Diary Effluent Treatment Using Membrane Bioreactor

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Abstract- *The dairy industry generates large quantities of wastewater containing high levels of organic matter, fats, oils, proteins, and detergents, leading to significant environmental concerns when improperly treated. Traditional wastewater treatment methods often struggle to meet the stringent discharge standards for such effluents due to their high pollution load. This project focuses on the application of Membrane Bioreactor (MBR) technology for the treatment of dairy effluent, combining biological degradation with membrane filtration to achieve superior effluent quality.*

The study investigates the efficiency of the MBR system in treating dairy effluent by assessing key parameters such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and the removal of pathogens. The biological component of the MBR consists of activated sludge, which facilitates the breakdown of organic matter, while the membrane filtration unit ensures effective separation of solids from treated water. The project aims to evaluate the system's performance under various operational conditions, including hydraulic retention time (HRT), mixed liquor suspended solids (MLSS) concentration, and flux rates.

Preliminary results suggest that MBR systems can achieve high removal efficiencies of over 90% for COD, BOD, and TSS, thus meeting the required discharge standards. Additionally, the project explores strategies for addressing the issue of membrane fouling, which can reduce the system's performance over time. Techniques such as periodic backwashing, membrane cleaning protocols, andoptimizing operational parameters are tested to minimize fouling and maintain membrane efficiency.

This research highlights the potential of MBRs as a sustainable and effective solution for dairy effluent treatment, offering advantages such as compact design, high treatment efficiency, and the potential for water reuse. The findings from this project will contribute to advancing MBR technology for industrial wastewater treatment, with a particular focus on its application in the dairy industry, promoting environmental sustainability and compliance with wastewater regulations.

I. INTRODUCTION

1.1 GENERAL

Water pollution is the introduction of polluted chemical, physical, biological materials, which degrades the quality of the water and affects the organism living in it. Bracklow (2007) reported that the discharge of untreated wastewater is single most important cause for pollution of surface and ground water in India.

Dairy is one of the major agriculture industry and India ranks first in the world in milk production. Dairy industry is one of the industries producing wastewater which is rich in organic matter and thus leading to creation of odorous and high BOD_5. Wash water after the process have high strength of organic content which is the cause for high BOD_5.Wash water composition includes high concentrations of cleaning products, fresh water, milk waste and animal waste. The dairy waste is basically organic and slightly alkaline in nature, when discharged in to streams without treatment, result in rapid depletion of dissolved oxygen (DO) and encourage the growth of algae i.e. eutrophication. Due to the overuse of surfactants in dairy, the waste can become unresponsive to the biological treatment. The dairy industry on an average has been reported to generate 6-10 liters of wastewater per liter of the milk processed. Quality of sewage also plays an important role in design and construction of various treatment units. In this juncture there is a need for treatment of the effluents before discharge in to the environment.

The present study involves the utilization of membrane bioreactor as a alternate method for existing older conventional process. The membrane bioreactor for dairy waste water is simulated using the waste water treatment plant simulation software Hydromantis GPS-X. The result obtained from the simulation is compared with the conventional treatment process and the experimental values of membrane bioreactor.

1.2 THE CONVENTIONAL PROCESS

A typical treatment train for dairy wastewater treatment is generally broken into preliminary, primary and secondary treatment levels, which is shown in figure 2.1.

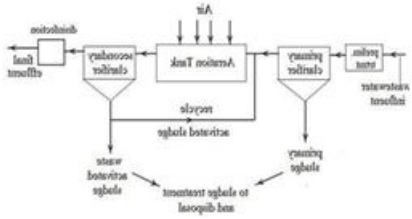

Figure 1.2 Conventional Treatment Process

1.2.1 Preliminary Treatment

During Preliminary Treatment, the influent is strained to remove all large objects that make their way into the sewer system. Generally bar screens, which come in a variety of shapes and sizes, are used to remove the unwanted solid particles. The influent flows across these screens, objects catch on the screens, are raised out of the water and are then raked (either mechanically or manually) off the screens.

Another component of Preliminary Treatment is the grit channel where the velocity of the incoming wastewater is carefully controlled to allow sand, grit, and stones to settle to the bottom of the channel while keeping the majority of the suspended organic material in the water column. The grit is removed from the channel, added to the larger objects removed by the bar screens, and taken to the landfill for disposal.

Preliminary Treatment is vital for preventing damage to pumps and other equipment in the remaining treatment stages.

1.2.2 Primary Treatment

Many plants have a sedimentation stage where the waste water is allowed to pass slowly through large tanks, commonly called primary clarifiers or primary sedimentation tanks. The tanks are large enough that sludge can settle and floating material such as grease and oils can rise to the surface and be skimmed off. The main purpose of primary treatment is to produce both a generally homogeneous liquid capable of being treated biologically and a sludge that can be separately treated or processed. Primary clarifiers are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to further sludge treatment stages. The clarified water flows on to the next step of treatment.

1.2.3 Secondary Treatment

Secondary treatment processes can remove up to 90% of the organic matter in wastewater by using biological treatment processes. The two most common conventional methods used to achieve secondary treatment are attached growth processes and suspended growth processes.

1.2.4 Attached Growth Processes

In attached growth (or fixed film) processes, bacteria, algae, fungi and other microorganisms grow and multiply on the surface of stone or plastic media, forming microbial growth or slime layer (biomass) on the media. Dairy wastewater passes over the media along with air to provide oxygen, and the bacteria consume most of the organic matter in the wastewater as food. Attached growth process units include trickling filters, bio towers, and rotating biological contactors.

1.2.5 Suspended Growth Processes

In suspended growth processes, the microbial growth is suspended in an aerated water mixture where the air is pumped in, or the water is agitated sufficiently to allow oxygen transfer. The suspended growth process speeds up the work of aerobic bacteria and other microorganisms that break down the organic matter in the sewage by providing a rich aerobic environment where the microorganisms suspended in the wastewater can work more efficiently.

In the aeration tank, wastewater is vigorously mixed with air and microorganisms acclimated to the wastewater in a suspension for several hours. This allows the bacteria and other microorganisms to break down the organic matter in the wastewater. Suspended growth process units include variations of activated sludge, oxidation ditches and sequencing batch reactors. After biological treatment, the water is pumped to secondary clarifiers where any leftover solids and the microorganisms sink to the bottom. These solids are handled separately from the supernatant, which continues on to disinfection

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1.2.6 Disinfection

The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment and is almost always the final step in the treatment process regardless of the level or type of treatment used. The effectiveness of disinfection depends on the quality of the water being treated (e.g., Turbidity, pH, ammonia content, etc.), the type of disinfection being used, the disinfectant dosage (concentration and time), and other environmental variables. Turbid water will be treated less successfully since solid matter can shield organisms. Generally, short contact times, low doses, and high flows all

prevent effective disinfection. Common methods of disinfection include ozonation, chlorine, and ultraviolet light.

1.2.7 Chlorination

Chlorination mains the most common form of wastewater disinfection due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines (formed by the combination of chlorine and ammonia) may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically de-chlorinated adding to the complexity and cost of treatment.

1.2.8 Ultraviolet (UV) Light

Ultraviolet (UV) light can be used instead of chlorine. In this no chemicals are used, the treated water has no adverse effect on organisms that later consume it. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement, and the need for a highly treated effluent to ensure that the target microorganisms are not shielded from the UV radiation.

1.2.9 Ozonation

Ozonation is also becoming a popular alternative to chlorine. Ozone (O_3) is generated by passing oxygen (O_2) through a high voltage potential resulting in a third oxygen atom becoming attached and forming O_3. Ozone is very unstable and reactive and oxidizes most organic material it comes in contact with thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than chlorine because it is generated onsite as needed and does not have to be stored.

Ozonation also produces fewer disinfection by-products. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for special operators.

Ozone is also useful at reducing the concentrations of iron, manganese, and sulfur by oxidizing these metals in water to form insoluble metal oxides or elemental sulfur. The insoluble particles are then removed by filtration. Ozonation is also effective at reducing or eliminating most taste and odor problems.

1.3 DISADVANTAGES OF CAS (CONVENTIONAL TREATMENT METHOD

- The conventional treatment process requires large area of land and produce undesirable odors.
- Requires mechanical device to aerate the basins and produces effluent with a high suspended solids concentration.
- Conventional treatment process produces low treatment efficiency and must be pumped.
- It requires landfills for disposal of sludge.
- Disinfection by chlorination again leads to pollution and other disinfection methods like ultraviolet light and ozonation leads to high cost.

The objective of this study is to overcome the limitations of the conventional wastewater treatment process in dairy industry using membrane bioreactor and to produce a high quality effluent, which can be reused effectively.

II. LITERATURE REVIEW

2.1 GENERAL

The dairy industry is one of the largest food processing industries worldwide, producing vast amounts of wastewater with high organic loads, fats, oils, and proteins. Dairy effluent is characterized by high biochemical oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS), which make its treatment complex and costly. Conventional treatment methods, such as activated sludge systems and anaerobic digesters, struggle to handle the high strength of dairy wastewater, often resulting in suboptimal effluent quality.

2.2 Zhao, S., et al. (2020)

Contribution: Zhao and colleagues investigated the performance of MBR systems in treating dairy wastewater, emphasizing the removal efficiencies for COD, BOD, and suspended solids. They also explored operational strategies to mitigate membrane fouling, a common challenge in MBR systems.

Key Focus: Membrane bioreactor performance, fouling control, and optimization of operational parameters in dairy wastewater treatment.

Yang, L., et al. (2019)

Contribution: This study optimized the operating parameters of MBRs, such as hydraulic retention time (HRT), mixed liquor suspended solids (MLSS), and membrane flux, to enhance the treatment of dairy wastewater.

Key Focus: Impact of operational conditions on MBR performance for dairy effluent treatment.

Li, Q., et al. (2019)

Contribution: Li et al. reviewed the membrane fouling mechanisms in MBR systems, with a focus on biofouling and inorganic fouling. They also discussed strategies for fouling mitigation, such as chemical cleaning and backwashing.

Key Focus: Membrane fouling mechanisms and fouling control strategies in MBRs.

Dhanasekaran, D., et al. (2015)

Contribution: This study evaluated the pathogen removal efficiency of MBR systems in dairy wastewater, demonstrating high removal rates of harmful microorganisms such as E. coli and fecal coliforms.

Key Focus: Microbial pathogen removal in MBR systems for dairy wastewater.

Hanjra, M. A., et al. (2020)

Contribution: Hanjra's work discussed the overall benefits of MBR technology for various industrial effluents, including dairy wastewater, highlighting its ability to produce high-quality effluent and its smaller footprint compared to traditional systems.

Key Focus: General benefits of MBR technology in industrial wastewater treatment, including dairy effluent.

Wang, Z., et al. (2017)

Contribution: This paper focused on inorganic fouling in MBR systems for dairy wastewater treatment, particularly the role of calcium and magnesium in scaling, and suggested mitigation strategies.

Key Focus: Addressing inorganic fouling (scaling) in MBRs during dairy effluent treatment.

Gao, B., et al. (2020)

Contribution: GAO Et Al. examined the relationship between mixed liquor suspended solids (MLSS) concentration and MBR performance, showing how varying MLSS affects organic matter removal and fouling.

Key Focus: MLSS optimization to improve MBR performance in dairy effluent treatment.

3.1 GENERAL

In order to accomplish the mentioned objectives the project work has been divided into ten major parts. The following Fig.3.1is a flow chart which describes the study in detailed way.

3.2 MATERIALS

The sample dairy effluent is collected from a dairy industry and maintained at a temperature of 20°C. The simulation of membrane bioreactor is done by Hydromantis GPS-X software version 6.0

3.3 PHYSICAL PARAMETERS

3.3.1 pH

The apparatus is calibrated with standard buffer solutions to check the linearity of the response of the electrode at different pH values and to detect a faulty glass electrode. The standardization of the apparatus with only a single solution may be completely erroneous and therefore at least two standard buffer solutions should be used for calibration. The presence of a faulty electrode will be detected by failure to obtain a reasonably correct value (± 0.04 unit) for the pH of the second standard solution when the apparatus has been standardized in terms of the first standard. A cracked electrode will yield pH values that are essentially the same for both solutions. If the difference between the known and the observed pH values for the second solution exceeds ± 0.04, another glass electrode should be substituted. If the difference persists, fresh standard solutions should be prepared.

After the apparatus has been calibrated, thoroughly wash the electrodes and the cup. Fill the cup with a portion of the solution to be tested and obtain a preliminary value for the pH. In general, this value will drift and is regarded as an approximation. Subsequent readings taken on additional portions of the same solution will yield successively more constant pH values. In the case of solutions that are well buffered, 3 portions may be sufficient to yield pH values that are reproducible to ± 0.04 unit and that show drifts of less than

± 0.04 unit in 1 or 2 minutes. In the case of very dilute or unbuffered solutions, as many as 6 portions of the test solution may be required, and the pH values may continue to drift and be reproducible to only ± 0.05 unit.

If a precision greater than 0.1 pH unit is desired, the temperature of the standard solutions, the glass and calomel electrodes, and the test solutions must be within 2 °C of one another, and the electrodes, standard solutions, test solutions, and wash water must be kept at the temperature of measurement for at least 2 hours prior to making the measurement in order to reduce to a negligible value the effects of thermal or electrical hysteresis of the electrodes.

3.3.2 Turbidity

The turbidity was determined using the nephlometer. The sample was poured into the turbidity meter tube after all the bubbles have dispersed. If sample is very cold, it is allowed to reach the room temperature before testing. The sample is diluted with turbidity free distilled water. To correct for color, apportion of well shaken sample is passed through filter paper. The turbidity of filtrate is measured and is subtracted from the unfiltered sample. The resulting value is the turbidity of the sample. The turbidity is expressed in terms of NTU.

3.3.4 Temperature

The temperature of waste samples was measured using thermometer at room temperature (29°C).

3.4 CHEMICAL PROPERTIES

3.4.1 Chemical Oxygen Demand (COD)

The COD was determined as per APHA standards. Ten ml of the sample were taken in a100 ml bottle then 5 ml of conc. $H_2SO_4$was added and about 1g of copper sulphate (CuSO4) also added. Then 3 ml of prepared N/40 KMnO4solution was added and immersed the bottle in boiling water for 30min while keeping the surface of the boiling water at the higher level than the surface of the sample. Then 3ml prepared N/40 sodium oxalate (Na2C2O4) was added and immediately titrated with N/40 potassium permanganate (KMnO4) until violet colour appeared then repeated for the blank separately under same condition using 10 ml of distilled water instead of 10 ml of sample. Then,

$$COD\ as\ mg\ O2/L = \frac{(1/40) * 8000 * (A - B)}{ml\ of\ sample}$$

3.4.2 Biological Oxygen Demand (BOD5)

The BOD5 was determined using Winkler method as described by APHA. Two 100 ml bottles was obtained with lid and cleaned well. 25 ml sample was taken in each bottle and 75 ml of distilled was added to the two bottles. Then the two bottles closed well .One bottle was kept in the incubator at (20-22) °C for 5 days. Then 10 ml of manganese sulphate solution and 2 ml of alkali- iodide solution were added to the other bottle well below the surface of the liquid by using a syringe. Then the bottle closed and mixed by inverting the bottle several times. When the precipitate settles leaving a clear supernatant above the precipitate shaked again slowly by inverting the bottle, and when the setting has produced at least 50 ml supernatant 8 ml of con. $H_2SO_4$was added.

Then the bottle was closed and mixed by gentle inversion until dissolution was completed. Then 100 ml of the sample was titrated with 0.05 M Na2S2O3solution until a pale yellow solution is reached.

Then 2 ml of freshly prepared starch solution was added and titration was continued until a blue colour appeared. The procedure was then repeated using 100 ml distilled water (blank). Then, repeated for incubated sample after 5 days. The BOD5 was calculated as follows:

$BOD5\ as\ mg\ O2/L$ = 16($V1$- $V2$)
Where,

V1 = ml of Na2S2O3used for the sample before incubation and V2 = ml of Na2S2O3used for the sample after incubation.

3.4.3 Total Suspended Solids (TSS)

The total suspended solids were determined according to the method described by APHA. Cleaned crucible with filter paper was ignited to constant weight in an oven (W1). Then 25 ml sample was taken and filtered through the crucible. Then the crucible was dried in a constant temperature oven maintained at 103°C for 24 hours. Then cooled in a dedicator and weight (W2). The suspended solids were then calculated as follows:

$$Suspended\ solid = \frac{W2 - W1}{V} * 100\ mg/L$$

3.4.4 Total Dissolved Solids (TDS)

Total dissolved solids were determined by evaporating the waste samples to dryness. In this method 50 ml of sample were transferred to a weighed evaporating dish,

and evaporated to dryness by heating for 1-2 hours at 180°C to a constant weight. Total dissolved solids were calculated as follows:

$$TDS\ mg/l = mg\ residue * 1000\ ml\ of\ sample$$

3.4.5 Total Solids

The total solids and volatile solids of the samples were determined as follows. Cleaned dish was taken and ignited to constant weight (W1). Then 25 ml of well-mixed sample transferred to the above dish. Then the sample evaporated to dryness at 103°C for 24 hours, in constant temperature oven. Then cooled the dish in a desiccators and weight was determined (W2). Then the dish was ignited at 600°C in furnace for 30 min. The total solids content was calculated as follows:

$$Total\ solids = \frac{W2 - W1}{V} * 100\ mg/l$$

3.5BIOLOGICAL PROPERTIIES

Determination of Total Caloriform Bacteria

Step1: Sterilize all equipment using either alcohol or an autoclave.

For pieces of equipment, which do not seal closed (such as pipettes, graduated cylinders, Petri dishes, and filtration units), the openings should be covered with metal foil before sterilization. This will prevent sterilized glassware from becoming contaminated before use.

To sterilize by autoclaving, partially loosen all caps or stoppers on the glassware to prevent pressure build up inside the containers. Then the equipment should be autoclaved at 121°C for 15 minutes. After sterilization, be sure that the pressure has returned to zero before the autoclave is opened since residual pressure can cause injuries and loss of sterilized lids.

Step 2: Prepare Petri dishes.

Step 3: Choose an appropriate sample size. An ideal sample size will result in 20 to 80 coliform colonies per dish.Once an appropriate sample size has been chosen, carefully collect a representative water sample and record the sample size in the Data section. Enough water shall be collected from each source to run three separate samples through the filtration apparatus.

Step 4: The filtration apparatus for the counting of total coliform bacteria is arranged as shown below.

Figure 3.5.1 Overhead view of the base of the filtering apparatus

Membrane filter is placed in the bottom piece of the filtration unit, as shown in Figure 3.5.1The grid side of the filter should be facing up. Sterile forceps should be used whenever you handle the membrane filter to prevent contamination and damage to the filter.

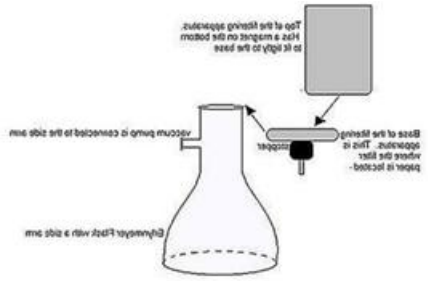

Figure 3.5.2 Experimental setup of membrane filter

Next, place bottom of the filtration unit in the mouth of the filtering flask. Then place the top of the filtration unit onto the bottom. The stopper should seal the bottom of the filtration unit into the flask and the magnet in the filtration apparatus should seal the top and bottom together which is shown in Figure 4.2.

Finally, attach a hose to the side arm of the filtering flask. Attach the other end of the hose to the vacuum pump. The completed setup is shown in Figure 3.5.3.

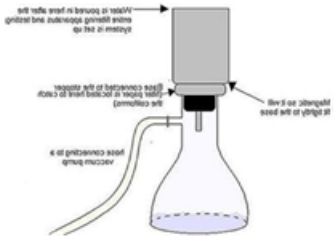

Figure 3.5.3 Sample water Filtration

Step 5: Filter the sample water.

Pour your water sample into the top of the filtration unit and turn on the vacuum pump. All of the water should pass through the filter and into the flask.

Rinse the interior surface of the funnel by filtering three 20 or 30 mL portions of sterile distilled water through

the unit. Once the water has passed through the filter, turn off the vacuum pump.

Step 6: The membrane filter is placed in the Petri Dish.
Take off the top of the filtration apparatus, exposing the membrane filter. Then, using sterile forceps, remove the membrane filter.

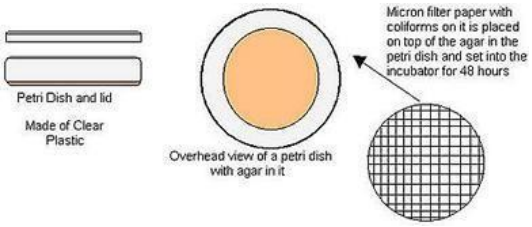

Figure 3.5.4 Culture medium in Petri plates

Place the membrane filter on the medium in a Petri dish using a rolling motion to avoid entrapment of air. The grid side of the membrane filter should be up.

Pour a small amount of sample water into the Petri dish on top of the membrane filter. The sample water will prevent the bacteria on the filter from going into shock.

Place the lid back onto the Petri dish. Seal the dish by placing two pieces of tape around the dish. The tape should go from the top of the dish to the bottom of the dish, like the ribbon on a present. Placing the tape around the edge of the dish will prevent air flow into the dish and will kill the bacteria. The Procedure from step 4 step 6 is repeated until three filtered samples is collected.

Step 7: Incubate the Petri dishes. Invert each dish and place the dishes inside an incubator at 35+0.5°C for 24 hours. This allows the bacteria captured by the filter to grow and form a visible colony.

Step 8: Count the number of colonies found on each filter. After the incubation period has been completed, take each petri dish out of the incubator and remove the lid from the dish. The surface of the medium should have growths of both coliform and other bacteria present.

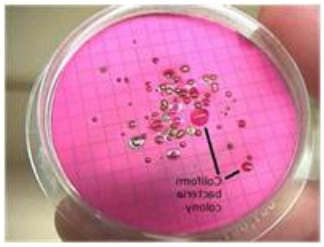

Figure 3.5.6 Coliform Bacteria Colonies

Chemicals present in the media will normally reduce the number of non-coliform colonies present to a minimum. In addition, colonies of coliform bacteria will have turned a pink or dark red color with a metallic surface sheen. You should count only bacteria with this coloring and sheen to ensure that you do not count other types of bacteria. (Some commercial media cause the coliform bacteria to turn other colors, so you should always read the instructions before counting coliform colonies.)

Set the dissecting microscope to a 10 to 15x magnification and use the microscope to help count the number of colonies found in the Petri dish. The Figure 4.6 illustrates one method of counting colonies, which should insure that all areas of the filter are observed.

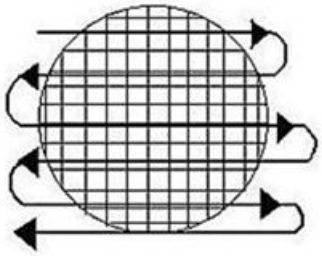

Figure 3.5.7 Colony Counting Technique

Once you have counted the number of colonies found on the filter, record the number in the Data section. Filters, which show a growth over the entire surface of the filter with no individually identifiable colonies, should be recorded as "confluent growth." If the number of colonies counted is greater than 80 or less than 20 per filter, then an incorrect sample size was chosen. You should choose a larger or smaller sample size and repeat the above procedure.

Step 9: Calculate the coliform density of each filter using the following formula and record the results in the Data section.

Coliforms/1000ml = (Number of colonies counted *100)/ (Sample size, ml).

Step 10: Calculate the average coliform density from all three samples.

When calculating the average coliform density, operators usually use a geometric mean rather than an arithmetic mean. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or very low values, which might be the result of an improper procedure. A geometric mean can be calculated using either of the two methods outlined below. These methods are also often used to calculate the average coliform density over time.

3.6 SIMULATION

3.6.1 Conventional Activated Sludge Process

The simulation of conventional activated sludge process is carried out using the construction of a construction of a conventional activated sludge treatment plant using the model available in the library of the Hydromantis GPS-X. The flow sheet of the conventional activated sludge treatment plant is shown below.

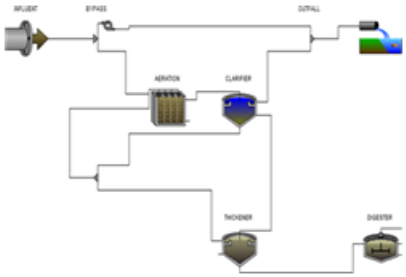

Figure 3.6.1 Flow sheet of the CAS process

3.6.2 Membrane Bioreactor

The simulation of conventional activated sludge process is carried out using the construction of a construction of a membrane using the model available in the library of the Hydromantis GPS-X. The flow sheet of the membrane bio reactor is shown below.

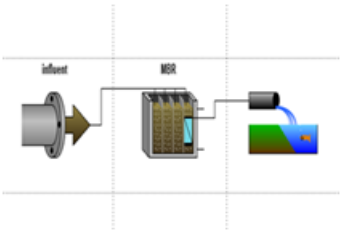

Figure 3.6.2 Flow sheet of MBR

IV. MEMBRANE BIOREACTOR

Membrane bioreactor is the combination of biological reactor with a membrane process to produce high quality dairy effluent. The membrane bioreactor involves the separation and retention of solids; for bubble less aeration within the bioreactor and for extraction of priority organic pollutants from industrial wastewaters. Membranes, coupled to biological processes, are used as a replacement for sedimentation i.e., for separation of biomass. The membrane bioreactor process is shown in the Figure 3.1.

A membrane can be thought of as a material in which one type of substance can pass through more readily than others, thus presenting the basis of a separation process. It is therefore the property of the membrane to separate components of the water to be treated, which is of key interest when selecting or designing membrane separation systems duties arising as such in the water industry. For many processes the membrane acts in a way to reject the pollutants, which may be suspended or dissolved and allow the purified dairy wastewater water through it.

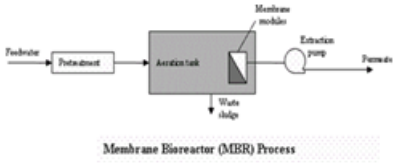

Figure 4.1 Membrane bioreactor process

4.1 MEMBRANE FOR BIOREACTORS

The range of available membrane materials is very diverse. They vary widely both in chemical composition and physical structure, however the most fundamentally important property is the mechanism by which separation is actually achieved. The membrane used in this study is an ultrafiltration membrane (0.2 micron) made up of polypropylene.

4.2 .MEMBRANE PROCESS

There are two popular types of MBR processes. A submerged system consists of an ultrafiltration (UF) membrane with pore sizes ranging from 0.1 – 0.4 microns. These membranes are submerged in the reaction tanks, with the wastewater being drawn into the membranes using a pump. These systems will treat a side stream of the mixture in the aeration tank. This type of system requires a high amount of pumping power to keep the velocities high to prevent membrane fouling, and high pressure to force the water through the membrane. In addition, tubular systems have a larger footprint than submerged systems due to the external location of the membranes.

The MBR replaces the secondary clarification. The sub- merged membranes are typically placed directly into the existing aeration tank. The membranes allow the purified water to pass through the pores, while creating a complete barrier to the passage of any solid greater than 0.2-microns, which includes almost all bacteria. The permeate is drawn through the membranes using a suction lift pump leaving the suspended biomass material in the aeration tank. Biomass is removed using a sludge pump on an as-required basis.

SIMULATION OF MEMBRANE BIOREACTOR

The industrial wastewater treatment plants can be simulated with the design software called Hydromantis GPS-X.The Hydromantis GPS-X is a modular, multi-purpose modeling environmental for the simulation of municipal and industrial wastewater treatment plants. The GPS-X is capable of simulating the conventional and membrane bioreactor for the given influent characteristics. It has the provision to analyze the different operating conditions under different load conditions and the result produced by this method is more reliable.

V. RESULTS AND DISCUSSION

The dairy effluent is collected and stored at a temperature of 20°C and the various Physical, chemical and biological characteristics of the wastewater were determined.

The pollution control board recommends a pH of 6.5 to 8.5 for food processing and dairy industries. The pH of the sample collected is 7.5, which is agreeable as per the pollution control board as shown in Figure 5.1

From Figure 5.2 the Turbidity of the dairy wastewater is 49 NTU that is very much higher than the agreeable limits of pollution control board, which demands a turbidity of 5 NTU. The high value of turbidity indicates the presence of high amount of impurities.evident that the TSS, TDS, TS, BOD5, COD are very much higher than the value recommended by the pollution control board. The TSS, TDS, TS, BOD5 and COD for dairy wastewater is 222, 1442, 1664, 649.6 and 1504 mg/l respectively. But as per the pollution control board norms these values should be below 100, 500, 600, 30 and 250 mg/l respectively.

The higher values of these parameters need an efficient wastewater treatment plant which would produce the effluent wastewater in accordance with the pollution controls board standards to release into the water bodies The characteristics of wastewater shown in Table 5.1 are used as the characteristics of influent waste water to simulate the conventional activated sludge process and membrane bioreactor. It is apparent from Table 5.2 that the MBR produced superior quality outlet wastewater than the CAS. The Table 5.2 shows the removal of TSS, BOD5, COD, Ammonia and TKN achieved by MBR and CAS.

It can be seen that the value of TSS in the outlet of MBR is 3.13 mg/l whereas CAS has a value of 33.57 mg/l. Also the COD and BOD5 of CAS are 120.18 mg/l and 13.82 mg/l which is greater than the MBR which has 54.16 mg/L and 9.6 mg/l respectively. The Ammonia and TKN values for CAS is 65.08 mgN/l and 92.91 mgN/l, which is very much higher and does not meet the requirements of pollution control board. On the other hand, the outlet wastewater from MBR contains a lower level of Ammonia (5.12 mgN/l) and TKN (6.42 mgN/l). Thus the effluent waste water produced by the membrane bioreactor meets the requirements of pollution control board.the removal efficiency of MBR and CAS in percentage. The TSS removal efficiency of MBR is 98.58 %, which shows a significant improvement from the CAS‟s TSS removal efficiency of 84.87 %. Both the MBR and CAS have achieved a similar range of BOD5 removal. The removal efficiency of BOD5 for MBR and CAS are 96.79 % and 95.39 %. The COD removal by MBR is superior to the CAS as MBR achieved 92.27 % removal and CAS achieved 82.85 % removal. The ammonia and nitrogen removal efficiency is again higher for MBR, which is 98.99 % and 98.88 % in comparison to the 87.28 % and 83.85 % achieved by CAS.
Hence the membrane bioreactor has produced far superior quality wastewater than the CAS and the characteristics are well within the norms of the pollution control board. Thus membrane bioreactor can be used to treat the wastewater from dairy industry, which is rich in organic matter to produce a high quality effluent. The Wastewater treated by CAS is not in accordance with the pollution control board and cannot be released into the environment. If the waste water produced by CAS is released into the environment, it poses a major threat to the environment. Whereas the wastewater treated by the MBR can be released into the environment and it will not pose any threat of environmental pollution. The use of single membrane for the experiment, the MBR produced a high quality effluent. Certainly, these characteristics can be further improved if the membrane module is used instead of a single membrane. Membrane module contains 10 to 16 membranes attached together and is used in the production of membrane bioreactor.

Dairy industry is the major source of effluent wastewater in agriculturalist country like India and the treatment plant in dairy industry needs improvement. It is apparent from the Table 5.2 and Table 5.3 that the membrane bioreactor produces high quality effluent wastewater which can be released into the environment. Also the membrane bioreactor can be easily incorporated into the existing conventional treatment plant which reduces the installment cost. cost analysis for the conventional reactor and membrane bioreactor for the treatment of 5000 liters of effluent per day. The cost of membrane is higher but the membrane bioreactor requires half the land area than the conventional reactors and results in low capital cost. The membrane bioreactor needs less manpower to operate and needs less maintenance leading to low operating and maintenance cost than conventional reactors.

VI. CONCLUSION

The effluent sample were collected and analyzed as per the APHA standards.

The extensive literature study on the treatment of dairy effluent was made and compared.

Membrane Bioreactor is selected as an alternate process to treat the dairy effluent water.

Before going for implementation of membrane bioreactor, the simulation studies were carried out.

The simulation studies were carried out using Hydromantis GPS-X for conventional reactor and membrane bioreactor. The pH, TSS, TDS, BOD5, and COD of the influent wastewater was 7.5, 222 mg/L, 1442 mg/L, 649.6 mg/L and 1504 mg/L respectively.

The MBR treated effluent was analyzed and the quality of treated wastewater is compared with the conventional method.

From Table 5.2 it can be seen that the percentage removal of TSS, TDS, TS, BOD5 and COD for MBR was 98.6, 96.8, 92.2, 98.9 and 98.8 respectively whereas the percentage removal for conventional method are 84.8, 95.3, 82.8, 87.28 and 83.8 respectively.

The cost for membrane bioreactor is low when compared with the conventional reactors. Hence it is recommended to embed MBR with conventional treatment system to improve the efficiency of treatment process.

In conclusion, the MBR system is a promising alternative to conventional dairy effluent treatment technologies, offering both technical and environmental benefits. It enables dairy plants to reduce their environmental impact, conserve water, and ensure compliance with discharge standards, ultimately contributing to the sustainability of the dairy industry. The ongoing optimization of the MBR process and addressing operational challenges like membrane fouling will ensure its continued success in wastewater treatment applications.