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Performance Evaluation of Fixed Film Fixed Bed Anaerobic bio-Reactor for Treating Dairy Industry Wastewater

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Abstract: In present times, the dairy industries have started cleaning processing equipments with "clean in place" systems, the conventional water use pattern is largely reduced to almost less than one against one liter of milk processing.

Presently anaerobic digestion for Dairy industry wastewater has not been encouraged in India. Anaerobic wastewater treatment process became more popular due to its advantages over aerobic process. Anaerobic treatment of wastewater has a distinct advantage of recovery of inherent energy in the form of methane gas with much less sludge production.

The fixed film fixed bed anaerobic reactor is evaluated with a laboratory model (20 l) for the treatment of Dairy effluent. The experiment was run for two different operating conditions viz., Influent COD was observed to be 6500, 5500, 4500, 3500, 2500, 1500, 500 mg/l and HRT in days (1, 2, 3, 4, 5 and 6 days) at constant pH 7.5 and temperature 35^{0}C. The optimum COD removal was observed to be 98.50% at 4 day HRT and the biogas conversion was 0.0409 m^3 per Kg COD removed at 5 day HRT.

Keywords: Fixed film fixed bed reactor (FFFBR), Microbial support media, Chemical oxygen Demand (COD), Hydraulic Retention time (HRT) and Bio-gas

I. INTRODUCTION

In today's world, India has the credit of being the largest producer and consumer of milk in the world as milk production in India has doubled and has reached the 116.2 million tons a year in the past 20 years, thus becoming India's No.1 farm commodity.

In milk processing, the water requirement for washing and cleaning operations is in the range of 0.9 to 2 liters per liter of milk. Per liter of processed milk a dairy industry generates about 0.2–10 liters of effluent. [2, 3] The milk industry generates between 3.739 and 11.217 million m^3 of waste per year (i.e. 1 to 3 times the volume of milk processed).

The dairy industry wastewater is having high Chemical oxygen demand (COD) and it is biodegradable. As such, two stage aerobic reactors are used for wastewater treatment in most of the dairies. Anaerobic reactors with the use of fixed bed offer more area for active microorganisms to grow all over the filling media. The most important aspects in the design of an anaerobic fixed bed reactor is selecting an adequate support material. The type of support media (porous or non-porous) greatly affects the reactor's performance in anaerobic filter reactors. An ideal packing material used for the fixed bed material should be of low cost, light weight, durable, easy to ship and install, it should also have a large specific surface area for bacterial growth and high porosity to prevent clogging by the increased biomass. It has been reported that the organic matter removal efficiency in fixed-bed reactors is directly related to the characteristics of the support materials used for the immobilization of anaerobes. [2, 5]

In this paper, a system of Fixed Film Fixed Bed anaerobic reactor to treat dairy industry wastewater with low cost and high fibreous material coconut coir and coconut shell as a supporting media for microbial growth is used and is evaluated for the removal of COD and biogas determination

II. EXPERIMENTAL SETUP

The experimental setup consists of a fixed film fixed bed reactor (FFFBR) reactor having 20 liters of effective volume. The physical features and process parameters are listed in Table-1. The schematic of the experimental setup is presented in Fig 1.

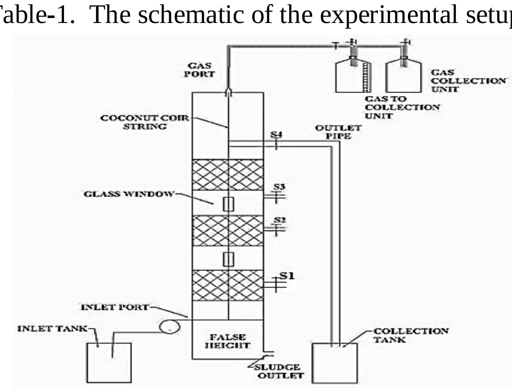

Figure 1 Schematic diagram of Up-flow anaerobic Fixed Film Fixed Bed Bio-film Reactor

Table 1: Physical features and process parameters of experimental model

Sr. No.	Specifications of the reactor	Value
1	Total volume of Reactor, liters	20
2	Effective volume of Reactor, liters	18
3	Total height of Reactor , cm	163
4	Effective height of Reactor , cm	111
5	Total diameter of Reactor , cm	16
6	Effective diameter of Reactor , cm	15
7	Height of the bio mass support media fill, cm	12
8	Diameter of the influent pipes, cm	0.6
9	Diameter of the effluent pipes, cm	1
10	Peristaltic Pump (make) : PP model	NFP – 01; Flowtech

Plate 1 Photo of FFFBR

III. EXPERIMENTAL METHODOLOGY

After the start-up period, when the reactor reaches stable effluent characteristics, which was considered as the "steady state" operation, the reactor was operated continuously to investigate the process performance of inflow wastewater characteristics. After start-up, time was allowed for the reactor to achieve stability of operation, and planned experimentation with actual wastewater commenced on the 60th day. Acclimatization of the reactor system to actual wastewater was done by gradual increase in the amount of dairy industry wastewater by reducing the sewage seed flow proportionately. The dairy industry wastewater was added to the reactor each day, to promote and sustain biofilm growth within the reactor. The random samples were obtained from the dairies nearby Amravati & Akola in Maharashtra and were analyzed for specific parameters.

After the completion of the start-up phase, during steady-state operation, the reactor was operated at 350 C temperatures at each organic loading rate. Later, The performance of the reactors was studied by reducing and operating the Hydraulic retention time (HRT) from 6 d to 5 d, 4 d, 3 d, 2 days and 1 day HRT individually, corresponding to influent COD loading rate as 6500, 5500, 4500, 3500, 2500, 1500 & 500 mg/l at a particular influent pH of 7.5.

IV. RESULTS AND DISCUSSION

To evaluate the performance of the reactor, COD removal (%) and biogas yield was chosen as significant parameters for the above evaluation. To determine optimum operational parameters such as HRT only graphical method is used. In this method it becomes necessary to keep any two parameters constant and draw the graph for other two parameters. In this study the temperature has kept constant at 35^{0}C and influent pH of 7.5 was also kept constant. To study the operational parameter of HRT, mainly percentage COD removal efficiency of the reactor and biogas determination was considered.

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For each influent COD for a graph of HRT versus % removal for COD, and HRT versus biogas released was drawn to understand the performance of the reactor. The observations for % COD removal were recorded in table 2. A graph was plotted in fig. 2 for varying influent COD studied and HRT for % COD removal efficiency to determine optimum influent COD.

Table 2: Observation table for varying HRT and influent COD versus % COD Removal Efficiency at Temp 35^{0}C and pH 7.5

HRT	% Removal Efficiency						
	COD 6500	COD 5500	COD 4500	COD 3500	COD 2500	COD 1500	COD 500
1	88.2	89.2	92.2	91.2	90.6	89.4	89.3
2	89.4	91.1	94.5	93.7	92.4	91.6	91.1
3	92.1	92.8	96.2	95.4	94.9	93.2	92.6
4	94.2	94.9	98.5	96.8	95.3	94.5	93.8
5	91.8	93.3	95.7	94.9	94.2	93.7	93.2
6	88.9	90.5	93.8	92.6	91.9	90.3	89.9

The graph for HRT vs. % COD removal efficiency was shown in Fig 2. It shows that the maximum COD removal as 98.59% at 4 day HRT which corresponds to 4500 mg/lit of influent COD which is equivalent to an organic loading rate of 0.004 Kg COD/m^3.day

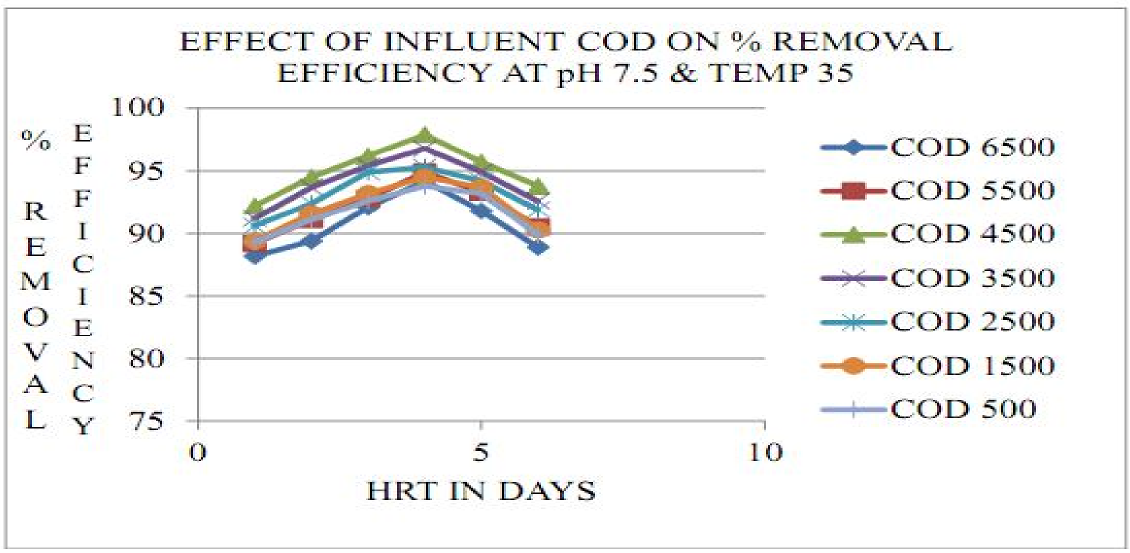

Fig. 2: Effect of varying HRT and influent COD on % COD Removal Efficiency at Temp 35^{0}C and pH 7.5

The observations for biogas evolved out were recorded in table 3. And a graph was plotted in fig. 3 for varying influent COD studied and HRT versus Biogas evolved out from the reactor to determine optimum influent COD and HRT.

Table 3: Observation for varying influent COD & HRT at Temperature 35^{0}C for specific Biogas formation

HRT	Specific Biogas Formation in m^3/Kg CODr at Temp. 35^0 C & pH 7.5						
	COD 6500	COD 5500	COD 4500	COD 3500	COD 2500	COD 1500	COD 500
1	0.00084	0.00111	0.00217	0.00133	0.001	0.00112	0.00078
2	0.00448	0.00608	0.00821	0.005	0.00348	0.0035	0.00218
3	0.00848	0.01136	0.01589	0.01023	0.00733	0.00762	0.00467
4	0.01417	0.0173	0.02763	0.01867	0.01083	0.0119	0.00763
5	0.02153	0.02825	0.04094	0.03038	0.02036	0.01939	0.01141
6	0.02094	0.02681	0.03972	0.02591	0.01634	0.01796	0.01067

The graph for HRT vs. biogas released was shown in Fig 3 which shows that the maximum yield of bio-gas as 0.0409 m^3per Kg COD removed at 5 day HRT

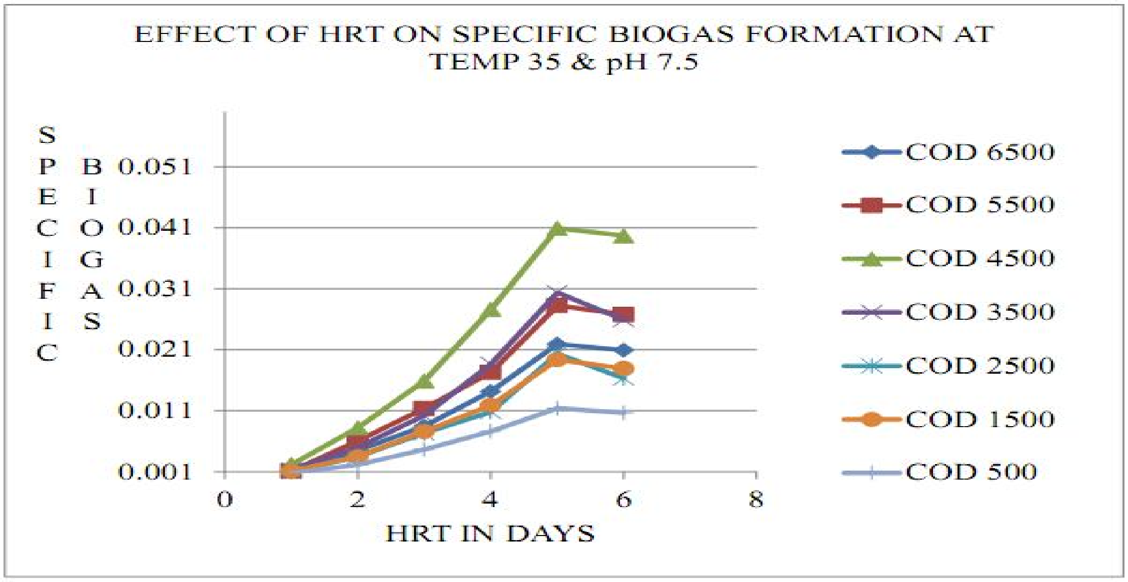

Fig. 3: Effect of varying HRT and influent COD on specific biogas formation at Temp 35^0C and pH 7.5

V. CONCLUSION

The FFFBR anaerobic reactor is found to treat Dairy industry wastewater with influent COD of 4500 mg/l at four day HRT for a maximum COD removal efficiency of 98.50 % and 0.0409 m^3 of Bio-gas production per Kg COD removed at five day HRT.

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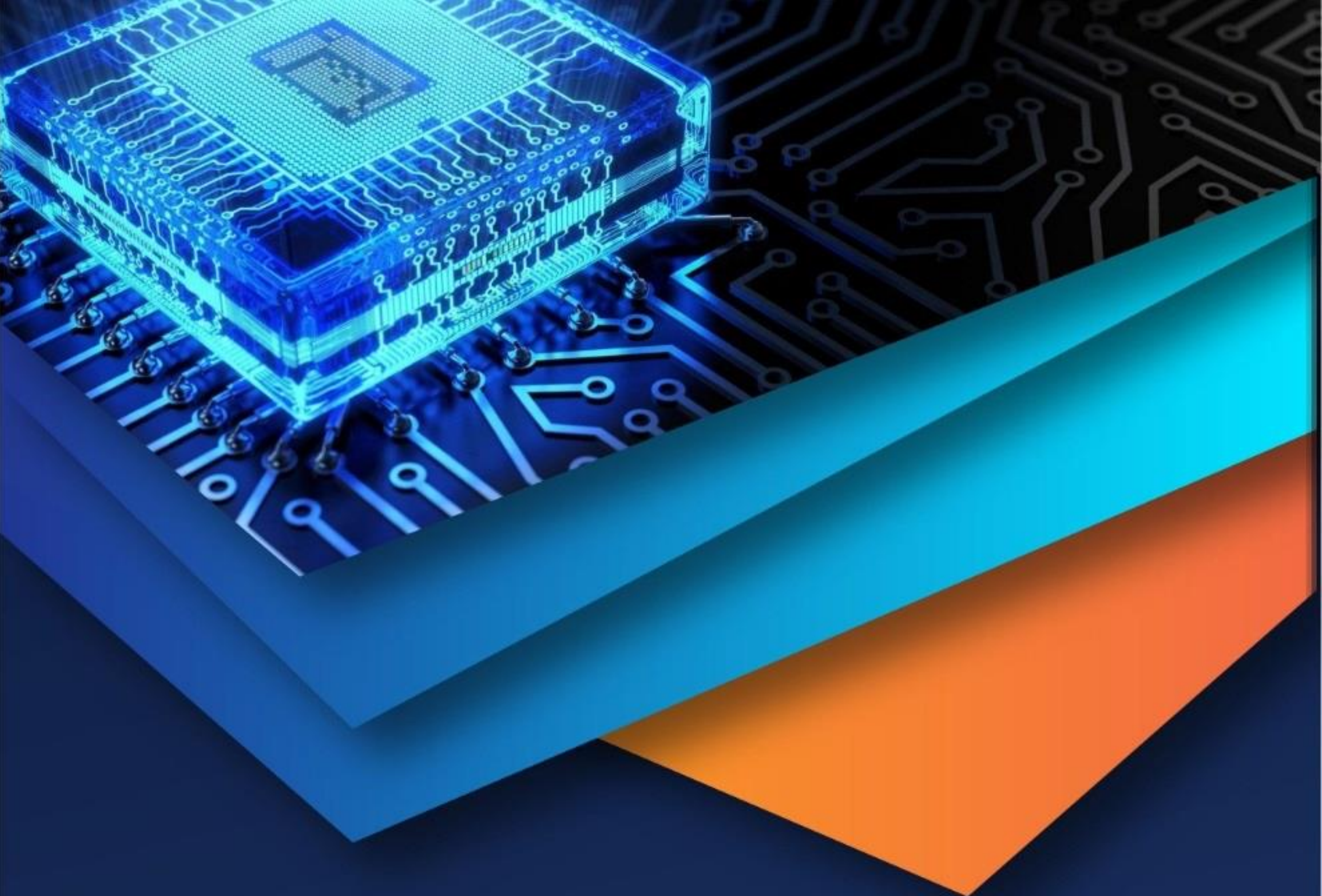

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