TREATABILITY OF DAIRY WASTEWATER IN ANAEROBIC MIGRATING BLANKET REACTOR (AMBR)

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Abstract - *The present work is carried to study about treatability of Anaerobic Migrating Blanket Reactor (AMBR) for the treatment of dairy wastewater. AMBR is blanket reactor where anaerobic sludge is equally distributed over reactor by periodically reversing the inlet and outlet. But in the present work reactor performance during start-up is evaluated to build the AMBR. Reactor is started batch-wise with increasing organic loading rate till its full strength along with decreased hydraulic retention time. Whenever the changes occur in OLR and retention time due to sudden stress, the outlet COD obtained will show a suddenly increased pattern and later decreases as the reactor attains its ability to digest the organic load. At end of 32 days of operating period, with 3.597 kg-COD/m^3/day of maximum organic loading rate at 24 hours of hydraulic retention time, reactor attained the maximum COD removal efficiency of 76.6 %.*

Key Words: Anaerobic migrating blanket reactor, organic loading rate, hydraulic retention time, COD removal efficiency.

1. INTRODUCTION

The increase in industrialization with urbanization results in deterioration of environment considerably with water pollution, air pollution, solid waste and noise pollution etc. The dairy industry growth was tremendous because of increased demand for milk products in last decades. Water pollution one of main concern with dairy industry as it contains high organic loads in its wastewater. Dairy will process the collected milk, which are sent to milk sterilize unit, homogenization, pasteurizing, solids separating and solids filtering. Condensed milk, curd, butter, milk powder, cheese, yogurt, ice cream with many milk related products were made. Water is main processing element. Water used to clean, heat, sanitize, cool and floor washing. One to three litre of sanitizing agents with cleaning water for processing a litre of milk will generate about two to two-and-half litre of wastewater per litre of milk processed [14].

Since the wastewater from dairy contain high organic content, its biological degradation is more effective in removing organic matter. In biological treatment ability of sludge in adsorbing toxic heavy metals along with the organic compounds will be beneficial. Microbial transformations in dairy wastewater having microbes with complex organics will also adsorb heavy metals. The main objective is to understand the treatability of dairy wastewater using Anaerobic Migrating Blanket Reactor (AMBR). With this objective, performance of AMBR during the initial stage of start-up is studied.

2. STUDY AREA AND DATA ACQUISITION

Study area for present work is Shivamogga, Davanagere and Chitradurga Co-Operative Milk Producer's Societies Union Limited (SHIMUL) which is situated at Machenahalli, Shivamogga, Karnataka. SHIMUL dairies will manufacture milk products and Machenahalli plant at Shivamogga has total process capacity of 1.5 lakh litre per day and within its jurisdiction it markets other milk related products of KMF (Karnataka Milk Federation).

After the screening unit at 0.4 MLD SHIMUL Effluent Treatment Plant (ETP) wastewater was collected. Samples were collected in the PVC bottles and are kept inside ice box later taken to BIET Environmental laboratory, Davanagere. Samples were stored in refrigerator under 4°C Laboratory analysis carried as per IS codes and data related to dairy wastewater is collected. Data compiled and collected are adequate enough to determine the feasibility treating dairy effluent using AMBR.

3. METHODOLOGY

In this study, efficiency of COD removal in dairy wastewater is carried to study feasibility of AMBR in anaerobic treatment of dairy wastewater. Glass model fabrication of AMBR (Anaerobic Migrating Blanket Reactor) is done.

3.1 Wastewater Characteristics

Characterization of dairy wastewater in terms of pH, colour, VSS (Volatile Suspended Solids), TSS (Total Suspended Solids), COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) by following standard methods.

Table -1: IS codes for testing

Parameters	Test Methods
pH value at 25°C	IS:3025(Part-11)1983, Reaffirmed 2012
TSS and VSS	IS:3025(Part-18)1984, Reaffirmed 2012
Biological Oxygen Demand	IS:3025(Part-44)1993, Reaffirmed 2014
Chemical Oxygen Demand	IS:3025(Part-58)2006, Reaffirmed 2012

3.2 Experimental setup

Experimental AMBR model is fabricated from glass with PVC pipes as shown in figure to a working volume of 20 litres. The reactor with rectangular dimensions of length 45.72 cm, height of 22.86 cm and width of 22.86 cm. Reactor then divided to form three compartments, having glass sheets separating these compartments. Openings of diameter 2.5 cm were provided in those glass sheets at 3.81 cm from reactor bottom. In creating sufficient contact and ensuring migration of biomass, those openings were placed. The headspace in reactor not compartmentalized. Inlet of the reactor was at left-top below that of top level of baffles, Outlet being placed 3.81 cm from bottom opposite to that of inlet. Production of methane and other gases were not quantified, they were collected by water displacement method and scrubbed through water.

Table - 2: Physical features of model

Reactor	Dimensions
Length	45.72 cm
Depth	22.86 cm
Width	22.86 cm
Compartment free board	3.81 cm
Total volume	23.90 liters
Working Volume	20 liters
Volume used while start-up	10 liters
Number of compartments	3
Each compartment length	22.86 cm

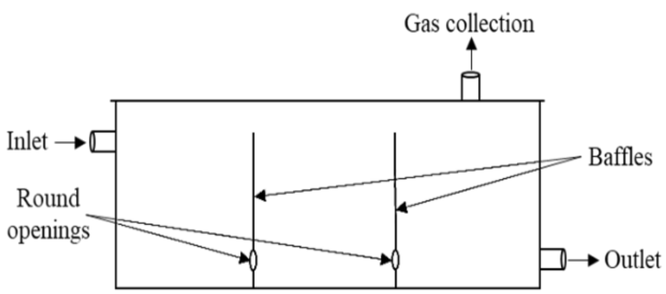

Fig - 1: Typical AMBR model

3.3 Procedure to Start-up

Reactor was filled for 10 litres that is for its half capacity and reactor is fed with a dairy wastewater diluted to 500 mg/l COD for 48 hours of Hydraulic Retention Time (HRT). Above feeding corresponds to 0.25 kg-COD/m^3/day of OLR (Organic Loading rate). On the next loading feed OLR was increased to 1.00 kg-COD/m^3/day, which is 1000 mg/l COD along 24 hours of HRT. Step-by-step organic loadings to reactor increased by decreasing HRT. Inlet COD and outlet COD were analysed. To determine feasibility of reactor COD removal efficiency is tested. Since outlet is at a 3.81 cm height from the bottom, wastewater will reside inside the reactor which will hold the biomass that will then be utilized by substrate. Since working volume set to its half-capacity, gases thus produced will reside in top-half and headspace of reactor, gases escaped will then scrubbed through water. It is operated batch-wise, long retention times were used to start the reactor with low organic loads. Retention time and loading are changed step-wise. The loading rates its corresponding retention time were tabulated as below.

Reactor with 18 hours of minimum HRT is given when there is constant efficiency in COD removal is observed. To study treatability, COD removal efficiency of reactor is taken as baseline which indicates the feasibility of AMBR in treating the dairy wastewater.

Table - 3: OLR with corresponding HRT

Feed COD (mg/l)	Organic loading rate (kg-COD/m^3/day)	Hydraulic retention time (hours)
500	0.25	48
1000	1.00	24
1500	1.50	24
2000	2.00	24
2500	2.50	24
Target COD	$OLR = \frac{COD \times 0.001}{HRT/24}$	24
		18

4. RESULTS AND DISCUSSIONS

4.1 Wastewater Characteristics

Effluent Characterization is carried, by following standard IS code methods. Table shows dairy wastewater characteristics.

Table - 4: Characteristics of wastewater

Parameter	Value
Color	White
pH	7.8
Total Suspended Solids	740 mg/l
Volatile Suspended Solids	610 mg/l
Bio-chemical Oxygen Demand (BOD)	1780 mg/l
Chemical Oxygen Demand (COD)	2695 mg/l

4.2 Reactor Feasibility

Method adopted to determine feasibility of AMBR is by knowing the Chemical Oxygen Demand (COD) removal efficiency. Decreased organic load in reactor by the system of migrating blanket reactor will be determined by COD test, removal of COD was considered as pathway in determining the feasibility. Organic loading rates (OLR) are increased from initial 0.247 kg-COD/m^3/day at HRT of 48 hours to 18 hours of HRT along with loading of 3.597 kg-COD/m^3/day. While there is increase in the stress when change in either of hydraulic retention time or organic loading rates, affecting the efficiency of COD removal.

Efficiency decreases when organic loading increases and also when retention time shortened efficiency is decreased. The increasing pattern efficiency suddenly drops when there occurs a change in retention time and load. Chart 1 shows increase in organic loading rates which are employed to start AMBR. Chart 2 shows COD concentration at inlet to the reactor. Graphs of both inlet COD and OLR follows same pattern, as they were related to each other. Outlet COD graph obtained is shown in the Chart 3. At 32 days of operating, with maximum OLR of 3.597 kg-COD/m^3/day at a HRT of 24 hours, AMBR attained the maximum removing of COD with efficiency of 76.6 %. In Chart 4 variability in COD removal efficiency is shown.

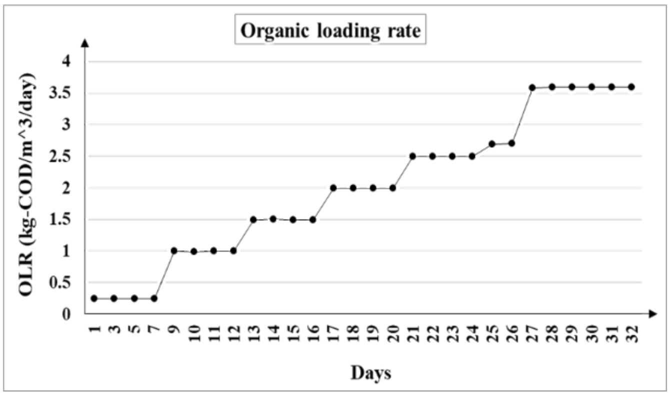

Chart - 1: Organic loading rates during start-up

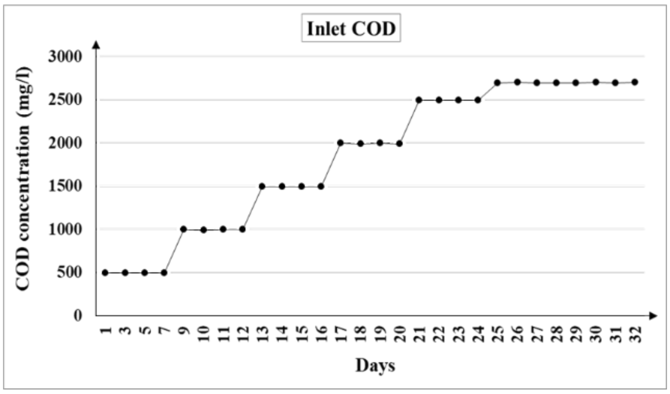

Chart - 2: Inlet COD during start-up

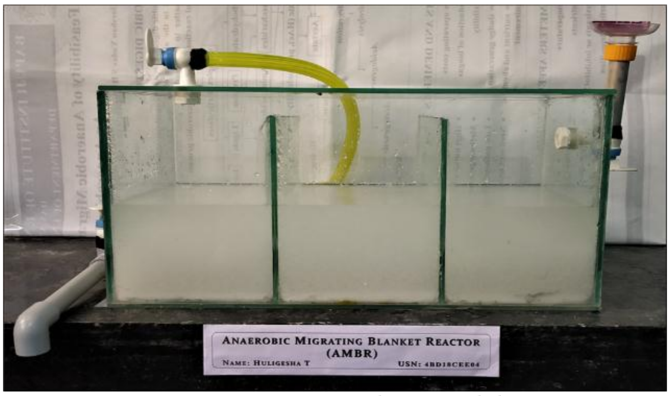

Fig - 2: AMBR working model

5. CONCLUSION

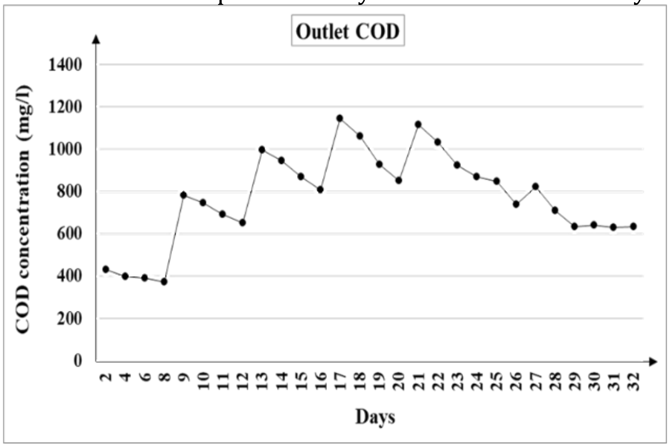

Chart - 3: Outlet COD from AMBR

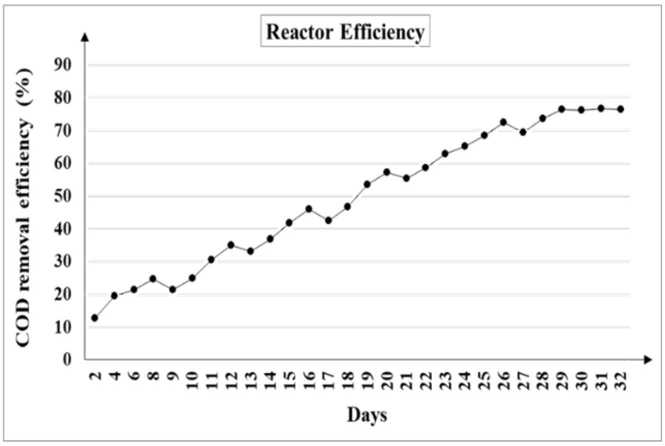

Chart - 4: COD removing efficiency

Work discussed in present study focuses about feasibility of treating dairy effluent using migrating blanket reactor by anaerobic treatment. The outlet and inlet were reversed periodically to effectively use the biomass and in controlling the produced fatty acids. Present study only concetrated on start-up of the reactor. Started batch-wise, having low organic loading rate initially and then increased to its full strength and corresponding decrease in hydraulic retention time. COD test is one of the ways to determine the organic load. COD removing from reactor is taken as baseline to determine the efficiency. COD removing variability and trends were observed. It was seen 76.6 % of COD removing efficiency is obtained. As reactor operated at half capacity, biomass utilizing substrate was small and so we still got at outlet some organic content. Reactor might show even more efficiency if operated to its full capacity. Mainly efficiency is affected by nutrients, retention time, pH, mixing, feed characteristics, toxic materials and temperature. Two-stages of treatment can be provided first-stage AMBR effluent fed into second-stage AMBR can remove organic matter completely from the dairy effluent. As organic waste is largely present in dairy effluent and AMBR removes organic load considerably, AMBR can be used in place of conventional clarifiers.

Table - 5: COD removing efficiencies to corresponding OLR

OLR (kg-COD/m^3/day)	HRT (hours)	Inlet COD (mg/l)	Outlet COD (mg/l)	COD removal efficiency (%)
0.246	48	493	430	12.7
0.247	48	495	398	19.6
0.249	48	498	391	21.5
0.248	48	496	373	24.8
0.996	24	996	782	21.5
0.993	24	993	745	25.0
0.998	24	998	693	30.6
0.998	24	998	650	34.9
1.493	24	1493	998	33.1
1.498	24	1498	945	36.9
1.496	24	1496	871	41.8
1.497	24	1497	808	46.0
1.996	24	1996	1146	42.6
1.993	24	1993	1062	46.7
1.997	24	1997	927	53.6
1.992	24	1992	852	57.2
2.494	24	2494	1115	55.3
2.497	24	2497	1034	58.6
2.493	24	2493	923	63.0
2.496	24	2496	868	65.2
2.694	24	2694	849	68.5
2.698	24	2698	740	72.6
3.588	18	2691	823	69.4
3.593	18	2695	711	73.6
3.594	18	2696	634	76.5
3.597	18	2698	640	76.3
3.593	18	2695	630	76.6
3.596	18	2697	634	76.5

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