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Treatment of dairy wastewater using rotating biological contactors

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ABSTRACT

In India, Dairy Industry is one of the major industries causing water pollution. In any dairy industry the quantity and characteristics of effluent depends upon the extent of production activities, pasteurization to several milk product. Dairy wastewater is enriched in organic matter & also contains biodegradable carbohydrates. The biofilm model was implemented for three-stage Rotating Biological Contactor on a laboratory scale experimental set up. Various concentrations of dairy waste water with influent BOD & COD were introduced into the RBC system. In present study COD & BOD removal efficiency (%) of Rotating Biological Contactor (RBC) was determined for treating dairy waste water. Three staged RBC with each tank of working volume of 12 L was fabricated with acrylic sheets & tanks were placed in series. Rotational speed of the discs was 6,8,10 rpm and 42% submergence throughout the study. Biofilm formed on disc helped in treatment of dairy waste water. It was observed from the study that BOD removal efficiency of 96%, COD removal efficiency of 80% and TSS removal efficiency of 79% occur at 8 rpm.

Keywords: Dairy Wastewater, RBC, COD Removal

INTRODUCTION

During the past few years, many agro based industries have come up in India. The milk processing industry is one such industry during the last two decades due to enormous increase in the milk production. The number of the dairy plants of medium and large size has increased for the efficient handling and processing of milk. Consequent to the increased milk production and processing waste water generation has also increased. The dairy industry in India on an average has been reported to generate 6-10 liters of waste water per liter of the milk processed.

The dairy industry wastewaters are generated primarily from the cleaning and washing operations in the milk processing plants and are estimated to be 2.5 times the volume of the milk processed. Thus, some 200 million tons of wastewaters are generated annually from the Indian dairy industry. Dairy waste effluents consist of carbohydrates, proteins and fats originating from the milk. Moreover, the dairy industry produces different products, such as milk, butter, yoghurt, ice-cream, various types of desserts and cheese, thus, the characteristics of these effluents also vary greatly, depending on the type of system and the methods of operation used [4].

Globally, cheese whey, a by-product of cheese production, is being generated in enormous quantities as a result of increasing in the trend of cheese production. Disposal of the whey having a high chemical oxygen demand (COD) of about 60,000 to 80,000 mg/l causes environmental problem.

The environmental impact of dairy effluents can be very high, especially due to very large discharge of wastewaters which contain high organic matters and other nutrients including nitrogen and phosphorus. Discharge of dairy plant effluents to the water resources can lead to destruction of aquatic life and other marine creatures, which can provide more food for microbial consortia and causes further oxygen depletion [5].

Dairy industry is an important economic sector, but the pollution potential of such activity may be considered high, mainly when recovery of proteins, lipids and lactose is not performed. In many countries, the cost of treatment systems may represent a barrier to achieve high quality wastewater standards. Thus, the search for low-cost, effective techniques may contribute to reduce the environmental impacts generated by the dairy industry [3].

MATERIALS AND METHODS

The samples were collected from the dairy industry named " Yashodhara Milk & Food Products" situated at MIDC area Nandagaon Peth, Amaravti. The various products like paneer, cheese, butter, milk cream etc. are produced in it. The quantity of wastewater discharge is nearly 10,000 l/day.

2.1 Fabrication of RBC unit

A lab-scale three stage RBC was fabricated with an acrylic plastic transparent sheet thickness of 5 mm. A schematic experimental setup is shown in Figure 1. The total and working volume of RBC were 17 L And 12 L, respectively. The reactor was semicircular in shape having outer diameter of 30 cm and length of each stage was 60 cm. Each stage had 12 discs, with 24, 22 & 20 cm diameter. The interspacing of the discs was 50 mm. The discs were mounted on a shaft of PVC pipe, geared with a rotational speed of 5 to 10 rpm by an electric motor. The shaft passed through the center of each disc and was mounted on the bearing attached to the ends of the wastewater container and the submergence of the discs was 42 percent.

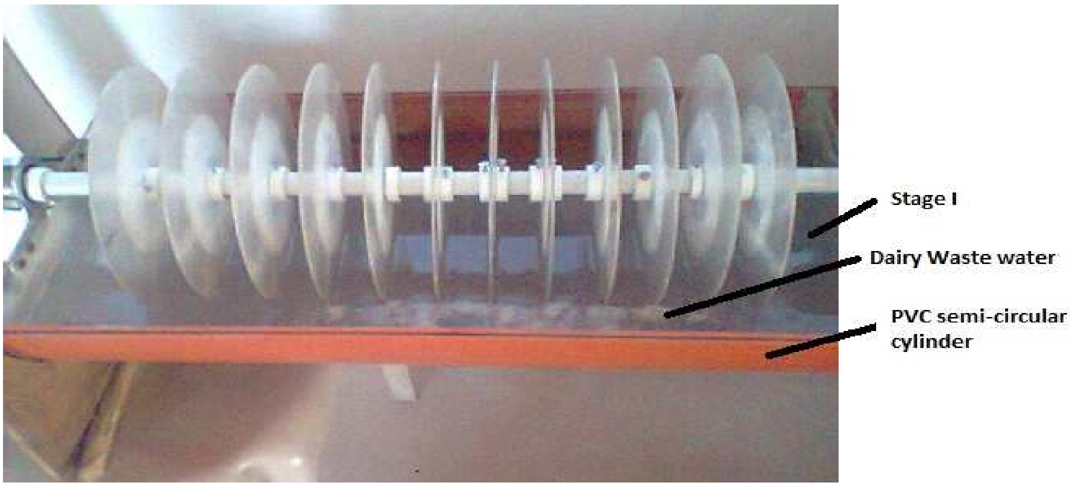

Fig. 1 RBC unit

2.2 Methods

The samples collected before and after treatment were analyzed for pH, TSS, BOD_5 and COD by using standards methods.

The samples were collected from the dairy industry. The barrel was used as a primary settling tank. In order to make sure that the large solids had settled to the bottom of the barrel, samples were not taken until two hours after collection. Before the beginning of data collection, the RBC was allowed to run for three weeks to make sure that microorganisms growth on the discs was well established and the system had reached a steady state.

After those three weeks, the first stage was covered by a layer of light brown biofilm and the effluent was quite clear. Actual observations were taken after three weeks i.e. after formation of biofilm.

The following parameters were measured:
1. Five Days Biochemical Oxygen Demand, BOD_5
2. Chemical Oxygen Demand, COD
3. Total Suspended Solids, TSS

2.2.1 Five-Day Biochemical Oxygen Demand (The Dilution Method)
The dissolved oxygen content of liquid was determined by the Azide modification of the Winkler's method before and after incubation for five days at 20°C. The difference gave the BOD_5 of the sample after allowance had been made for the dilution, if any, of the sample. For optimum biochemical oxidation, the pHs of the samples for analysis was 6.5 to 8 [6]. pH value was determined by pH meter.

2.2.2 Chemical Oxygen Demand (COD) Using the Open Reflux Method
The sample, to be measured, was oxidized under reflux with a known amount of potassium dichromate in strong sulphuric acid with silver sulphate as a catalyst. Organic matter reduced part of the dichromate and the remainder was determined by titration with iron (II) ammonium sulphate or iron (II) sulphate using ferroin as indicator. Interferences from chloride were suppressed by the addition of mercuric sulphate to the reaction mixture. The chemical oxygen demand (COD) was expressed as milligrams of oxygen absorbed from standard dichromate per liter of sample [6].

2.2.3 Total Suspended Solids (TSS) Using the Gravimetric after filtration
Dry a glass fiber filter in an aluminum foil dish to constant weight at 103 °C, cool it in desiccators and weight it and the dish. Filter a known volume of sample water through the filter. Place the wet filter and trapped solids in the dish again it in the oven to constant weight at 103 °C again and weigh it again. Subtract the first weight from the second weight and divide by volume of sample in liters to get suspended solids in mg/lit [6].

Observations
Five day BOD, COD and TSS were observed by varying the different parameters such as:
1. **Rotational speed**: The disc were rotated at 6,8 and 10 rpm
2. **Diameter of disc**: Disc of various diameters were used in 3 stages. The diameter of disc rotated were 20 cm, 22 cm, 24 cm and 26 cm.
3. **Number of Disc**: The discs were used in increasing nos. such as 6, 9, 12, and 15 nos.

After taking all the observations, it has been observed that the reactor was optimized for 12 nos. of 24 cm diameter disc rotated at 8 rpm. The optimum results are given in the table 1.

Graph 1: Optimum Removal in mg/lit

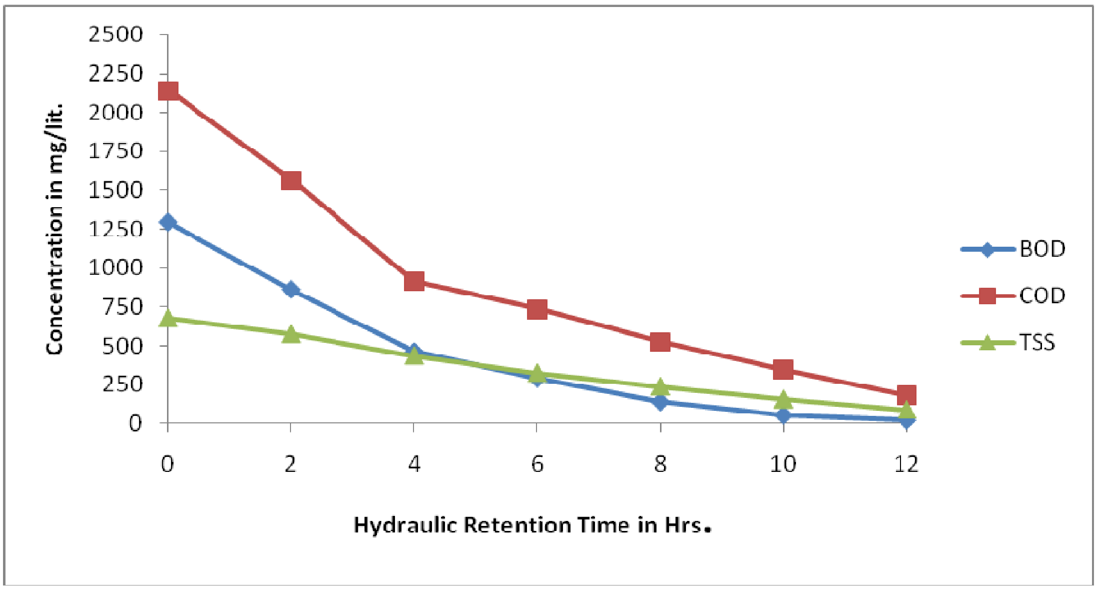

Table 1: Characteristics of Dairy Wastewater

Diameter of disc (cm)	**24**		
No. of disc	**12**		
RPM	**8**		
Stage	**BOD**	**COD**	**TSS**
Influent	1294.25	2143.25	680
Aeration tank	860.7	1565.75	577.2
PST	460.22	915.15	436.98
I stage	288.33	734.56	324.44
II stage	138.04	523.67	237.81
III stage	51.75	345.66	155.43
SST	18.17	177.23	88
Total % Removal	**96.05**	**80.63**	**79.86**

RESULTS AND DISCUSSION

1. BOD Removal

When 12 nos. of 24 cm diameter discs were rotated at 8 rpm, the BOD in stage-I reduced to 288.33 i.e. the removal of 37.35%, in Stage-II reduced to 138.04 the overall removal of 70.01% and in Stage-III reduced to 51.75 removal of 88.76% and after secondary sedimentation tank it was reduce to 18.17 i.e. the total removal of 96.05%.

2. COD Removal

When 12 nos. of 24 cm diameter discs were rotated at 8 rpm, the COD in Stage-I reduced to 734.56 i.e. the removal of 19.76%, in Stage-II reduced to 523.67 the overall removal of 42.78% and in Stage-III reduced to 345.66 removal of 62.23% and after secondary sedimentation tank it was reduce to 177.23 i.e. the total removal of 80.63%.

3. TSS Removal

When 12 nos. of 24 cm diameter discs were rotated at 8 rpm, the TSS in Stage-I reduced to 324.44 i.e. the removal of 25.76%, in Stage-II reduced to 237.81 the overall removal of 45.58% and in Stage-III reduced to 155.43 removal of 64.44% and after secondary sedimentation tank it was reduce to 88 i.e. the total removal of 79.86%.

CONCLUSION

1. The RBC is an efficient method of treating wastewater because of its simplicity to maintain and operate, low energy consumption, ability to withstand shock or toxic load, freedom from odors and good sludge settling properties.
2. RBC energy consumption is equivalent to or less than extended aeration activated sludge plants, and it requires less maintenance and operational skill.
3. About 45 to 50 % of organic compounds were removed in the first stage of RBC. This three stage RBC system was aerobically experimented as an efficient process for treating high-strength organic wastewater under fixed rotational speed of the biodiscs (8 rpm) and submergence of 42%
4. For small wastewater treatment plant, the capital cost of RBC is lower than activated sludge plant; therefore, RBC can result in more savings for small community.
5. When the surface area in contact was maximum i.e. 12 no. of 24 cm. diameter disc, the removal of BOD 96% at 8 r.p.m.
6. As the surface area in contact decreases, the removal efficiency also decreases.

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