78%
PAC	4.66	7.57	-2.91	-38.44%

After applying coagulant dosages of 40gm/L in wastewater, variations in pH were found for tamarind seed, moringa oleifera, Corn powder, Neem leaf powder, and PAC. Generally, coagulation is most effective within the pH range of 6 to 8.

All of the coagulants tested decreased the pH of the wastewater, but PAC was the most effective, decreasing the pH by 38.44%. Neem leaf powder was the least effective, with an increase in pH of only 9.78%. Here it is seen that tamarind seed powder and neem leaf powder as natural coagulants were able to hold up pH between 6 and 8, where corn and Moringa oleifera powder reduced pH less than 6, and PAC reduced pH less than 5.

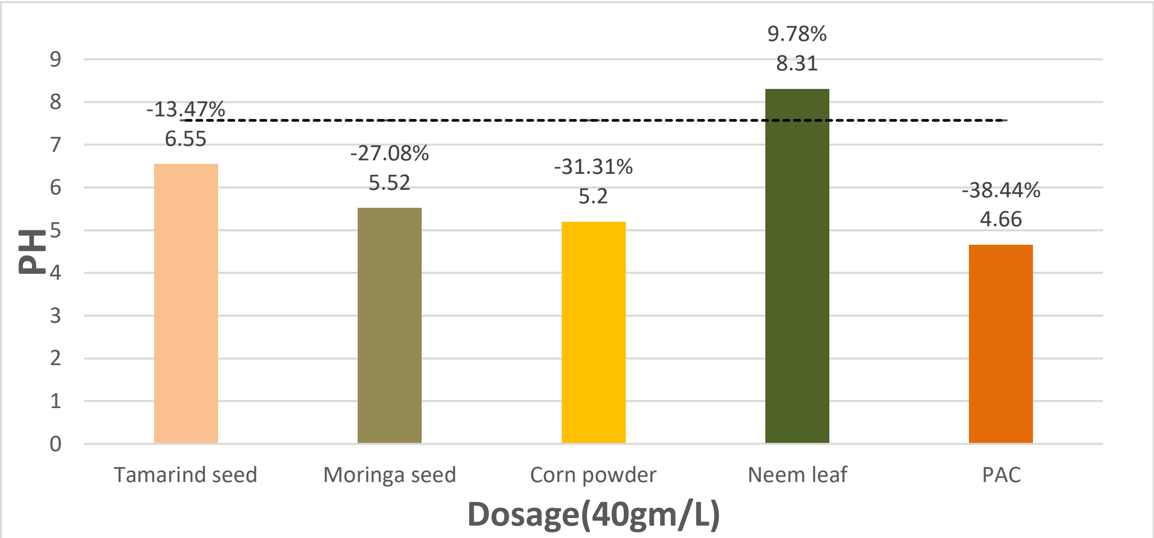

Figure 4.2: pH conditions using 40gm/L dosage

4.3.3 Effective pH removal using 80 gm/L:

Table 4.4: pH removal percentage (%) using 80gm/L dosage

Dosage (80gm/L)	**PH**	**Initial**	**Differ**	**Perc**
Tamarind seed	5.99	7.57	-1.58	-20.87%
Moringa seed	6.35	7.57	-1.22	-16.12%
Corn powder	6.61	7.57	-0.96	-12.68%
Neem leaf	8.05	7.57	0.48	6.34%
PAC	3.59	7.57	-3.98	-52.58%

The table shows the variations in wastewater pH resulting from the use of different dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC. Typically, coagulation is most effective within the pH range of 6 to 8.

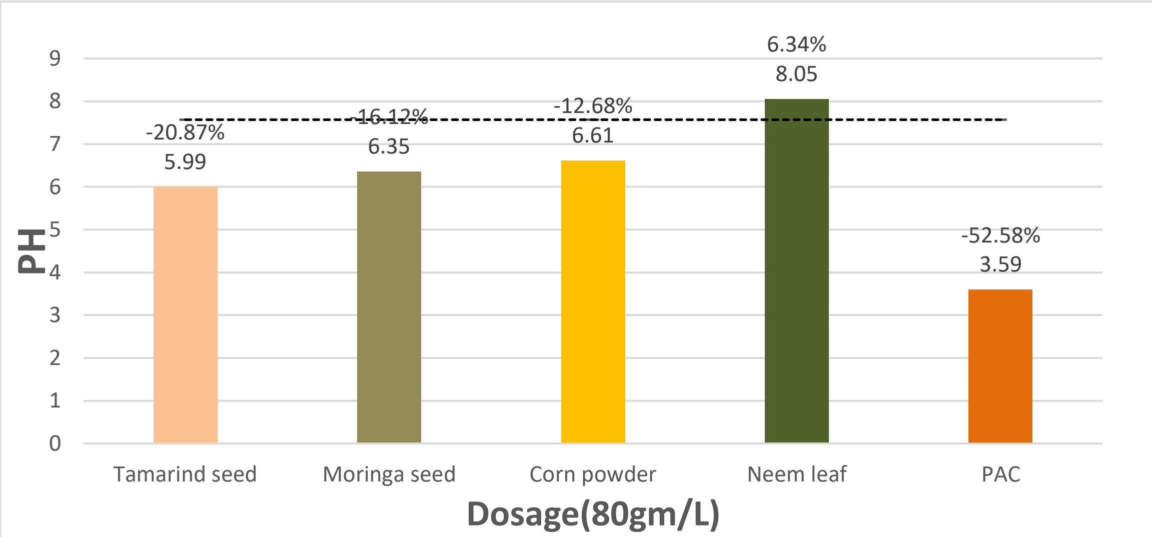

Figure 4.3:pH conditions using 80gm/L dosage

All of the coagulants tested decreased the pH of the wastewater, but PAC was the most effective, decreasing the pH by 52.58%. Neem leaf powder was the least effective, with an increase in pH of only 6.34%. Here it is seen that Neem leaf powder, Moringa oleifera, and corn as natural coagulants were able to hold up pH between 6 and 8, where tamarind seed reduced pH less than 6 and PAC reduced pH less than 4.

4.4 BOD removal Conditions:

4.4.1 Effective BOD removal using 20gm/L dosage:

Table 4.5: BOD percentage (%) removal using 20gm/L

Dosage (20gm/L)	BOD	Initial	Differ	Perc
Tamarind	2.85	0.12	2.73	2275.00%
Moringa	4.82	0.12	4.7	3916.67%
Corn	1.25	0.12	1.13	941.67%
Neem leaf	0.04	0.12	-0.08	-66.67%
PAC	2.11	0.12	1.99	1658.33%

The table shows the variations in wastewater BOD resulting from the use of different dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC. Typically, coagulation is most effective within the BOD range of 2 to 8 gm/L.

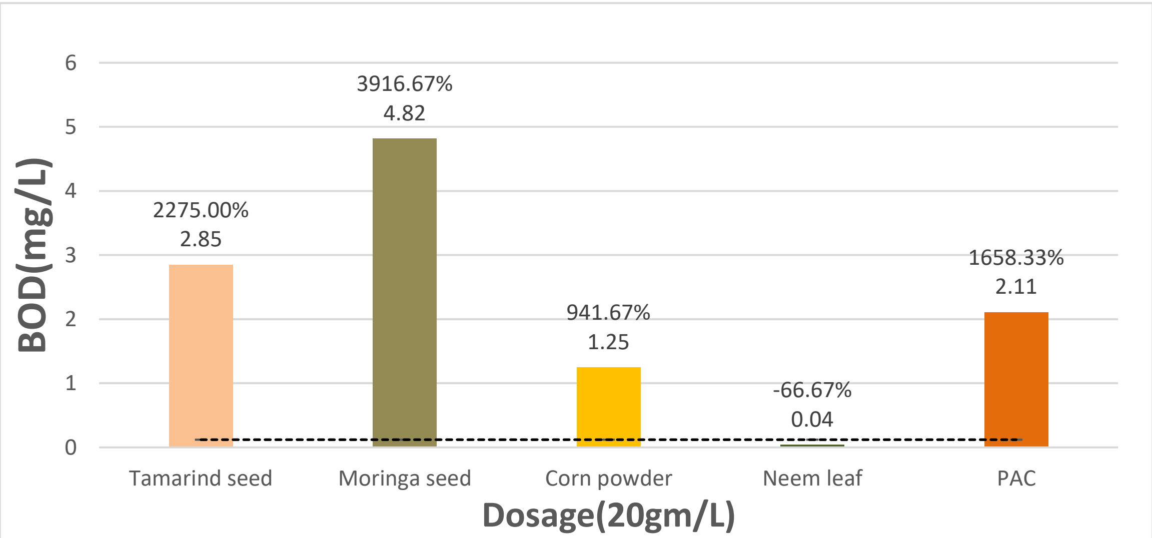

Figure 4.4: BOD conditions using 20gm/L dosage

Moringa oleifera shows the highest percentages. Moringa oleifera performance, with a percentage of 3916.67%. Tamarind seed powder also exhibits an exceptionally high percentage of 2275%. Corn powder shows a promising performance in the percentage of BOD at 941.67%. But neem leaf powder has a negative removal percentage of -66.67%, which indicates decrease in BOD. PAC shows increasing performance in percentage of 1658.33%.

4.4.2 Effective BOD removal using 40gm/L dosage:

Table 4.6: BOD percentage (%) removal using 40gm/L dosage

Dosage (40gm/L)	BOD	Initial	Differ	Perc
Tamarind	2.85	0.12	2.73	2275.00%
Moringa oleifera	1.68	0.12	1.56	1300.00%
Corn	1.27	0.12	1.15	958.33%
Neem leaf	0.01	0.12	-0.11	-91.67%
PAC	2.12	0.12	2	1666.67%

The table shows the variations in wastewater BOD resulting from the use of different dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC. Typically, coagulation is most effective within the BOD range of 2 to 8 gm/L.

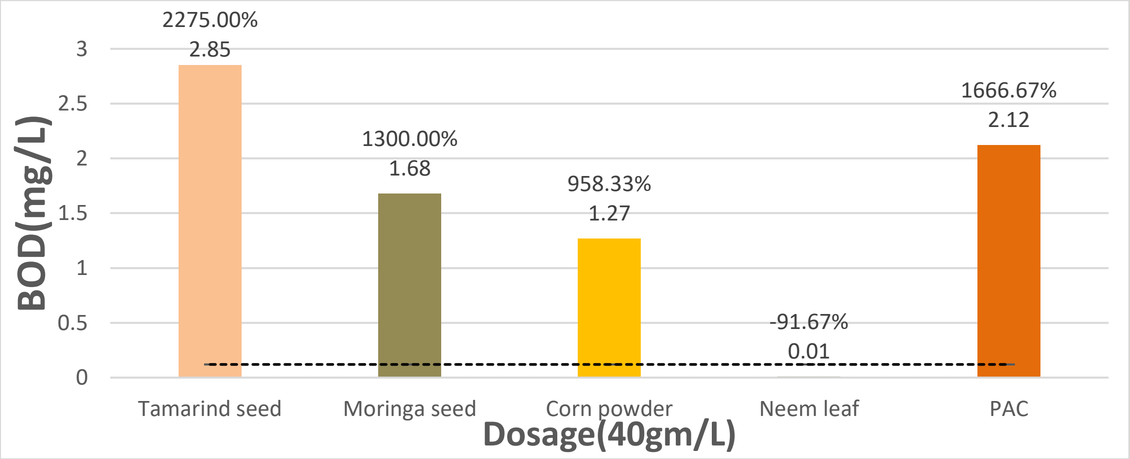

Figure 4.5: BOD conditions using 40gm/L dosage

Tamarind seed powder shows a remarkably high percentage in BOD at 2275.00%. PAC and Moringa oleifera are showing better performance, with BOD levels within the desired range of 1666.67% and 1300%, respectively. Corn shows a promising coagulation property, with a percentage of 958.33%. But Neem leaf has a negative percentage difference of -91.67%, which means decreasing BOD.Moringa oleifera has also shown improvement of BOD in the sample water.

4.4.3 Effective BOD removal using 80gm/L dosage:

Table 4.7: BOD Percentage (%) removal using 80gm/L dosage

Dosage (80gm/L)	BOD	Initial	Differ	Perc
Tamarind	1.22	0.12	1.1	916.67%
Moringa oleifera	1.03	0.12	0.91	758.33%
Corn	5.92	0.12	5.8	4833.33%
Neem leaf	0.17	0.12	0.05	41.67%
PAC	2.02	0.12	1.9	1583.33%

The table shows the variations in wastewater BOD resulting from the use of 80mg/L dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC coagulant.

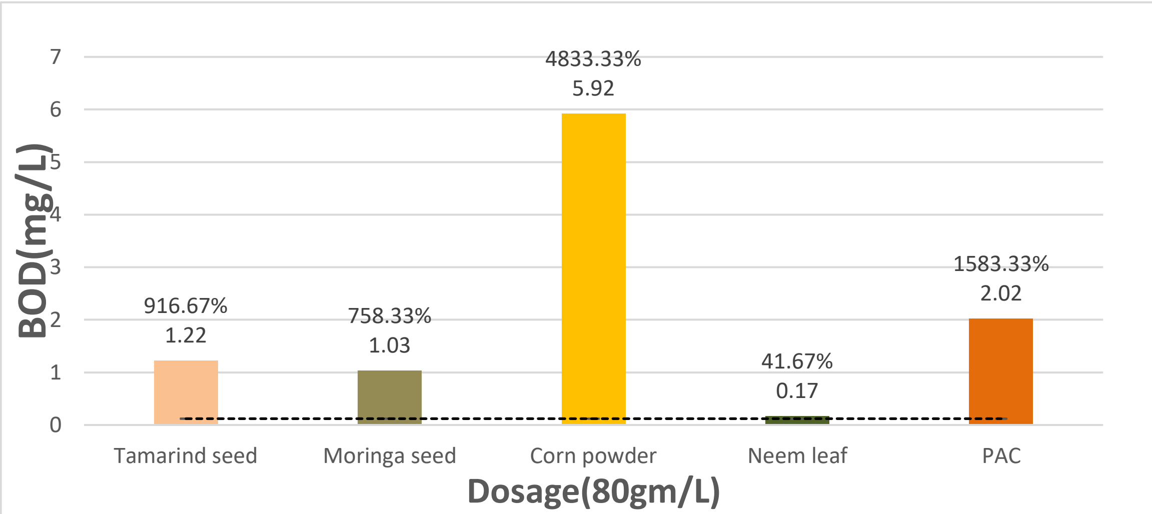

Figure 4.6: BOD conditions using 80gm/L dosage

Tamarind seed powder shows a remarkably high percentage in BOD at 2275.00%. PAC and Moringa oleifera are showing better performance, with BOD levels within the desired range of 1666.67% and 1300%, respectively. Corn shows a promising coagulation property, with a percentage of 958.33%. But Neem leaf has a negative percentage difference of -91.67%, which means decreasing BOD level .PAC appears to be relatively effective, as its BOD is within the optimal range. Moringa oleifera has also shown improvement of BOD in the sample water.

4.5 TDS removal condition

4.5.1 Effective TDS removal using 20gm/L dosage:

Table 4.8: TDS percentage (%) removal using 20gm/L

Dosage (20gm/L)	TDS	Initial	Differ	Perc
Tamarind	381	1120	-739	-65.98%
Moringa seed	425	1120	-695	-62.05%
Corn	249	1120	-871	-77.77%
Neem leaf	432	1120	-688	-61.43%
PAC	583	1120	-537	-47.95%

The table shows the variations in wastewater Total Dissolved solid (TDS) resulting from the use of 20mg/L dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC coagulant.

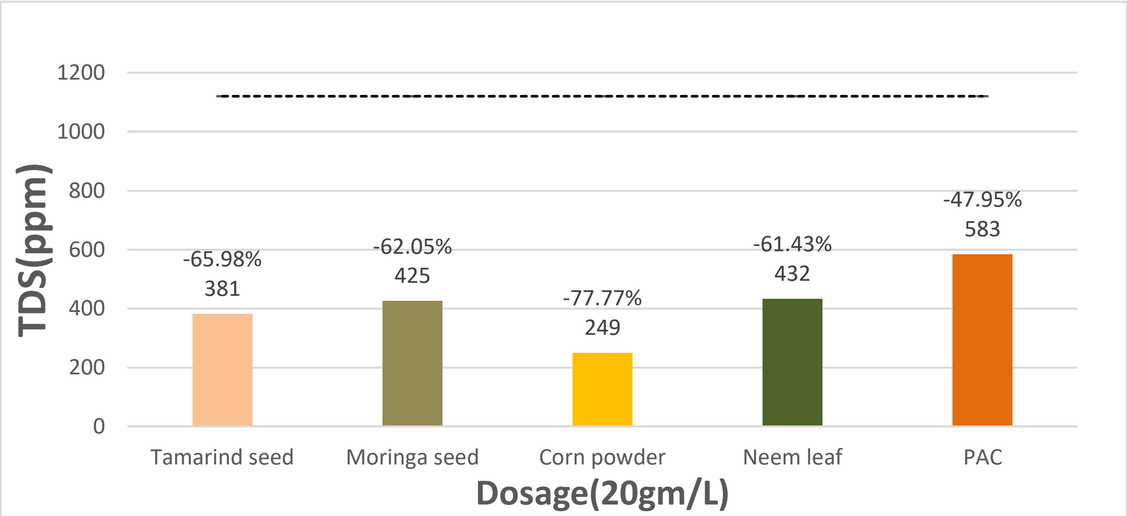

Figure 4.7: TDS conditions using 20gm/L dosage

Tamarind exhibits a substantial negative percentage change in TDS (-65.98%), indicating effective TDS reduction. Moringa oleifera and Neem leaf show a significant negative percentage change in TDS (-61.43%) and (-61.43%). PAC also exhibits a negative percentage change in TDS (-47.95%). Here, corn shows the highest percentage of TDS reduction (-77.77%). This performance makes corn a promising coagulant for TDS removal.

4.5.2 Effective TDS removal using 40gm/L dosage:

Table 4.9: TDS percentage (%) removal using 40gm/L

Dosage (40gm/L)	TDS	Initial	Differ	Perc
Tamarind	308	1120	-812	-72.50%
Moringa	350	1120	-770	-68.75%
Corn	214	1120	-906	-80.89%
Neem leaf	437	1120	-683	-60.98%
PAC	662	1120	-458	-40.89%

The table shows the variations in wastewater Total Dissolved solid (TDS) resulting from the use of 40mg/L dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC coagulant.

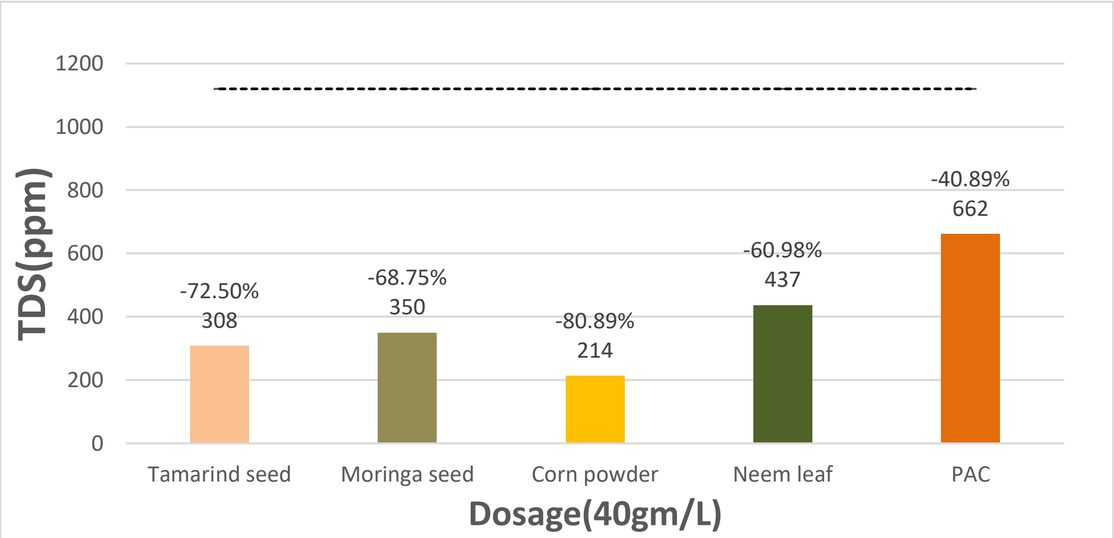

Figure 4.8: TDS conditions using 40gm/L dosage

Tamarind seeds show a substantial reduction in TDS, with a negative percentage change of -72.50%. This indicates that tamarind, at a dosage of 40 mg/L, is effective in removing dissolved solids from the water. Moringa oleifera and Neem leaf powder also show effectiveness, with a negative percentage change of -68.75% and -60.98%, respectively. PAC exhibits a percentage change of -40.89%. While the reduction is comparatively lower than that of some other coagulants, like the 20 mg/L dosage, corn is the most effective, with a removal rate of 80.8%

4.5.3 Effective TDS removal using 80gm/L dosage:

Table 4.10: TDS percentage (%) removal using 80gm/L dosage

Dosage (80gm/L)	TDS	Initial	Differ	Perc
Tamarind	366	1120	-754	-67.32%
Moringa seed	493	1120	-627	-55.98%
Corn	283	1120	-837	-74.73%
Neem	408	1120	-712	-63.57%
PAC	997	1120	-123	-10.98%

The table shows the variations in wastewater Total Dissolved solid (TDS) resulting from the use of 80gm/L dosages of tamarind seed powder, moringa oleifera seed powder, Corn powder, Neem leaf powder, and PAC coagulant.

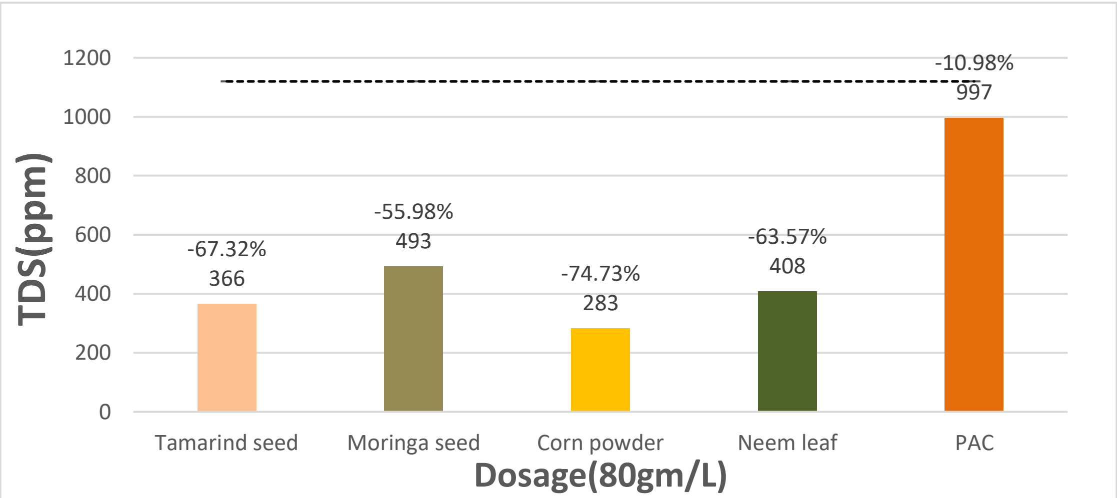

Figure 4.9:TDS conditions using 80gm/L dosage

Tamarind shows effectiveness in TDS reduction, with a negative percentage change of 67.32%. Which has the second-best performance among the other coagulants in the 80 gm/L dosage. Moringa oleifera and Neem leaf powder also show impressive results in reducing TDS at 55.98% and 63.57%, respectively. Neem leaf powder coagulant shows its best performance among the three dosages at 80 gm/L. PAC also shows a negative percentage, which means its reduction of TDS is 10.98%. Corn stands out as the most effective coagulant, with a negative percentage change of 74.73%. Corn powder is the most effective coagulant for TDS removal.

Based on the results, corn powder is the most effective coagulant for TDS reduction. Corn powder showed remarkable performance at a 40 gm/L dosage, which was an 80.89% TDS reduction. Tamarind seed powder provides a significant result; among the three dosages, 72.50% was the best reduction percentage of tamarind seed. Moringa oleifera maintains its effectiveness; among the three dosages (20 gm/l, 40 gm/L, and 80 gm/L), its reduction percentage is 62.05%, 68.75%, and 55.98%. Neem leaf powder gives a consistency result of 61.43%, 60.98%, and 63.57%. PAC showed effective removal, but compared to natural coagulants, PAC's performance wasn't the best. The best removal percentage for PAC at 20 gm/L was 47.95%, and the lowest at 80 gm/L was 10.98%.

4.6 Conductivity Removal Conditions:

4.6.1 Effective Conductivity removal using 20gm/L dosage:

Table 4.11: Conductivity removal percentage (%) using 20gm/L dosage

Dosage (20gm/L)	Conductivity	Initial	Differ	Perc
Tamarind	2.61	2.38	0.23	9.66%
Moringa seed	2.58	2.38	0.2	8.40%
Corn	2.39	2.38	0.01	0.42%
Neem	3.69	2.38	1.31	55.04%
PAC	13.19	2.38	10.81	454.20%

The table shows the variations in dosages and effectiveness of different coagulants in wastewater conductivity resulting from the use of 20 gm/L of tamarind seed powder, moringa oleifera seed powder, corn powder, neem leaf powder, and PAC coagulant.

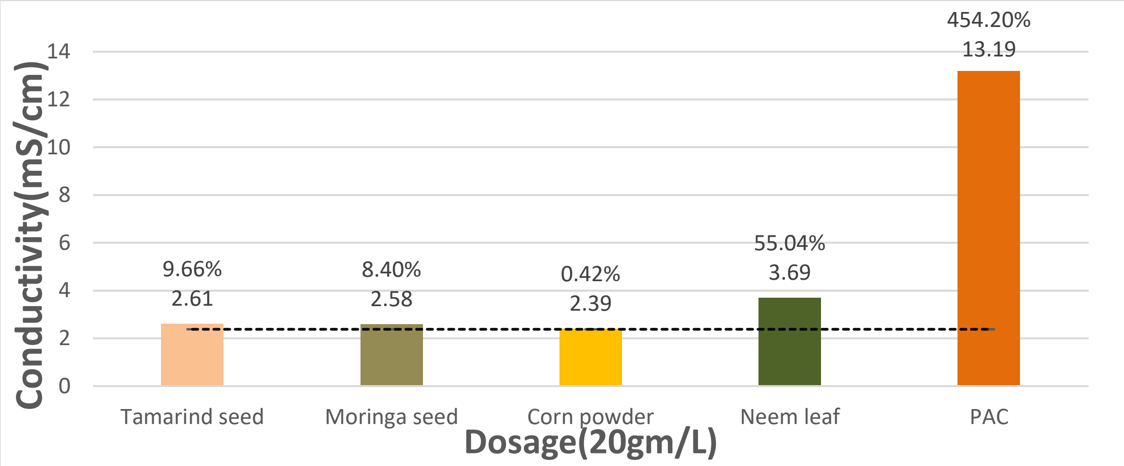

Figure 4.10: Conductivity conditions using 20gm/L dosage

Tamarind seed and Moringa oleifera show a similar level performance, with a percentage change of 9.66% and 8.40%, respectively. Corn exhibits a minimal value in conductivity, with a percentage change of 0.42%. Neem powder provided a percentage change of 55.04%. PAC shows a remarkably high percentage change of 454.20%.

4.6.2 Effective Conductivity removal using 40gm/L dosage:

Table 4.12: Conductivity removal percentage (%) using 40gm/L dosage

Dosage (40gm/L)	Conductivity	Initial	Differ	Perc
Tamarind	3.01	2.38	0.63	26.47%
Moringa oleifera	3.94	2.38	1.56	65.55%
Corn	2.57	2.38	0.19	7.98%
Neem	4.71	2.38	2.33	97.90%
PAC	22.9	2.38	20.52	862.18%

The table shows the variations in dosages and effectiveness of different coagulants in wastewater conductivity resulting from the use of 40 gm/L of tamarind seed powder, moringa oleifera seed powder, corn powder, neem leaf powder, and PAC.

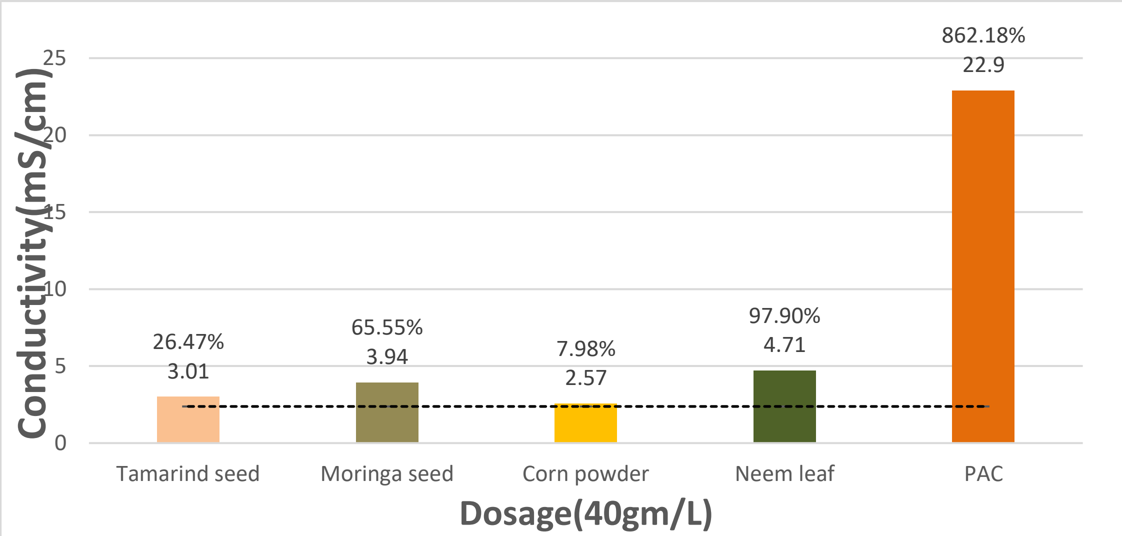

Figure 4.11: Conductivity condition using 40gm/L dosage

Tamarind exhibits a moderate level of improvement, with a percentage change of 26.47%. The increase in dosage results a higher improvement in conductivity compared to the 20 gm/L dosage. Moringa oleifera also shows increased at the higher dosage, with a percentage change of 65.55%. Corn powder and Neem leaf powder increased in compared to 20gm/L. PAC exhibits a remarkable increase of 862.18%. Neem and PAC give the highest increasing percentages in conductivity at the dosage of 40 gm/L.

4.6.3 Effective Conductivity removal using 80gm/L dosage:

Table 4.13: Conductivity removal percentage (%) using 80gm/L

Dosage (80gm/L)	Conductivity	Initial	Differ	Perc
Tamarind	3.16	2.38	0.78	32.77%
Moringa oleifera	4.85	2.38	2.47	103.78%
Corn	0.42	2.38	-1.96	-82.35%

Neem	6.8	2.38	4.42	185.71%
PAC	42.4	2.38	40.02	1681.51%

The table shows the variations in dosages and effectiveness of different coagulants in wastewater conductivity resulting from the use of 80 gm/L of tamarind seed powder, moringa oleifera seed powder, corn powder, neem leaf powder, and PAC.

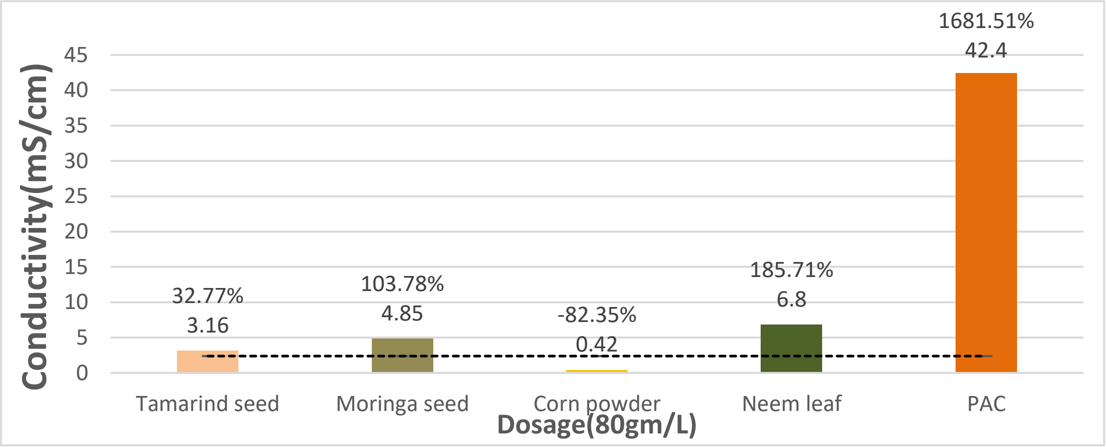

Figure 4.12: Conductivity condition using 80gm/L dosage

Tamarind seed powder increased at the higher dosage, with a percentage change of 32.77%. Moringa oleifera also exhibits increased at higher dosages, with a percentage change of 103.78%. Corn shows a negative result of -82.35%. This means that at a higher dosage, corn might have an unexpected impact on decreasing conductivity. Neem leaf powder continued to increase its effectiveness at the higher dosage, with a percentage change of 185.7%. PAC exhibits an extraordinary increase at the higher dosage, with a percentage change of 1681.51%.

Overall Assessment for Conductivity:

Tamarind seed powder, Moringa oleifera seed powder, Neem leaf powder, and PAC show increasing values that indicate those coagulants can be used to increase conductivity in water. But on the other hand, corn powder coagulants show a reduction in the conductivity of wastewater. Corn powder proved itself to be an effective coagulant for conductivity removal in wastewater. Corn powder at 80 gm/L dosage shows the best removal effectivity.

4.7 All Dosages Combined Performance

4.7.1 Effect of coagulant dosages on pH adjustment:

Table 4.14:Combined performance of all coagulant on pH adjustment

Dosages (gm)	Tamarind	Moringa oleifera	Corn	Neem	PAC
20	7.16	6.09	6.04	8.04	4.71
40	6.55	5.52	5.2	8.31	4.66
80	5.99	6.35	6.61	8.05	3.59

In the initial stage, the pH of the wastewater was 7.57, and with the application of different dosages of coagulants, a significant change occurred. Specifically, when a dosage of 20 gm/L was used, tamarind seed, Moringa oleifera, corn, neem leaf, and polyaluminum chloride (PAC) changed the pH levels of the sample water to 7.16, 6.09, 6.04, 8.04, and 4.71, respectively. Similarly, when dosages of 40 gm/L and 80 gm/L were applied, the pH levels of the sample water showed varying changes. For the 40 gm/L dosage, the pH values for tamarind seed, Moringa oleifera seed, corn powder, neem leaf powder, and PAC were 6.55, 5.52, 5.2, 8.31, and 4.66, respectively. In the case of the 80 gm/L dosage, the pH values were 5.99, 6.35, 6.61, 8.05, and 3.59.

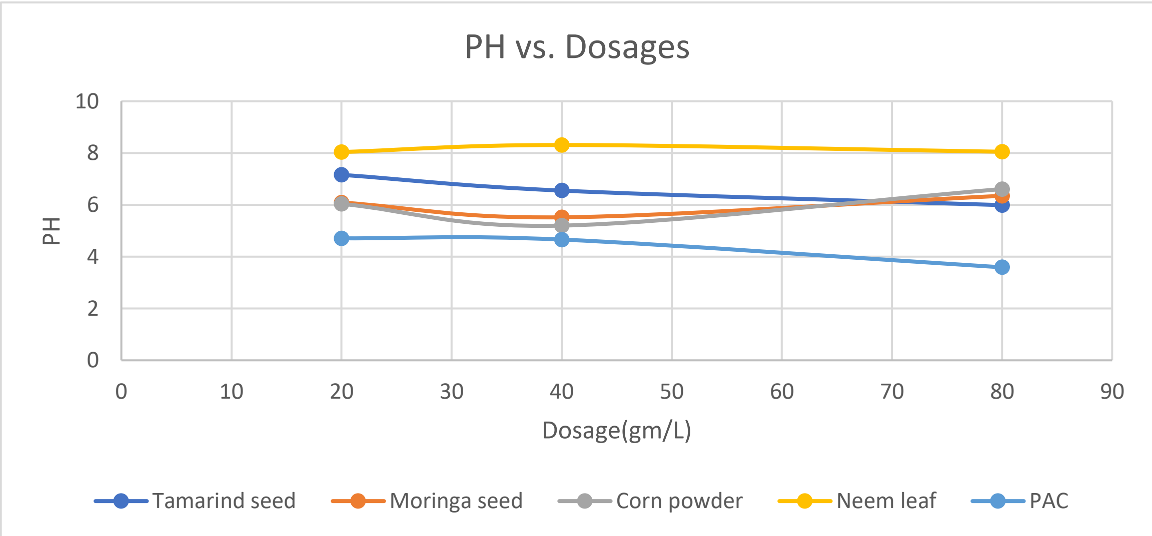

Figure 4.13: pH adjustment vs Dosages

At the 20 gm/L dosage, neem leaf showed the highest increase in pH. At the 40 gm/L dosage, neem leaf maintained a high pH. Neem consistently increases pH, making it the most effective coagulant for raising pH levels, while PAC decreased in pH level. PAC consistently showed the most significant pH reduction across all dosages. Tamarind, Moringa oleifera, and Corn exhibit moderate effect of pH reduction.

4.7.2 Effect of coagulant dosages on BOD adjustment:

Table 4.15: Combined performance of all coagulant on BOD adjustment

Dosages (gm)	Tamarind seed	Moringa Oleifera	Corn powder	Neem leaf	PAC
20	2.85	4.82	1.25	0.04	2.11
40	2.85	1.68	1.27	0.01	2.12
80	1.22	1.03	5.92	0.17	2.02

In the initial condition, the BOD of wastewater was 0.12, and the application of different coagulant dosages brought about significant changes. Specifically, with a dosage of 20 ml/L, tamarind seed, Moringa oleifera, corn, neem leaf, and polyaluminum chloride (PAC) altered the BOD levels of the sample water to 2.85 mg/l, 4.82 mg/l, 1.25 mg/l, 0.04 mg/l, and 2.11 mg/L, respectively. Similarly, when dosages of 40 gm/L and 80 gm/L were applied, the BOD levels of the sample water exhibited varying changes. For the 40 gm/L dosage, the BOD values for tamarind seed, Moringa oleifera seed, corn powder, neem leaf powder, and PAC were 2.85 mg/L, 1.68 mg/l, 1.27 mg/l, 0.01 mg/l, and 2.12 mg/l, respectively. In the case of the 80 ml/L dosage, the BOD values were 1.22 mg/L, 1.03 mg/L, 5.92 mg/L, 0.17 mg/L, and 2.02 mg/L.

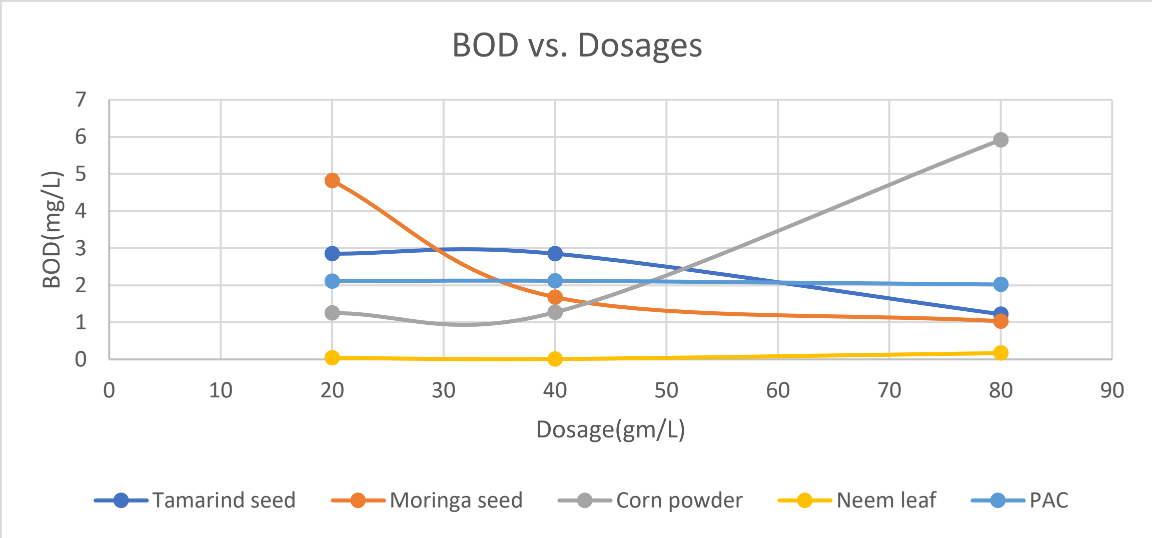

Figure 4.14:BOD adjustment vs Dosages graph

The coagulants show an increase in BOD at different dosage. At 80 mg/L dosage tamarind seed show a decrease compare to 20 gm/L and 80 gm/L dosages. Moringa Oleifera exhibits a decrease in BOD at 40 gm/L compared to 20 gm/L dosage. Corn Powder shows an increase in BOD at 80 gm. And the 40 mg/L dosage shows a mixed response, with Neem Leaf showing a significant decrease in BOD. In 80 mg/L dosage, there is a decrease in BOD for tamarind seed, moringa oleifera seed, neem leaf, and PAC, but an increase for corn powder. For reducing BOD, the 80 mg/L dosage appears more effective, especially for tamarind seed, Moringa oleifera seed, neem leaf, and PAC. And for increasing, the 20 mg/L dosage shows consistent effectiveness across coagulants

4.7.3 Effect of coagulant dosages on TDS adjustment:

Table 4.16:Combined performance pf all coagulant on TDS adjustment

Dosages (gm)	Tamarind seed	Moringa oleifera	Corn	Neem leaf	PAC
20	381	300	149	432	583
40	308	262	214	437	662
80	366	493	283	408	997

The initial Total Dissolved Solids (TDS) measurement of wastewater was recorded at 1120 ppm. With the application of various coagulant dosages, significant variations in TDS levels were observed. With a dosage of 20 mg/L, tamarind seed, moringa oleifera seed, corn powder, neem leaf, and polyaluminum chloride (PAC) coagulants had TDS levels of 381 ppm, 300 ppm, 149 ppm, 342 ppm, and 583 ppm, respectively. Similarly, when dosages of 40 gm/L and 80 gm/L were applied, the TDS changes were 308 ppm, 262 ppm, 214 ppm, 43 ppm, and 662 ppm, and 366 ppm, 493 ppm, 283 ppm, 408 ppm, and 997 ppm, respectively.

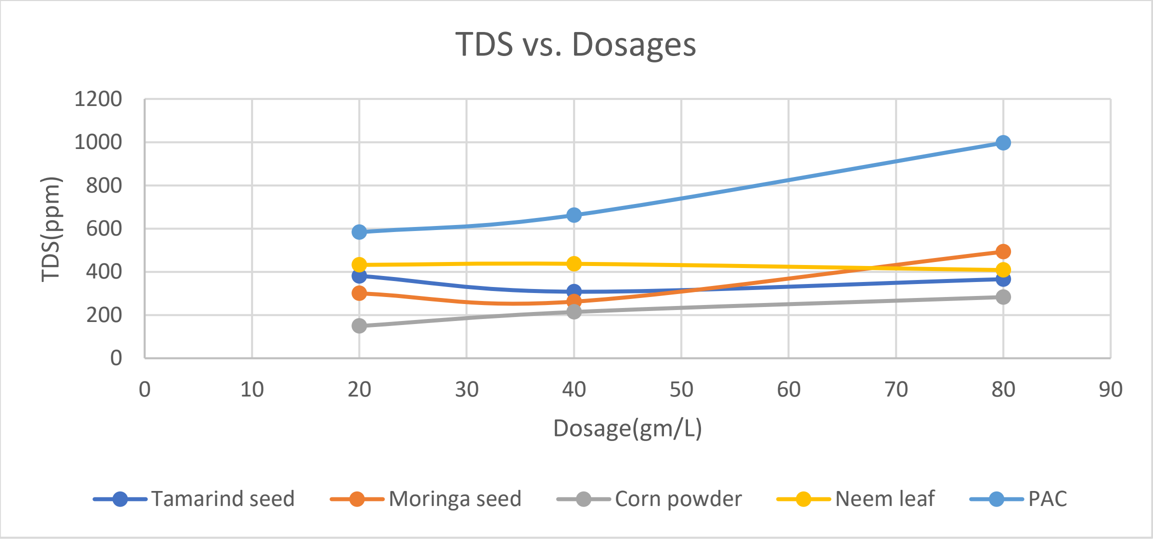

Figure 4.15: TDS adjustment vs Dosages

The 40 gm/L dosage showed the most significant reduction in TDS levels for all coagulants, especially for PAC. Moringa oleifera seed at an 80 g/L dosage resulted in the highest increase in TDS levels. Tamarind seed and neem leaf showed a moderate increase. The 40 g/L dosage appears to be the most effective in reducing TDS levels. PAC showed the best performance across dosages in reducing TDS levels. PAC exhibited low TDS levels at 40 gm/L.

4.7.4 Effect of coagulant dosages on Conductivity adjustment:

Table 4.17:Combined performance of all coagulant on Conductivity

Dosages (gm)	Tamarind	Moringa oleifera	Corn	Neem	PAC
20	2.61	2.58	2.39	3.67	13.19
40	3.01	3.64	2.56	4.71	22.9
80	3.16	4.85	0.42	6.8	42.4

The initial conductivity measurement of wastewater was recorded at 2.38 mS/cm. The application of various coagulant dosages resulted in significant variations in conductivity levels. With a dosage of 20 mg/L, tamarind seed, Moringa oleifera seed, corn powder, neem leaf, and polyaluminum chloride (PAC) coagulants showed conductivity levels of 2.61 mS/cm, 2.58 mS/cm, 2.39 mS/cm, 3.67 mS/cm, and 13.19 mS/cm, respectively. Similarly, when dosages of 40 gm/L and 80 gm/L were applied, the conductivity changes were 3.01 mS/cm, 3.64 mS/cm, 2.56 mS/cm, 4.71 mS/cm, and 22.9 mS/cm, and 3.16 mS/cm, 4.85 mS/cm, 0.42 mS/cm, 6.8 mS/cm, and 42.4 mS/cm, respectively.

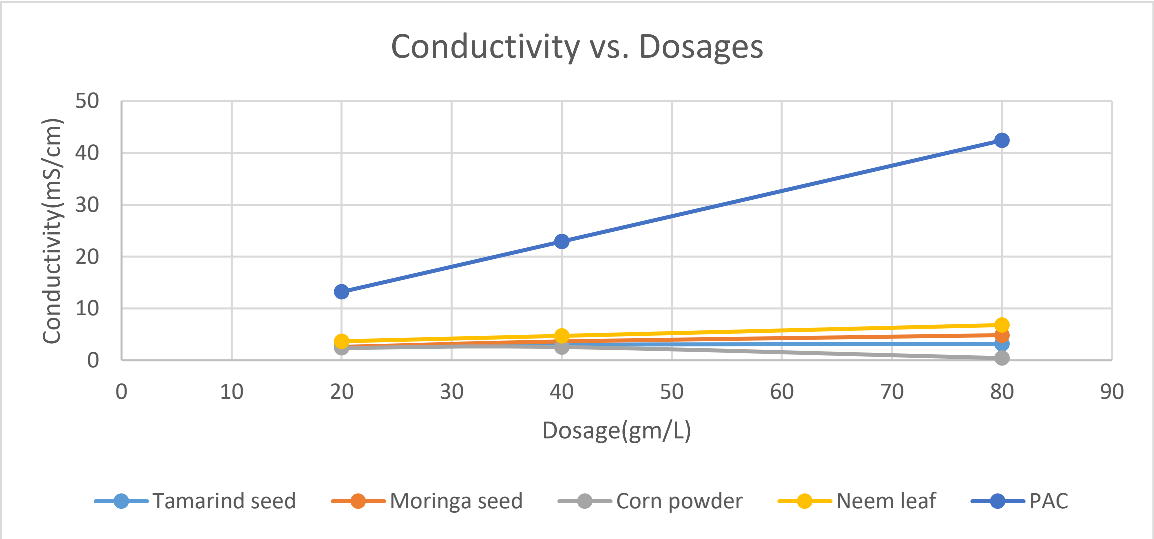

Figure 4.16: Conductivity performance vs Dosages

PAC exhibited the most significant increase in conductivity. Tamarind Seed, Moringa Oleifera Seed, and Neem Leaf showed sustained increases in conductivity. Corn powder showed limited effectiveness, with minor changes in conductivity. Among those coagulant corn powder shows best conductivity removal.

4.8 Summary

This chapter contain the performance of all coagulants in three dosages(20mg/L,40mg/L,80mg/L) of coagulant. Based on the result Tamarind seed powder shows better pH adjustment. Neem leaf powder shows a better BOD adjustment. Corn powder coagulant shows best TDS removal comparing to others coagulants. The best TDS removal was at the dosage of 40mg/L and removal percentage 80.89%. Corn powder shows comparatively best Conductivity removal at 80mg/L dosage.

CHAPTER 5

Conclusions and Future Works

5.1 Conclusions

This study investigated the effectiveness of natural coagulants compared to the chemical coagulant Poly Aluminum Chloride (PAC) in removing total dissolved solids (TDS) from water. Various tests were conducted, including pH, biochemical oxygen demand (BOD), conductivity, and TDS, using different coagulant dosages.

5.2 Key findings:

- Natural coagulants, particularly corn powder, outperformed PAC in removing TDS. This suggests that natural options can be just as effective, if not more, than traditional chemical coagulants for certain applications.

- PAC significantly lowered the pH due to its acidic nature, whereas natural coagulants maintained a neutral pH. This is advantageous for natural coagulants as they are less likely to alter the treated water's pH, making them more environmentally friendly and potentially reducing the need for additional pH adjustment.

- Settling time differed significantly between the coagulants. While PAC required a full day to achieve optimal TDS removal, natural coagulants accomplished it in just two hours. This faster settling time translates to improved efficiency and potentially lower treatment costs.

- The optimal PAC dosage for TDS removal was found to be 20mg/L or less. This highlights the importance of optimizing coagulant dosage to achieve desired results while minimizing potential drawbacks.

- Further experiments using dosages below 20mg/L for PAC are recommended. This could potentially lead to even greater efficiencies and reduced environmental impact compared to the currently identified optimal dosage.

- Overall, this study demonstrates the promising potential of natural coagulants as a sustainable and effective alternative to chemical coagulants for water treatment, particularly in TDS removal. Their advantages in terms of neutral pH, faster settling, and potentially lower optimal dosages make them worthy of further investigation and development.

5.3 Limitations and Recommendations for Future Works

Limitation of the Study:

During the study several shortcomings, limitations and challenges were identified. Among them some are:

- Absence of permission to collect influent wastewater directly from the treatment plant, the research was conducted using the effluent discharged from the Common Effluent Treatment Plant (CETP) as a representative sample.
- After the water collection, it was stored at room temperature instead of being refrigerated.
- Due to a shortage of equipment, the coagulant and wastewater was prepared manually by hand mixing.

Scope of the Study:

The study outline boundaries and parameters that can be extended for further research. This work is limited to investigation of the potential of those coagulants.

- The research can be done on a large scale by the discharge of tannery wastewater which content with organics effluents, salts, and chromium.
- Can be used more amount of coagulant in a larger volume of water sample.
- More test can be performed such COD, turbidity, chromium test
- The study could be expanded to include other natural coagulants and test their effectiveness on different types of wastewaters.
- The long-term effects of using natural coagulants on wastewater treatment systems need to be investigated.
- The economic feasibility of using natural coagulants compared to chemical coagulants should be assessed.
- Can use two coagulants combine for a good result, such as corn powder and neem leaf powder.

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