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Feasibility Studies on The Treatment of Dairy Wastewater Usingrotating Biological Contactor (RBC) Undervariable Experimental Conditions

Dr.Palakshappa.K[1],
Professor, Department of Civil Engineering.
P. A. College of Engineering,
Mangaluru, Karnataka, India.

Sneha.M.K [2]*
Assistant Professor, Department of Civil Engineering, Acharya Institute of Technology,
Bengaluru, Karnataka, India.
Corresponding author e-mail: snehamatad@gmail.com

Chiranjeevi.M.R[3]
Assistant Horticulture Officer,
Bengaluru, Karnataka, India

ABSTRACT

There are numerousmethods for treatment of effluents of dairy waste/waste water. Rotating Biological Contactors (RBC) is one 0f the most popular because of itseasy operation, lowenergy usage and less area requirement. RBC is an aerobictreatment process. In the present study RBC is used to treat dairy waste water. Three stage RBC with each tank of total volume 10 litres and working volume of 8 litres is taken and kept in series. Rotational speed of discs is fixed to 40 rpm and with 40% submergence throughout the study. Biofilm formation has been taken because of continuous rotation of RBC discs. Hydraulic Retention Time [HRT] varies with 48,24,12,8 and 4 hrs for initial COD concentration 1000mg/l. Optimum HRT is fixed for 8hrs as per the study. With increasing loading rate of COD to 1500mg/l efficiency is reduced. To fix the COD loading rate, 1000 mg/l was increased to 1100mg/l, 1200 mg/l,1300 mg/l and 1400mg/l. With initial COD concentration of 1000mg/l with different HRT it is found 8hrs with COD removal efficiency (tank 1+tank 2+ tanks 3) was 85%. It is evident from the results thatforan optimum HRT of 8 hrs, optimum COD loading rate is 1300mg/l with COD removal efficiency of tank 1+tank 2+ tanks 3 is 94%.

Keywords: Rotating Biological Contactor, COD loading rate, HRT

I. Introduction

Water is such an important natural resource which maintains eco-sustainability and we are facing water scarcity because of increasing demand, rapid growth of urban population, development of agriculture and industrial activities. Indirectly affecting the economy of country since the availability of water varies with time, quantity and quality. Hence conservation, optimum utilization and management of this precious resource is very important (1).

Global warming and climatic changes disturb the hydrological cycle, which accounts in 700 million people from 43 countries (approx) facing water scarcity problem. As per the population forecasting, because of increasing population and its waste water generation it is most important to treat waste water especially in urban areas (2).

Considering past few years growth in agro based industry, milk processing industry is also one among them. As the milk production increases waste water generation also increased. It is reported that on an average dairy industry in India generates 6-10 liters of waste water while processing one liter of milk (3).Dairy waste water consists of high COD and BOD rate which reflects the organic content of it. Dairy effluents are concentrated wastewater of carbohydrates, proteins and fats (4).

Dairy waste water which has biodegradable matter disrupts the marine life when disposed into water body. It causes serious environmental problems. Hence it is important to treat dairy effluent (5).RBC is also ideal for anammox process with its own advantages. It has high specific surface area which removes nitrogen at higher rate (6).

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Study shows that treatment of grey water using RBC for pollutant removal. Later the same water can be reused mainly for toilet flush purposes (7).RBC is advantageous in many ways like easy operation, simple design, low land area requirement, less energy consumption, less operation and maintenance cost (8).

RBCs are attached growth biological reactors containing a series of closely spaced circular discs which will be remounted to a horizontal shaft. These rotating discs are partially submerged on which micro organisms will grow. Micro organisms will be exposing to air and waste water alternatively. Thus process forms the biofilm which degrade organic matter present in the waste water. Individual RBC units are placed in series to maximize the efficiency of the system. Each unit is referred as stage. Rotation of discs provides oxygen to biofilm and makes it as aerobic reactor(9).

Many comparisonshave been done considering the performance of RBC. VanBuuenproved that by taking HRT 3 hrs, Trickling filters and submerged filters removes COD by 50 % while RBC 70%. Therefore he concluded that RBC can remove highest amount of organic matter that trickling and submerged units(10).RBC is efficient in treating distillery waste water with 83% COD, 50% TS and 50% DS removal efficiencies after treating it three days (11).

II. Materials and Method

Composition of synthetic dairy waste water:
Milk powder-varied, NH_4Cl-2.8 g/l,$MgSo_4.7H_2O$-0.1g/l,KH_2Po_4-2g/l,$CaCl_2$-0.076g/l, $NaHCO_3$-4g/L(16).

A. Characteristics of dairy wastewater

The diary waste water is the substrate and no additional nutrients are supplied for micro organisms. Here the micro organisms will grow by using the nutrients which are present in the dairy wastewater. The characteristics of dairy waste water are as in the following table 1.

Table 1: Characteristics of dairy wastewater

Characteristics	Average value
pH	6.89
Phosphorus (mg/l)	12
BOD5(mg/l)	2300
COD(mg/l)	3350
Total Solids (mg/l)	2850
Dissolved Solids (mg/l)	2410
Suspended Solids (mg/l)	440
Nitrogen (mg/l)	50

B. Fabrication of Rotating Biological Contactor

The three stage lab scale RBC reactor was fabricated using acrylic sheet (non corrosive,non reactive) of 5mm thick discs. Each reactor has 6 discs placed at 1cm spacing which is placed over a single shaft. To provide a rough surface area which helps in growth of micro organisms, a cloth mesh is used over the discs. For the rotation of shaft,a AC motor of specification 1400rpm, was provided. (12, 13, 4, 15,16)

C. Experimental setup of Rotating Biological Contactor (RBC)

Three stage RBC which are placed in series, with each tank of total volume was 10litres and working volume 8 litres was constructed. Schematic representation of setup is shown in Figure 1. Waste water was released from inlet of the reactor. Discs were rotated at constant speed of 35rpm and constant submergence of 40% throughout the study (15). Reactor was operated at room temperature of $29\text{-}32^0$ c. formation of biofilm on the discs was observed.

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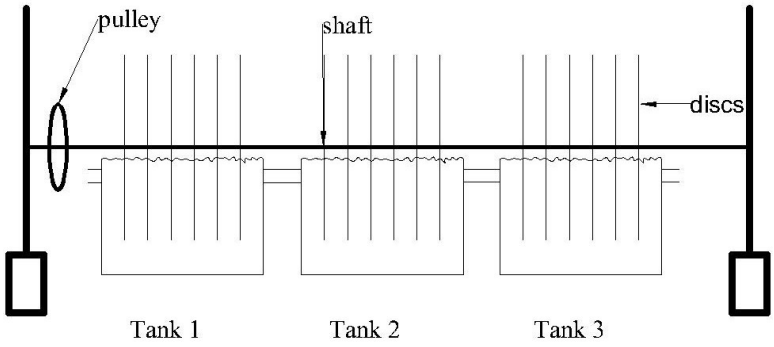

Fig1.Three stage Rotating BiologicalContactor

D. Reactor studies

The initial HRT was set to 48 hours for the COD concentration 1000 mg/l. gradually it was varied when the reactor reached steady state condition. HRT's were 24, 12, 8 and 4 which shows optimum HRT for 1000 mg/l.

After finding optimum HRT, COD loading rate was increased to 1500 mg/l. treatment efficiency decreased because of increasing COD loading rate. To find optimum COD loading rate, COD loading was increased from 1000 mg/l to 1100 mg/l, 1200 mg/l, 1300 mg/l, 1400 mg/l finally 1550 mg/l. and thus optimum COD loading rate was found.

E. Analysis

Dairy waste water samples were analyzed as per the standard methods (1995)[17].

III. Results and Discussions

Performance of RBC reactor at initial COD

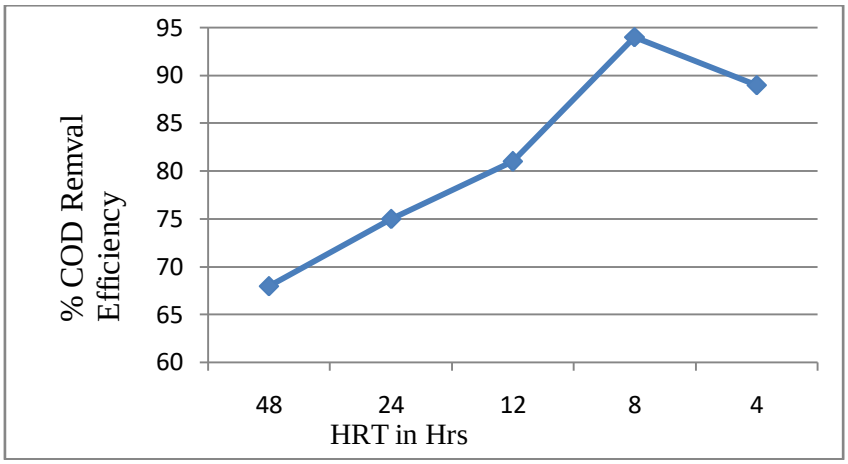

Fig 2: COD removal efficiency at different HRT's

A. Reactor Operation

The reactor was inoculated with 1.4 litters of cow dung in each tank. Dairy waste water of COD loading rate 1000 mg/l was fed to RBC reactor and was left for acclimatization with rotating shaft. After two weeks a biofilm was observed. Analysis was started to find optimum HRT for 1000 mg/l of COD loading rate (15). During the study the feed concentration was increased with an increment of 250 mg/l.

B. p^H and Temperature:

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The p^H and temperature of influent and effluent were recorded daily. pH was varying from 6.3 to 7.5 and temperature between 28-32^{0}c during study period.

C. COD removal efficiency (%)

With initial COD loading rate of 1000mg/l of dairy waste water HRT's were varied i.e 48,24,12,8 and 4 hours. COD removal efficiency was recorded and it is as shown in Figure 2. It is found that optimum HRT is to be 8hours.

Taking out optimum HRT for 8 hours, COD loading rate was increased to 1500 mg/l. Removal efficiency is decreased when it loading rate was increased. To find the optimum COD loading rate between 1000-1500 mg/l, it was varied with 100 mg/l. now the COD loading rates are 1100, 1200, 1300, 1400 and 1500 mg/l at optimum HRT 8 hours.

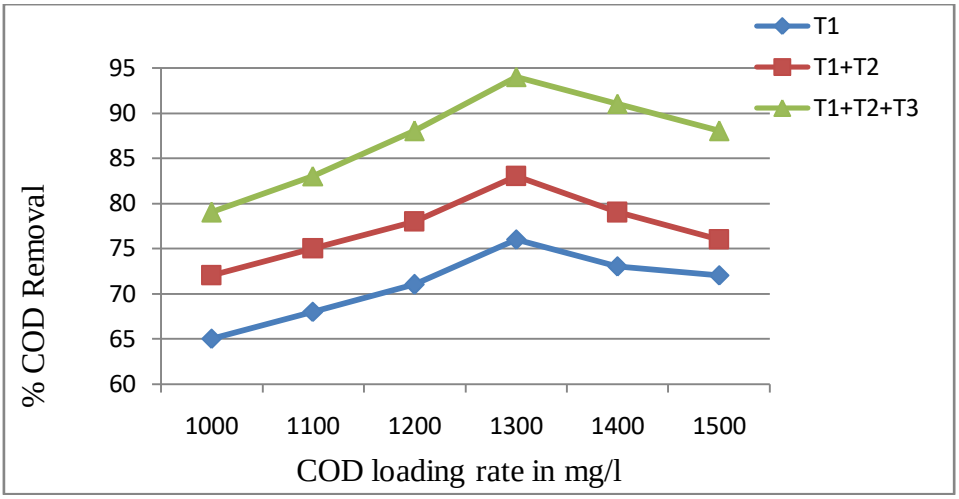

Fig 3: COD removal efficiency in % at different concentrations (mg/l) in three stages

From the above graph we can consider that Optimum COD Loading rate is 1300 mg/l at optimum HRT 8 hours. At this optimum COD loading rate of 1300 mg/l the COD removal efficiency is : in tank 1= 76%, in tank 1 + tank 2=83% and in tank 1+tank2+tamk3= 94%.

Chen *et al*., achieved the COD and total nitrogen removal rates of 78.8–89.7% and 40.2–61.4%, respectively, in aerobic treatment of low COD municipal-type wastewater at hydraulic retention times (HRT) from 5 to 9 hrs [15]. Najafpour*et al*., reported 88% COD removal from palm oil mill effluent with 55 hrsHRT(3). Ebrahimi *et al*., achieved 96% COD removal from dairy wastewater (4). Coetzee *et al*., 2004 reported the reduction of COD of the winery effluent by 23% (from 3828 mg/l to 2910 mg/l) and increased the pH by 0.95 units (from 5.77 to 6.13) at an average retention time of 1hr (18)

D. Total solids

Total solids concentration is recorded for the entire COD loading rate at optimum HRT 8 hours. By the Table 2 it shows that total solids concentration in tank at 1300 mg/l of COD rating is in tank 1-2500mg/l, tank 1 +tank 2- 1950mg/l, tank 1+tank2+tank3-950mg/l.

Table 2: Variation in Total Solids for optimum HRT 8hrs at different concentrations (mg/l)

Feed concentration	HRT in	Total solids concentration in mg/l for	Total solids concentration in mg/l for	Total solids concentration in mg/l for

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in mg/l	hours	tank 1	tank 1+tank 2	tank 1+tank 2+tank 3
1000	8	2000	1200	700
1100	8	2200	1320	850
1200	8	2350	1900	900
1300	8	2500	1950	950
1400	8	2800	2300	1300
1500	8	2940	2500	1500

IV. Conclusions

The following conclusions are drawn from the present for study:

1. For the initial concentration of 1000mg/l with varying HRT 48, 24, 12, 8 and 4 hours, found that maximum removal efficiency is 94% from tank 1+ tank 2 +tank3 for 8 hours HRT. So optimum HRT is fixed for 8 hours.
2. Results shows that at optimum HRT 8 hours the optimum removal efficiency from tank 1 + tank2 + tank 3 is 94%, so optimum COD loading rate is 1300 mg/l.
3. The variation in the amount of total solids for optimum COD loading rate of 1300 mg/l at optimum HRT is tank 1=2500mg/l, Tank1 +tank2=1950mg/l and for tank1+tanj2+tank3 =950mg/l.
4. From this study we can say that three stage RBC is an effective and efficient reactor for treating dairy waste water.

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