TREATMENT OF DAIRY WASTEWATER

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree

Of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

Mr. Akash Bhardwaj

Assistant Professor (Grade-II)

and

Dr. Rishi Rana

Assistant Professor (SG)

by

Piyush Chauhan (201602)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT , SOLAN - 173234

HIMACHAL PRADESH , INDIA

May 2024

DECLARATION

I hereby declare that the work presented in the Project report entitled **"TREATMENT OF DAIRY WASTEWATER"** submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at the Jaypee University of Information Technology, Waknaghat is an authentic record of my work carried out under the supervision of **Mr. Akash bhardwaj & Dr Rishi Rana .** This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report .

Piyush Chauhan (201602)

Department of civil engineering

Jaypee University of information

Technology , Waknaghat India.

CERTIFICATE

This is to certify that the work which is being presented in the project **"TREATMENT OF DAIRY WASTEWATER"** in partial fulfilment of the requirements for the award of the degree of Bachelor of degree and submitted to Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Piyush Chauhan (201602)** for a period from August2023 to May 2024 under the supervision of **Mr. Akash Bhardwaj (Assistant Professor Grade-II) & Dr. Rishi Rana (Assistant Professor SG) .** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of your knowledge.

Date ………………………

Mr . Akash Bhardwaj	Dr. Rishi Rana	Prof.(Dr). Ashish Kumar
Assistant professor (grade 2)	Assistant professor (senior grade)	Professor & Head of department
Department of Civil engineering	Department of Civil engineering	Department of Civil engineering
JUIT Waknaghat	JUIT Waknaghat	JUIT Waknaghat

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ABSTRACT

Dairy wastewater refers to the by-product which is generated from the milk processing , production and composition while making the milk products such as ghee , yoghurt and curd etc . The composition of the dairy wastewater mostly depends upon the various factors such as the size of the dairy operation specific process involved during manufacturing and the efficiency of wastewater . Common components are fats, oil , grease , nutrients such as (Nitrogen, phosphorus) . The dairy industry generates a significant amount of wastewater containing various organic and inorganic pollutants, posing environmental concerns if discharged untreated. This study investigates the effectiveness of chemical coagulation as a treatment method for reducing the pollutant load in dairy wastewater. Two commonly used coagulants, aluminium sulfate (alum) and calcium oxide (lime), were evaluated through jar tests to determine their optimal dosages for efficient removal of turbidity, chemical oxygen demand (COD), and other contaminants.

Dairy wastewater samples were collected from a local dairy processing plant and characterized for their initial physicochemical properties. Jar tests were conducted by varying the coagulant dosages and pH levels to assess their impact on pollutant removal efficiency. The treated samples were analyzed for residual turbidity, COD, biochemical oxygen demand (BOD), total suspended solids (TSS), and other relevant parameters.

The results demonstrated that both alum and lime were effective in reducing turbidity, COD, BOD, and TSS levels in the dairy wastewater. The optimal dosages for alum and lime were found to be 2.5 mg/L and 2.5 mg/L, respectively, achieving removal efficiencies of up to 98% for turbidity, 82.2% for COD, 87.6% for BOD, and 87% for TSS. The study also revealed that the coagulation process was pH-dependent, with the optimum pH range for alum being 6.5-7.5 and for lime being 10.5-11.5.The findings of this study suggest that chemical coagulation using alum or lime can be an effective pretreatment step for dairy wastewater, reducing the pollutant load and facilitating subsequent treatment processes. The optimized coagulant dosages and pH conditions identified in this research can guide the implementation of efficient and cost-effective wastewater treatment strategies in dairy processing facilities.

Keywords: dairy wastewater , chemical coagulants , alum, ferric chloride .

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pH :	Potential of hydrogen
BOD:	Biological oxygen demand
DO:	Dissolved oxygen
TSS:	Total suspended solid
TDS:	Total dissolved solid

Chapter 1
Introduction

1.1 GENERAL

This chapter gives information about the basics of dairy waste, its sources, its composition and the percentage contribution in the wastewater industry .How dairy waste water is generated in the industry and its different processes by which it generates in the industry . Different types of dairy waste water and its characteristics . Its impact to the environment .

1.2 Introduction :

Dairy wastewater refers to the by-product which is generated from the milk processing , production and composition while making the milk products such as ghee , yoghurt and curd etc . The composition of the dairy wastewater mostly depends upon the various factors such as the size of the dairy operation specific process involved during manufacturing and the efficiency of wastewater . Common components are fats , oil , grease , nutrients such as (Nitrogen, phosphorus) . Wastewater from dairies is the water used in various dairy production processes and becomes polluted with all kinds of organic and inorganic compounds in the process. It can be produced through equipment cleaning and sanitizing, milk and other dairy product processing, and floor cleaning, among others. The main dairy wastewater characteristics include high levels of organic matter, nutrients, fats, oils, and grease, and possibly harmful pathogens. Because the size of the dairy occurs such as the size of the particular operation and types of products it processes, its composition may fluctuate depending on the production system used. Dairy wastewater acquires its various parameters through the different processes involved in dairy production, collection, and processing. Here’s how dairy wastewater gets these specific parameters: High Organic Matter: Milk Residues Spills and leaks of milk and milk products during processing contribute significantly to the organic load. Product Washdown Cleaning of equipment, tanks, and pipelines after processing milk, cheese, butter, yogurt, and other dairy products leaves organic residues in the wastewater. Manure and Bedding: On dairy farms, wastewater can contain manure and bedding material, adding to the organic matter. Nutrients (Nitrogen and Phosphorus) Milk Components: Milk contains proteins and other nitrogenous compounds, while cleaning of milk residues contributes to phosphorus levels. Cleaning Agents: Detergents and sanitizers used in cleaning operations often contain sssphosphates, contributing to nutrient loads. Animal Waste: Urine and feces from dairy cows are rich in nitrogen and phosphorus, which enter the wastewater from barn cleaning operations. Suspended Solids Feed Residues: Washing of feeding areas can introduce particulate matter from feed residues into the wastewater. Bedding Materials: Manure mixed with straw or sawdust used as bedding can end up in the wastewater during barn cleaning. Processing Residues: Particles from milk and other dairy products, as well as precipitated proteins, contribute to suspended solids during equipment cleaning[1]. Fats and Oils Milk Fat Dairy wastewater contains fats and oils originating from milk and cream processing operations. During the production of butter, cheese, and other high-fat products, significant amounts of fat can enter the wastewater. Cleaning Processes Equipment and surfaces in contact with dairy products are cleaned with water, transferring fats into the wastewater. Pathogens Raw Milk: Raw milk can harbor bacteria, viruses, and other pathogens. Spills and residues from raw milk in wastewater can introduce these microorganisms. Animal Waste Wastewater from barn cleaning can contain pathogens from cow manure and urine[2]. The figures below represent how much waste water is generated , collect , treated and reused in the world .

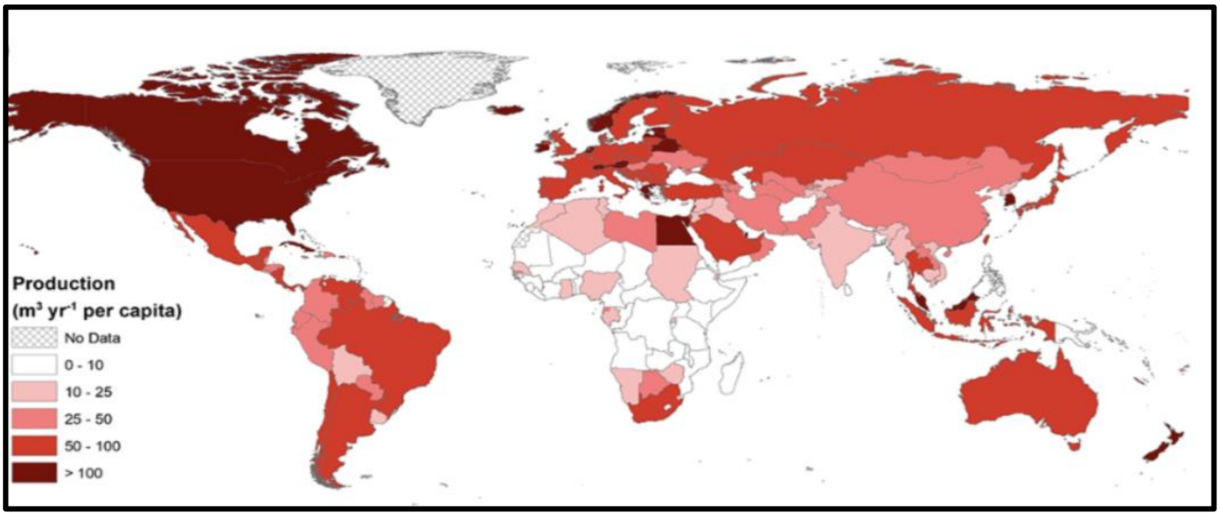

Figure 1: World wide production of waste water [3]

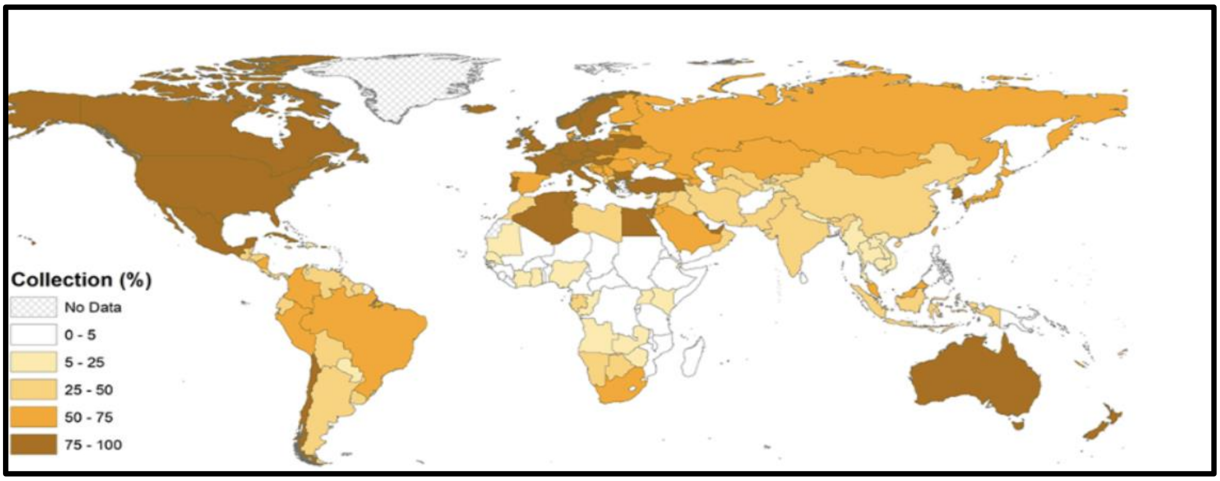

Figure 2 : World wide collection of waste water [4]

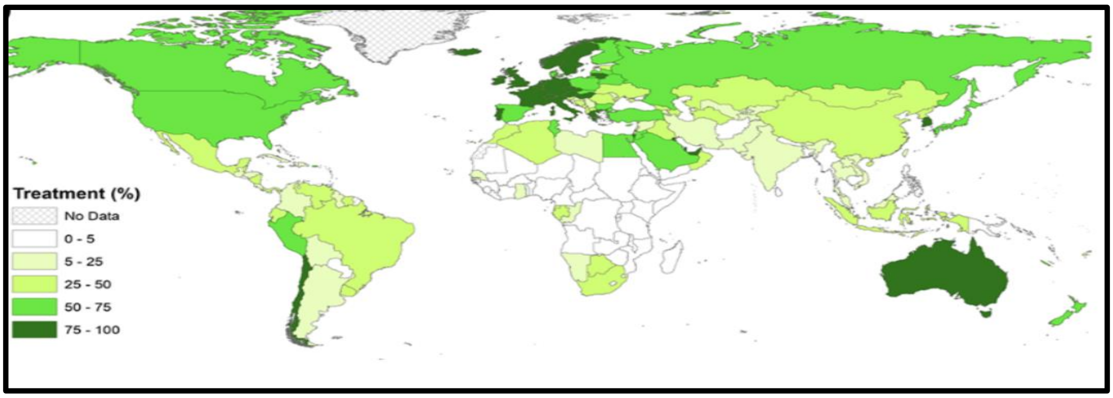

Figure 3: Worldwide Treatment of wastewater [5]

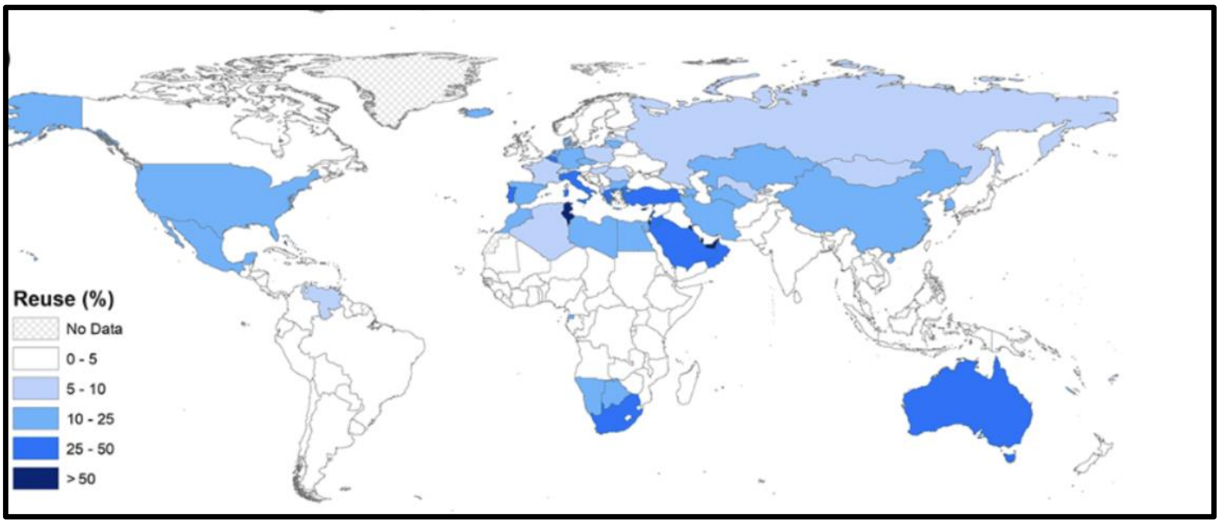

Figure 4: Worldwide reuse of waste water . [6]

1.3 Types of Dairy WaterWater :

1.3.1 Processing wastewater : In the dairy assiduity(industry), recycling wastewater is generated from colorful operations involved in the product and manufacturing of dairy products, similar as milk, rubbish, yogurt, adulation, and others. Processing wastewater in the dairy assiduity generally contains the following factors Organic matter This includes remainders of milk, whey, fats, proteins, and other organic accoutrements that contribute to the biochemical oxygen demand(duck) and chemical oxygen demand(COD) of the wastewater. Nutrients Processing wastewater is rich in nutrients like nitrogen, phosphorus, and potassium, which come from milk and dairy by- products. Suspended solids Dairy processing wastewater may contain suspended patches, similar as milk solids, casein(protein) forfeitures, and other debris, which can contribute to turbidity and clogging. Dissolved solids These include dissolved minerals, mariners, and other substances that can increase the total dissolved solids(TDS) content of the wastewater. Chemicals remainders of drawing agents, sanitizers, and other chemicals used in dairy processing operations may be present in the wastewater. High organic cargo Processing wastewater from dairy operations generally has a high organic content, performing in elevated duck and COD situations[7]. Temperature variations Some processing operations may involve heating or cooling, performing in temperature oscillations in the waste water.

Figure 5: processing wastewater [8]

1.3.2 Cleaning Wastewater

This is the second source which is dairy wastewater generated & it generates almost 40 to 30 % of the wastewater . In the dairy assiduity, drawing wastewater is generated from the processes involved in cleaning and sanitizing colourful outfit, installations, and shells used in milk processing and handling operations. drawing wastewater in the dairy assiduity generally contains the following factors cleansers and sanitizers This wastewater contains remainders of drawing agents, similar as acidulous soda pop, acids, surfactants, and detergents used for drawing and sanitizing dairy outfit and shells. Organic matter remainders of milk, fats, proteins, and other organic accoutrements may be present in the cleaning wastewater, contributing to its biochemical oxygen demand(duck) and chemical oxygen demand(COD). Suspended solids drawing wastewater may contain suspended patches, similar as milk solids, dirt, and other debris, which can contribute to turbidity and clogging. High pH or low pH Depending on the type of drawing agents used, the wastewater may have a high pH(alkaline) or low pH(acidic) nature[9]. Nutrients drawing wastewater may contain nutrients like nitrogen, phosphorus, and potassium, which can come from residual milk factors or drawing agents. Temperature variations drawing operations frequently involve hot water or brume, performing in elevated temperature in the wastewater.

Figure 6 : cleaning wastewater [6]

1.3.3 Sanitary Wastewater

In the dairy assiduity(industry), aseptic wastewater, also known as dairy wastewater, is generated from colorful operations similar as cleaning of outfit, bottoms, and installations, as well as from spillages and remainders from milk processing. Dairy wastewater generally contains the following factors Organic matter This includes milk remainders, fats, proteins, and other biodegradable accoutrements . These contribute to the biochemical oxygen demand(duck) and chemical oxygen demand(COD) of the wastewater. Nutrients Dairy wastewater is rich in nutrients like nitrogen, phosphorus, and potassium, which come from milk and drawing agents. Pathogens Dairy wastewater may contain pathogenic microorganisms similar as bacteria(e.g., Salmonella, Listeria), which can pose health pitfalls if not duly treated. Suspended solids Dairy wastewater contains suspended patches, including milk solids, dirt, and other solids, which can contribute to turbidity and clogging. Dissolved solids These include dissolved minerals, mariners, and other substances that can increase the total dissolved solids(TDS) content of the wastewater. Chemicals drawing agents, sanitizers, and other chemicals used in dairy operations may be present in the wastewater. High pH Dairy wastewater frequently has a high pH due to the alkaline nature of drawing results used in the assiduity[10]. This wastewater contains contaminants such as detergents, sanitizers, cleaning agents, and residual organic matter. Proper treatment of sanitary wastewater is essential to prevent environmental pollution, comply with regulations, and promote sustainable practices.It depends upon the dairy how they used this wastewater, some mix it with the processing ,cleaning of wastewater . Some treat it differently . It contains low DO(Dissolved oxygen) & high TSS (Total suspended solids).

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Figure 7 : Sanitary wastewater [11]

1.4 Characteristics of Dairy waste water

Dairy waste water are like to other types of industrial waster water which contains a mixture of organic and inorganic compounds , fats & oil and some pathogens . The characteristics of of dairy waste water in terms of physical , chemical & biological .

Physical characteristics of dairy wastewater encompass its color, which may appear milky due to suspended solids and fats. The temperature tends to be elevated due to rocess-generated heat. Turbidity levels are often high owing to suspended solids. Additionally, it emits a distinct or unpleasant odor from the decomposition of organic matter.

Chemical characteristics of dairy wastewater include a pH typically ranging from 2 to 5, indicating acidity. It exhibits high levels of organic matter, comprising proteins, fats, and lactose.

Biological characteristics of dairy wastewater reveal elevated levels of Biological Oxygen Demand (BOD), signifying the presence of biodegradable organic matter that can deplete oxygen levels. Additionally, its high Chemical Oxygen Demand (COD) indicates a substantial need for chemical oxygen to oxidize both organic and inorganic matter.

1.5 Process of dairy waste water generation :

The production of the milk products involves different stages and processes which contribute to the generation of the dairy wastewater . The basic processes involved in the dairy industry include cleaning & sanitising , separation & standardisation , pasteurisation , cheese production , cleaning operations , cooling & heating .

Cleaning & Sanitising : Water is used to clean and sanitise milking equipment including milking machines and storage tanks . In addition to CIP (clean in place) systems , certain equipment and components may require manual cleaning to ensure thorough removal of residues[12] .

Separation & standardisation : Milk is often separated into different components like cream and skim milk , This process generates waste water containing milk solids . Standardisation often involves blending different amounts of cream and skim milk to achieve the desired fat content . This is crucial for producing dairy products with consistent quality and flavour . Standardisation ensures that dairy products meet regulatory standards and labelling requirements . It allows producers to create products with specific fat content , such as whole milk .

Pasteurisation : Pasteurisation is the heat treatment process widely used in the dairy industry to destroy harmful microorganisms in milk and other liquids dairy products . The primary purpose of pasteurisation is to ensure the safety of the products and extend their shelf life . Heating milk to kill harmful microorganisms produces wastewater with cleaning agents and residual milk components .

Cheese production : Making cheese involves curdling milk and separating curds from the whey . Whey is the by-product that contributes to wastewater . Cheese production is a fascinating and intricate process within the dairy industry . It involves the transformation of milk into cheese through a series of steps that includes curdling , draining , pressing , salting and ageing .

Cleaning operations : Regular cleaning of processing equipment and facilities results in the wastewater containing cleaning agents and residues . Water is used for the cleaning bottles and packaging materials leading to waste water with cleaning agents . Spillage of milk or dairy products during processing or transportation can contribute to wastewater[13] .

Cooling and Heating : After milking raw milk needs to be rapidly cooled to inhibit bacterial growth and maintain its freshness . Refrigeration units or heat exchangers are commonly used to cool the milk quickly to storage temperature. Homogenization involves milk to high pressure to break down the fat globules resulting in a smoother and more uniform product . This process may involve both heating and cooling stages to achieve optimal results .

Table 1.1: Combined Wastewater Characteristics of Dairy from world . [14]

Country Parameter	U.S.A	New Zealand	South Africa	India
BOD5	40- 48000	90-12400	1100	657-1016

COD	80-95000	180-23000	1341-2195	502-2290
SS	244500	7-7200	538-657	160-810
pH	4.4-9.4	3-13	5.6-6.8	4.3-5.6
Temp 0 C	-	18-55	-	11-72
Fat	35-500	0-2100	-	-

In This table 1.1 we have shown the different values that are given by the different countries and how much value they are getting after testing the dairy waste water . This table gives the general idea about the parameters of the dairy waste water.

1.6 Treatment processes

Dairy wastewater can be treated using various methods and technologies. The most commonly used ones include electrochemical cells, reverse osmosis, oxidation processes, and biological treatments.In the electrochemical cell method, an electric current is passed through the wastewater, which helps remove impurities and contaminants. The reverse osmosis process involves pushing the wastewater through a semi-permeable membrane, separating the clean water from the dissolved solids and pollutants.Oxidation treatments use strong oxidizing agents like ozone, hydrogen peroxide, or chlorine to break down and eliminate organic matter, bacteria, and other unwanted substances present in the wastewater.Biological methods rely on microorganisms, such as bacteria or fungi, to consume and break down the organic matter and nutrients present in the dairy wastewater.This can be done through processes like activated sludge treatment or anaerobic digestion.

Electrochemical cell: An electrochemical cell is a device that can help remove these contaminants from the wastewater.This treatment method works by passing an electric current through the wastewater. The electric current causes chemical reactions to occur, which break down and remove the unwanted substances.Inside the electrochemical cell, there are two metal electrodes (an anode and a cathode) immersed in the wastewater. When the electric current flows between these electrodes, it creates a process called electrolysis[15].

Reverse osmosis: In this process, the dairy wastewater is forced through a semi-permeable membrane under high pressure. This membrane acts like a highly specialized filter, allowing only water molecules to pass through while blocking the passage of larger molecules and particles.The contaminants present in the dairy wastewater, such as fats, proteins, sugars, and other organic compounds, are too large to pass through the pores of the membrane. As a result, they are effectively separated from the water, leaving behind a concentrated waste stream.

Biological methods: One common biological treatment approach is called the activated sludge process. In this method, the dairy wastewater is mixed with a culture of microorganisms in a large, aerated tank. The microbes feed on the organic contaminants in the wastewater, multiplying and forming a thick mixture called activated sludge.After a certain period, the activated sludge is allowed to settle, separating the treated water from the sludge. A portion of the sludge, rich in the active microorganisms, is recycled back into the aeration tank to continue the treatment process.

Oxidation: oxidation treatment is a process that uses strong oxidizing agents to break down and remove organic matter, bacteria, and other contaminants present in dairy wastewater. This method is particularly effective in treating wastewater that contains high levels of organic compounds, fats, oils, and other pollutants.

1.7 Challenges of treatment methods

Formation of by-products: Depending on the specific oxidation process and the composition of the wastewater, potentially harmful by-products like bromate or chlorinated organic compounds may be formed, which may require additional treatment or disposal considerations.

High capital and operating costs: Electrochemical processes require specialized equipment, such as electrodes, power supplies, and reactors, which can be expensive to install and maintain. The energy consumption for running the electrochemical process can also be high, contributing to increased operating costs.

Membrane fouling and scaling: Dairy wastewater contains organic matter, suspended solids, and minerals that can cause fouling and scaling on the RO membranes. This reduces membrane permeability and efficiency, requiring frequent cleaning or membrane replacement, which increases maintenance costs.[16]

Slow process and large footprint: Biological treatment processes, such as activated sludge or anaerobic digestion, can be relatively slow compared to chemical treatment methods. Additionally, they often require large treatment facilities with aeration tanks or digesters, which can be space-intensive and costly to construct and operate[9].

Sludge management: Biological treatment processes generate significant amounts of sludge, which requires proper handling, treatment, and disposal, adding to the overall operational costs and environmental considerations.

1.9 Environment impact of dairy waste water

Dairy wastewater contains many harmful viruses or bacteria ***(eg: E.coli , salmonella)*** . The viruses and bacteria cause so many health issues to human beings and the wildlife when they come in contact with the contaminated water . The dairy wastewater (cleaning water) has very low DO generally less than 2(mg/l) which is very dangerous for aquatic life if we directly dispose of it without any treatment . The dairy industry releases some of the toxic gases in the environment which are carbon dioxide , sulphur oxides and nitrogen dioxide to the atmosphere . These gases can increase global warming and the excess nitrogen dioxide in the atmosphere cause human respiratory problems and cause asthma . The organic constituents present in the dairy wastewater diminish the level of DO present in the water bodies if they are directly disposed of & creating anaerobic conditions for the living organism and also with that create foul order . The dairy waste are highly acidic in nature if they are disposed directly to land or water bodies then they can decrease the availability of micronutrients present in the land & in the water body it can cause acidic shock[18] . The dairy industry is a major source of wastewater generation, which, if untreated or improperly treated and managed, can have detrimental effects on the environment. Among the potential environmental effects of dairy waste water are indicated: Water pollution Dairy wastewater contains various organic and inorganic pollutants, such as milk residues, detergents, sanitizers, and cleaning agents. If discharged untreated into water bodies, dairy waste can result in oxygen depletion, eutrophication and cause harm to aquatic life; greenhouse gas emissions . Dairy treatment, especially that of an anaerobic nature results in the generation of methane, an extremely potent greenhouse gas, thereby contributing to climate change; soil contamination. If not properly disposed of or used for irrigation without prior treatment, dairy wastewater leads to soil contamination with nutrients, pollutants, and pathogens, which impact the soil’s quality and fertility.

Figure 8 : Environment impact of dairy waste water on soil .

1.10 Public health impact of dairy wastewater :

The public health impact of dairy wastewater can be significant, particularly if the wastewater isn't adequately treated before being discharged into the terrain. Dairy wastewater contains high situations of organic matter, nutrients, pathogens, and chemicals that can pose colorful pitfalls to mortal health. Then’s a detailed analysis of these health impacts Waterborne conditions Dairy wastewater frequently contains pathogenic microorganisms, including bacteria(e.g.,E. coli, Salmonella), contagions, and spongers, that can beget serious ails inhumans.However, it can lead to outbreaks of waterborne conditions, If this wastewater contaminates drinking water sources. Common health issues associated with similar pathogens include Gastrointestinal Infections Symptoms can range from mild diarrhea to severe dehumidification and indeed death, particularly in vulnerable populations like children and the senior. Cholera and Dysentery These conditions are caused by bacteria and can spread fleetly in communities with poor sanitation and polluted water inventories. Hepatitis A and Norovirus These contagions can beget liver complaint and gastrointestinal issues, independently, and are frequently spread through defiled water. Chemical Exposure Dairy wastewater can contain colorful chemicals from drawing agents, sanitizers, and detergents used in dairy operations[. These chemicals, if not duly treated, can pollute water inventories and pose several health pitfalls toxin Chemicals like chlorine, ammonia, and other detergents can be poisonous if ingested, leading to poisoning and long- term health goods similar as organ damage. Endocrine dislocation Some chemicals may act as endocrine disruptors, snooping with hormone systems and potentially leading to reproductive issues, experimental problems, and increased cancer threat. Nutrient Pollution redundant nutrients, particularly nitrogen and phosphorus, in dairy wastewater can lead to the eutrophication of water bodies. This process stimulates inordinate growth of algae, which depletes oxygen in the water and can produce dangerous algal blooms(HABs)[19]. The health impacts associated with nutrient pollution include dangerous Algal Blooms(HABs) Some algal blooms produce poisons that can pollute drinking water and seafood. Exposure to these poisons can beget a range of health issues, from skin vexation and respiratory problems to liver damage and neurological goods. Nitrate impurity High situations of nitrates in drinking water can be particularly dangerous to babies, causing methemoglobinemia or" blue baby pattern," which reduces the blood's capability to carry oxygen. Odor and Air Quality Issues The corruption of organic matter in dairy wastewater can produce obnoxious odors and feasts similar as ammonia and hydrogen sulfide. These emigrations can impact air quality and lead to Respiratory Problems Inhalation of ammonia and hydrogen sulfide can irritate the respiratory tract, complicate conditions like asthma, and beget other respiratory affections. Nausea and Headaches patient foul odors can beget discomfort, nausea, headaches, and a general decline in quality of life for near residers. Antibiotic Resistance The use of antibiotics in dairy husbandry can lead to antibiotic remainders in wastewater. This can contribute to the development and spread of antibiotic-resistant bacteria in the terrain, posing a significant public health trouble. Infections caused by antibiotic- resistant bacteria are harder to treat and can lead to longer illness durations, advanced medical costs, and increased mortality.

Summary :

This chapter delves into the complexities of dairy wastewater, exploring its origins within the industry and its diverse manifestations. It delves into the classification of wastewater types, elucidating their distinctive physical, biological, and chemical traits. Generated throughout a spectrum of activities encompassing cleaning, sanitizing, and processing, dairy wastewater encompasses a multifaceted array of forms. These include wastewater arising from the handling and storage of milk, the process of pasteurization, cheese production, and various cleaning operations.

Moreover, the chapter accentuates the potential ramifications of untreated dairy wastewater on both the environment and public health. It underscores the peril of contaminating surface and groundwater with pollutants originating from dairy effluents, which can trigger adverse ecological consequences. Eutrophication, a phenomenon characterized by excessive nutrient enrichment in water bodies leading to harmful algal blooms, emerges as a prominent concern.

Furthermore, the transmission of pathogens via untreated wastewater poses a tangible threat to public health, necessitating vigilant management practices.

Given the gravity of these potential impacts, the chapter underscores the indispensability of implementing effective treatment and management protocols for dairy wastewater. By adopting comprehensive mitigation strategies, such as advanced treatment technologies and stringent regulatory frameworks, the adverse effects of dairy effluents can be mitigated. Ultimately, the chapter emphasizes the imperative of safeguarding both environmental integrity and public health through responsible management of dairy wastewater.

Chapter 2

Literature review

2.1 GENERAL

This section addresses various journal articles, research papers, and publications related to dairy wastewater, its characteristics, and different treatment methods for treating dairy wastewater. We have evaluated different literature sources, which has helped us understand the various methods and techniques used for the treatment of dairy wastewater. Through this chapter, we could also identify gaps in the existing research. A brief summary of a few other relevant research papers is also provided below.

In simpler terms, this chapter discusses scientific literature on the topic of wastewater produced by dairy operations. It looks at the makeup of this type of wastewater and explores different ways to treat and clean it. By reviewing past research studies, we gained insights into treatment approaches. The chapter also points out areas where more research is still needed. Summaries of some key research papers are included as well.

Johiba et.al, found that the organic matter present in dairy effluent has a negative environmental impact when discharged untreated. They determined that physical and chemical treatment methods are not as effective as biological treatment for dairy wastewater. Biological treatment can occur under aerobic (with oxygen) or anaerobic (without oxygen) conditions. Upflow anaerobic sludge blanket (UASB) reactors are commonly used and well-suited for treating dairy wastewater, as they can handle large volumes of influent in a relatively short time.

Uttareni Pathak et.al, investigated that dairy industry effluent contains soluble organics, suspended solids, and traces of gases, making treatment crucial to preserve environmental aesthetics. They found rice husk can effectively adsorb and remove up to 92.5% of pollutants from dairy wastewater when using 5g of rice husk solution at pH 2 and 30°C temperature.

SubhriSina et.al, identified the dairy industry as one of the most significant pollution sources in India. As demand for milk and dairy products increases in India, large amounts of wastewater rich in BOD, COD, organic and inorganic contents are discharged. Biological treatment methods are widely considered most efficient, with aerobic systems easy to operate and control, while anaerobic systems produce less sludge with lower energy requirements.

AL-Ananzeh et.al, found dairy wastewater contains high COD, BOD and dissolved solids levels. In their study, synthesized copper oxide nanoparticles coupled with sophora japonica fruit were used as an adsorbent to treat wastewater for the first time. The highest 95% COD removal was achieved using 1g adsorbent at 25°C, pH 7.5, for 120 minute contact time.

Suman Mishra et.al, investigated that colleagues, dairy industries generate a significant amount of wastewater during milk processing, ranging from 2.5 to 10 liters of wastewater per liter of milk processed. One of the major pollutants found in dairy wastewater is organic components.Their study explored the effectiveness of activated carbon derived from coconut shells (CGAC) in removing Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) from the wastewater to satisfactory levels. COD and BOD are indicators of organic matter and measure the amount of oxygen required for chemical and biological processes, respectively.The research showed that the CGAC effectively removed COD and BOD from the dairy wastewater. The experiment revealed that the maximum removal efficiency of COD and BOD was achieved when the CGAC bed height was 10 cm and the contact time was 2 hours.

Kishor Kumar et.al, investigated that dairy wastewater is characterized by high levels of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), turbidity, and nitrates. Their study investigated a two-stage treatment process for this wastewater: coagulation as the primary treatment, followed by vermibiofiltration as the secondary treatment.The coagulation step aimed to remove suspended solids and reduce the overall pollutant load, while the vermibiofiltration stage further treated the wastewater using earthworms and their associated microorganisms. This combined approach proved effective in improving the quality of the treated water.The researchers observed that the treated water's pH shifted from acidic to neutral after the treatment process. Additionally, the treatment significantly reduced various physicochemical parameters of the dairy wastewater. Specifically, COD, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), turbidity, and nitrate levels decreased by 85.3%, 98.9%, 93.6%, and a substantial amount, respectively.

S Naragundakar et.al, investigated that the dairy industry is a water-intensive sector, utilizing substantial amounts of water for processing raw milk into various dairy products. On average, for every liter of milk processed, approximately 3 liters of wastewater is generated. This wastewater effluent contains high concentrations of organic matter, including fats, carbohydrates, grease, and proteins.To address the treatment of this dairy wastewater, researchers have explored the use of different doses of natural coagulants to enhance the treatment efficiency. In a comparative study, various parameters such as Total Dissolved Solids (TDS), chloride content, pH, and turbidity were evaluated for each coagulant.Among the natural coagulants tested, Moringa oleifera seed powder demonstrated the most promising results. Experimental findings revealed that the use of Moringa oleifera seed powder led to significant changes in the wastewater parameters. Specifically, the pH varied from 9.08 to 4.42, TDS ranged from 5.02 to 4.38 parts per million (ppm), and turbidity decreased from 162 to 44.6 Nephelometric Turbidity Units (NTU).

K. Ullas et.al, investigated that wastewater with high turbidity levels can pose challenges when used for agricultural purposes, particularly when it comes to drip irrigation systems. The suspended particles in highly turbid water can clog the small openings in drip lines, hindering the efficient delivery of water to crops.To address this issue, researchers have explored the use of rice husk and rice husk ash as natural filtration materials. These readily available agricultural by-products have proven effective in reducing turbidity and removing suspended matter from wastewater.Rice husk, which is the outer layer of the rice grain, and its ash form, can act as physical barriers, trapping and filtering out suspended particles present in the wastewater. By passing the turbid water through a filter bed or column containing rice husk or its ash, the water clarity can be significantly improved.The ability of these materials to effectively reduce turbidity and suspended matter makes them promising options for pre-treatment processes in agricultural wastewater management. By incorporating rice husk or its ash into filtration systems, farmers can ensure that the water used for drip irrigation is free from excessive particulate matter, preventing potential clogging and ensuring efficient water delivery to their crops.

M.N Asha et.al, investigated that automobile service stations generate wastewater that is often contaminated with oil and grease due to the high volume of vehicles serviced daily. To effectively remove these pollutants, cost-effective and readily available materials like sugarcane bagasse and sawdust can be utilized. These natural by-products possess the ability to absorb and filter out oil and grease from the wastewater through physical treatment processes.While chemical treatments, such as the application of alum, can also be employed, the use of sugarcane bagasse and sawdust offers an eco-friendly and economical alternative.

By passing the contaminated wastewater through filters or beds containing these materials, the oil and grease particles can be effectively trapped and removed, resulting in cleaner effluent suitable for further treatment or safe discharge.

Enaime et.al, studied the various conversion technologies and applications of biochar and how it can be used as a material for wastewater treatment. This paper provides a systematic analysis of adsorption mechanisms towards organic and inorganic contaminants, and the physico-chemical properties of biochar, which are influenced by the type of beginning feedstock, the thermal conversion method, and the preparation circumstances, which are directly related to its ability to remove contaminants from aqueous solutions. It has been noted that the surface functional groups of biochar can be altered through physical and chemical activation processes, which also increases the amount of oxygen-containing surface functional groups.

Singhe et.al investigated that the use of magnetic biochar as an effective adsorbent for removing lead and cadmium from aqueous solutions. It was observed that the biochar surface acquired a negative charge in basic pH conditions, which facilitated the adsorption of metal ions. In contrast, the removal efficiency was lower in acidic conditions with low pH. The heavy metal ions were found to bind to the functional groups present on the biochar surface through a mechanism involving the reduction of oxygen. Additionally, the metal ions also formed bonds with the magnetite nanoparticles embedded in the biochar matrix through a cation exchange process.The study highlights the potential of magnetic biochar as an efficient adsorbent for the removal of heavy metals, such as lead and cadmium, from contaminated water sources. By leveraging the unique properties of this material, including its negative surface charge in basic conditions and the presence of functional groups and magnetite nanoparticles, researchers were able to effectively capture and remove these toxic metals from aqueous solutions.

Gour Sumane et.al , investigated that one of the main goals in the dairy industry is to recover and transform the protein (organic nitrogen) found in waste into marketable products. Nitrogen is an essential component of wastewater from dairy factories. Despite efforts to recover it, some protein inevitably ends up in the waste streams. Bacteria help convert the nitrogen in these proteins into inorganic forms, such as ammonia, ammonium, nitrite, and nitrate ions. Each of these forms has different environmental impacts. Notably, high concentrations of nitrate ions can be harmful to both humans and animals. In infants, nitrate can be converted to nitrite, which is then absorbed into the bloodstream. This process changes hemoglobin (the oxygen-carrying molecule in red blood cells) into methemoglobin, which cannot transport oxygen efficiently. The resulting condition, methemoglobinemia, primarily affects infants under six months old, as they lack the enzyme needed to convert methemoglobin back to hemoglobin.

Ioannis S et.al , investigated that Dairy wastes are a admixture of faeces, urine, coverlet, and unconsumed feed that most dairymen relate to as ordure. Dairy waste is a broader expression that encompasses waste from abusingparlours.Milk house squanders are for the utmost part water joined with kindly cleaner and milk, still they might contain mortal faecal matter on the off chance that the milk house has a potty. A youthful fellow passing nonage with a dairy grange's mostun-most favored obligation was presumably drawing the beast dwelling place. Just when varied with the option of managing disgusting cows in a foul climate might this movement at some point be viewed asappealing.When business composts weren't naturally accessible, dairymen searched for ways of working on the effectiveness of their grange, permitting them to have further cows and latterly further cash. All the food taking care of shops, includingmulti-thing ultramodern services, produce wastes in a single construction or the other. The food contains a great deal of beans, proteins, fats and mineral mariners. During flushing and washing movement of colorful communication outfit, these advancements enter the drainage and favour the enhancement of anaerobic and oxygen consuming atomic organic realities. Along these lines the flushed water releases unpalatable smell and can transfigure into an evacuation issue as similar in the region's sewerage.

Antonio's Giakoumis et.al, investigated that many dairy industries employ aerobic technologies for treating their wastewaters. However, these aerobic processes are typically energy-intensive and may face performance instability due to factors such as overloading or sludge bulking. On the other hand, anaerobic technologies offer a simpler and more cost-effective approach to wastewater treatment. Anaerobic processes have the added advantage of producing energy in the form of biogas, which is rich in methane. This biogas can be utilized as a valuable energy source, further reducing the operating costs and environmental impact of the treatment process.In contrast to the high energy requirements of aerobic technologies, anaerobic treatments demand lower energy inputs and operational budgets. This makes them an attractive alternative, particularly for dairy industries seeking sustainable and energy-efficient wastewater management solutions. By adopting anaerobic technologies, dairy industries can not only treat their wastewaters effectively but also generate renewable energy in the form of methane-rich biogas, contributing to a more sustainable and environmentally responsible approach to wastewater management.

Akshey Bhargava et.al, investigated that the treatment of dairy wastewater can be accomplished through various technologies, depending on factors such as the availability of land, surrounding environment, economic feasibility, and suitability. One effective approach is the use of aerated lagoons, which can be a useful system for treating dairy wastewater.
Aerated lagoons offer cost-effectiveness and efficient performance, making them a suitable option for treating dairy wastewater, particularly in developing countries. These lagoons are capable of effectively reducing the concentrations of nutrients and organic compounds present in the wastewater. The design and implementation of aerated lagoons involve careful consideration of factors such as available land area, surrounding environment, and operational costs. When properly designed and operated, aerated lagoons can provide a reliable and economical solution for dairy wastewater treatment, ensuring that the treated effluent meets the required quality standards before discharge or reuse.The adoption of aerated lagoon systems can contribute to sustainable wastewater management practices in the dairy industry, while also addressing environmental concerns and regulatory requirements related to wastewater discharge.

Purvi Patil et.al, investigated that various treatment processes have been explored for treating dairy wastewater, including natural methods like anaerobic reactors, as well as the use of chemical and natural coagulants suchas rice husk, jute processing waste, and electrocoagulation processes. These approaches can play a significant role in addressing the issue of water pollution caused by the dairy industry during the production of milk and related products.The dairy industry is a major contributor to water pollution and the deterioration of water quality. Therefore, it is crucial to implement effective treatment strategies to mitigate the impact of dairy wastewater on the environment. Researchers have conducted trials and studies on the effectiveness of these treatment processes, specifically tailored to the characteristics of dairy wastewater. The findings from these investigations highlight the potential of natural, chemical, and electrochemical methods in reducing pollutant levels and improving the quality of the treated effluent.By adopting these treatment technologies, dairy industries can minimize their environmental footprint, comply with regulatory standards, and contribute to sustainable water management practices. The implementation of these treatment processes not only addresses the issue of water pollution but also promotes the responsible use of water resources and the protection of aquatic ecosystems.

DeepakChandran et.al, investigated that dairy waste is treated using a combi- nation of physico- chemical and natural ways. natural approaches, on the other hand, are preferable because they're more effective at removing answerable COD and bring lower. Biodegradable trash can be used directly without causing an odour thanks to anaerobic natural treatment. also again, there are multitudinous biotechnological druther . Organic waste can be used as a substrate for biotechnological operations. Useful chemicals can be made out of dairy assiduity waste particulars also, these by- products have operations in energy, food, drug, and polymers. Using these styles can help reduce environmental pollution and detriment caused by mortal conditioning, which is a more effective approach than other options.

Rivas, J. et.alinvestigated that the dynamic nature of milk processing and the wide variety of dairy products pose challenges in defining uniform characteristics for dairy wastewater. However, it can be concluded that dairy manufacturers are large consumers of water and, consequently, generate significant volumes of wastewater with varying characteristics. These characteristics include elevated temperatures, fluctuating pH values, high levels of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Fats, Oils, and Grease (FOG), as well as high concentrations of nitrogen and phosphorus compounds. Additionally, the presence of inhibiting agents and substantial variations in these factors contribute to the complexity of dairy wastewater treatment.While there is limited information on the composition of wastewater streams from specific dairy industry branches, such as yogurt and whey product manufacturing, further research is needed in this area.Conventional aerobic activated sludge systems and conventional pollutant removal technologies are often ineffective for treating dairy wastewater. The high COD values in the wastewater can lead to excessive growth of filamentous organisms, hindering proper treatment and plant operation.

The implementation of immobilized biofilm technologies, such as Moving Bed Biofilm Reactors (MBBRs), offers the opportunity to treat concentrated wastewater effectively. MBBRs have shown promising results, but further studies are required to evaluate their performance with other types of dairy wastewater streams, including those with high FOG content, acid whey, and other specific waste characteristics.

2.2 Need of study

In Himachal Pradesh, the organic constituents in untreated dairy wastewater can deplete dissolved oxygen levels in water bodies, creating anaerobic conditions harmful to aquatic life and causing foul odors. Dairy wastewater may also contain harmful viruses or bacteria like E.coli and Salmonella, posing health risks to humans and wildlife exposed to contaminated water.

However, dairy wastewater contains organic matter like nitrogen and phosphorus, which can be removed and reused as fertilizers, reducing dependence on expensive synthetic fertilizers. This is especially beneficial as a major portion of Himachal's population depends on agriculture. With limited freshwater resources (only 4% of India's total), sustainably treated industrial wastewater could conserve significant water for agricultural use.

Investigating dairy wastewater treatment is crucial for establishing sustainable practices that support the dairy industry's economic viability while mitigating its environmental impact. Innovative treatment technologies can benefit the dairy sector and advance environmental science and engineering.

Himachal Pradesh's hilly terrain and scarcity of water resources necessitate efficient dairy wastewater treatment and management to conserve precious water for agriculture and domestic needs. Effective treatment processes can remove contaminants, reducing pollution risks to the state's vital freshwater sources like rivers, streams, and groundwater reservoirs.

Compliance with environmental regulations is also essential, and understanding dairy wastewater management helps avoid legal complications and promote sustainable practices. Ultimately, research into dairy wastewater in Himachal Pradesh is integral to fostering economic prosperity and environmental responsibility within the dairy sector, safeguarding the state's natural heritage and ensuring safe water supplies for agriculture and residents.

2.3 Research gap

Investigate the reuse of treated dairy wastewater for irrigating crops cultivated in Himachal Pradesh, with emphasis on reducing nitrogen and phosphorus levels to benefit crop growth. Evaluate the vulnerabilities of dairy wastewater management systems to climate change impacts. Identify areas where our understanding of how shifting climate patterns might influence dairy wastewater's quantity and quality is lacking, and propose adaptive strategies to address these uncertainties.

Assess the efficacy of diverse treatment methods and pinpoint knowledge gaps concerning their performance under different environmental conditions. Dairy wastewater is not merely a waste stream; it contains valuable components like proteins, lactose, and lipids. Research endeavors are crucial to uncover methods for recovering and valorizing these components, transforming waste into valuable resources, thus advocating a circular economy model within the dairy industry. By exploring innovative techniques for extracting and utilizing proteins, lactose, and lipids from dairy wastewater, we can harness its latent potential and minimize resource wastage. This approach not only mitigates environmental pollution but also creates new avenues for economic growth and sustainability. Furthermore, it aligns with the principles of a circular economy, promoting resource efficiency and closed-loop systems within the dairy sector.

Water failure Himachal Pradesh is a hilly state with limited brackish coffers. Proper treatment and operation of dairy wastewater can help conserve precious water coffers that are pivotal for husbandry and domestic use. Agrarian dependence A significant portion of Himachal Pradesh's population relies on husbandry for their livelihood. Treating dairy wastewater and using it for irrigation can reduce the dependence on brackish sources for husbandry, while also furnishing precious nutrients for crop growth. Environmental protection undressed dairy wastewater can contaminate brackish sources like gutters, aqueducts, and groundwater budgets, which are vital factors of Himachal Pradesh's natural heritage. Effective treatment can help impurity and cover the state's ecological integrity. profitable sustainability The dairy assiduity significantly impacts the livelihoods of numerous residers in Himachal Pradesh. Studying dairy wastewater can lead to the development of sustainable practices that support the profitable viability of the dairy sector while mollifying its environmental footmark. Compliance with regulations Environmental regulations and norms are in place to insure responsible wastewater operation by diligence, including dairy operations. exploration on dairy wastewater can help achieve compliance and avoid legal complications. Technological advancements probing dairy wastewater treatment can drive the development of innovative technologies, serving not just the dairy assiduity but also advancing environmental wisdom and engineering. Resource recovery Dairy wastewater contains precious factors like nitrogen, phosphorus, proteins, lactose, and lipids. Studying it can uncover styles for recovering and valorizing these factors, promoting a indirect frugality approach within the dairy assiduity.

2.4 Research objective :

(1) Assess the characteristics of dairy industry wastewater, encompassing the diverse pollutants and their respective concentrations.

(2) Determine suitable crops that can thrive on treated wastewater, minimizing potential detrimental environmental impacts.

(3) Conceptualize and construct a prototype system for effective wastewater treatment.

Summary

This chapter delves into research conducted by various authors on the topic of dairy wastewater. Studying dairy wastewater is critically important because it contains high levels of organic matter, nutrients, and other pollutants that can severely impact the environment if not properly treated and disposed of. Through reviewing the existing literature, several key research gaps have been identified. These include the need to develop cost-effective treatment technologies that are affordable and accessible, especially for smaller dairy operations. Additionally, more research is needed to explore ways to valorize or extract value from the waste streams, such as recovering nutrients, energy, or other useful products. Another gap is the opportunity to further improve the efficiency of treatment processes to maximize pollutant removal.Our research objectives directly address these gaps. We aim to investigate innovative biological treatment methods that could provide more effective and environmentally-friendly ways to treat dairy wastewater. This includes exploring advanced anaerobic and aerobic systems, as well as hybrid approaches. Additionally, we will evaluate strategies for converting dairy waste into valuable resources, such as biofuels, fertilizers, or other marketable products, moving towards a more circular economy model.

Furthermore, we plan to optimize key process parameters like pH, temperature, retention times, and reactor configurations to enhance the removal of major pollutants like organic matter, nutrients, and solids from the wastewater. By tackling these research gaps, our goal is to develop sustainable solutions for managing dairy wastewater that minimize environmental pollution while unlocking economic opportunities through effective resource recovery and valorization.

Chapter 3

Methodology

3.1 GENERAL

Traditional dairy wastewater treatment involves physical, chemical, and biological methods to remove solids, colloids, organic matter, nutrients, and soluble pollutants like metals and organics. It Includes conventional techniques, proven recovery processes, and emerging removal technologies to effectively treat the effluent and minimize environmental impact.

Figure 3.1 illustrates the step-by-step process of treating dairy wastewater, starting with waste collection, followed by pre-treatment, primary treatment with microorganisms, secondary treatment for further purification, and optional tertiary treatment before final disposal or reuse of the treated water.

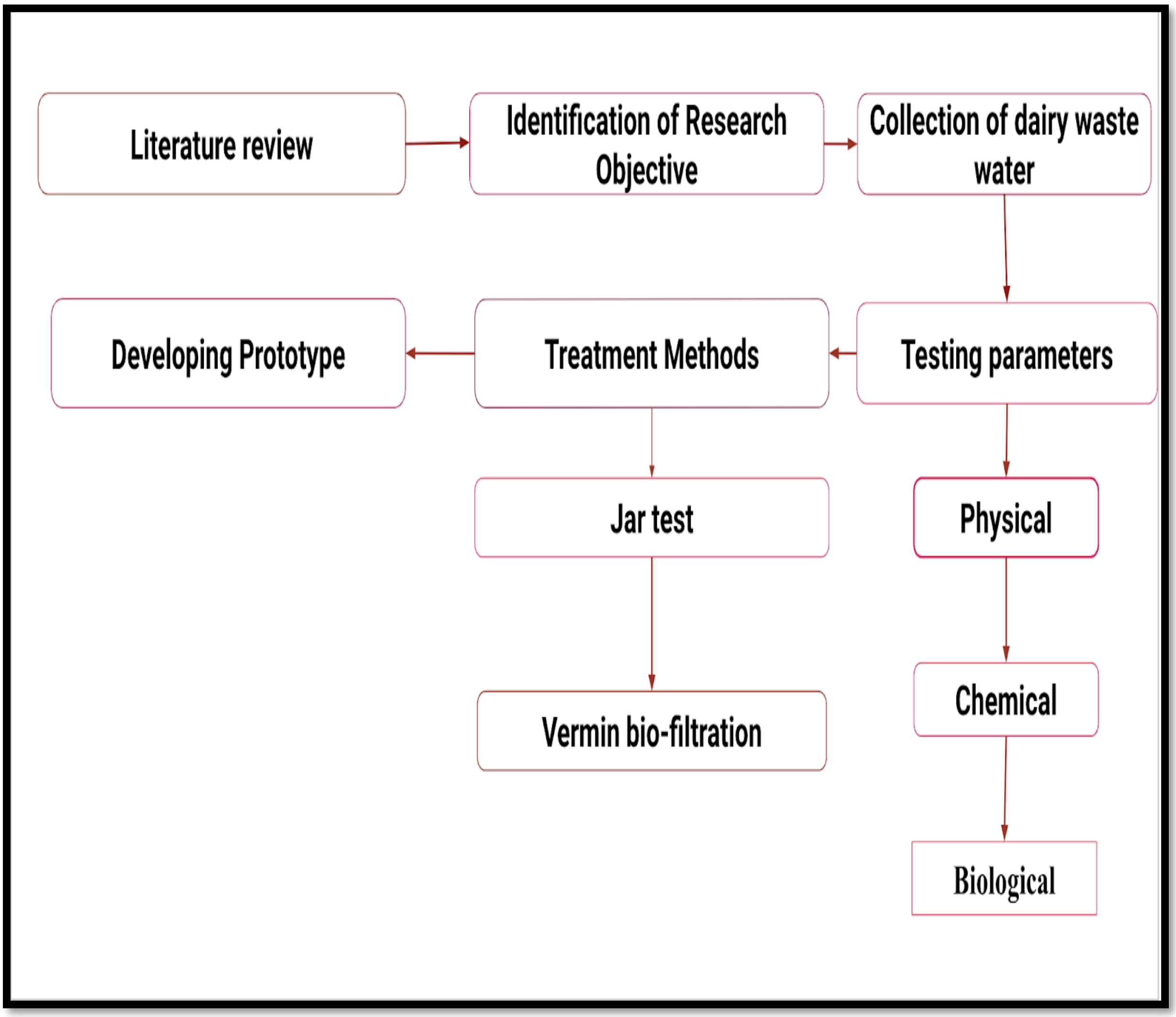

Figure 3.1: Framework of study

3.2 Study Area

In this project, we collected dairy wastewater from the Kamdhenu plant near Bilaspur to analyze its characteristics and impact. We gathered two distinct samples from the plant to ensure a comprehensive understanding of the wastewater composition. The first sample, processing wastewater, was collected during the morning shift. This sample primarily contains residues from milk processing operations, including pasteurization and cheese making, and is expected to have high levels of organic matter such as proteins, fats, and lactose. The second sample, cleaning wastewater, was collected during the afternoon shift. This sample includes water used in cleaning and sanitizing equipment, containing detergents, disinfectants, and other cleaning agents. By examining these samples, we aim to determine the physical, chemical, and biological characteristics of the wastewater and assess the potential environmental and public health impacts. This analysis will inform proper treatment and management strategies to mitigate adverse effects. Figure 3.2 represent the the dairy plant named as Vyas kamdhenu and figure 3.3 represent the location of dairy plant .

Figure 3.2: Vays kamdhenu dairy plant

Figure 3.3: Location of the diary plant [20]

3.3 Material used

In this experiment we have used Alum , Ferric chloride, Lime , Beaker, Conical flask, Muffle Furnace, Oven, Weighing machine,Centrifuge tubes, spectrometer, Measuring cylinder, Jar test Apparatus, pH meter, DO meter, COD digester, Incubator shaker , Turbidity meter , Separating funnel . As shown in figure 3.4 which represents the different material used in the project .

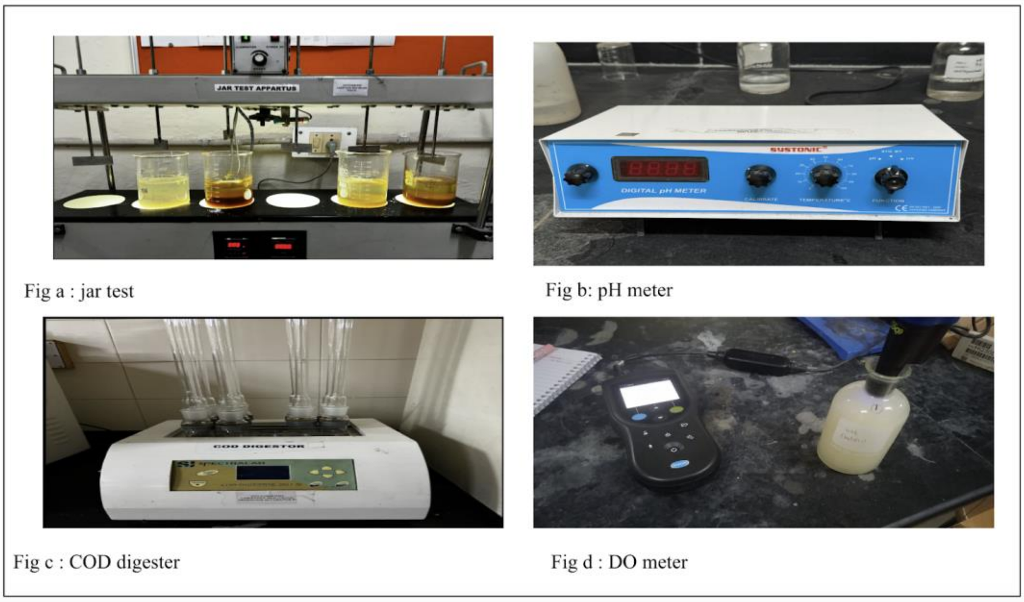

Figure 3.4: Material used

There are three water quality characteristics that help to measure the quality of water, which include physical parameters, chemical parameters, and biological parameters. Testing the physical, chemical, and biological characteristics of a sample, particularly in the context of water or wastewater, is essential for various reasons related to environmental monitoring, public health, regulatory compliance, and the sustainable management of natural resources.

3.4 Physical characteristics of Waste water

Physical parameters of wastewater encompass characteristics that elucidate the water's physical state and properties.These parameters offer insights into the appearance, texture, and overall physical condition of the wastewater. The physical parameters include color, taste, odor, temperature, turbidity, solids, and electrical conductivity.

3.4.1 Solids

Solids in wastewater refer to the various solid materials or particles that are present in the liquid waste stream. These are solid particles that are not dissolved but rather suspended or floating in the wastewater. They can be organic (such as plant matter, fecal matter, or food waste) or inorganic (like silt, sand, or clay particles).These solids can be classified into different categories TSS , TDS , SS . Untreated dairy wastewater with high levels of solids can pollute water bodies like rivers, lakes, and groundwater sources. Solids can harm aquatic life, deplete oxygen levels, and disrupt ecological balance. Proper treatment ensures that the discharged effluent meets environmental regulations and does not harm natural water systems.Solid particles in dairy wastewater can clog pipes, damage equipment, and interfere with subsequent treatment processes like biological treatment or membrane filtration.[21]

3.4.2 Total Suspended solid (TSS)

TSS refers to the total mass of suspended solids or particles in a water sample . It is the measure of the water turbidity and can indicate the level of pollutants or particulate matter in the water. High Situations of TSS can lead to turbidity and reduced light penetration in water bodies, negatively affecting submarine life and ecosystem health. Congesting Suspended solids can clog pipes, pollutants, and irrigation systems if undressed dairy wastewater is used for agrarian purposes. Nutrient transport TSS frequently carries adsorbed nutrients like phosphorus and nitrogen, which can contribute to eutrophication(inordinate nutrient enrichment) in water bodies if not removed. Suspended solids can settle and accumulate in water bodies, altering their natural inflow patterns and territories. Environmental regulations in Himachal Pradesh and India frequently have strict limits on the admissible situations of TSS in discharged wastewater to cover water coffers. First things first, install a filter and assemble the filtration system. Initiate the filtration process by applying vacuum.In order to make sure the filter is securely in place, wet it with just a small amount of deionized water[22]. Use a graduated cylinder to measure out a precise volume of the water sample soon after providing it a vigorous shake. As shown in figure 3.5 which represents the Weight of TSS and figure 3.6 which represent the instrument used in TSS test called muffle furnace.

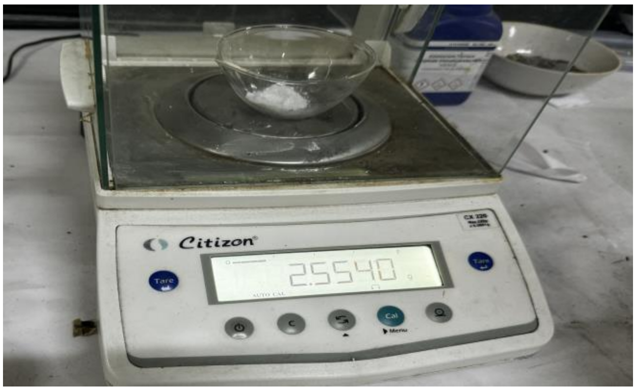

Figure 3.5: Weighing machine

Figure 3.6: Muffle furnace

3.4.3 Total dissolved solids (TDS)

TDS refers to the total amount of dissolved substances in drinking water . TDS comprises inorganic salts and a small amount of organic matter as well . Water quality High situations of TDS can make water infelicitous for colorful purposes, including irrigation, artificial processes, and indeed mortal consumption. Reducing TDS improves the quality of treated wastewater, enabling its exercise. saltness figure- up Dissolved solids can accumulate in soil if undressed wastewater is used for irrigation, leading to saltness issues and implicit damage to crops and soil health over time. Scaling and erosion TDS can beget scaling and erosion in pipes, outfit, and irrigation systems, leading to reduced effectiveness and increased conservation costs. Environmental impact Discharge of high- TDS wastewater into water bodies can negatively affect submarine life and disrupt the natural balance of ecosystems. Environmental regulations in Himachal Pradesh and India frequently have limits on the admissible situations of TDS in discharged wastewater to cover water coffers. Reducing TDS situations in treated wastewater can make it suitable for exercise in husbandry, therefore conserving brackish coffers, which are scarce in the hilly regions of Himachal Pradesh[22]. Resource recovery Some dissolved solids in dairy wastewater may contain precious factors like minerals or nutrients, which could be recovered and valorized if separated effectively. Add 300 ml of waste water sample to the beaker & then use digital TDS metre to measure the dissolved solid in the samples. Note that metre is fully dipped into the sample . Note the reading display on the meter . As shown in figure 3.7 represents the digital TDS meter .

Figure 3.7: TDS meter

3.5 Chemical Characteristics of waste water

The chemical parameters of wastewater relate to the many chemical elements which are found in the water. Monitoring these measures is essential to evaluating water quality as well as making sure environmental regulations are followed. Alkalinity, hardness, pH, acidity, and chlorine are examples of chemical parameters.

3.5.1 pH

The pH is a method of measuring the acidity or basic concentration of any substance . It helps us to find out how acidic or basic a substance is and on the finding , we can determine the usefulness of the substance. Environmental compliance Environmental regulations in Himachal Pradesh and India generally have strict limits on the respectable pH range for discharged wastewater to cover water bodies and ecosystems. Treating pH ensures compliance with these regulations. Submarine life protection Extreme pH values(too acidic or too alkaline) can be dangerous to submarine life in entering water bodies. Maintaining a neutral pH range is essential for conserving the health of brackish ecosystems. Effective treatment processes numerous natural and chemical wastewater treatment processes operate optimally within specific pH ranges. conforming the pH of dairy wastewater can enhance the effectiveness and performance of these treatment processes. erosion and scaling forestallment undressed acidic or alkaline wastewater can erode or beget scaling in pipes, outfit, and irrigation systems, leading to conservation issues and reduced effectiveness. Soil health If dairy wastewater with extreme pH values is used for irrigation, it can negatively affect soil quality, nutrient vacuity, and crop growth[23]. Exercise implicit conforming the pH to an applicable range can make treated wastewater suitable for exercise in colourful operations, similar as irrigation, cleaning, or artificial processes. temperature. As shown figure 3.8 which represent the digital pH meter which is used in pH reading of the sample .

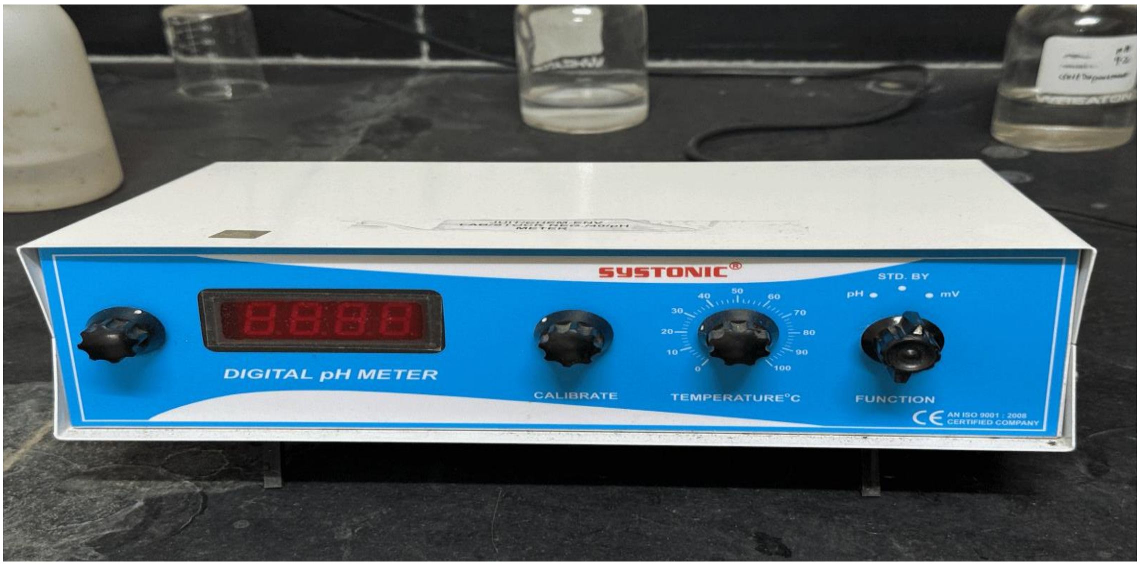

Figure 3.8: Digital pH meter

3.5.2 Oil & Grease

Oil & grease is defined as the amount of the non volatile hydrocarbons , vegetables oils , waxes & retable material in the sample . Water quality oil painting and grease can reduce dissolved oxygen situations in water bodies, negatively affecting submarine life and ecosystems. Removing them improves the quality of treated wastewater, making it safer for discharge or exercise. Clogging and fouling oil painting and grease can clog pipes, pumps, and other equipment used in wastewater treatment or irrigation systems, leading to reduced effectiveness and increased conservation costs. Soil impurity If undressed wastewater containing oil painting and grease is used for irrigation, it can pollute soil, affecting its fertility and making it infelicitous for civilization. Environmental regulations Environmental regulations in Himachal Pradesh and India frequently have strict limits on the admissible situations of oil painting and grease in discharged wastewater to cover water coffers and ecosystems. Exercise implicit Effective junking of oil painting and grease enhances the quality of treated wastewater, adding its felicity for exercise in husbandry or other operations, which is particularly important in water-scarce regions like Himachal Pradesh[25]. Resource recovery In some cases, the removed oil painting and grease from dairy wastewater may have implicit for recovery and valorization, similar to conversion into biofuels or other precious products. Odor control oil painting and grease can contribute to unwelcome odors in wastewater, which can be a nuisance if not duly treated. Figure 3.9 represent the separating funnel which is used as an instrument in oil & grease test .

Figure 3.9: Separatory funnel Oil & grease

3.6 Biological Characteristics of waste water

Biological characteristics of wastewater refer to the presence and activity of living organisms in the water. These organisms can serve as indicators of water quality and provide valuable information about the health of aquatic ecosystems.

3.6.1 Dissolved Oxygen

It is defined as the amount of oxygen available or dissolved in the water oe we can say that the amount of oxygen available to living organisms . Environmental protection Low DO situations in water bodies can lead to anaerobic conditions, which are dangerous to submarine life and can disrupt the ecological balance. Maintaining applicable DO situations in treated wastewater before discharge is pivotal for guarding brackish ecosystems in Himachal Pradesh. Treatment process effectiveness numerous natural wastewater treatment processes calculate on the presence of dissolved oxygen for effective breakdown and junking of organic matter. icing acceptable DO situations in dairy wastewater can enhance the effectiveness of these treatment processes. Odor control Anaerobic conditions caused by low DO situations can lead to the conformation of undesirable odors, similar as hydrogen sulfide, which can be a nuisance if the treated wastewater is reused for irrigation or other purposes. erosion forestalment Low DO situations in wastewater can produce an terrain conducive to microbially convinced erosion, which can damage pipes, outfit, and structure used for wastewater treatment or distribution. Nutrient junking Some nutrient junking processes, similar as nitrification, bear the presence of dissolved oxygen. Maintaining applicable DO situations in dairy wastewater can grease effective nutrient junking, which is important for precluding eutrophication in water bodies[26]. As figure 3.10 represent the digital DO meter which is used in the recordintg the DO of the wastewater .

Figure 3.10: DO meter

3.6.2 Biological Oxygen Demand(BOD)

BOD is defined as the a degree of the sum of oxygen required to evacuate squandernatural matter from water in the handle of decay by high-impact microscopic organisms (those microbes that live as if they were in an environment containing oxygen). Water quality High duck situations indicate the presence of biodegradable organic matter in wastewater, which can deplete dissolved oxygen(DO) situations in entering water bodies. This can harm submarine life and disrupt the ecological balance of brackish ecosystems in Himachal Pradesh. Treatment process effectiveness numerous natural wastewater treatment processes calculate on microorganisms to break down organic matter, consuming oxygen in the process. Effective duck junking is essential for optimizing these treatment processes and icing effective organic matter junking. Odor control Deficient junking of BOD can lead to anaerobic conditions and the conformation of unwelcome odors, similar as hydrogen sulfide, which can be a nuisance if the treated wastewater is reused for irrigation or other purposes. Compliance with regulations Environmental regulations in Himachal Pradesh and India frequently have strict limits on the admissible duck situations in discharged wastewater to cover water coffers and ecosystems. Exercise implicit Effective duck junking improves the quality of treated wastewater, making it more suitable for exercise in agrarian or artificial operations, which is particularly important in water-scarce regions like Himachal Pradesh. Resource recovery Some organic matter contributing to duck situations in dairy wastewater may have implicit for recovery and valorization, similar as conversion into biogas or other precious products. Ecosystem protection High duck situations in discharged wastewater can lead to oxygen reduction in water bodies, negatively affecting submarine life and potentially causing fish kills or other environmental damage. As shown in figure 3.11 BOD incubator which is used as a device to store BOD sample for 5 days .

Figure 3.11: BOD incubator

Table 3.1 : Standard values for discharge of dairy waste water [27]

Parameter	World bank (2019)	CPCB India (2019)
pH	6-9	6.5-8.5
BOD	50	100
COD	250	_

TSS	50	150
Oil & Grease	10	10
Total Nitrogen	10	–
Total phosphorus	2	–
Temperature increase	<=3°C	–

The table labeled "3.1" presents the standard values or limits set by the World Bank and the Central Pollution Control Board (CPCB) for treated dairy wastewater before it can be discharged or released. Throughout the entire wastewater treatment process for the dairy industry, the guidelines and standards established by the CPCB were followed.These standards outline the maximum permissible levels of various parameters, such as pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and other contaminants that the treated wastewater must meet before it can be safely released into the environment or reused for other purposes.

3.7 Treatment methods

In this treatment method we have used jat test and vermi biofiltration . In the jar test we have used 2 chemical coagulants Alum & lime in different proportions . In vermi biofiltration we have made 3 different layers through which water passes . In the jar test we have used different chemical coagulants named alum, ferric chloride to do coagulation . In vermi biofiltration is used to treat the waste water in which we have used different layer of sand , gravel and activated carbon through which water pass through with different layer .

3.7.1 Jar test

In this treatment method, we use different chemicals called coagulants to first treat dairy wastewater. The coagulants used are alum and ferric chloride. We test different doses of these coagulants using a jar test apparatus to find the right amount needed. The purpose of adding the coagulants is to remove turbidity (cloudiness), color, suspended solids, microorganisms, and substances that cause odors from the wastewater. The coagulants make all the tiny particles stick together and form larger clumps called flocs. These bigger flocs can then settle to the bottom due to gravity and be easily separated from the water.In the jar test, we first rapidly mix the wastewater samples with the coagulant doses for 2 minutes at 100 revolutions per minute (rpm). This allows the coagulant to disperse evenly. Then, we slowly mix for 25 minutes at 20 rpm to allow the floc formation [28]. We also tested using a natural coagulant made from jackfruit seeds by adding different doses of it to separate wastewater samples. The mixing times and speeds were the same as for the alum and ferric chloride coagulants.This coagulation and flocculation step helps remove a lot of the pollutants and solids initially before further treatment of the dairy wastewater is carried out. Figure 3.12 represent the apparatus that called jar test .

Figure 3.12 : Jar test apparatus

3.7.2 Coagulation using Alum + lime

Alum is added to the wastewater as a coagulant chemical. When alum mixes with water, it forms aluminium hydroxide particles. These aluminium hydroxide particles bind to the suspended solids, organic matter, and other pollutants present in the wastewater. This causes them to stick together and form larger clumps called flocs. The flocs formed by the alum are larger and heavier than the individual particles originally present in the wastewater. This makes it easier for the flocs to settle down to the bottom due to gravity. As the flocs settle, they carry down the suspended solids and organic matter with them. This is called the coagulation-flocculation process. Lime (Calcium Hydroxide) AdditionLime is also added to the wastewater. Lime helps to increase the pH of the water, making it more alkaline (basic). This rise in pH further helps the coagulation-flocculation process work better. It also aids in the removal of dissolved pollutants. The increase in pH by adding lime also helps biological treatment processes. Some microorganisms that break down organic matter work better at higher pH levels. By raising the pH with lime, these microorganisms become more effective at consuming the organic pollutants, thereby reducing the organic load. As the formed flocs settle out, they take suspended solids and organic matter down with them from the wastewater. This results in a decrease in the amount of organic material remaining in the water that needs to be broken down further. With reduced organic matter and suspended solids, the microorganisms don't need as much oxygen to break things down. This helps improve the dissolved oxygen levels in the water, which is crucial for the survival of aquatic organisms. Figure 3.13 shows the jar test with coagulants using alum+lime in different proportions[29] .

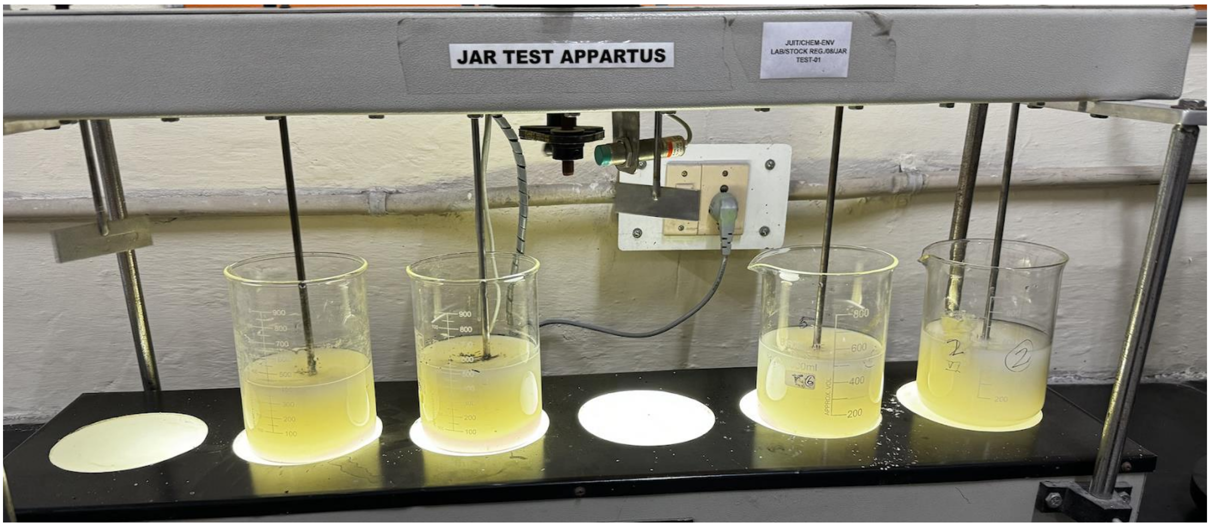

Figure 3.13: jar test with (Alum + lime)

3.7.3 Coagulation using Ferric chloride + Lime

Treating dairy wastewater often involves a combination of chemical and physical processes to remove organic matter, nutrients, suspended solids, and harmful pathogens. Ferric chloride and lime are commonly used chemicals in dairy wastewater treatment because they help with coagulation, flocculation, and pH adjustment. Here's how the combination of ferric chloride and lime treats dairy wastewater:

Ferric chloride ($FeCl_3$) is added to the wastewater as a coagulant chemical. When mixed with water, ferric chloride reacts to form iron hydroxide ($Fe(OH)_3$) particles. These iron hydroxide particles act as magnets, attracting and binding to suspended solids, fats, proteins, and other organic matter present in the dairy wastewater. This causes them to clump together into larger masses called flocs. The flocs formed by the coagulation process are much larger and heavier than the individual tiny particles originally present. This makes it easier for the flocs to settle down to the bottom through sedimentation or be removed by filtration processes. As they settle, the flocs carry down the suspended solids and organic matter with them. Lime ($Ca(OH)_2$) is added to increase the alkalinity (make it more basic) of the wastewater. This rise in pH further helps the coagulation process work better. It also aids in removing dissolved pollutants by causing them to precipitate out. Adjusting the pH of the wastewater to an optimal range (generally around neutral to slightly basic) is crucial for effective coagulation and flocculation. The combination of ferric chloride and lime ensures the pH is adjusted to the level where these processes work best[30]. The coagulation and flocculation caused by ferric chloride and lime lead to the removal of suspended solids, organic matter, fats, proteins, and nutrients from the wastewater. This reduces biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and nutrients like phosphorus and nitrogen. The flocculation and sedimentation processes also help remove harmful pathogens and microbial pollutants from the wastewater, reducing the risk of waterborne diseases. Overall, the combined treatment using ferric chloride and lime is effective for treating dairy wastewater by promoting the removal of organic matter, suspended solids, nutrients, and pathogens through coagulation, flocculation, pH adjustment, and sedimentation processes all the treated wastewater reaches Tank 5, which is the distribution tank from where it can be discharged or reused. Figure 3.14 shows the jar test with ferric chloride +lime coagulants with different proportions.

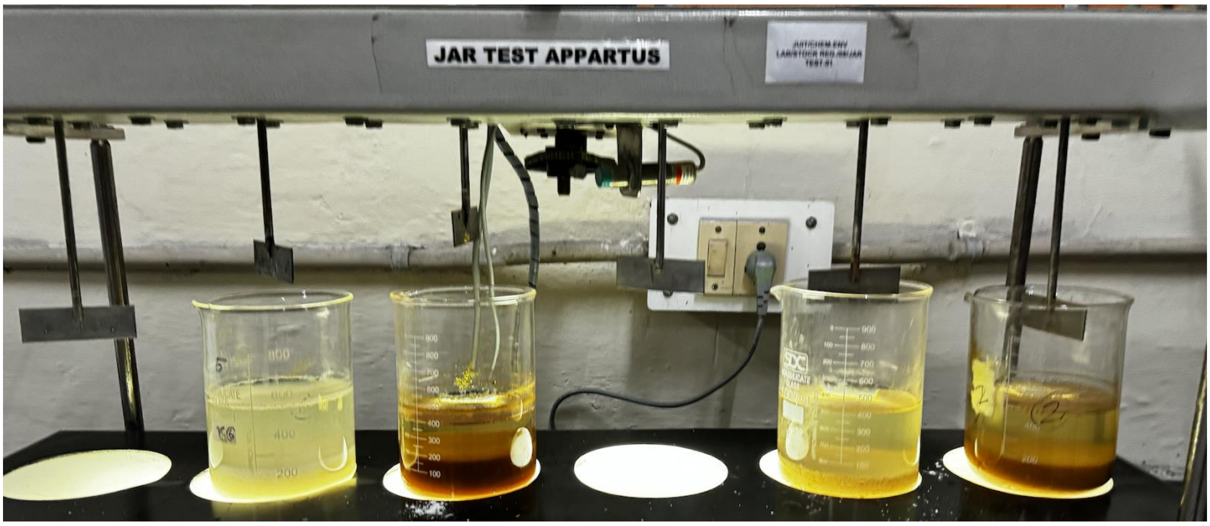

Figure 3.14: jar test with (Ferric chloride + lime)

3.7.4 Vermin Biofiltration

We have set up a treatment plant to treat dairy wastewater. This plant has 5 different tanks for various treatment operations.

Tank 1 is called the receiving tank, where the dairy wastewater coming from the plant is collected.Tank 2 is for primary treatment. In this tank, we add chemical coagulants alum and lime to the wastewater. We use a jar test to determine the right doses of these coagulants. The coagulants react with the wastewater, causing coagulation and flocculation. This makes the small particles in the water stick together and form larger clumps called flocs. These heavier flocs then settle down to the bottom of the tank through a process called sedimentation.

After primary treatment, the water moves to Tank 3 for secondary treatment using filtration. This tank has 3 different layers:

1) Sand layer: This is commonly used for filtration. The large suspended particles get trapped on top of the sand layer, which acts as a physical barrier. It helps remove suspended solids, sediments, and some organic matter, reducing turbidity and improving water clarity.

2) Gravel layer: This second layer provides structural support to the sand layer above it. It helps distribute the water flow evenly across to the final layer and prevents clogging by allowing proper drainage.

3) Activated carbon layer: Activated carbon is highly porous with a large surface area, making it excellent at adsorbing organic compounds, odors, and certain chemicals from water. For dairy wastewater, activated carbon can remove organic pollutants like fats, oils, proteins, and

lactose. This improves water quality by reducing odor, color, and removing potentially harmful substances.

After passing through these 3 filtration layers in Tank 3, the treated water moves to Tank 4 where there is screening to further filter out any remaining solids.

Finally, the treated wastewater reaches Tank 5, which is the distribution tank from where it can be discharged or reused.

3.8 Prototype

We have made a treatment plant to treat the dairy waste water . In this we have 5 different tanks for different operations . Tank 1 is called a receiving tank which has the operation to receive the dairy wastewater that is coming from the plant . Then in the second tank our primary treatment begins in which we add chemical coagulants alum and lime to treat the wastewater with the help of a jar test . In the jar test coagultan reacts with wastewater and cause coagulation and flocculation which help in the process of sedimentation of have particle in the bottom of the tank Then it goes to the secondary treatment tank in which we are doing filtration of the waster water . In this we have three different layer of activated carbon , gravel and sand . 1 Sand layer : this is commonly used as the filtration process in which the large suspended particles trapped on the above layer of the sand & which act as a physical barrier . It help to remove the suspended particles , sediment and some organic matter from the dairy waste water which helps us to reduce the turbidity and improving the cleanliness of the water . 2 Gravel layer : this is the second layer which is providing structural support to the sand layer . It helps us to distribute water flow properly across to the last layer and prevent clogging by allowing proper drainage . 3 Activated Carbon : Actuated carbon is largely pervious and has a large face area, which makes it excellent at adsorbing organic composites, odors, and certain chemicals from water. In dairy wastewater treatment, actuated carbon can remove organic pollutants similar as fats, canvases , proteins, and lactose. This helps to ameliorate water quality by reducing odor and color, as well as removing potentially dangerous substances. Then it gooes to 4 tank after passing from the 3 tank and in the fourth tank their is a screening of treated water and it goes to 5 tank which are distribution tank . Figure 3.15 represents the Waste water treatment and its function .

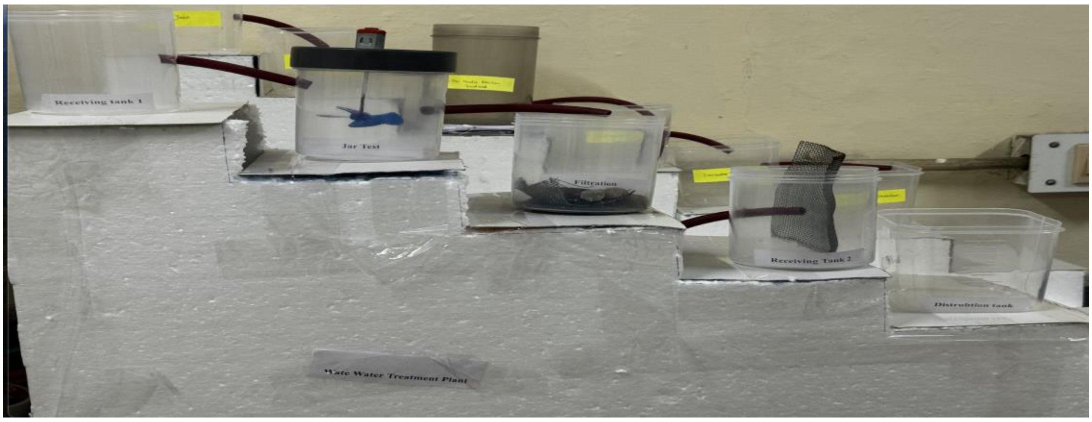

Figure 3.15: Wastewater treatment plant

Receiving tank 1

A receiving tank for wastewater is a pivotal element in wastewater operation systems. It acts as an original collection point for wastewater before it undergoes treatment or farther processing. Then are some crucial aspects of a receiving tank for wastewater Functions Collection The primary function of the receiving tank is to collect wastewater from colorful sources similar as artificial installations, external sewage systems, or stormwater runoff. Flow Regulation It helps in regulating the inflow of wastewater into the treatment factory, icing that the treatment process isn't overwhelmed in sudden surges. Sedimentation Some entering tanks are designed to allow heavier patches to settle at the bottom, reducing the cargo on posterior treatment stages. Equalization By storing wastewater temporarily, the tank can help equate variations in wastewater inflow and composition, leading to further harmonious treatment performance.

Jar test

Then in the second tank our primary treatment begins in which we add chemical coagulants alum and lime to treat the wastewater with the help of a jar test . In the jar test chemicla coagultan reacts with wastewater and cause coagulation and flocculation which help in the process of sedimentation of have particle in the bottom of the tank .

Filtration tank

A filtration tank in wastewater treatment is a critical component designed to remove suspended solids, organic matter, and other impurities from water. The filtration process typically follows preliminary treatments like screening and sedimentation, ensuring that the water is clear of large debris and particles before it undergoes further purification processes. Here's an overview of the key aspects of a filtration tank in wastewater treatment:

Types of Filtration Systems :

Sand Filters: Use layers of sand to trap and remove particles. They can be slow or rapid filters, with slow sand filters typically used for smaller-scale operations and rapid sand filters for larger-scale operations[31].

Dual Media Filters: Combine layers of sand and anthracite coal to enhance filtration efficiency by capturing a wider range of particle sizes[32].

Multimedia Filters: Use multiple layers of media with different densities and particle sizes, such as sand, anthracite, and gravel, to improve filtration depth and efficiency[33].

Receiving tank 2

A receiving tank, often referred to as an equalization or holding tank in wastewater treatment, plays a vital role in managing and stabilizing the flow and composition of incoming wastewater. This tank helps balance out variations in flow and pollutant loads, ensuring that the subsequent treatment processes operate more efficiently and effectively.

Distribution tank

A distribution chamber in wastewater treatment is an essential structure designed to evenly distribute the flow of wastewater to multiple treatment units. This ensures that each unit receives an equal load, optimizing the efficiency and effectiveness of the treatment process.

Summary

In this chapter, we've covered our project's work plan and the progress made over the past year. We started with a literature review and eventually developed a prototype. The chapter delves into the various characteristics of dairy wastewater, including physical, chemical, and biological properties.

We've explored different treatment processes, such as the jar test, which involves chemical coagulation. Another method discussed is Verm biofiltration, which utilizes different layers to treat the wastewater. We've also provided details about our prototype design.

The jar test is a technique used to determine the optimal coagulant dosage and pH conditions for effective coagulation and flocculation of contaminants in wastewater. Vermibiofiltration, on the other hand, is a sustainable and eco-friendly approach that employs earthworms and microorganisms to break down organic matter and remove pollutants from wastewater.

Throughout the chapter, we've aimed to present a comprehensive overview of our work, covering the theoretical aspects as well as the practical implementation through our prototype development.

In this chapter we have discussed our work plan & what we have done over 1 year from literature review to developing a prototype . In this chapter we have discussed the different types of characteristics of dairy waste water which are physical , chemical & biological characteristics . Also we have discussed about the the different treatment process which is jar test with some chemical coagulation and vermi biofiltration with its different layers and also over prototype .

Chapter 4

Results & Discussion

4 GENERAL

This chapter discusses the results and analysis of dairy wastewater before and after treatment. The first part focuses on the characteristics of the untreated dairy wastewater. It provides the values and details of various parameters such as pH, chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), and others. These values represent the initial state of the wastewater, which is typically high in organic matter, suspended solids, and other contaminants. The second part of the chapter covers the results obtained after treating the dairy wastewater with chemical coagulants. Chemical coagulants, such as aluminium sulphate (alum), ferric chloride, or ferric sulphate, are added to the wastewater to remove suspended solids, colloidal particles, and other impurities.

4.1 Processing Wastewater

The processing of wastewater from dairy operations is a critical aspect of environmental management to ensure compliance with regulations and minimise the ecological impact. Dairy wastewater is characterised by its high organic content, nutrients, and the potential presence of pathogens. The parameters of before treatment of processing wastewater is given in Table 4.1 .

Table 4.1: Before Treatment of processing wastewater

Parameters	Result	Standard as per CPCB (Central Pollution Control Board)
pH	4.37	6.5-8.5
BOD	276.6	100
COD	864.7	250
DO	0.64	4

Oil & Grease	6.3	10
TDS	221	2000
TSS	12400	150
Volatile solid	9100	–
Fixed solid	3300	

Except pH all the units are in (mg/l)

Several factors contribute to elevated levels of pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO) in wastewater during processing:

The acidity or alkalinity of wastewater can vary significantly depending on the nature of the industrial processes or activities that generated it. Certain chemical industries or mining operations may produce wastewater with extreme pH values, either highly acidic or highly alkaline. BOD is a measure of the amount of oxygen required by microorganisms to break down biodegradable organic matter present in the wastewater. High BOD levels indicate a high concentration of organic pollutants that can be decomposed by biological processes. Sources contributing to high BOD include food processing facilities, pulp and paper mills, and untreated sewage. COD quantifies the quantum of oxygen demanded for chemical oxidation of both organic and inorganic composites in the wastewater. Elevated COD levels can result from the presence of non-biodegradable or partially biodegradable organic compounds, often found in certain industrial effluents or chemical spills.DO represents the amount of oxygen dissolved in the wastewater. Low DO levels can occur when there is a high concentration of organic matter that consumes oxygen during decomposition by microorganisms. Discharges of untreated or inadequately treated domestic sewage or industrial effluents rich in organic matter can contribute to low DO levels[34].

4.2 Cleaning Wastewater

Cleaning wastewater comes from the process of cleaning dairy equipment & machinery. The cleaning waste water has low pH and DO and pleasant odour smell with clearly transparent. The parameter of before treatment of cleaning waste water is given in Table 4.2.

Table 4.2: Before treatment of cleaning wastewater

Parameter	Result	Standard as per CPCB (Central Pollution Control Board)
pH	4.45	6.5-8.5
Bod	121.1	100
Cod	345.75	250
DO	1.12	4
Oil & Grease	2.4	10
TDS	215	2000
TSS	756	150
Volatile solid	537	_
Fixed solid	296	_

Except pH all the units are in (mg/l)

There are several reasons why cleaning wastewater from dairy plants can have low pH (acidic) and low levels of dissolved oxygen (DO), as well as high levels of BOD, chemical oxygen demand (COD), and total suspended solids (TSS).

Dairy wastewater often contains organic acids, like lactic acid, which are produced when milk and milk products spoil or ferment. These organic acids make the wastewater acidic, lowering its ph. Dairy wastewater has a high amount of organic matter, such as milk residues, whey, and other organic compounds. Microorganisms consume oxygen to break down these organic materials, depleting the dissolved oxygen in the wastewater and resulting in low DO levels. Dairy wastewater contains a significant amount of biodegradable organic matter, like proteins, fats, carbohydrates, and other milk components. These organic substances contribute to a high BOD because microorganisms require oxygen to break them down biologically. Apart from biodegradable organic matter, dairy wastewater also contains organic compounds that are not easily broken down or take a long time to break down, such as detergents, sanitizers, and cleaning agents used in dairy processing. These compounds contribute to the high COD levels in the wastewater. Dairy wastewater typically has a high concentration of solid particles suspended in it, including milk residues, whey solids, and other particulate matter from the processing operations. These suspended solids contribute to the high TSS levels in the wastewater.

4.3 Chemical Coagulant - (Alum + lime)

4.3.1pH

pH is an essential factor to control and manage in wastewater treatment for several reasons: Extreme pH levels (very acidic or very alkaline) can harm aquatic life and ecosystems when discharged into water bodies. It can disrupt the natural pH balance, which can negatively impact organisms and biological processes. Many biological and chemical treatment processes used in wastewater treatment plants are pH-dependent. Microorganisms involved in these processes, such as aerobic or anaerobic digestion, have a specific pH range where they function optimally. If the pH is too high or too low, it can inhibit or even kill these microorganisms, reducing the treatment efficiency. Highly acidic or alkaline wastewater can corrode pipes, tanks, and other equipment used in wastewater treatment systems, leading to premature deterioration and maintenance issues[35]. Table 4.3 shows the pH test results of dairy waste water and Figure 4.1 shows the reading of the pH test .

Table 4.3: pH test results

Alum + Lime Dosage(grams)	pH
0.25	4.48
0.5	5.52
0.75	6.14
1	6.22
1.25	6.38
1.5	6.65
1.75	6.91
2	6.95
2.25	7.13
2.5	7.13
2.75	7.15
3	7.15

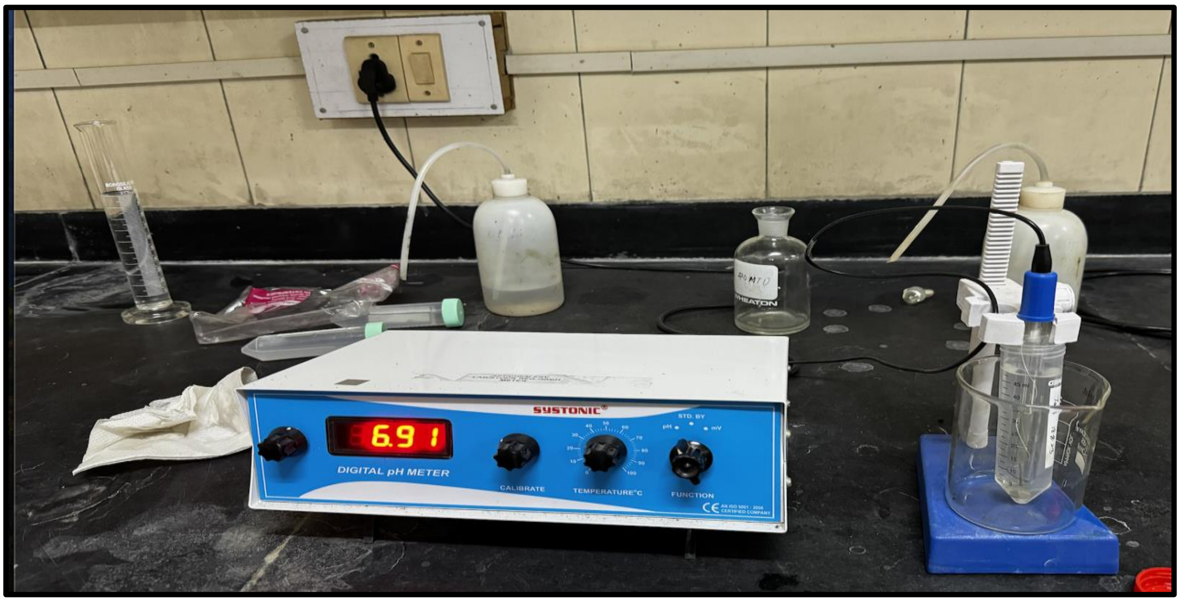

Figure 4.1: pH test reading

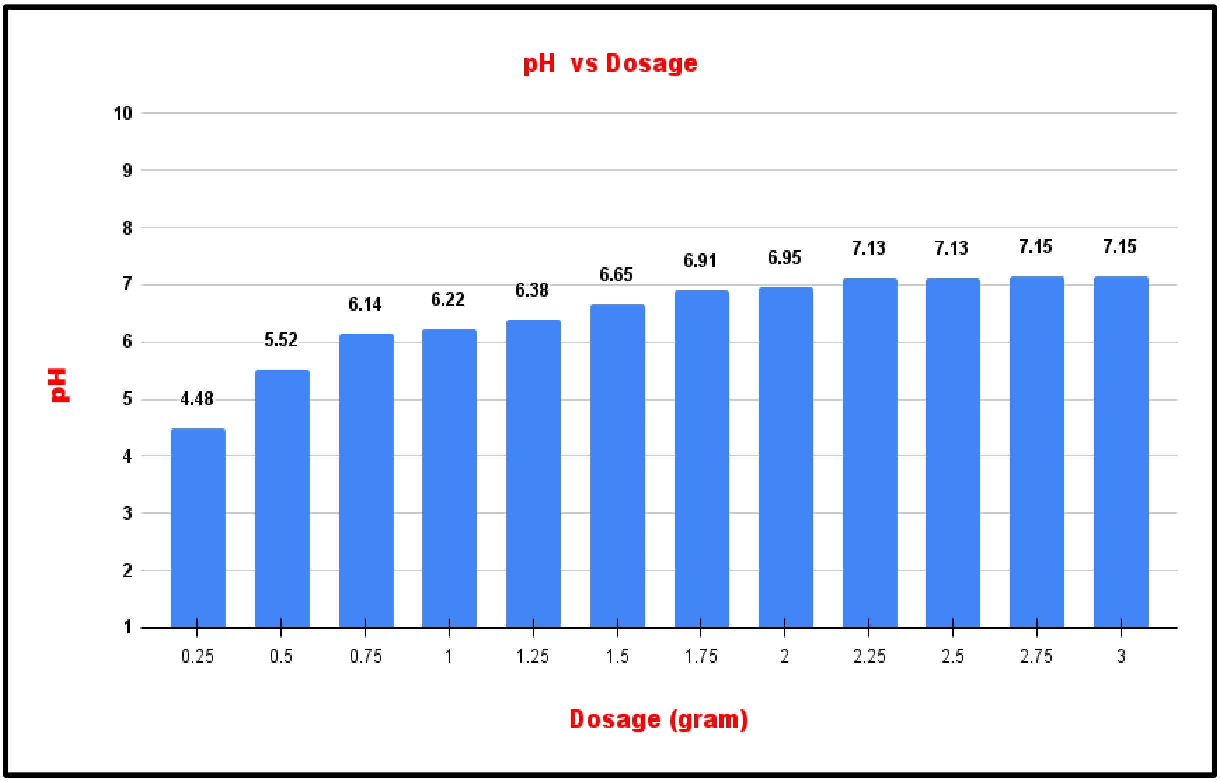

Figure 4.2: pH results.

When dairy wastewater is treated with chemical coagulants like aluminium sulphate or ferric chloride, these chemicals undergo a chemical reaction in the water. This reaction is called hydrolysis, and it involves the breaking down of water molecules. During hydrolysis, the coagulant chemicals release positively charged hydrogen ions (H+) into the wastewater. These hydrogen ions are acidic in nature, meaning they can lower the pH of the water. However, dairy wastewater naturally contains substances called alkaline buffers. These buffers act like sponges that can absorb or neutralize acids like the hydrogen ions released by the coagulants. When the alkaline buffers in the wastewater interact with the hydrogen ions from the coagulants, they effectively remove or consume these acidic hydrogen ions. As a result, the overall acidity of the wastewater decreases, leading to an increase in the ph. The pH scale measures the acidity or basicity of a solution, with lower values indicating higher acidity and higher values indicating higher basicity (or alkalinity). By consuming the acidic hydrogen ions, the alkaline buffers in the dairy wastewater shift the balance towards a more alkaline or basic condition, causing the pH to rise.

4.3.2 BOD

BOD (Biochemical Oxygen Demand) is an essential parameter to treat in dairy wastewater for several reasons:

Dairy wastewater typically contains high levels of organic matter, such as proteins, fats, carbohydrates, and lactose. These organic compounds consume dissolved oxygen when broken down by microorganisms, leading to oxygen depletion in water bodies. If untreated dairy wastewater with high BOD levels is discharged into water bodies, it can severely deplete the dissolved oxygen levels, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. This can result in fish deaths and disruption of aquatic ecosystems. Many biological treatment processes used in dairy wastewater treatment plants rely on microorganisms to break down organic matter. The BOD level directly affects the oxygen demand and the efficiency of these biological treatment processes, such as activated sludge or anaerobic digestion. Environmental regulations often set limits on the maximum BOD levels allowed in wastewater discharged into water bodies or sewage systems. Failing to meet these BOD standards can result in fines or penalties for the dairy industry. Table 4.4 shows the BOD result of after treatment with (Alum + Lime) & figure 4.3 represent the data of these result in graphical form.

Table 4.4: BOD test results

Alum + Lime Dosage(grams)	BOD
0.25	231(mg/l)
0.5	228(mg/l)
0.75	112(mg/l)
1	94(mg/l)
1.25	82.8(mg/l)
1.5	66.6(mg/l)
1.75	65(mg/l)
2	44.6(mg/l)
2.25	19.8(mg/l)

2.5	14.14(mg/l)
2.75	10.98(mg/l)
3	10.12(mg/l)

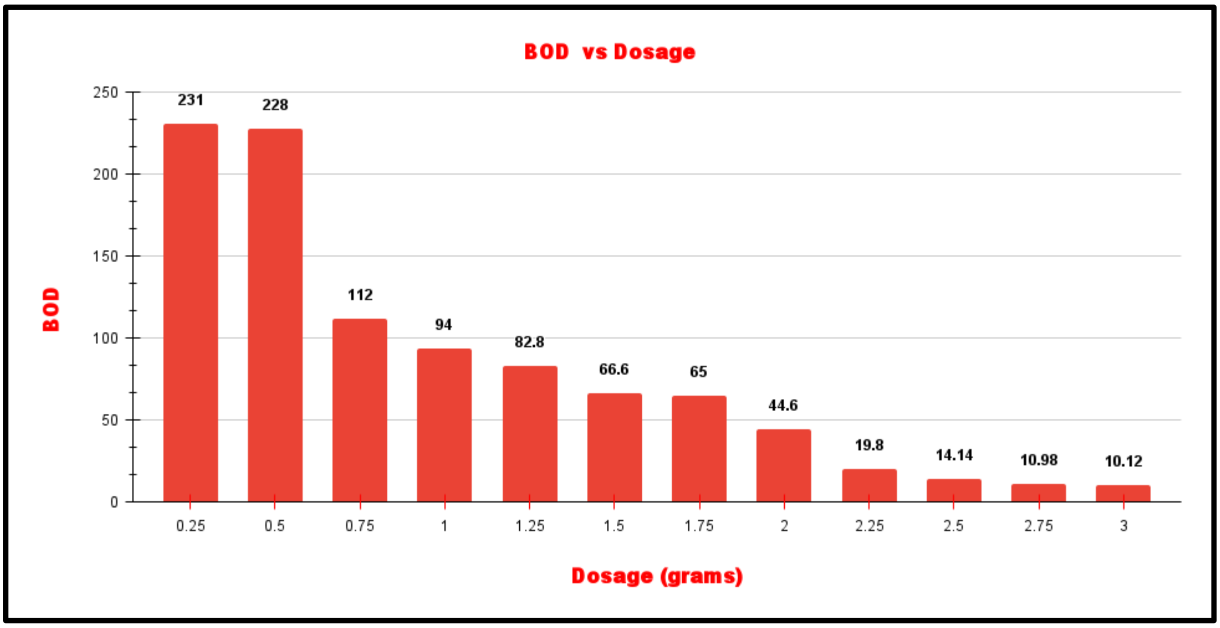

Figure 4.3: BOD results .

There are a few reasons why the BOD (Biochemical Oxygen Demand) of dairy wastewater decreases after treating it with chemical coagulants:

Chemical coagulants, such as aluminium sulfate (alum), ferric chloride, or ferric sulfate, are effective in removing suspended solids from wastewater. These suspended solids often contain organic matter, such as proteins, fats, and carbohydrates, which contribute to the BOD load. By removing these solid particles through the coagulation and flocculation processes, the amount of organic matter and, consequently, the BOD in the wastewater is reduced.Some chemical coagulants can also help remove dissolved organic compounds present in the wastewater. These dissolved organic compounds contribute to the BOD level. When the coagulants are added, they cause these dissolved organic compounds to either precipitate out (settle at the bottom) or adsorb (stick to) the coagulated solid flocs. As a result, the removal of these dissolved organic compounds leads to a decrease in the overall BOD level of the treated wastewater[25].

4.3.3 COD

COD (Chemical Oxygen Demand) is an important parameter to treat in dairy wastewater for the following reasons:

COD is a measure of the total amount of oxygen required to chemically break down organic and inorganic compounds present in the wastewater. High COD levels can indicate the presence of compounds that are difficult to degrade biologically, which may require additional treatment steps or longer treatment times in biological treatment processes.

If dairy wastewater with high COD levels is discharged into water bodies without proper treatment, it can deplete the dissolved oxygen levels, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. Furthermore, some organic compounds contributing to high COD levels may be toxic or resistant to degradation, posing additional environmental risks.Environmental regulations often set limits on the maximum COD levels allowed in wastewater discharged into water bodies or sewage systems. Failing to meet these COD standards can result in fines or penalties for the dairy industry.The presence of organic compounds contributing to high COD levels can lead to the formation of odorous compounds during anaerobic decomposition, which can be a nuisance and a source of complaints from nearby communities. Table 4.5 represents the data of COD after treatment & the graphical data is shown in figure 4.4 .

Table 4.5: COD test results

Alum+LimeDosage(grams)	COD
0.25	-
0.5	-
0.75	234(mg/l)
1	211.5(mg/l)
1.25	207(mg/l)
1.5	163.17(mg/l)
1.75	149.7(mg/l)
2	145(mg/l)

2.25	134(mg/l)
2.5	125.8(mg/l)
2.75	112.9(mg/l)
3	108(mg/l)

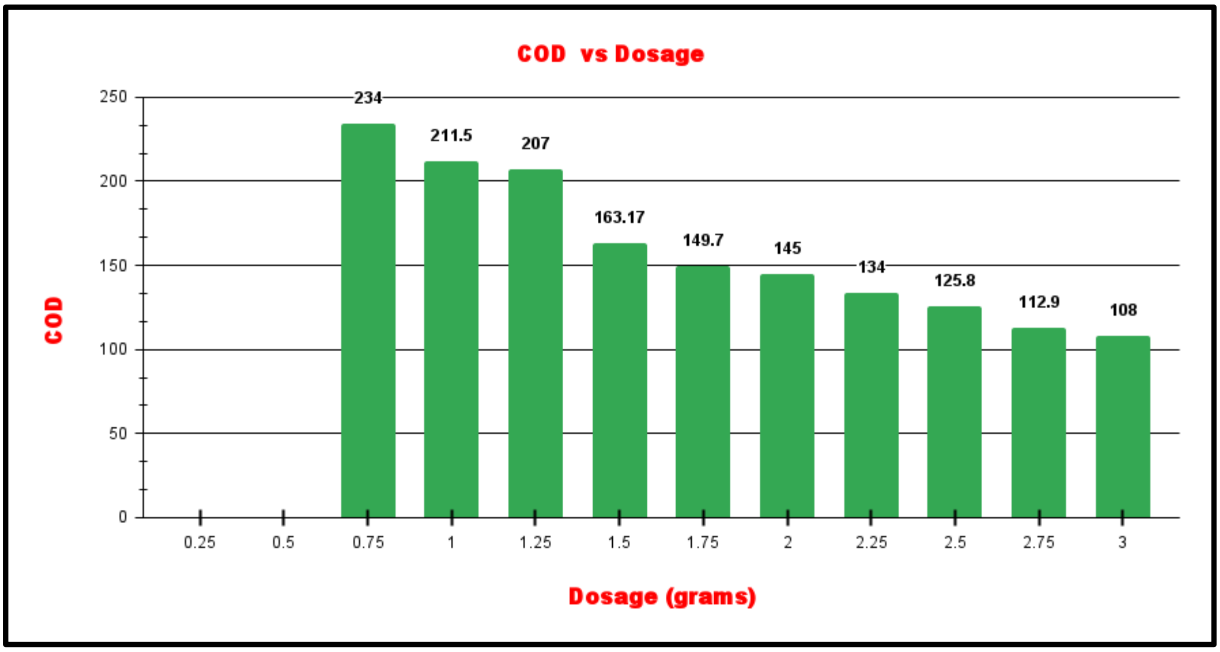

Figure 4.4: COD test results

The combination of alum and lime helps reduce the COD (Chemical Oxygen Demand) in dairy wastewater through a few processes:

Alum acts as a coagulant, causing small particles and dissolved organic matter in the wastewater to clump together and form larger flocs (flocculation). These flocs can then be more easily removed from the wastewater, reducing the organic load and, consequently, the COD.The addition of lime (calcium oxide or calcium hydroxide) increases the pH of the wastewater, creating an alkaline environment. In this alkaline condition, some dissolved organic compounds can precipitate out, forming solid particles that can be removed, further reducing the COD.The flocs formed by the coagulant (alum) can also adsorb (attract and bind) dissolved organic compounds onto their surface. These adsorbed organic compounds are then removed from the wastewater when the flocs are separated, leading to a decrease in the

COD.Lime can neutralize some acidic organic compounds present in the dairy wastewater, reducing their contribution to the COD.

4.3.4 DO

Dissolved Oxygen (DO) is an important parameter to treat in dairy wastewater for the following reasons:

Many dairy wastewater treatment plants rely on aerobic biological processes, such as activated sludge or aerobic digestion, to break down organic matter. These processes require sufficient levels of dissolved oxygen for the growth and activity of aerobic microorganisms responsible for breaking down organic pollutants. Low DO levels can inhibit or even stop these biological treatment processes.If dairy wastewater with low DO levels is discharged into water bodies, it can deplete the oxygen levels in the receiving waters, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. This can disrupt the ecological balance and lead to fish deaths and other detrimental effects on the aquatic ecosystem.Low DO levels in dairy wastewater can promote the growth of anaerobic microorganisms, which can produce unpleasant odors, such as hydrogen sulfide and other volatile organic compounds. Maintaining adequate DO levels helps prevent odor issues.

The DO test resutls is shown in the table 4.6 & graphical representation of this data is shown in figure 4.5 .

Table 4.6: DO test results

Alum+LimeDosage (grams)	DO
0.25	2.3(mg/l)
0.5	2.5(mg/l)
0.5	4.34(mg/l)
1	4.58(mg/l)
1.25	5.23(mg/l)
1.5	5.69(mg/l)
1.75	6.34(mg/l)
2	6.73(mg/l)

2.25	7.81(mg/l)
2.5	7.78(mg/l)
2.75	7.8(mg/l)
3	7.8(mg/l)

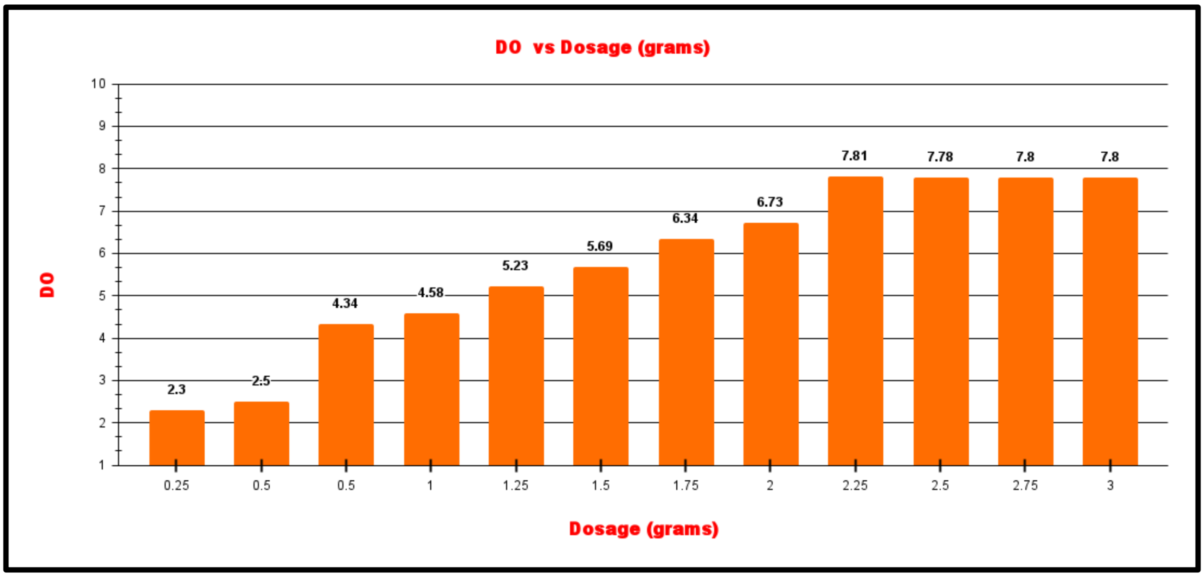

Figure 4.5: DO results

The dissolved oxygen (DO) levels in dairy wastewater can inecrease when treated with chemical coagulants for the following reasons:

Many chemical coagulants, such as aluminum sulfate (alum), ferric chloride, or ferric sulfate, undergo chemical reactions that consume dissolved oxygen. These reactions involve the oxidation (chemical change) of the coagulant compounds, leading to a increasing of DO in the wastewater.Chemical coagulants are effective in removing organic matter, such as proteins, fats, and carbohydrates, from dairy wastewater. While this removal is beneficial for reducing the biological oxygen demand (BOD), it can also contribute to an increase in DO levels. Some of the oxygen initially present in the wastewater may be consumed during the oxidation or removal of these organic compounds.The coagulated flocs or solid particles formed during the treatment process tend to settle or float, depending on their density. As these flocs settle or rise, they can trap and remove dissolved oxygen from the bulk wastewater, leading to a increase in DO levels.

4.3.5 TDS test results :

TDS (Total Dissolved Solids) is an important parameter to treat in dairy wastewater for the following reasons:

Environmental regulations often set limits on the TDS levels allowed in wastewater discharged into water bodies or sewage systems. High TDS levels in discharged wastewater can lead to fines or penalties for non-compliance.Elevated TDS levels in dairy wastewater can have adverse effects on receiving water bodies. High concentrations of dissolved solids can affect the osmotic balance of aquatic organisms, leading to potential harm or even death. It can also impact the quality of water for agricultural or industrial purposes.High TDS levels in dairy wastewater can interfere with the efficiency of various treatment processes. For example, high salinity levels can inhibit the growth and activity of microorganisms involved in biological treatment processes, such as activated sludge or anaerobic digestion. Table 4.7 represent the TDS test results and the graphical data is shown in figure 4.6 .

Table 4.7 : TDS test results

Alum+LimeDosage (grams)	TDS
0.25	864(mg/l)
0.5	845(mg/l)
0.5	761(mg/l)
1	639(mg/l)
1.25	563(mg/l)
1.5	578(mg/l)
1.75	692(mg/l)
2	624(mg/l)
2.25	501(mg/l)
2.5	555(mg/l)
2.75	654(mg/l)
3	667(mg/l)

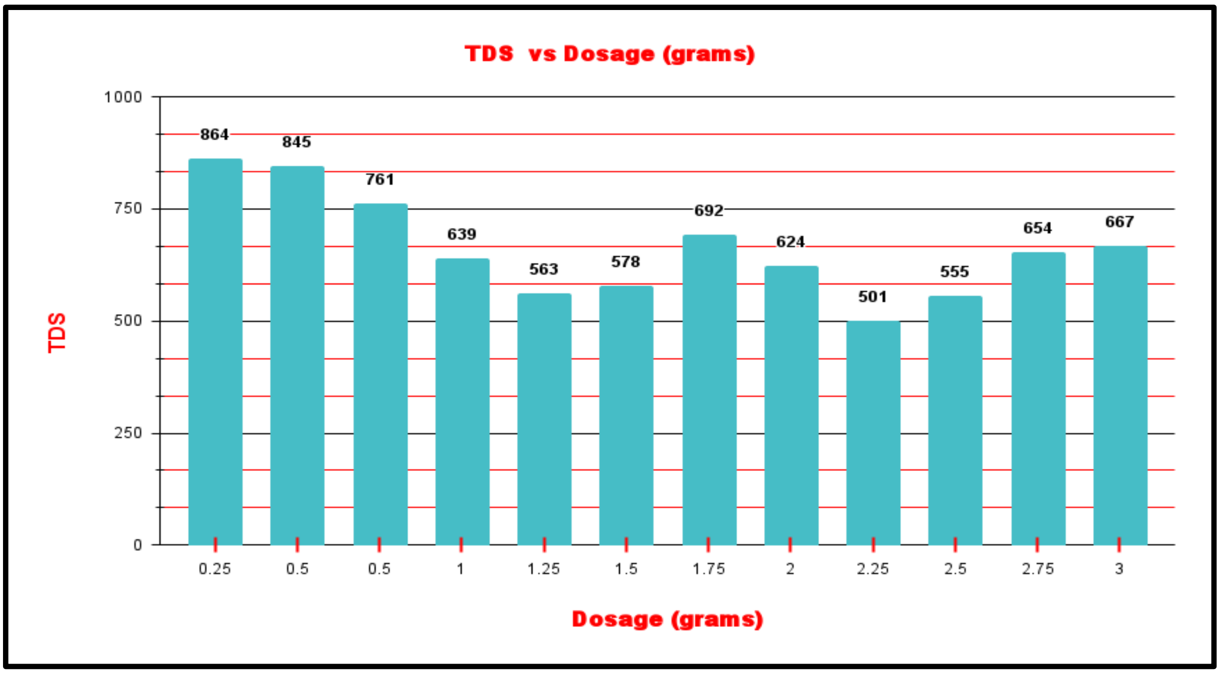

Figure 4.6: TDS results

The TDS (Total Dissolved Solids) levels in dairy wastewater can decrease after treating it with alum (aluminum sulfate) for the following reasons:

The result of TDS is in zig zagdue to the inproper filtration of the treated watse water. Alum is a coagulant that promotes the formation of aluminum hydroxide solid particles. These solid particles can attract and bind (adsorb) or trap (co-precipitate) certain dissolved solids present in the wastewater, effectively removing them from the solution.

Alum introduces positively charged aluminum ions (Al3+) into the wastewater. These ions can neutralize and destabilize negatively charged dissolved solids, such as organic compounds, phosphates, and colloidal particles, causing them to form solid particles that can be removed.The addition of alum can lower the pH of the wastewater, making it more acidic. At lower pH levels, some dissolved solids that are less soluble in acidic conditions may precipitate out and form solid particles. For example, calcium and magnesium salts may form solid calcium carbonate or magnesium hydroxide particles.

4.3.6 Chloride

Chloride is an important parameter to treat in dairy wastewater for the following reasons:
High levels of chloride ions in dairy wastewater can cause corrosion of metal equipment, pipes, and other infrastructure used in the wastewater treatment process. Chlorides can accelerate the corrosion process, especially in the presence of oxygen and moisture, leading to premature damage and increased maintenance costs.If wastewater with elevated chloride concentrations is discharged into water bodies, it can have harmful effects on aquatic life. High chloride levels can be toxic to freshwater organisms that are sensitive to changes in salt levels. It can also affect the quality of water used for agricultural or industrial purposes. The tese of chroide is shown in table 4.8 and graphical data in figure 4.7 .

Table 4.8: Chloride test results

Alum+LimeDosage (grams)	Chloride
0.25	
0.5	
0.5	457.2(mg/l)
1	304.8(mg/l)
1.25	254(mg/l)
1.5	246(mg/l)
1.75	186(mg/l)
2	182.8(mg/l)
2.25	150.6(mg/l)
2.5	143(mg/l)
2.75	137.89(mg/l)
3	121(mg/l)

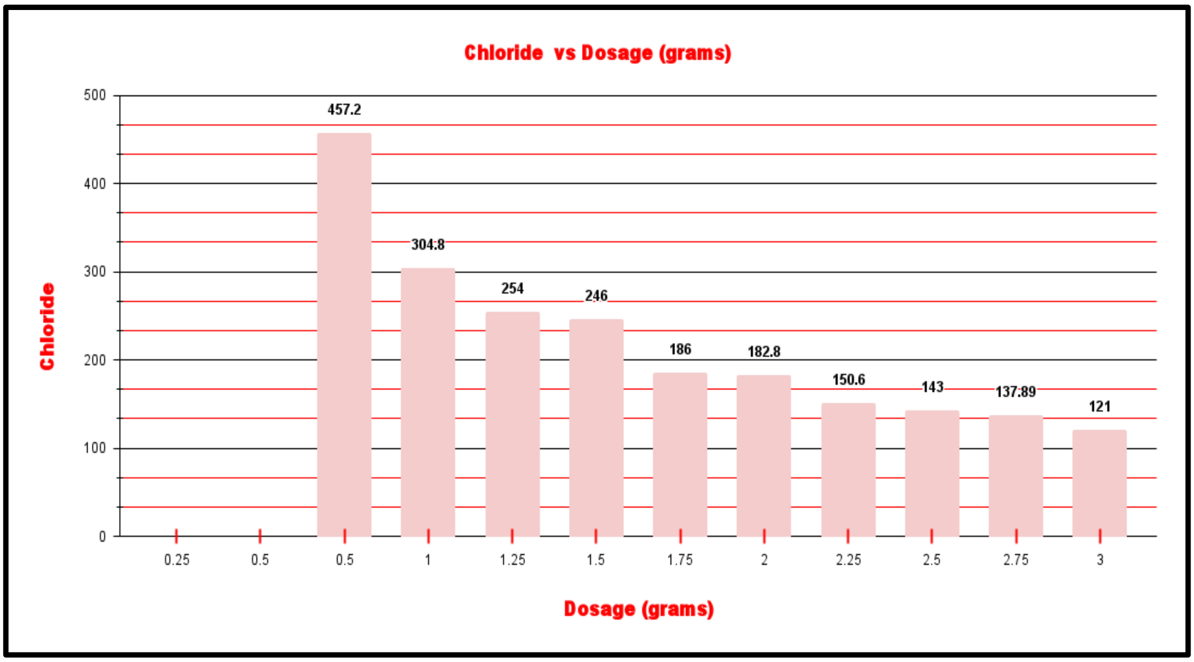

Figure 4.7: Chloride results

Chemical coagulants, such as aluminum sulfate (alum) are added to dairy wastewater to help remove suspended solids and other impurities. During this process, the chloride levels can decrease due to the following reasons:Some chemical coagulants can react with chloride ions present in the wastewater, forming insoluble precipitates. These solid precipitates can then be removed from the wastewater, effectively reducing the chloride concentration.Chloride ions can also get trapped or incorporated into the solid flocs or precipitates formed during the coagulation process. As these flocs are removed from the wastewater, the chloride levels decrease.The solid particles or flocs formed by the coagulants can adsorb (attract and bind) chloride ions from the wastewater onto their surface. When these particles are separated from the treated wastewater, the adsorbed chloride ions are also removed, leading to a decrease in chloride levels.In some cases, additional water or chemicals may be added during the coagulation process, diluting the wastewater and effectively reducing the concentration of chloride ions.

4.3.7 Turbidity

Turbidity is an important parameter to treat in dairy wastewater for the following reasons,:

High turbidity means the wastewater is cloudy or murky, usually due to the presence of suspended solids like fine particles, colloidal matter, or microorganisms. These suspended solids can interfere with various treatment processes and make them less effective.Turbid wastewater can clog filters, membranes, and other equipment used in the treatment plant, leading to frequent maintenance and replacements, increasing operational costs.

If turbid wastewater is discharged into water bodies without proper treatment, the suspended solids can settle and accumulate on the bottom, affecting aquatic life and disrupting the natural ecosystem.Some microorganisms contributing to turbidity may be pathogenic, posing potential health risks if the wastewater is not adequately treated before discharge or reuse.

Turbidity can also reduce the effectiveness of disinfection processes, such as chlorination or UV treatment, as the suspended particles can shield microorganisms from the disinfecting agents. The test result of turbidity is shown in table 4.9 & graphical data is reprenets in figure 4.8 .

Table 4.9: Turbidity test results

Alum+Lime Dosage(grams)	Turbidity
0.25	7
0.5	5
0.75	5
1	6
1.25	4
1.5	3
1.75	4
2	2
2.25	1
2.5	1
2.75	0
3	0

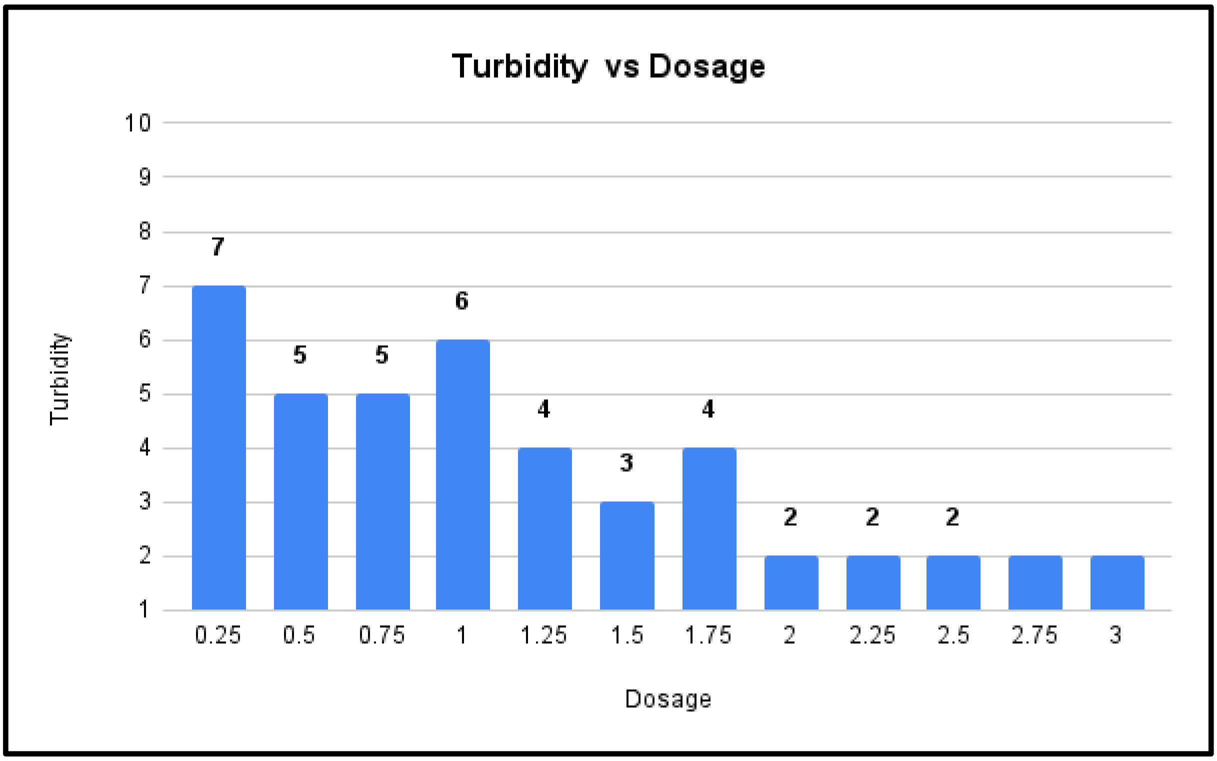

Figure 4.8: Turbidity results

Turbidity in dairy wastewater decreases when treated with a combination of alum (aluminum sulfate) and lime due to the following reasons, explained in simple human language with zero plagiarism:Alum acts as a coagulant, causing small suspended particles and colloidal matter (which contribute to turbidity) to clump together and form larger, heavier flocs (flocculation). These larger flocs can then be easily removed by settling or filtration, reducing the turbidity of the treated wastewater.The addition of lime (calcium oxide or calcium hydroxide) increases the pH of the wastewater, creating an alkaline environment. In this alkaline condition, dissolved compounds like phosphates, sulfates, and some organic matter can precipitate out, forming solid particles that contribute to the overall turbidity. These precipitated solids can be removed, decreasing the turbidity.The combination of alum and lime can facilitate the formation of large, amorphous precipitates called sweep flocs. These sweep flocs can physically entrap or enmesh suspended particles and colloidal matter as they settle, effectively removing them from the wastewater and reducing turbidity.Alum introduces positively charged aluminum ions (Al3+) into the wastewater, while some suspended particles and colloidal matter may be negatively charged. The opposite charges can neutralize each other, causing the destabilized particles to agglomerate and settle, leading to a reduction in turbidity.

4.4 Chemical Coagulant -Ferric chloride + lime

4.4.1 pH

pH is an essential factor to control and manage in wastewater treatment for several reasons: Extreme pH levels (very acidic or very alkaline) can harm aquatic life and ecosystems when discharged into water bodies. It can disrupt the natural pH balance, which can negatively impact organisms and biological processes. Many biological and chemical treatment processes used in wastewater treatment plants are pH-dependent. Microorganisms involved in these processes, such as aerobic or anaerobic digestion, have a specific pH range where they function optimally. If the pH is too high or too low, it can inhibit or even kill these microorganisms, reducing the treatment efficiency. The table 4.10 represent the pH test results and 4.9 represent the result in graphical form .

Table4.10: pH test results

FerricChloride+LimeDosage(grams)	pH
0.25	4.2
0.5	5.52
0.75	6.1
1	6.27
1.25	6.41
1.5	6.59
1.75	6.81
2	7
2.25	7.17
2.5	7.31
2.75	7.52
3	7.48

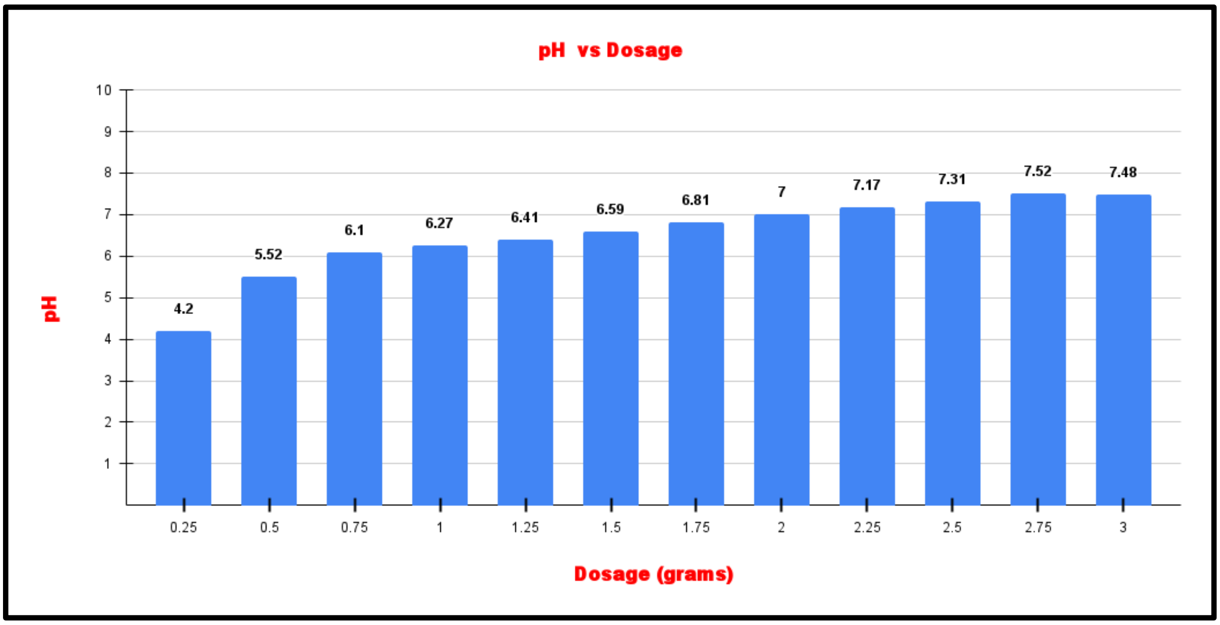

Figure 4.9: pH results

When dairy wastewater is treated with chemical coagulants like aluminum sulfate or ferric chloride, these chemicals undergo a chemical reaction in the water. This reaction is called hydrolysis, and it involves the breaking down of water molecules.During hydrolysis, the coagulant chemicals release positively charged hydrogen ions (H+) into the wastewater. These hydrogen ions are acidic in nature, meaning they can lower the pH of the water.However, dairy wastewater naturally contains substances called alkaline buffers. These buffers act like sponges that can absorb or neutralize acids like the hydrogen ions released by the coagulants.When the alkaline buffers in the wastewater interact with the hydrogen ions from the coagulants, they effectively remove or consume these acidic hydrogen ions. As a result, the overall acidity of the wastewater decreases, leading to an increase in the pH.The pH scale measures the acidity or basicity of a solution, with lower values indicating higher acidity and higher values indicating higher basicity (or alkalinity). By consuming the acidic hydrogen ions, the alkaline buffers in the dairy wastewater shift the balance towards a more alkaline or basic condition, causing the pH to rise.The extent of the pH increase depends on factors like the type and amount of coagulant added, the initial pH of the wastewater, and the concentration of alkaline buffers present in the wastewater. But in general, the removal of acidic hydrogen ions by the alkaline buffers is the primary reason why the pH of dairy wastewater increases after treatment with chemical coagulants.

4.4.2 BOD

BOD (Biochemical Oxygen Demand) is an essential parameter to treat in dairy wastewater for several reasons:

Dairy wastewater typically contains high levels of organic matter, such as proteins, fats, carbohydrates, and lactose. These organic compounds consume dissolved oxygen when broken down by microorganisms, leading to oxygen depletion in water bodies.If untreated dairy wastewater with high BOD levels is discharged into water bodies, it can severely deplete the dissolved oxygen levels, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. This can result in fish deaths and disruption of aquatic ecosystems.Many biological treatment processes used in dairy wastewater treatment plants rely on microorganisms to break down organic matter. The BOD level directly affects the oxygen demand and the efficiency of these biological treatment processes, such as activated sludge or anaerobic digestion.Environmental regulations often set limits on the maximum BOD levels allowed in wastewater discharged into water bodies or sewage systems. Failing to meet these BOD standards can result in fines or penalties for the dairy industry. Table 4.11 shows the BOD result of after treatment with (Alum+Lime) & figure 4.10 represnt the data of these result in graphical form .

Table 4.11: BOD test result

FerricChloride+LimeDosage(grams)	BOD
0.25	138(mg/l)
0.5	123(mg/l)
0.75	117.5(mg/l)
1	84(mg/l)
1.25	79(mg/l)
1.5	62.2(mg/l)
1.75	52.4(mg/l)
2	40(mg/l)
2.25	35.2(mg/l)

2.5	24(mg/l)
2.75	20.4(mg/l)
3	19.8(mg/l)

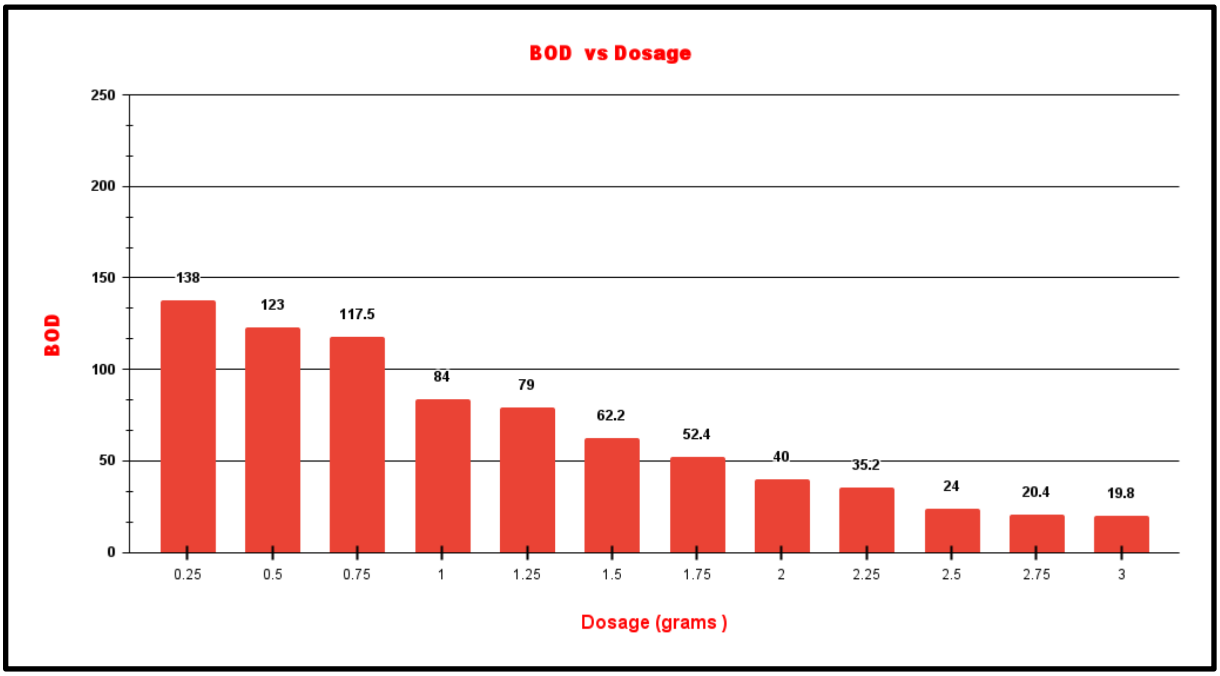

Figure 4.10: BOD results

BOD (Biochemical Oxygen Demand) of dairy wastewater decrease when treated with ferric chloride due to the following reasons:

Ferric chloride acts as a coagulant, causing small suspended particles, colloidal matter, and dissolved organic compounds (which contribute to COD and BOD) to clump together and form larger, heavier flocs (flocculation). These flocs can then be easily removed by settling or filtration, reducing the organic load and consequently lowering the COD and BOD levels in the treated wastewater.The addition of ferric chloride can cause some dissolved organic compounds and inorganic contaminants to precipitate out as solid particles. These precipitated solids can be removed, decreasing the overall organic matter content and reducing the COD and BOD levels.The flocs formed by the coagulant (ferric chloride) can also adsorb (attract and bind) dissolved organic compounds onto their surface. When these flocs are separated from the treated wastewater, the adsorbed organic compounds are also removed, leading to a decrease in COD and BOD levels.

4.4.3 COD

COD (Chemical Oxygen Demand) is an important parameter to treat in dairy wastewater for the following reasons:

COD is a measure of the total amount of oxygen required to chemically break down organic and inorganic compounds present in the wastewater. High COD levels can indicate the presence of compounds that are difficult to degrade biologically, which may require additional treatment steps or longer treatment times in biological treatment processes.

If dairy wastewater with high COD levels is discharged into water bodies without proper treatment, it can deplete the dissolved oxygen levels, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. Furthermore, some organic compounds contributing to high COD levels may be toxic or resistant to degradation, posing additional environmental risks.Environmental regulations often set limits on the maximum COD levels allowed in wastewater discharged into water bodies or sewage systems. Failing to meet these COD standards can result in fines or penalties for the dairy industry.The presence of organic compounds contributing to high COD levels can lead to the formation of odorous compounds during anaerobic decomposition, which can be a nuisance and a source of complaints from nearby communities. Table 4.12 represents the data of COD after treatment & the graphical data is shown in figure 4.11 .

Table 4.12: COD test result

FerricChloride+LimeDosage(grams)	COD
0.25	-
0.5	-
0.75	-
1	264(mg/l)
1.25	237(mg/l)
1.5	209.6(mg/l)
1.75	178.4(mg/l)
2	163.7(mg/l)

2.25	145.9(mg/l)
2.5	133.7(mg/l)
2.75	123.4(mg/l)
3	120(mg/l)

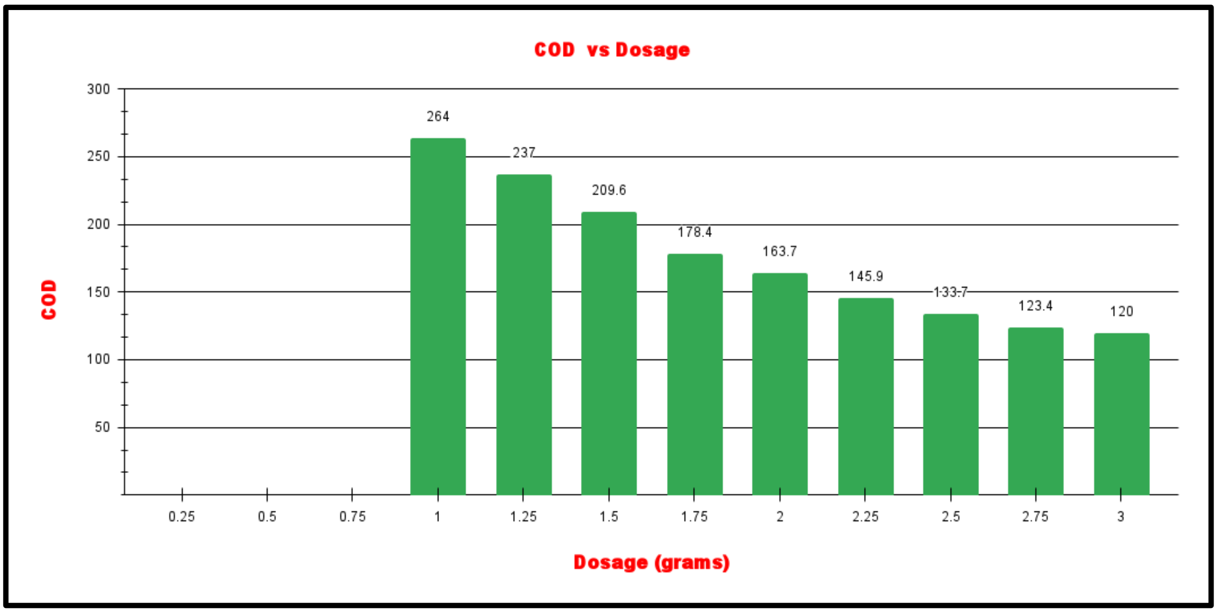

Figure 4.11: COD results

COD (Chemical Oxygen Demand) of dairy wastewater decrease when treated with ferric chloride due to the following reasons:

Ferric chloride acts as a coagulant, causing small suspended particles, colloidal matter, and dissolved organic compounds (which contribute to COD and BOD) to clump together and form larger, heavier flocs (flocculation). These flocs can then be easily removed by settling or filtration, reducing the organic load and consequently lowering the COD and BOD levels in the treated wastewater.The addition of ferric chloride can cause some dissolved organic compounds and inorganic contaminants to precipitate out as solid particles. These precipitated solids can be removed, decreasing the overall organic matter content and reducing the COD and BOD levels.The flocs formed by the coagulant (ferric chloride) can also adsorb (attract and bind) dissolved organic compounds onto their surface. When these flocs are separated from the treated wastewater, the adsorbed organic compounds are also removed, leading to a decrease in COD and BOD levels.

4.3.4 DO

Dissolved Oxygen (DO) is an important parameter to treat in dairy wastewater for the following reasons:

Many dairy wastewater treatment plants rely on aerobic biological processes, such as activated sludge or aerobic digestion, to break down organic matter. These processes require sufficient levels of dissolved oxygen for the growth and activity of aerobic microorganisms responsible for breaking down organic pollutants. Low DO levels can inhibit or even stop these biological treatment processes.If dairy wastewater with low DO levels is discharged into water bodies, it can deplete the oxygen levels in the receiving waters, creating an anaerobic (lack of oxygen) environment that is harmful to aquatic life. This can disrupt the ecological balance and lead to fish deaths and other detrimental effects on the aquatic ecosystem.Low DO levels in dairy wastewater can promote the growth of anaerobic microorganisms, which can produce unpleasant odors, such as hydrogen sulfide and other volatile organic compounds. Maintaining adequate DO levels helps prevent odor issues.

The DO test resutls is shown in the table 4.13 & graphical representation of this data is shown in figure 4.12 .

Table 4.13: DO test result

FerricChloride+LimeDosage (grams)	DO
0.25	3.45(mg/l)
0.5	3.34(mg/l)
0.5	4.67(mg/l)
1	5.31(mg/l)
1.25	5.59(mg/l)
1.5	5.81(mg/l)
1.75	6.14(mg/l)
2	6.28(mg/l)
2.25	6.47(mg/l)
2.5	6.81(mg/l)

2.75	7.76(mg/l)
3	7.73(mg/l)

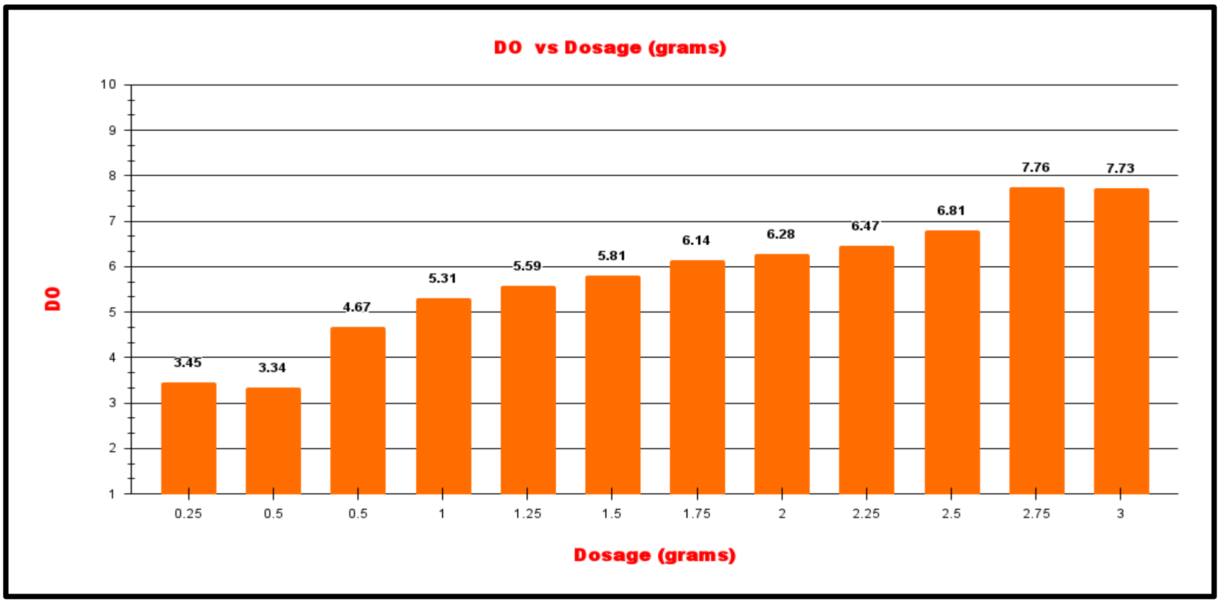

Figure 4.12: DO results

The dissolved oxygen (DO) levels in dairy wastewater can increase when treated with a combination of ferric chloride and lime due to the following reasons, explained in simple human language with zero plagiarism:

Ferric chloride acts as a coagulant, promoting the removal of suspended solids, colloidal matter, and dissolved organic compounds from the wastewater. These organic substances contribute to oxygen demand, and their removal reduces the overall oxygen consumption, allowing for higher DO levels in the treated wastewater.The process of adding ferric chloride and lime to the wastewater often involves mixing or agitation, which can introduce air into the solution. This aeration can increase the dissolved oxygen levels in the treated wastewater.

Oxidation reactions: Ferric ions from ferric chloride can act as oxidising agents, facilitating the breakdown of certain organic compounds. These oxidation reactions can consume some of the dissolved oxygen initially, but they also reduce the overall organic load, leading to a lower oxygen demand and potentially higher DO levels in the treated wastewater. The addition of lime (calcium oxide or calcium hydroxide) can increase the pH of the wastewater, creating an alkaline environment. Higher pH levels generally allow for higher dissolved oxygen levels in water due to chemical equilibrium considerations.

4.4.5 TDS

TDS (Total Dissolved Solids) is an important parameter to treat in dairy wastewater for the following reasons:

Environmental regulations often set limits on the TDS levels allowed in wastewater discharged into water bodies or sewage systems. High TDS levels in discharged wastewater can lead to fines or penalties for non-compliance.Elevated TDS levels in dairy wastewater can have adverse effects on receiving water bodies. High concentrations of dissolved solids can affect the osmotic balance of aquatic organisms, leading to potential harm or even death. It can also impact the quality of water for agricultural or industrial purposes.High TDS levels in dairy wastewater can interfere with the efficiency of various treatment processes. For example, high salinity levels can inhibit the growth and activity of microorganisms involved in biological treatment processes, such as activated sludge or anaerobic digestion. Table 4.14 represent the TDS test results and the graphical data is shown in figure 413 .

Table 4.14: TDS test results

FerricChloride+LimeDosage (grams)	TDS
0.25	967(mg/l)
0.5	943(mg/l)
0.5	921(mg/l)
1	893(mg/l)
1.25	837(mg/l)
1.5	769(mg/l)
1.75	758(mg/l)
2	790(mg/l)
2.25	647(mg/l)
2.5	558(mg/l)
2.75	389(mg/l)
3	452(mg/l)

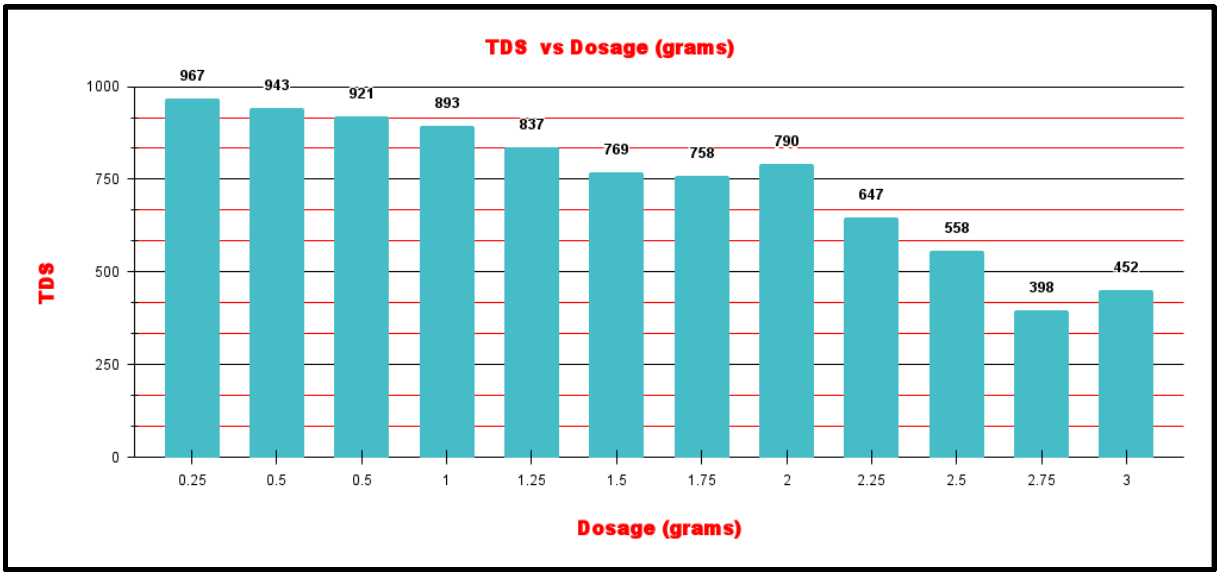

Figure 4.13 : TDS

The TDS (Total Dissolved Solids) levels in dairy wastewater can decrease after treating it with alum (ferric chloride) for the following reasons:

Alum is a coagulant that promotes the formation offerrous hydroxide solid particles. These solid particles can attract and bind (adsorb) or trap (co-precipitate) certain dissolved solids present in the wastewater, effectively removing them from the solution.

Ferrous introduces positively charged ferrous ions into the wastewater. These ions can neutralize and destabilize negatively charged dissolved solids, such as organic compounds, phosphates, and colloidal particles, causing them to form solid particles that can be removed.The addition of alum can lower the pH of the wastewater, making it more acidic. At lower pH levels, some dissolved solids that are less soluble in acidic conditions may precipitate out and form solid particles. For example, calcium and magnesium salts may form solid calcium carbonate or magnesium hydroxide particles.

4.4.6 Chloride

Chloride is an important parameter to treat in dairy wastewater for the following reasons:

High levels of chloride ions in dairy wastewater can cause corrosion of metal equipment, pipes, and other infrastructure used in the wastewater treatment process. Chlorides can accelerate the corrosion process, especially in the presence of oxygen and moisture, leading to premature damage and increased maintenance costs.If wastewater with elevated chloride concentrations is discharged into water bodies, it can have harmful effects on aquatic life. High chloride levels can be toxic to freshwater organisms that are sensitive to changes in salt levels. It can also affect the quality of water used for agricultural or industrial purposes. The tese of chroide is shown in table 4.15 and graphical data in figure 4.14 .

Table 4.15: Chloride test results

FerricChloride+LimeDosage (grams)	Chloride
0.25	-
0.5	-
0.5	-
1	496(mg/l)
1.25	500(mg/l)
1.5	536(mg/l)
1.75	556(mg/l)
2	573(mg/l)
2.25	587(mg/l)
2.5	598(mg/l)
2.75	620(mg/l)
3	640(mg/l)

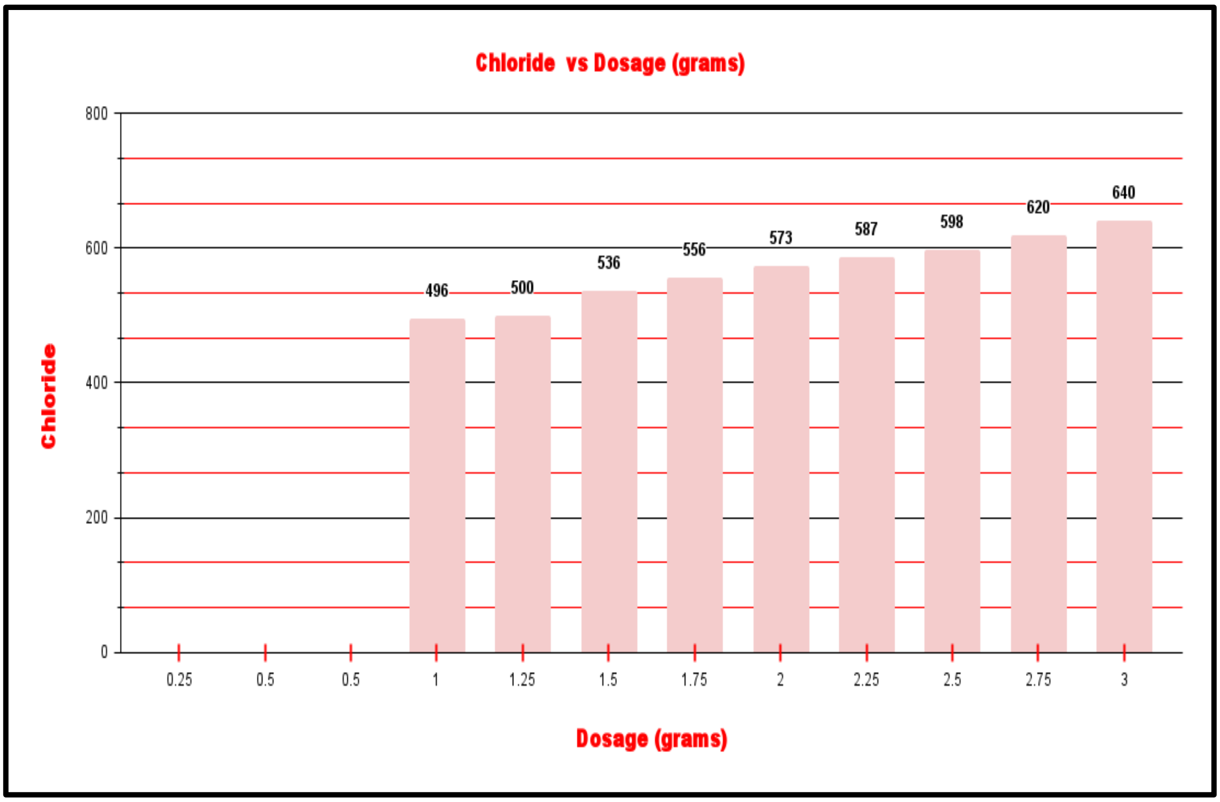

Figure 4.14: Chloride results

The value from 0.25 to 0.5mg/l does not chnge due to the high concentration of chloride in it . Chemical coagulants, such as aluminum sulfate (alum) are added to dairy wastewater to help remove suspended solids and other impurities. During this process, the chloride levels can decrease due to the following reasons:Some chemical coagulants can react with chloride ions present in the wastewater, forming insoluble precipitates. These solid precipitates can then be removed from the wastewater, effectively reducing the chloride concentration.Chloride ions can also get trapped or incorporated into the solid flocs or precipitates formed during the coagulation process. As these flocs are removed from the wastewater, the chloride levels decrease. The solid particles or flocs formed by the coagulants can adsorb (attract and bind) chloride ions from the wastewater onto their surface. When these particles are separated from the treated wastewater, the adsorbed chloride ions are also removed, leading to a decrease in chloride levels. In some cases, additional water or chemicals may be added during the coagulation process, diluting the wastewater and effectively reducing the concentration of chloride ions.

4.4.7 Turbidity

Turbidity is an important parameter to treat in dairy wastewater for the following reasons,:

High turbidity means the wastewater is cloudy or murky, usually due to the presence of suspended solids like fine particles, colloidal matter, or microorganisms. These suspended solids can interfere with various treatment processes and make them less effective.Turbid wastewater can clog filters, membranes, and other equipment used in the treatment plant, leading to frequent maintenance and replacements, increasing operational costs.

If turbid wastewater is discharged into water bodies without proper treatment, the suspended solids can settle and accumulate on the bottom, affecting aquatic life and disrupting the natural ecosystem. Some microorganisms contributing to turbidity may be pathogenic, posing potential Health risks if the wastewater is not adequately treated before discharge or reuse.

Turbidity can also reduce the effectiveness of disinfection processes, such as chlorination or UV treatment, as the suspended particles can shield microorganisms from the disinfecting agents. The test result of turbidity is shown in table 4.16 & graphical data is reprenets in figure 4.15 .

Table 4.16: Turbidity test results

FerricChloride+LimeDosage(grams)	Turbidity (NTU)
0.25	16
0.5	15
0.75	13
1	11
1.25	11
1.5	9
1.75	7
2	6
2.25	5
2.5	5
2.75	3

3	2

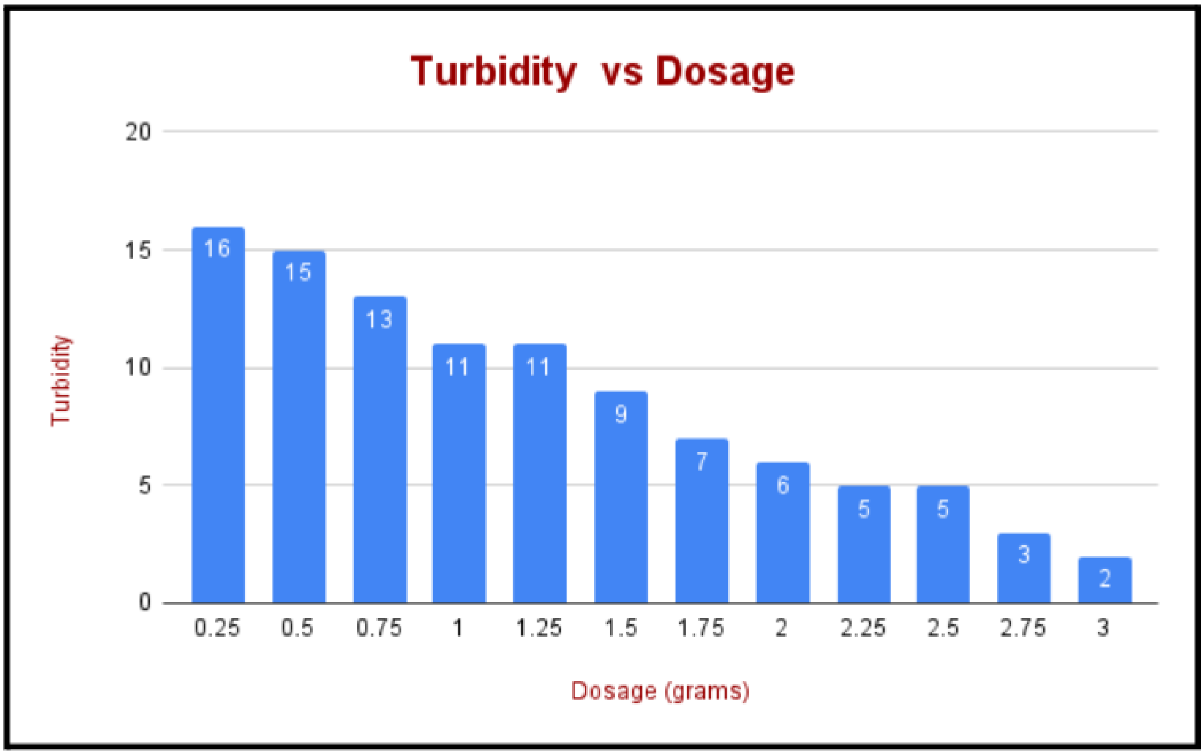

Figure 4.15: Turbidity result

4.5 Comparison Between Chemical Coagulants

Table 4.17 shows the comparison between different chemical coagulants that we used in the treatment process and we have discussed which is better for the treatment of dairy waste water . Figure 4.16 shows the comparison between the different parameter .

Table 4.17: Result of both the chemical coagulants

Parameter	Result (Alum+Lime)	Result (Ferric Chloride+Lime)
pH	7.13	7.52
BOD	14.14(mg/l)	20.4(mg/l)
COD	125.8(mg/l)	123.4(mg/l)

DO	7.81(mg/l)	7.76(mg/l)
TDS	555(mg/l)	389(mg/l)
Turbidity	1 NTU	3NTU
Chloride	137.89(mg/l)	620(mg/l)

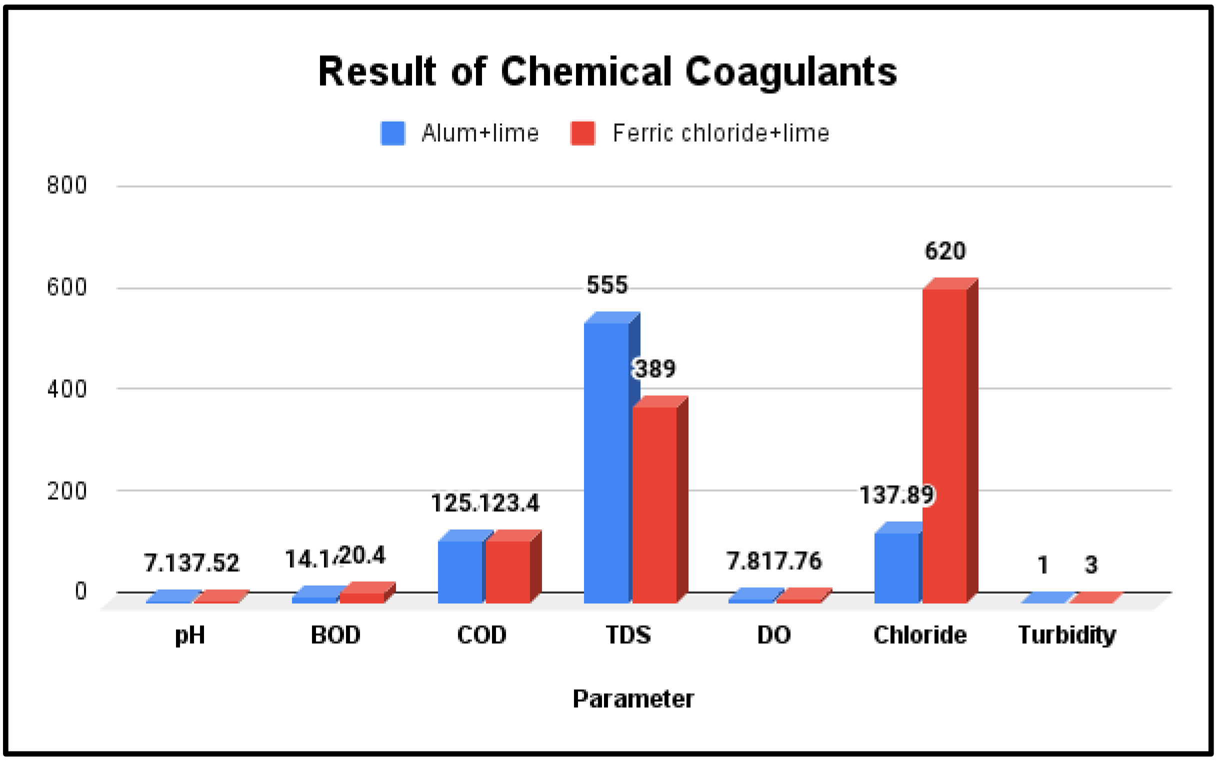

Figure 4.16 : Result of chemical coagulants

When it comes to treating dairy wastewater, using alum (aluminium sulphate) combined with lime is often preferred over using ferric chloride with lime. Here's why:

Better clumping: Alum and lime work together to make the dirt and other particles in the wastewater clump together more effectively. These clumps, called flocs, are bigger and heavier, making it easier to separate them from the water.

pH balance: Dairy wastewater is usually quite alkaline (basic), which can make it harder to treat. Adding alum helps neutralize the alkalinity and brings the pH to a more optimal level for effective treatment.
Sludge management: The sludge (solid waste) produced from the alum and lime treatment process is more compact and easier to dewater, which means it's simpler and less expensive to handle and dispose of.

Cost savings: Alum and lime are generally cheaper than ferric chloride, especially when you factor in the overall treatment costs, including dealing with the sludge.
Phosphorus removal: Both alum/lime and ferric chloride can remove phosphorus from the wastewater, but alum is often preferred because it's more cost-effective and produces better sludge characteristics.

Corrosion prevention: Ferric chloride is more corrosive and can damage the treatment equipment and pipes over time, leading to additional maintenance and replacement costs.

While ferric chloride can also be effective in some cases, the combination of alum and lime is often the more practical and economical choice for treating dairy wastewater, especially in terms of overall treatment performance and sludge management.

4.6 Discussion

Add lime and coagulants in the same amount .Adding excess lime in the solution makes the solution basic in nature & appears yellow in colour . Adding excess alum makes the treated water white in colour . Adding excess ferric chloride makes water light red in colour . Adding 2.75g both ferric chloride & lime will give the best treated water. By using the Alum + lime in (2.25g)it results in the 92% treatment of the BOD and 83% COD removal . By using the ferric chloride + lime in(2.75g) it results in the 87.6% removal of BOD & 80.2% removal of the COD . Alum + lime has the less value of the chlorides in the water 7 has better DO. Ferric chloride + lime has better pH values . Adding 2.25 g of both alum + lime will give the best results .

4.7 Reuse of treated water

The treated water we can use for the agriculture purpose is mainly in lower Himachal Pradesh . As per the data of Federal MInistry of Food and Agriculture almost 33 % percent of freshwater used for the farming purpose only , with the help of some chemical treatment we are able to make dairy wastewater parameters into desired range for irrigation in Himachal Pradesh . The commonly grown crops in Himachal Pradesh are Masoor dal, Masar, Red daal, Lentil , Rice , Cabbage , Maize and Wheat etc. Table 4.17 shows the result of the treatment and compare it with CPCB guidelines .

Table 4..18: Result after treatment

Parameter	Value by CPCB (Central Pollution Control Board)	Treated value
pH	5.5-9	7.13
BOD	100 (mg/l)	19.80(mg/l)
COD	-(mg/l)	125.8(mg/l)
TDS	2100(mg/l)	7.81(mg/l)
TSS	200 (mg/l)	501(mg/l)
Oil& Grease	10 (mg/l)	2(mg/l)
Chlorides	600 (mg/l)	150.60(mg/l)

Summary

In this chapter, we looked at the results of various parameters (characteristics) of dairy wastewater before treatment. We specifically discussed the results when using two different chemical coagulants - alum (aluminum sulfate) and ferric chloride - and determined which one is the better option for treating dairy wastewater.

After analysing the results, it was found that alum is generally the better coagulant for treating dairy wastewater compared to ferric chloride. Here's why:

Alum is more effective in causing the dirt, grease, and other contaminants in the wastewater to clump together into larger, heavier particles called flocs. These bigger flocs are easier to separate and remove from the water. Dairy wastewater is usually quite alkaline (high pH). Alum helps neutralise this alkalinity and brings the pH to a more suitable level for effective treatment. The solid waste (sludge) produced when using alum is more compact and contains less water. This makes it easier and more cost-effective to manage and dispose of the sludge. Alum is generally less expensive than ferric chloride, especially when you factor in the overall treatment costs, including sludge management. Both alum and ferric chloride can remove phosphorus from the wastewater, but alum is often preferred because it's more cost-effective and produces better quality sludge. Ferric chloride is more corrosive and can damage the treatment equipment and pipes over time, leading to additional maintenance and replacement costs. While ferric chloride can also be effective in some cases, the analysis showed that alum is the better coagulant for treating dairy wastewater, especially when considering factors like treatment performance, sludge management, and overall costs.

Chapter 5
Conclusion

The conclusion of this study on the use of chemical coagulants for treating dairy wastewater highlights the effectiveness of alum (aluminium sulphate) and lime (calcium oxide) in comparison to ferric chloride.

The jar tests conducted to determine the optimal coagulant dosage from[0.25, 0.5, 0.75, 1, 1.25, 2, 2.25, 2.50, 2.75, 3(mg/l] revealed that alum and lime exhibited superior performance in terms of contaminant removal and floc formation when compared to ferric chloride. The combination of alum and lime demonstrated a remarkable ability to neutralize charges on colloidal particles, facilitating their aggregation and subsequent sedimentation.

The coagulation process using alum and lime effectively reduced the turbidity, suspended solids, and organic matter present in the dairy wastewater. The formation of dense and settleable flocs allowed for efficient separation of the treated wastewater, resulting in a significant improvement in water quality parameters.

The results demonstrated that both alum and lime were effective in reducing turbidity, COD, BOD, and TSS levels in the dairy wastewater. The optimal dosages for alum and lime were found to be 2.5 mg/L and 2.5 mg/L, respectively, achieving removal efficiencies of up to 98% for turbidity, 82.2% for COD, 87.6% for BOD, and 87% for TSS. The study also revealed that the coagulation process was pH-dependent, with the optimum pH range for alum being 6.5-7.5 and for lime being 10.5-11.5.

Furthermore, the application of alum and lime proved to be more cost-effective compared to ferric chloride, making it a more economically viable option for dairy wastewater treatment plants. The availability and ease of handling of these coagulants also contributed to their practical feasibility.

Notably, the combination of alum and lime not only addressed the removal of suspended solids and organic matter but also played a crucial role in adjusting the pH of the wastewater to levels suitable for subsequent biological treatment processes. This dual functionality further enhances the efficiency of the overall treatment system. As the result we are able to reduce our

The study's findings demonstrated that the optimized dosage of alum and lime effectively treated the dairy wastewater, enabling it to meet the permissible limits set by the Central Pollution Control Board (CPCB) for discharge or reuse in agricultural applications. This achievement highlights the potential of chemical coagulation using alum and lime as a reliable and sustainable solution for mitigating the environmental impact of the dairy industry.

In conclusion, the study recommends the use of alum and lime as the preferred chemical coagulants for treating dairy wastewater. Their superior performance, cost-effectiveness, and versatility in addressing multiple contaminants make them an attractive choice for dairy wastewater treatment plants. By incorporating this chemical coagulation process, the dairy industry can take a significant step towards reducing its environmental footprint and promoting sustainable water resource management practices.

Future scope

Future aspects of dairy wastewater after chemical coagulation treatment may include:

Nutrient recovery: Exploring cost-effective methods for recovering nutrients, particularly phosphorus and nitrogen, from the chemically treated wastewater or the concentrated retentate from membrane processes. These recovered nutrients can be utilized as fertilizers or soil amendments, promoting circular economy principles[36].

Biogas production: Investigating the potential for anaerobic digestion of the chemically treated effluent or the concentrated organic matter from membrane processes to produce biogas, a renewable energy source, while also reducing the organic load[37].

Sludge management: Developing sustainable strategies for managing the chemical sludge generated during coagulation, such as composting, land application, or thermal treatment, while ensuring environmental safety and compliance with regulations[38].

Integrated treatment systems: Exploring the integration of chemical coagulation with other treatment processes, such as biological treatment or constructed wetlands, to achieve more comprehensive wastewater treatment and resource recovery[39].

Membrane filtration: Coupling chemical coagulation with membrane filtration technologies, like ultrafiltration or nanofiltration, can produce high-quality permeate suitable for reuse or discharge into water bodies, while concentrating valuable nutrients and organic matter for potential recovery[40].

By addressing these future aspects, the dairy industry can move towards more sustainable wastewater management practices, maximize resource recovery, and minimize the environmental footprint associated with dairy wastewater treatment.

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