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Original Research Paper

Feasibility Studies on the Treatment of Synthetic Dairy Wastewater Under Variable Experimental Conditions

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ABSTRACT

The requirement of milk and milk products is kept growing in steady rate, making a significant impact on the Indian agricultural domain. The dairy industries require large quantity of water for the purpose of washing of canes, machinery and floors, and the liquid waste in dairy originates from the manufacturing processes, utilities and service sections. The various sources of waste generation from a dairy are spilled milk, spoiled milk and skimmed milk whey. The objective of this study is to focus on finding out the optimal parameters for efficient biodegradation of organics in the dairy wastewater. An experimental setup was designed and fabricated, and made to comprehend the degree of wastewater stabilization in the form of COD at variable experimental conditions. The main characteristics of dairy waste streams were identified and the anaerobic degradation of the wastewater in the fixed film fixed bed reactor was carried out with operating condition of variable organic loading rates.

INTRODUCTION

Water pollution has become one of the most serious problems in our society. Water is the most important resource and due to increased concern for the future of today's water supplies (aquifers, rivers, etc.) humans have been forced to develop new technologies to protect these bodies of water from contamination.

Nowadays, industrial growth creates environmental pollution and generates hazardous wastewater, which is one of the major concerns for the mankind. The biggest problem due to the dairy industry is the disposal of wastewater which is not meeting the standards.

The dairy industry wastewater contains high concentrations of organic matter, and therefore, proper treatment prior to discharge is required (Abdulsalam Tawfeeq Dawood et al. 2011). The dairy industry wastewater is generated primarily from the cleaning and washing operations in the milk processing plant and estimated to be 2.5 times the volume of the milk processed. Thus, some 200 million tons of wastewater is generated annually from the Indian dairy industry. The interest in anaerobic reactors has increased rapidly with the realization that the cost-effective anaerobic treatment is generally not possible without some form of biomass retention.

The anaerobic process could remove above 75% of the BOD and COD all the year round but this was not enough to prevent malodours during the winter season (Ziv Arbelia et al. (2006). The separation of fibrous solids increased the COD to VS ratio of the flushed dairy manure wastewater (Wilkie et al. 2004).

In the present study an experimental model of fixed film fixed bed reactor was constructed to conduct an experiment for simulated, synthetic waste streams of dairy to evaluate the treatment efficiency under varying experimental conditions.

MATERIALS AND METHODS

The experimental model is made up of plexiglass, which was hermetically sealed to avoid any air entrapment. The experimental design was made on the basis of flow rate, hydraulic retention time, organic loading rate and influent COD. Fig. 1 shows the schematic diagram of the laboratory scale, fixed film fixed bed reactor.

DESIGN OF PHYSICAL MODEL

The model is designed to have a fixed film fixed bed reactor with a working volume of 13 litres. The influent feed was envisaged through a peristaltic pump which can pump at 0 to 500 CFCC/hour. The physical characteristics of the reactor are depicted in Table 3.

ACCLIMATION AND PROCESS STABILITY

The treatment process acclimation was achieved by operating the plant with screened sewage drawn from the treatment facilities of Annamalai University. The reactor was seeded properly with an active anaerobic sludge from the treatment facility of "Hutsun Agro Industries, Salem".

PREPARATION OF SYNTHETIC DAIRY EFFLUENT

The synthetic composition was designed to stimulate dairy effluent, based on the characteristics of the normal dairy effluent. The chemical composition of the synthetic dairy effluent is presented in Table 1.

RESULTS AND DISCUSSION

The laboratory model of fixed film fixed bed reactor as shown in Fig. 1 was used to conduct an experiment with a working volume of 13 litres. The performance of the model was accessed with respect to the parameters at regular intervals by using peristaltic pump (PP10). The influent flow rates have been regulated with desired Hydraulic Retention Time (HRT) and Organic Loading Rate (OLR). The measured parameters such as COD were interpreted with respect to OLR and HRT.

The treatment performance of the reactor: The process stability was achieved by operating the model with the combination of sewage and dairy wastewater. The process stability of the model was accessed with uniform COD reduction at 65% to 72% in the reactor after 35 days from the date of start of the experiment.

After achieving the stabilization of biochemical fermentation process with sewage, the dairy wastewater was introduced into the reactor to evaluate the performance of the reactor. The synthetic dairy wastewater was prepared and introduced with a flow rate of 0.43 L/day to the reactor by the gradual addition of 20%, 40%, 60%, 80% and 100%. After allowing the synthetic dairy wastewater at 100% concentrations, the COD removal was monitored.

Synthetic dairy milk effluent preparation was used for the entire experiment for evaluation of the performance of fixed film fixed bed reactor model for treating the dairy effluent. The synthetic dairy milk effluent was prepared for feed for 3 different average COD loadings of 2072, 2448, 2760 mg/L.

The varied flow of effluent as feed was pumped for 0.43, 0.86, 1.20, 1.72, 2.16 L/day using peristaltic pump. The corresponding organic loading rates were 0.045 to 0.066 kg COD/m^3.day. The treatment performance was essentially measured in terms of % COD reduction.

The maximum COD removal efficiency of 81% was observed at corresponding OLR of 0.066 kg COD/m^3.day. The minimum COD reduction efficiency of 61% was observed while the OLR was 0.045 kg COD/m^3.day. The substrate concentrations at different applied OLR from 0.045 to 0.066 kg COD/m^3.day. The % COD removal efficiency from 61 to 81% was achieved, which showed that increase in OLR decreases the COD removal efficiency (Fig. 2).

Table 1: Chemical composition of the synthetic dairy wastewater.

S. No	Parameters		
1.	Milk Powder	-	Varied
2.	NH_4Cl	-	Varied
3.	$MgSO_4.7H_2O$	-	50mg/L
4.	$FeCl_3.6H_2O$	-	3mg/L
5.	$CaCl_2.H_2O$	-	0.4 mg/L
6.	KCl	-	60 mg/L
7.	$(NH_4)_2PO_4$	-	Varied

Table 2: Physical features and process parameters of experimental model.

Reactor volume, litres	:	13
Reactor height, cm	:	125
Reactor diameter, cm	:	12
Height of the biomass support media fill, cm	:	50
Diameter of the influent and effluent pipes, cm	:	0.6
Influent average COD, mg/L	:	2072, 2448, 2760
Hydraulic Retention Time, days	:	1.87, 2.08, 2.88, 3.74, 5.34
Peristaltic Pump (Miclin's Make)	:	PP10 model

Table 3: Characteristics of dairy effluent.

Sl. No.	Parameters	Sample 1	Sample 2	Average
1	pH	6.75	6.82	6.785
2	BOD_5 (mg/L)	2180	1950	2065
3	COD (mg/L)	3360	4230	3795
4	TS (mg/L)	2940	3150	3045
5	TSS (mg/L)	560	610	585
6	TDS (mg/L)	2560	2630	2595
7	TVS (mg/L)	2360	2130	2245
8	Total Kjedahl nitrogen (TKN) (mg/L)	17.7	17.6	17.3
9	Phosphorus (mg/L)	15	14.3	14.65
10	Sodium (mg/L)	170	165	167.5

From the Fig. 2, the COD removal percentage increases as influent COD concentration decreases. It is also apparent from these experiments that the efficiency of COD removal is associated with the nature and properties of support materials involved in the attachment of biomass.

CONCLUSION

To study the treatment performance under steady-state conditions, synthetic preparation of waste streams was allowed in the reactor, which was operated continuously. The experiment was envisaged for an average COD loading at 2072, 2448, 2760 mg/L which was corresponding to the organic loading rate. The minimum COD removal efficiency was at 61% observed for an OLR of 0.045 kg COD/m^3.d with a HRT of 1.87 days. The maximum COD removal was observed 81% at a HRT of 5.34 days with an OLR of 0.066 kg COD/m^3.d, which shows that no biomass washout was ob-

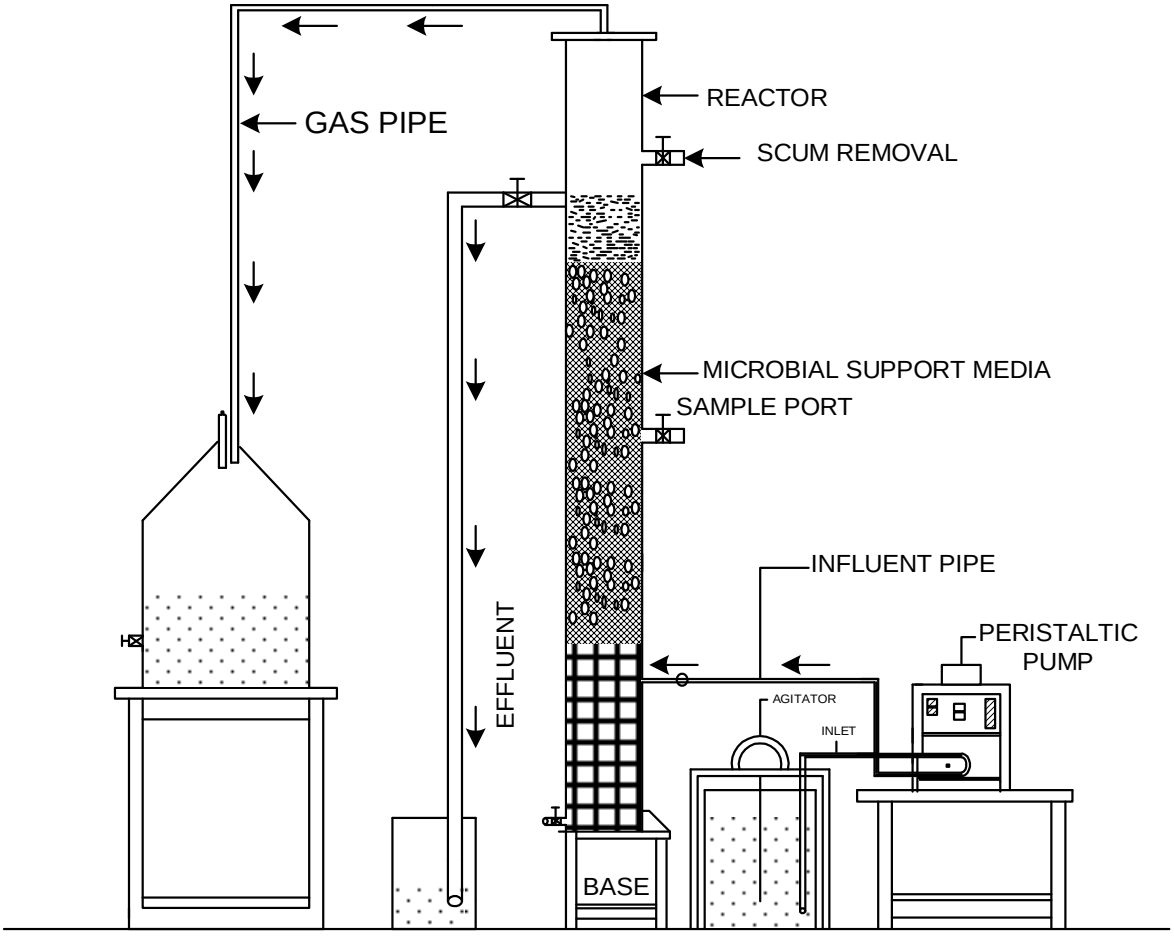

Fig. 1: Experimental model of fixed film fixed bed reactor.

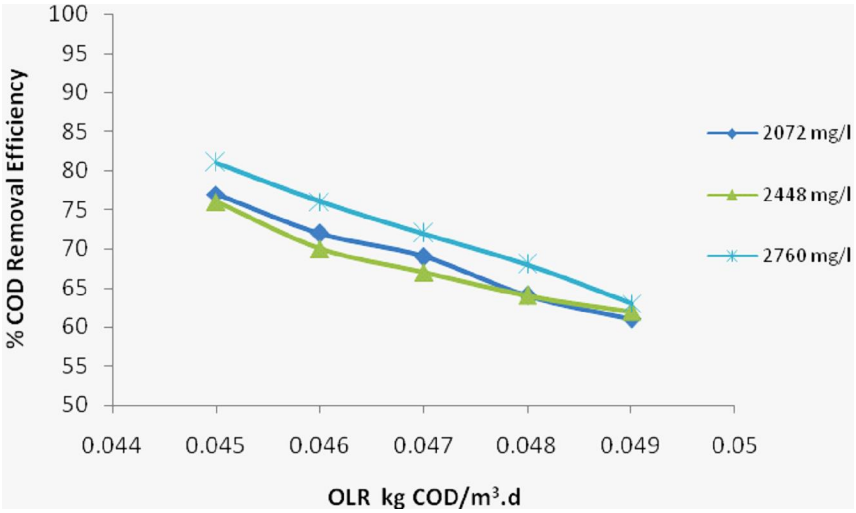

Fig. 2: Percent removal of COD at different organic loading rates.

served and most of the waste contained in the dairy wastewater was successfully degraded. Hence, the anaerobic fixed bed fixed film reactor successfully treated the dairy wastewater and a final effluent with a COD content around 440 mg/L was obtained.

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