Review On Fat Degradation Of Dairy Industry Effluent Using Anaerobic Treatment.

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Abstract:

Biodegradation of fats, oil and grease (FOG) in dairy wastewaters has been a major challenge for the industry. Many treatment processes have been tried to solve the issue of environmental degradation caused by the wastewater effluents from the dairy industry. The anaerobic reactor has been suggested by several researchers with some success in the degradation of FOG. Biodegradation of dairy effluent by using selected microbial isolates. So mixed culture was proved to be the most effective in reducing selected physiochemical parameters of water. And single isolate was proved to be less effective in reducing selected physiochemical parameters of water.

Key words: Fat degradation, Lipids, Oil and grease, Dairy effluent, Bacterial isolates, COD contents, Activated sludge.

Introduction:

The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. It is estimated that about 2% of the total milk processed is wasted into drains. The wastewater generated from milk processing can be separated into two groups, the first group concerns wastewater having high flow rates and the second concerns the effluents produced in small milk transformation units (cheese production for instance). Dairy wastewater is characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contains fats, nutrients, lactose, as well as detergents and sanitizing agents. Nutrients lead to eutrophication of receiving waters, and detergents affect the aquatic life. Due to the high pollution load of dairy wastewater, the milk processing industries discharging untreated/partially treated wastewater cause serious environmental problems. Moreover, the Indian government has imposed very strict rules and Regulations for the effluent discharge to protect the environment. Thus, appropriate treatment methods are required so as to meet the effluent discharge standards [02, 04].

Dairy wastewaters are generally treated using biological methods such as activated sludge process, aerated lagoons, trickling filters, sequencing batch reactor (SBR), anaerobic sludge blanket (UASB) reactor, anaerobic filters, etc. Dairy industries are involved in the manufacturing of various types of milk products such as fluid milk, butter, cheese, yogurt, condensed milk, flavored milk, milk powder, ice cream, etc. Typical by-products obtained include buttermilk, whey, and their derivatives. A chain of operations involving receiving and storing of raw materials, processing of raw materials into finished products, packaging and storing of finished products, and a group of other ancillary operations (e.g., heat transfer and cleaning) are examples of some of the great variety of operations performed in the dairy industries. The initial operations such as homogenization, standardization, clarification, separation, and pasteurization are common to most plants and products. Clarification (removal of suspended matter) and separation (removal of cream for milk standardization to desired butterfat content), generally, are accomplished by specially designed large centrifuges [05]. Drying, condensing, etc. are also used in dairy industries for the production of various products.

The types and size of processes and equipment used are determined by raw material inputs and the finished products manufactured. The dairy industry is one of the most polluting of industries, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well. In the dairy industry, some amount of wastewater gets produced during starting, equilibrating, stopping, and rinsing of the processing units (flushing water, first rinse water, etc.). However, a majority of wastewater gets produced during cleaning operations, especially between products changes when different types of products are produced in a specific production unit and clean-up operations.

The Biological treatment of Dairy wastewater includes both Aerobic and Anaerobic processes.

AEROBIC PROCESS:

Aerobic biological treatment involves microbial degradation and oxidation of waste in the presence of oxygen. Conventional treatment of dairy wastewater by aerobic processes includes processes such as activated sludge, trickling filters, aerated lagoons, or a combination of these. All compounds of dairy wastewater are biodegradable except protein and fats which are not easily degraded. Conventional treatment of dairy wastewater by aerobic processes includes processes such as activated sludge, trickling filters, aerated lagoons, or a combination of these. All compounds of dairy wastewater are biodegradable except protein and fats which are not easily degraded. Nitrogen and phosphorus removal were found to be 96 and 80%, respectively; whereas BOD removal was found to be in the range of 97-98%.

ANAEROBIC TREATMENT:

Dairy effluents have high COD and organic content and are warm, enabling them to be ideal for anaerobic treatment. Furthermore, no requirement for aeration, low amount of excess sludge production, and low area demand are additional advantages of anaerobic treatment processes in comparison to aerobic processes. UASB reactors have been widely used for the dairy wastewater treatment in full-scale applications. The basic elements of a typical UASB reactor are a sludge blanket, influent-distribution system, gas-solid separator, and the effluent withdrawal system. In the UASB reactor, the influent is distributed at the bottom and travels in up-flow mode.

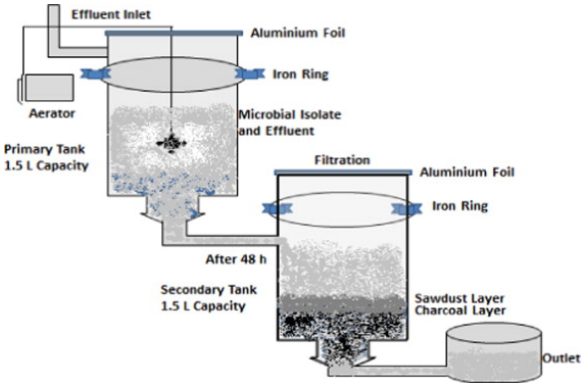
Dairy wastewater contains fats and the inhibitory action of the fat to the anaerobic treatment does not allow fast and increased removal efficiency. The enzymatic hydrolysis of fats as pre-treatment may remove this problem. Due to the gas generation, all types of anaerobic reactor are well mixed but the reactor performance gets affected by the degree of mixing and the solid content in the waste [07].

The dairy industry on an average has been reported to generate 6-10 L of wastewater per liter of the milk processed [01]. Dairy wastewater are generally treated using biological methods such as activated sludge process, aerated lagoons, trickling filters, sequencing batch reactor (SBR), anaerobic sludge blanket (UASB) reactor and anaerobic filters [01]. Strains isolated from soil rich in organic matter degraded olive oil and tributyrin, and the most active strain belonged to the genus Bacillus. Other genera of bacteria, such as Pseudomonas, Burkholderia, Acinetobacter, Escherichia, and fungi (Candida, Rhodotorula, Yarrowia) are known to have the ability to degrade contaminants as well as Bacillus. However, the natural microbial degradation of FOGs is slow due to their low lipolytic activity.

Materials and Methodology:

A two stage model was set up for the experimental treatment of the effluent. The model was modified as per the requirements of present study. Two used plastic bottles of capacity 1.5 L each were reused for making two columns (considered as primary and secondary tanks) of the model. The bottles were cut from the bottom and inverted to make columns. They were rested on iron rings which were nailed onto a wooden plank. Holes were made at required positions in the bottles and transparent silicon pipes were connected using an adhesive, araldite. An aerator was used to provide continuous aeration and maintain desired level of dissolved oxygen above 5 mg/L. Activated charcoal powder and sawdust were used for filtration following the microbial treatment in

secondary tank. The activated charcoal powder was heated up in an oven at 70 °C for 2 h before use. Sawdust was obtained from a plywood shop located in Timber Market of Pune. Thus the experimental model was constructed from reused plastic bottles and filtration materials.



The two columns of the treatment cum filtration unit were washed with alcohol to make it sterile and then rinsed with sterile distilled water. The laboratory scale 1.5 L reactor (primary tank) was then fed with 1 L autoclaved untreated dairy wastewater. The autoclaved effluent was cooled to room temperature and then added to the reactor. Then 10 ml of microbial culture was added to the effluent. An aerator was inserted into the reactor and the open top portion of the reactor was covered with aluminum foil paper. The aerator was used to maintain desired level of dissolved oxygen above 5 mg/L in the effluent and to support the proper growth and survival of the aerobic microorganisms used for the study. The aeration was provided for a period of 48 h. The effluent was given a retention time of 48 h in the primary tank where the microorganisms were allowed to carry out degradation. After 48 h, the aeration was stopped and effluent was allowed to stand for 1 h to allow settling of the sludge formed. The treated effluent from primary tank was then allowed to flow into secondary tank through outlet pipe of the primary tank. The filtration was carried out in secondary tank containing one inch layer of activated charcoal powder at the bottom of bottle and one inch layer of sawdust above it. On completion of filtration, treated effluent was tested for various physicochemical parameters in laboratory [01].

Dairy waste

Wastewater from dairy plant was collected.

Microorganisms

Some bacterial isolates were obtained from activated sludge of dairy plant according to the method described.

Enrichment cultural media

In this stage 10 g of the activated sludge was dissolved in 90 ml of sterile physiological serum and it was added to an enrichment cultural medium such as nutrient broth. 1 ml of the suspended solution was inoculated to 250 ml of sterile nutrient broth and was shake for 24 - 48 h at 30 °C.

Specific culture media

In nutrient broth a good growth of bacteria were observed after 24 hrs. Milk broth was used as specific cultural media, which contained: peptone=50 g, yeast extract=3 g, milk solid or fresh milk=10 ml. After preparation and sterilization of this medium, 1 ml of enrichment culture was added to it and shakes for 24-48 h at 30 °C. If a good growth of microorganisms occurred, this procedure would be repeated.

Transport to solid culture media

After complete growth of the microorganisms, they were transferred to the sterilized solid cultures such as milk agar and plate count agar, and they were incubated at 30 °C.

Screening

After the wide growth of the bacteria, they were inoculated into the new sterilized media and were incubated at 30 °C for 24 to 48 h. Each bacteria grew as a pure colony and was transferred to the prepared slant, for quality and quantity tests [03].

The UASB reactor was operated at a flow rate of 1.2 ml/min by using a peristaltic pump for 24 h in a day for 70 days. 1.25 liters of the secondary sludge was added to the reactor prior to the inflow of the wastewater into the reactor. After 24 h of maintaining the secondary sludge in anaerobic conditions in the reactor, a synthetic mixture of wastewater (750 g of glucose + 250 g of sucrose) with a COD of 2000 mg/l was fed into the UASBR. Every 24 hours, a

sample was drawn from the outlet of the UASBR to measure the changes in the COD level. This was used for the first 20 days. The primary sludge was maintained at anaerobic conditions for the development of microorganisms. Every 24 hours, a sample was drawn to analyses for changes in the COD levels, which would indicate the growth of microorganisms. However, no significant change in the COD level occurred for 7 days. Therefore, the reactor was emptied of secondary sludge and cleaned. Then 1.25 liters of primary sludge obtained from the dairy processing unit was introduced into the UASBR. As in the case of the secondary sludge, a synthetic mixture of wastewater (750 g of glucose +250 g of sucrose) with a COD of 2000 mg/l was fed into the UASBR. Every 24 hours, a sample was drawn from the outlet of the UASBR to measure the changes in the COD level. The changes in the COD level of the sample from the outlet of the UASBR was measured every 24 h for a period of 30 days. Once significant reduction of COD indicating the growth of microorganisms was observed, the synthetic wastewater inflow into the UASBR was stopped. After the confirmation of the formation of the microorganisms in the reactor chamber within the matrix of the primary sludge, the dairy wastewater was introduced into the UASBR at the rate of 1.2 mg/min at a hydraulic retention time of 24 h. Every 24 h, a sample of the treated dairy wastewater was drawn from the UASBR and the FOG, COD, TDS and VSS were measured [06].

Results and discussion:

The present investigation indicated that after aeration period of 48 h, DSI_4 (mixed culture) was proved to be the most effective in reducing selected physiochemical parameters of water. DSI_3 (bacterial isolate) was second most effective in reduction of EC, TSS, TDS, TS, COD, BOD, chlorides and sulfates. However, DSI_1 (yeast isolate) found to be more effective to reduce turbidity and O&G as compared with DSI_2 and DSI_3. DSI_2 (bacterial isolate) showed least reduction in all selected water parameters as compared to other three cultures. Findings reveal that DSI_3 (bacterial isolate) would be the best option among three selected isolates for the treatment of dairy effluent. However, the mixed culture would prove to be more effective and beneficial than a single culture [01].

10 bacterial isolates were obtained and after Gram method and microscopic observation table 2 was obtained which shows the characteristic specification of the selected bacteria. These selected microorganisms were examined for their ability to reduce the chemical oxygen demand and the other chemical tests. The initial concentration of the wastewater was 3000 mg/l and each bacterium was inoculated to the waste at 30 °C in the shaker incubator at 150 rpm. The pH of the system was adjusted to 11. The COD measurement was carried out during 30 days. In this study, the rate of aeration was not measured, but the shaker incubator provides enough air for better growth of the aerobic microorganism. The COD removal is higher at shaking rate of 150-160 rpm than the other values. The best temperature intervals were found to be 30-35°C. The effect of temperature variation was lower for BP3 than BP4 and BM1, and it was the most resisted bacteria in the system. pH variation from 7 - 11, reduced the removal of the COD content up to 10 % for BP 3 and BP4, and 13 % for BM1. The optimum pH was 11 [03].

The FOG content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for FOG has a confidence level of 98%. The COD content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for COD has a confidence level of 98%. The VSS content linearly decreases with time owing to the increased growth of microorganisms with time. The linear regression model given in the figure for VSS has a confidence level of 99%. The laboratory scale UASBR with an increased sludge retention area that allows for a larger surface area of the sludge base has beneficial effects in terms of reduction of FOG, COD, TDS and VSS. This in particular is remarkable for the degradation of FOG [06].

Conclusion:

The mixed culture would prove to be more effective and beneficial than a single culture. According to the results, bacterial isolate BP3 is the most effective organisms to reduce the COD concentration more than 84 %. This value was obtained at 32 °C, pH=11 and the shaking rate of 150 rpm. It also decreased the carbohydrate, fat and protein content of the waste by 98 %, 45.30 % and 53 %, respectively. There is a significant decrease of FOG from 158 mg/l to 18 mg/l, which is caused by the increased sludge retention area and the resultant increase in the surface area of the sludge favoring enhanced microbial interaction. The COD levels are reduced linearly from 2880 mg/l to 440 mg/l over a period of 70 days. Similarly TDS reduces linearly from 3120 mg/l to 358 mg/l and the VSS from 416 mg/l to 127 mg/l during the 70-day period [01, 03, 06].

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