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Treatment of Dairy Wastewater using Aerobic Bio-Reactor

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Aruna C,
Research Scholar, Department of Civil Engineering, Annamalai University

Asha B,
Associate Professor, Department of Civil Engineering, Annamalai University

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Abstract
The Performance of an Aerobic Bio-Reactor (ABR) for the behavior of synthetic dairy processing wastewater was investigated. The system with 13.3 liters of working volume was accomplished by attached as well as suspended growth process as a novelty of this research work. The experimental analysis was carried out with the influent Chemical Oxygen Demand of synthetic dairy wastewater of 2920 mg/l, 3488 mg/l and 4000 mg/l at Hydraulic Retention Times (HRT) of 11, 14, 17, 21, 28, 42, 84 and 141 hours. During the experiment, pH plays an important role and the MLSS was maintained within the permissible limit continuously. In an AHBR, the maximum COD removal efficiency was attained 93.15% with an Organic Loading Rate (OLR) of 2.489 kg COD/m3.day.

1. Introduction

Dairy production is one of the main users of water worldwide, according to industry experts. It produces a lot of effluent, which is directly released into aquatic habitats. The dairy business is regarded as the most polluting among the food industries because it uses a lot of water and produces a lot of liquid waste (Gopinathan M and Thirumurthy M 2012), both of which are major contributors to pollution in this sector of the economy. These wastewaters are distinguished by high concentrations of organic matter and nutrients, and are mostly made up of leftover cleaning agents, carbohydrates, proteins, and fats from milk. Dairy wastewater has a significant pollution load, thus enterprises that process milk that discharge untreated or only partially treated wastewater cause serious environmental issues (Kavitha RV et al., 2013). Additionally, in order to safeguard the environment, the Indian government has put very rigorous norms and regulations in place for the discharge of effluent. The organic, inorganic, nutrient, suspended, and various solid components are the key constituents of dairy effluents. These dairy effluent by-products are what give wastewater its unpleasant odour and turbidity. The manufacturing of dairy products involves a number of water-intensive processes that result in a large amount of effluents with a high organic waste composition. These processes include tanks, cleaning storage facilities, warm exchangers, channels, and homogenizers. Basically, the wastewater produced by all of the aforementioned units' effluents has a high organic load made up of a lot of COD, BOD, P, and N. Compared to other toxic gaseous and solid waste, organic effluent from the dairy sector is significantly more detrimental to the ecology. When compared to other industries, the production of wastewater by the organic waste industry is one of the largest. Organic waste that is dumped into fresh water

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sources causes extensive damage to the water's properties. Consequently, in order to comply with the effluent discharge criteria, proper treatment techniques are needed (World B 1998).

The use of primary treatment to remove solids, oils, and fats; secondary biological treatment to remove organic debris and nutrients; and, in certain situations, tertiary treatment such as polishing are all examples of conventional treatment systems for these wastewaters (Sharma P 2008). Nevertheless, a number of issues have been noted, including a high scum creation rate, poor sludge settleability, limited resistance to organic shock load, challenges removing nutrients (nitrogen and phosphorus), and issues with the breakdown of fats, oils, and other particular types of contaminants (Demirel B et al., 2005). In wastewater treatment plants (WWTPs), the biological treatment of municipal or industrial effluents is frequently carried out through the application of traditional aerobic processes, a century-old technology that was initially developed to oxidise organic matter and later adapted for nutrient removal (Sengil A and Ozacar M 2006). The aerobic method has become the new benchmark for home and industrial wastewater treatment, while recent intensive research is looking for ways to increase treatment efficiency while lowering investment and operational costs. In aerobic biological treatment procedures, microorganisms that are cultivated in oxygen-rich environments oxidise matter to break down organics into carbon dioxide, water, and cellular material. The traditional activated sludge process, rotating biological contactors, typical trickling filters, etc. are examples of aerobic treatment systems.

Aerobic therapy makes use of oxygen, in contrast to anaerobic therapy, which does not. These two terminologies are intimately related to the kinds of bacteria or germs that are present in 98 G. Thus, during high-impact treatment operations, only air is present, and microbes use this air to acclimatise organic contaminants that are eventually converted to CO2, H2O, and biomass. The natural treatment is made up of the oxygen-consuming aerobic and oxygen-starving anaerobic processes. In addition to being used to remove organic additives like P and N, aerobic treatment of dairy effluent is also used to reduce BOD. The dangerous bacteria that are present in the industrial effluent from the dairy are degraded during the aerobic treatment because the wastewater is subjected to an oxidation process in the presence of oxygen. The two stages of suspended growth and attached growth are the two categories into which the aerobic therapy is often divided. The treatment of organic industrial effluents is often accomplished using a variety of aerobic treatment techniques, including aerated lagoons, oxidation ponds, and activated sludge process (ASP). Although aerobic treatment seems to be one of the most effective ways to treat dairy waste, controlling how the air is circulated becomes a crucial problem (Bandpi AM and Bazari H 2004).

The goal of this research is to investigate the biological purification of an artificial dairy wastewater in a continuous regime. Both the organic debris and the nutrients are removed during the treatment. For this, the Aerobic Bio-reactor was used for the experimental analysis. As a result, it would be safe to dump effluent into a waterway without endangering the plants and animals.

2. Material and Method:

A Plexiglas-built rectangular bioreactor with a working volume of 13.3 L and a height to width ratio of 1.3 was employed for reactor setup and operation in the trials (Figure 1). Air flow (6-8 L/minute) through fine air bubble diffusers continually provided dissolved oxygen, ensuring the airlift fluidized bed type movement of biomass inside the bioreactor and the necessary dissolved oxygen for the metabolic needs of the bacteria (Mahvi AH 2008).

Figure 1. Photographic outlook of the Reactor

The influent was made up of water and full-cream milk combinations with a pH of roughly 11, and it had a chemical oxygen demand of 4000 mg/L, which is quite comparable to typical dairy industry effluents.

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To avoid changes, this synthetic wastewater was kept in cold tanks and dosed into the reactors using peristaltic pumps. The bacteria came from a household sewage treatment facility together with those from a dairy effluent.

From the last section of the reactor, samples were collected. pH, total solids (TS), dissolved oxygen (DO), chemical oxygen demand (COD), and turbidity were examined. All analyses were conducted according to the steps indicated in standard techniques.

3. Result and Discussion:

pH

The pH values were steady overall, which is typical of the aerobic treatment of dairy wastewater ranges from 11.2 to 11.9. According to the findings, the transitional value between the performances of Organic Loading Rate (OLR) is from 0.497 to 7.930 kg COD/m3.day. The pH levels are very comparable at greater weights, as can be shown in the figure 2. However, when the organic load diminishes, these values rise dramatically. Once more, it is obvious that the system is overloaded for loads greater than 7.930 kg COD/m3.day; the decrease in the stabilisation pH is linked to lower concentrations of dissolved oxygen and the occurrence of smaller-scale fermentations. The pH values in the reactor are ranges from 7.04 to 7.28. There is a rise in pH values as the effluent moves through the reactors. This demonstrates that the initial reaction where the organic matter gets removed where the acidification caused by the action of lactic acid bacteria occurs most frequently.

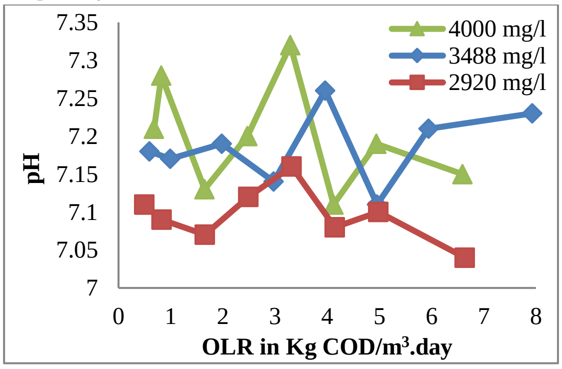
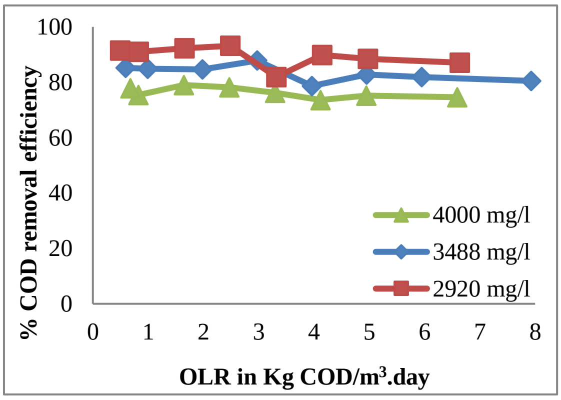


Figure. 2. OLR in Kg COD/m3.day with respect to Effluent pH with an average influent COD of 4000, 3488 and 2920 mg/l

Effect of OLR on COD Removal

At an operating OLR from 0.497 to 7.930 kg COD/m^3.day, the effluent COD concentrations are 2920 mg/l, 3488 mg/l and 4000 mg/l. The systems attained 79% COD removal efficiency in the first run at an OLR of 1.648 kg COD/m3.day. The ABR's effluent COD eventually reached 4000 mg/l. Similar patterns continued for 2 sets of 141 hours and the effluent COD reduced to 2920 mg/l at the maximum applicable loading rate of 7.930 kg COD/m3.day. Figure 2 depicts the link between Organic loading rate and COD removal efficiency. Over the study's applicable OLR range, the percentage of COD removed decreased linearly with increasing OLRs.



In the ABR, COD removal efficiency was 87.84% of influent COD 3488 mg/l during the operational OLR of 2.973 kg COD/m3.day. The existence of connected biomass meant that even when OLR values increased, the ABR consistently outperformed the conventional reactor in terms of performance. According to Chen et al., a hybrid method may be used to remove an organic compound that is easily biodegradable. Similar results were achieved by Wang et al., who discovered that a hybrid system could remove more than 80% of feed COD up to an OLR of around 3.5 g COD L d. Artiga et al. increased the OLR gradually up to 4.5 g COD L d and attained a COD removal effectiveness of 95%. As a result, by including carrier media inside the reactors, the current ABR may be improved to achieve greater performance at larger organic loads (Neczaj E et al., 2008). It should be noted that employing carrier materials, COD removal efficiency could only be attained in the range of 93.15% at an OLR of 2.489 kg COD/m^3.day.

4. Conclusion:

The dairy sector produces food items that are a wonderful source of nutrition. The organic, inorganic, and fatty chemicals found in the wastewater discharged by the dairy sector are the main pollution sources for fresh water sources. Aquatic life is harmed when the organic loading from the dairy sector is combined with fresh water sources, which leads to eutrophication and oxygen depletion in the marine environment. To lessen the negative effects of dairy effluents, wastewater treatment is essential. The aerobic treatment is a superb method for getting rid of the fatty and organic components in dairy effluents. One well-known drawback of aerobic treatment method is its high energy need and air circulation. The quality of the effluent was enhanced in the flow range investigated by increasing the intake flow. At the conclusion of the examinations, 93.15% of the CODs had been removed at an HRT of 42 hours. The overloading of the system is represented in a stabilisation of pH values at comparable levels. In essence, when the organic load is decreased, the pH tends to stabilise at the values attained in discontinuous testing treating comparable wastewaters under the same operating circumstances. The pH levels levelled off at about 7.3. The effluent had a low concentration of suspended particles and acceptable sedimentation properties. While obtaining a high-quality effluent, a solid residue that was enriched in nutrients was also produced. However, without the risk of diseases, this might be processed and utilised as fertiliser. After around 18-20 days, the reactor's peak performance was attained.

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