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Treatment of Dairy Wastewater and Sludge Production Using Algae Bio Reactor

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Abstract: The primary goal of this research is to evaluate the treatment of dairy effluent from a Coimbatore industry sector utilising algae bioreactor techniques. The activated sludge process is a biological wastewater treatment process for treating industrial wastewater for reducing solid particles and simultaneously treating dairy wastewater under aerobic conditions. In this present study, an aeration tank is designed and fabricated for the treatment of wastewater and sludge production by inoculating green algae. The algae bioreactor is operated continuously for 30 days by supplying oxygen. The wastewater characteristics are tested for their concentration to find the removal efficiency of the aerobic tank. This study attempts to reduce the pollutant concentration and CO_2 emission from wastewater as well as produce fertilisers from this treatment. This method of treatment is sustainable and eco-friendly.

Key words: Dairy wastewater, green algae, activated sludge process, microbial action, aerobic treatment.

Introduction

Dairy is one of the industries which have a chain process like production, packing, storage, transportation, distribution, and marketing (Karunanidhi et al., 2021; Venkatesan et al., 2023a). Dairy wastewater is generally high in organic matter such as proteins, carbohydrates, and lipids, has a high suspended oil and grease content, a wide range of hydrogen power, a high concentration of suspended solids, a high BOD and COD, and a high nitrogen content. The discharge of effluent from dairy plants to water resources can lead to the destruction of aquatic plants, animals, and life. The effluent affects the aesthetic view (Aishwarya et al., 2014a; Venkatesan et al., 2016a, 2016b; Venkatesan et al., 2022). In recent years, the consumption of milk and the number of dairy industries has increased in India. Generally, 6.5 MLD is generated from 22 units. The waste effluent must be treated for disposal or reused again in this process. The dairy industry is an important economic sector, but the pollution potential of activities may consist of organic proteins, lipids, carbohydrates, lactose, oil and grease, raw effluent like biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total organic carbon (TOC), total dissolved solids (TDS), phosphorous, nitrogen is in the range of value which is harmful to human and environment. Moreober, in the Dairy industry, many byproducts such as buttermilk, milk cream, ice cream, milk powder, etc, which contain fat, oil, and grease

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(Aishwarya et al., 2014b; Li et al., 2017). The majority of waste is produced while production and cleaning too. The conventional treatments for treating effluent are aerobic and anaerobic, in that there are many processes like the activated sludge process, trickling filters, aerated lagoons, and a combination of all. But now the aerobic process is used widely. The activated sludge process is a biotic therapy process for reducing solid particles in the effluent with the help of an aeration tank (Li et al., 2020).

Algae are a diverse group of photosynthetic eukaryotic organisms. It exhibits a wide range of reproductive strategies by sexual and asexual reproduction. Algae inadequacy is seen in the various structures that characterise land plants, such as the leaf, plant, roof, and coral reefs (Venkatesan et al., 2020b; Venkatesan et al., 2014). It can be categorised into seven breeds, each with unmistakable size, functions, and colour. The disparate cleaving includes Chlorophyta (Green algae), Chrysophyta (Golden brown algae), Euglenophyta (Euglenoids), Phaeophyta (Brown algae), Pyrrophyta (Fire algae), Rhodophyta (Red algae) and Xanthophyta (Yellow-green algae) (Rai et al., 1987; Venkatesan et al., 2020a).

It acts as a stabilising agent. Algae are collected from local ponds and well there is a wide-scale concoction of green algae (Ma et al., 2019; Venkatesan et al., 2020c; Sivaramakrishnan et al., 2017b). It is an agar medium. It stabilises the milk product to reduce a large number of chemicals and carbon-dioxide emissions through microbial activity (Venkatesan et al., 2018). The algae absorb light energy from the sun and convert it to chemical energy. The filamentous algae is grown in long chain or threads and look like wet wool (Venkatesan et al., 2019). It grows at the bottom of the rocks on sticks and it floats along the surface of the water like a carpet. Algae grown on wastewater channels are potential sources of lipids. the task of micro organism is to utilise the CO_2 from the atmosphere and uses it as a source to grow (Sivaramakrishnan et al., 2017a; Sivakumar et al., 2014; Venkatesan et al., 2012). Microalgae can attach CO_2 from three contrasting sources, discharge gases, and atmospheric CO_2 soluble carbonate (Shanmugam et al., 2020). During the time of photosynthesis task, microalgae exploit CO_2 from the atmosphere as a carbon source to grow and release oxygen. The wastewater collected from the dairy industry is treated by using an algae bioreactor. The main objective of this study is to develop an efficient treatment for pollutant removal and production of biomass (sludge) in dairy wastewater effluent by using microalgae (Venkatesan et al., 2016). Another motivation for this study is to use the treated water for agricultural and other external uses.

Methodology

Samples of water should be gathered in 220 L containers every 3 hours for 12 hours. The test specimens shall be treated immediately. The initial design is based on the conventional aerobic-activated sludge process. This design may be modified, to achieve as high SRT as possible based on the constraints required. The influent stream is divided into two parallel treatment lines, which follow the same treatment sequence (Figure 1 presents the methodology).

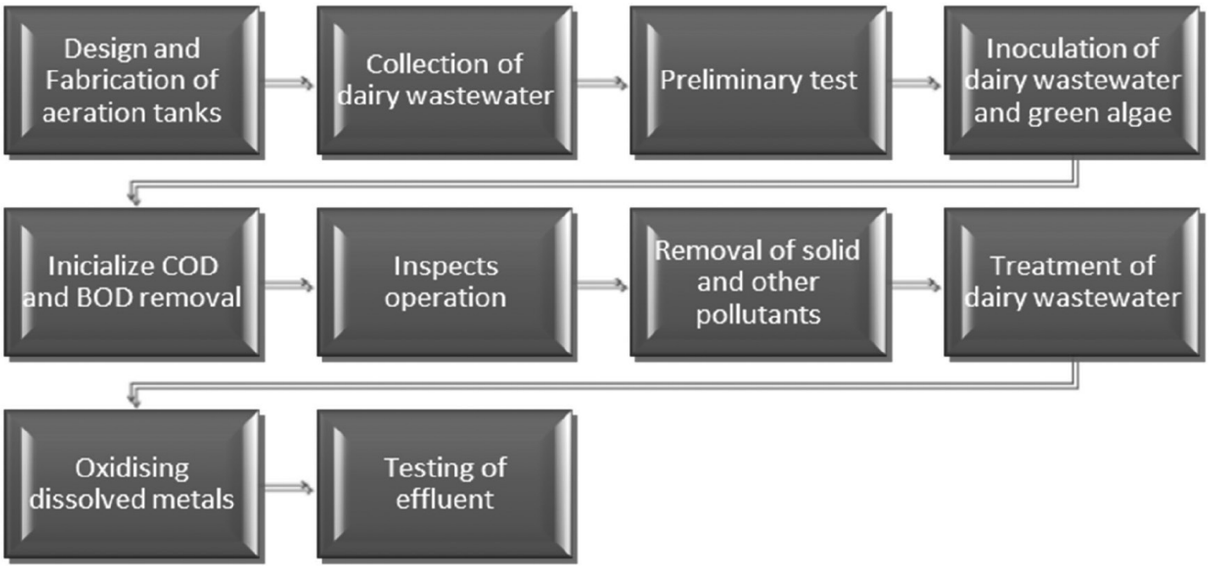

Figure 1: Methodology.

Design and Fabrication of Aeration Tank

Aeration is an activated sludge process based on pumping air into a tank, which promotes microbial growth in the wastewater. By examining raw wastewater for five days, the biochemical oxygen demand, or BOD is determined. A five-day test of BOD that escaped treatment, can be conveniently described as the necessary effluent suspended particles. A qualified laboratory shall supply the following size parameters: kinetic coefficient of yield, Y, and kinetic coefficient of decay, kd. Three variables are yet unknown: hydraulic retention time, SRT, and mixed liquid volatile suspended solids, MLVSS, or Xv (Figure 2 represents the design model for the aeration process).

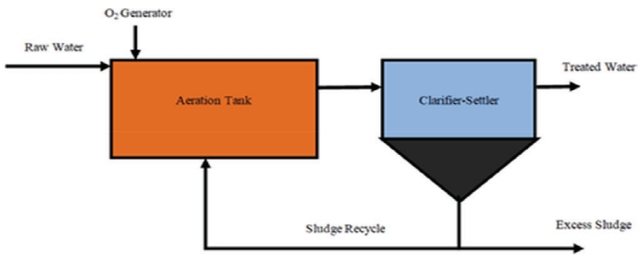

Figure 2: Design-model.

(SRT*Y*(BODi – BODesc))/(HRT*(1 + SRT*kd)) = Xv

This research proposes using MS Excel, or simply Excel, to calculate the quantity of Xv produced in the reactor for all conceivable values of HRT and SRT for the kind of AS WWTP under consideration. Here we choose glass material for the design and fabrication of the aeration tank and it is designed in the acreage of 30 × 20 × 20 cm. An oxygen motor is used to pledge an aeration tank with oxygen is of paramount importance for a tank equipped with wastewater and microalgae. It will take care that a tank remains free from ice in winter.

Sample Collection and Analysis

The unprocessed raw effluent discharged from the dairy industry after the production of dairy products and cleaning of the equipment, place, and containers are collected from the dairy industry (Figure 3 represents the microalgae).

Treatment of Dairy Wastewater

Pasteurized and sterilised milk, yogurt, ayran, cheese, cream, butter, ice cream, and milk powder are all produced by the dairy industry. Water is produced by both product manufacturing and packaging facilities. Aeration is the process by which water and air come into close contact to remove dissolved gases (such as carbon dioxide) and oxidise dissolved metals such as iron, hydrogen sulphide, and volatile organic compounds (VOCs). Aeration is often the first major process at the treatment plant. Wastewater aeration is the process of adding air into wastewater to allow aerobic bio-degradation of pollutant components. It is an integral part of most biological wastewater treatment systems. Unlike chemical treatment which uses chemicals to react and stabilise contaminants in the wastewater stream, biological treatment uses microorganisms that occur naturally in wastewater to degrade wastewater contaminants.

Figure 3: Microbial algae.

Inspection Operation

The unprocessed raw effluent discharged from the dairy industry after the production of dairy products and cleaning of the equipment, place, and containers are collected from the dairy industry (Figure 4 represents the Dairy Industry Effluent). The glass sheet is collected and fabricated in the size of 30 × 20 × 20 cm. The oxygen motor is fixed in the aeration tank for air supply. The collected raw effluent is inoculated in the aeration tank up to the dead end and the stabilising agent green algae are inoculated in the aeration tank for the growth of microorganism. The aeration tank is pledged with an oxygenator and is kept in sunlight for one month due to the action of sunlight there will be microbial action so that the green algae will be grown and will reduce the pollutant and it will reduce the solid particles simultaneously to treat the dairy wastewater under the aerobic condition which converts solar energy to chemical energy (Ji et al., 2015; Liu et al., 2018). The preliminary test is taken for collected raw effluent. Because industrial effluent has some characteristics like

Figure 4: Dairy effluent.

pH, COD, BOD, chloride, oil and grease, total suspended solids, total dissolved solids, and temperature. The aeration tank is kept in due to the action of sunlight-sustaining agent green algae improving the germination of microorganisms. The maturation of algae is noted and plotted in the form of a graph and sludge is produced from the raw effluent may be.

Testing of Dairy Effluent

The preliminary test is taken and the results are tabulated in Table 1. After 7 days, the growth of microalgae is noted and plotted as a graph, after 30 days the effluent is tested in the laboratory to know their characteristics like

Table 1: The initial and final characteristics results

S. no.	*Name of the parameter*	*Initial characteristics*	*Final characteristics*
1	pH	6.2	7.1
2	Temperature	32°C	34°C
3	BOD (mg/L)	3520.12	428
4	COD (mg/L)	5308	674
5	Total suspended solids (mg/L)	580	700
6	Total dissolved solids (mg/L)	810	340
7	Oil and grease (mg/L)	260	11.2
8	Chloride	120	64

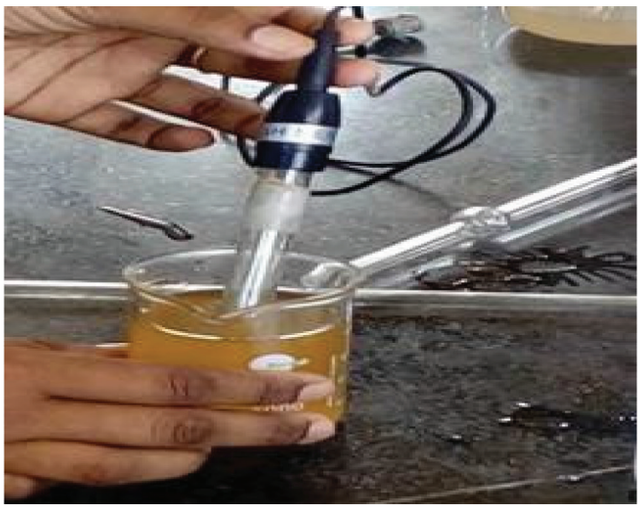

Figure 5: Testing of dairy effluent.

pH, COD, BOD, chloride, oil and grease, total suspended solid, total dissolved solids and temperature (Figure 5).

Results and Discussion

The raw dairy wastewater was tested for its physical and chemical characteristics (pH, temperature, BOD, COD, total suspended solids, total dissolved solids, oil and grease, and chloride) and was analysed for algae-treated water (The Initial and Final Characteristics of Dairy effluent results obtained are given in Table 1).

Production of Algae Biomass (sludge)

The growth rate of microalgae controlled the efficiency of wastewater treatment in the dairy industry. Under aerobic conditions, biomass was produced for effective pollutants. The curve was drawn based on the period of the effluent treated and the weight of the algae growth. The maximum biomass reached 1.00 weights per g/L in 30 days. It is depending on the nutrient consumption. The growth of microalgae varied based on the types of species of microalgae.

BOD and COD Removal

Dairy industry effluent contains large quantities of milk constituents such as casein, lactose, fat, and inorganic salts, besides detergents and sanitisers used for washing. All the components contribute largely towards their high biochemical oxygen demand. High BOD and COD values lead to the deprival of oxygen for aquatic life of water. The initial concentration in the dairy wastewater contained BOD and COD as 3520.12 mg/L and 5308 mg/L, respectively (Table 1). After the treatment

process, BOD and COD were analysed as 428 mg/L and 674 mg/L reduced by using microalgae. The calculated BOD and COD removal efficiencies were 87.84 mg/L and 87.30 mg/L, respectively, in the dairy effluent treatment process at 30 days under the condition of aerobic (Table 2 represents the Removal Efficiency).

Table 2: Removal efficiency of dairy effluents

S. no	*Name of the parameter*	*Removal efficiency (%)*
1	BOD (mg/L)	87.84
2	COD (mg/L)	87.30
3	Total suspended solids (mg/L)	20.69
4	Total dissolved solids (mg/L)	58.02
5	Oil and grease(mg/L)	96.03
6	Chloride	46.67

Removal of Solid Content

The Initial concentration of TSS (total suspended solids) in dairy effluent was analysed as 580 mg/L. after the treatment, the final concentration of total suspended solids increased to 700 mg/L due to the production of biomass in dairy wastewater treatment (Table 1). The reduction of TSS (total suspended solids) obtained in the dairy wastewater treatment using microalgae had less reduction, which reached 20.69 mg/L when compared to that of the BOD and COD removal efficiency (Table 2). This result indicated that the microalgae were ineffective due to the small amount of solids suspension in that particular dairy effluent. The TDS concentration reduced from 810 mg/L to 340 mg/L, respectively (Table 1). The removal efficiency of TDS (Total Dissolved Solids) was high 58.02 mg/L compared to the TSS.

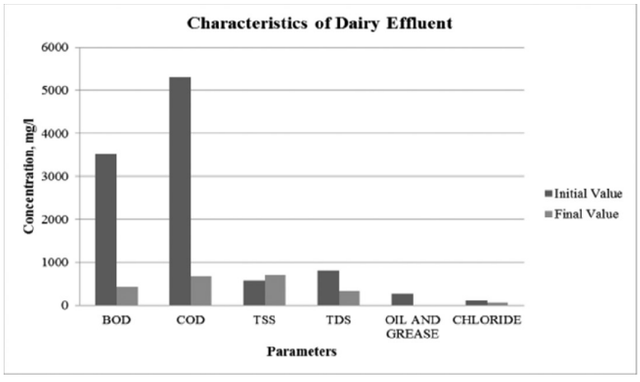

Figure 6: Removal efficiency parameters and concentration.

Removal of Other Pollutants

The maximum amount of oil and grease particles removed in the dairy effluent was 96.03 mg/L, from the initial and final concentration of 260 mg/L and 11.2 mg/L reduced effectively after the algae treatment. The chloride concentration of dairy effluent was reduced by the microbial activity of algae. The removal efficiency of chloride was 46.67% from 120 mg/L to 64 mg/L concentrations. The increase in pH value due to the aerobic condition was buffered by the production of CO_2 from the microbial activity to keep the pH at a constant value. The ranges were 6.2 and 7.1 from initial and final testing. The pollutant characteristics of dairy effluent are reduced by the degradation of organic matter in microalgae activity and to release the of CO_2 under the aeration process.

Removal Efficiency

The removal efficiency of dairy effluent was calculated based on their initial and final characteristics test results as shown in Table 2. The graph was drawn based on the test results (Figure 7). The highest removal efficiency was oil and grease at 96.03% after the microalgae treatment under the action of oxygen supply to the aeration tank. The least removal efficiency (Figure 6) was TSS 20.69 mg/L. The use of microalgae to reduce contaminants in dairy effluent resulted in both dairy wastewater treatment and biomass production. Dairy wastewater treatment using microalgae offers the added benefit of producing microalgae biomass for biofuel or high-value byproducts.

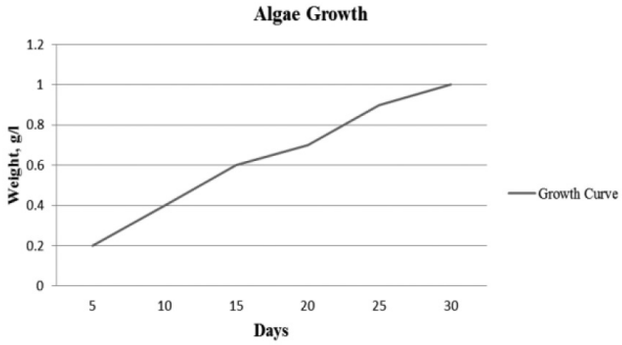

Figure 7: Represents the growth rate of algae.

Conclusions

The following conclusion was drawn from the study. Algae bioreactor is a new type of bioreactor for solar-chemical energy production and treatment of wastewater. Our study comprised eco-friendly

wastewater purification processes. Based on the result of this research project it can be concluded that the algae bioreactor is a viable and sustainable technology. Our project comprised eco-friendly wastewater purification processes. The removal efficiency of organic pollutant parameters BOD and COD is 87.84% and 87.30%, respectively. Other pollutants like oil and grease, TDS, TSS, and chlorides are also reduced effectively. There is a great need to control Water pollution as it is impacting the environment and human health seriously. When dairy effluent is disposed off without treatment, it can cause adverse effects on fish growth, reproduction, and immunity in water bodies, as well as harmful effects on beneficial microorganisms and plant growth due to decreased micronutrient solubility, serious health and hygiene problems, and eutrophication. To control water pollution, proper rules and regulations should be implemented by the Government. In addition, awareness should be created among the public, control of the population, number of vehicles, and industries' energy consumption. The stakes are high and the world needs to wake up and start acting right now because environmental issues are constantly growing in number and size. Therefore to reduce the water pollutant we are using very cheap materials like algae which are easily available. We need to take pollution issues seriously because ignorance is certainly not the proper way to go.

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