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**ORIGINAL RESEARCH ARTICLE**

# Kinetic Evaluation of Fixed Film Fixed Bed Anaerobic Reactor by Using Dairy WasteWater

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## ABSTRACT

A Fixed Bed Fixed Film anaerobic reactor (FBFFR) was studied for treating Dairy wastewater. The experiment was conducted for different COD loading and different flow rates. The COD reduction efficiency was observed for 66.75 % to 80.88%. The model prescribed by McCarty and Young is used to estimate the process kinetic parameters. The evaluated kinetic parameters are listed.

**Key words**: FBFFR, Kinetic parameters, COD, HRT and OLR.

## INTRODUCTION

Today, the annual production of processed milk in India is more than 150 Million Tones. Dairy plant wastewaters are generally high strength wastes containing soluble, colloidal and suspended solids with high concentration of biochemical oxygen demand [1,2]. Anaerobic decomposition is a biologically mediated process indigenous to nature and capable of being simulated for treating high strength wastes. Though the capital cost is higher the net operating cost of the system turns out to be either significantly less whereas the operating cost for aerobic process increases with increase in their strength [3]. Therefore, for high strength industrial wastewaters, anaerobic treatment process has long been economically attractive [4]. The development of processes with higher volumetric load capacity has gradually increased the interest in treating more wastes in anaerobic processes [5]. Reuse and energy conservation have become the words of the day and anaerobic processes have emerged with a new potential. With the new interest came new approaches, of which Fixed Bed Fixed Film anaerobic reactor (FBFFR) have assumed greater significance in treating high as well as medium strength wastewater [6,7]. A laboratory scale model of FBFFR mainly involved operating the reactors at various combinations of HRT and influent COD concentration. The data generated were used to determine the process kinetic values for substrate biomass [8].

## EXPERIMENTAL SETUP

The experimental setup consists of a FBFF reactor having 42.70 liters of effective volume. The physical features and process parameters are listed in (**Table 1**). The schematic of the experimental setup is presented in (**Figure 1**).

**Table 1 : Physical features and process parameters of experimental model**

**Type: FIXED BED-FIXED FILM ANAEROBIC REACTOR**

| | |
|---|---|
| Effective volume of the reactor, lit | 42.70 |
| Total height of the reactor, m | 2.00 |
| Effective height of the reactor, m | 1.36 |
| Effective diameter of the reactor, m | 0.20 |
| Height of the microbial support fill media, m | 0.70 |
| Fill media (v/v)<br>Type A<br>Type B | <br>14.71%<br>36.76% |
| Surface area of microbial support media<br>Type A (Top)<br>Type B (Bottom) | <br>500 $m^2/m^3$<br>350 $m^2/m^3$ |
| Peristaltic pump | PP-30 model (Miclin's make) |
| Influent flow, $m^3$/day | 0.14, 0.04, 0.07, 0.05, 0.02 |
| Hydraulic retention time, hrs | 7.30, 10.95, 14. 60, 21.90, 43.80. |
| Influent average COD, mg/l | 1559.17, 2605.64, 3557.76, 4116.40 and 4599.68 |
| Organic loading rate, Kg COD/$m^2$.day | 0.013, 0.022, 0.031, 0.035, 0.040 |

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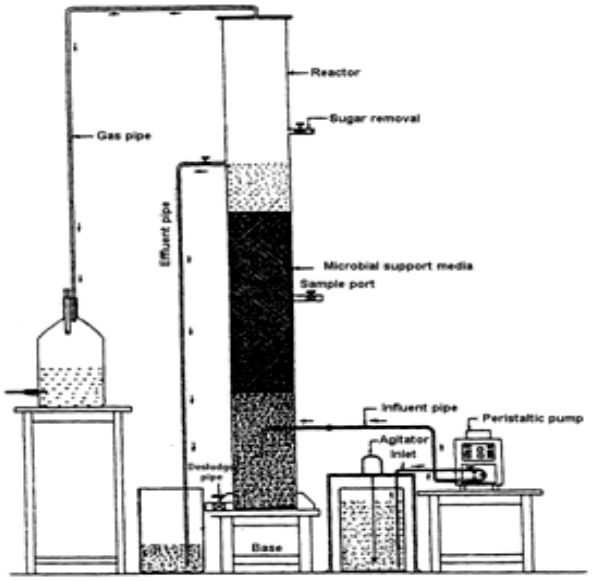
**Fig 1: Experimental setup consists of a FBFF reactor**




Schematics of the experimental setup

## EXPERIMENTAL METHODOLOGY

The experiment was started for treating the domestic wastewater. The reactor was observed to attain the steady state conditions after 48 days with an average COD removal of 74.45%. Three random samples were obtained from M/s. Hatsun Agro Industries Private Ltd., Karipatti, Salem district, Tamil Nadu, and were analyzed for specific parameters.

The real time wastewater was introduced in reactor with an average OLR of 0.021 kg COD/$m^2$.day and in stages, mixed with domestic wastewater, in proportion of 20%, 40%, 60% and 100%. The performance of the reactor was studied and the steady-state conditions were observed to attain with COD reduction for an average value of 73.5% after 34 days.

The synthetic dairy effluent is prepared using milk powder and introduced after the process stabilization. The model reactor was operated under different Organic Loading Rates from 0.004 to 0.073 kg COD/$m^2$.day, for the average influent COD of 1559.17, 2605.64, 3557.76, 4116.40 and 4599.68 mg/l and for different Hydraulic Retention Times (HRT) of 7.3, 10.95, 14.60, 21.60 and 43.8 hrs (The corresponding hydraulic loading are 0.016, 0.011, 0.008, 0.005, 0.003 $m^3/m^2$.day).

## MATHEMATICAL MODEL

### McCarty and Young Model

The hydraulic retention time, over which the substrate is maintained in the vicinity or contact with the bio film, could influence the treatment efficiency than any other parameter. Certain inhibitory factors in the substrate utilization could be overrun by increasing HRT of the process.

McCarty and Young provided a relationship between substrate removal and hydraulic retention time as

**Es = 100 (1- a / ∅ )**

Where; Es = substrate removal

a = probability constant or theoretical HRT at which efficiency

Would be zero (Critical HRT)

∅ = hydraulic retention time

The equation provides the concept that as HRT increases to infinity, the substrate removal efficiency would approach 100%

Anyhow, COD removal at 100% is hypothetical as the residual refractory of microbial stabilization will always keep some amount of COD in the system or in the effluent the refore a modified version of the model is proposed as

**Es = Es m (1-a/ ∅)**

Where; m = Maximum organic removal ( COD removal)

The plot was drawn for substrate removal efficiency versus HRT

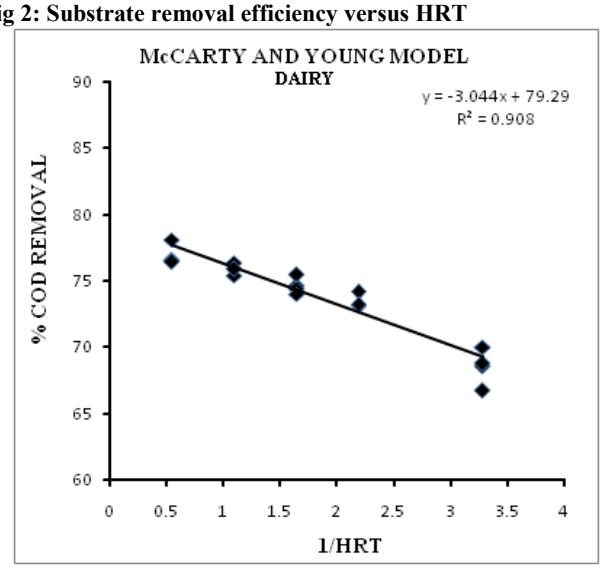
The drawn curve was shown in (**Figure 2**).

The results confirmed that 100% treatment or COD removal cannot be achieved even for longer HRT as large as infinity. This is essentially because of refractory organics present in the biodegradable dairy waste streams.

The experiment result on the model is assessed to give 80.88% as maximum COD removal in the reactor for the HRT of 43.8 hrs.

The prediction of required HRT for 100% COD removal, as could be noted from the graph is 54.10 hrs Vs HRT

**Fig 2: Substrate removal efficiency versus HRT**




## RESULTS AND DISCUSSION

The COD reduction is a maximum of 80.88% while treating dairy effluent for a varying influent COD from 1500 to 4700 mg/lit. The reduction of COD can be further enhanced with better

operating conditions in a full-fledged FBFFR reactor for treating biodegradable industrial waste streams. The minimum COD reduction in the reactor is 66.75% for the OLR of 0.073 kg COD/ $m^2$/day and HLR of 0.016 $m^3/m^2$day. The maximum COD reduction in the reactor is 80.88% for the OLR of 0.004 kg COD/ $m^2$/day and HLR of 0.003 $m^3/m^2$.day. The maximum gas conversion ratio is 0.265 $m^3$ of biogas per kg of COD removed. The Kinetics on substrate utilization was evaluated by the established mathematical models.

## CONCLUSIONS

- Kinetic constants for substrate removal were determined using McCarty and young model
- McCarty model has also been evaluated and modified to fit into the experimental condition
- As the Organic loading rate increases there will be a decline in the performance of the reactor system

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