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# Aerobic Treatment of Dairy Wastewater by Hybrid Bioreactor

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**Abstract:** A hybrid fluidized bed biological reactor was developed for the treatment of diary wastewater. The reactor influent was raw diary wastewater (pH 8, TSS 1600 mg/l, Total dissolved solids 900 mg/l, COD 2000 mg/l, BOD 1200 mg/l). The results show that the final COD was around 110 mg/L and the percentage reduction in COD is 94.5%. The comparative study has proved that the hybrid reactor has high efficiency in treating the organic loads than the fluidized bed reactor (FBR). The hybrid reactor setup increases the active reactor area and decreases the operating cost by utilizing the energy supplied for the direct fluidization to the inverse.
**Keywords:** dairy waste; biodegradation; fluidized bed bioreactor; Inverse fluidization; biogas.

## Introduction

Rapid industrialization has resulted in higher productivity and also led to release of toxic substances into the environment, creating health hazards and affected normal operations of environment. There is a need for higher efficient and low investment technologies to handle these types of organic and toxic waste. Today biotechnology can make a contribution to the socio-cultural, economic and technological developments particularly in developing countries. It has been recognized quite recently that biological systems, primarily of microbial origin could prove potential means of degrading such complex environmental pollutants as well as preventing pollution through waste treatment. Besides, like other industries that have serious waste disposal problems, the dairy and distillery industries are faced with the prospect of having to erect a large number of treatment plants. Liquid effluents from dairy industry cause both water and soil pollution[1] .

Dairy effluent which contains milk, yoghurt, butter, different types of desserts and cheeses and sometimes cheese whey is produced in two different ways

- Effluent flows with the high flow rate and are generally produced from the large industries.
- Effluent flow rate is small and are produced from the small processing units.

In the dairy industry, milk, water and detergents are released as a result of routine

Operations[2]. The nutrients present in the waste water, feed algal blooms which then further depletes oxygen thereby causing serious damage to the water course when it is discharged. In addition to high BOD, dairy waste also contains Ammonia, Nitrite, Nitrate, and Caustic soda, Potassium etc which can be reduced with the help of aerobic and anaerobic organisms[3,4]. They are normally irrigated into land (land spreading) or they are purified by some conventional methods and recycled back and can be further used. Hence it is necessary to treat this water before being discharged[5]. Typical process wastewater has a BOD of about 2,000 mg/L and a dissolved solids concentration of 1,800mg/L[6]. Characteristics of raw effluent given in the Table 1.

**Table 1 : Characteristics of Raw Effluent**

| **Characteristics of Raw Effluent** | |
|---|---|
| Colour | Grey |
| Odour | Fouling |
| COD (ppm) | 2000 |
| BOD (ppm) | 1800 |
| pH | 8 |
| Total Solids (ppm) | 1600 |
| Total dissolved Solids (ppm) | 900 |

## Materials And Methods

### A hybrid biological reactor

The hybrid bioreactor consists of direct and inverse fluidized bed in the inner and annular region with aerobic condition. Degradation of the effluent is achieved by means of biofilm formed on the surface of support particles. Selection of the support particles were done on the basis of the densities required to achieve fludization. Direct fluidization is achieved by pumping the effluent from the bottom of the reactor (heavier density ceramic particles were used as support particles). The inverse fluidization is achieved by the down flow current of the liquid (low density plastics support particles were used).

### Sample collection and preservation

The dairy effluent was collected from a Dairy & Farm Products (P) Ltd located nearby Thanjavur, and stored in a refrigerator at 19°C to prevent biodegradation.

### Support particles

Ceramic and plastic beads were used as support particles in the bioreactor. The surface of the beads was made rough by rubbing with emery sheet for enhancing Biofilm support. 2mm diameter ceramic particle with bulk density of 1516 kg $m^{-3}$ were used for direct fluidization and 4 mm diameter spherical PVC beads with bulk density of 518 kg $m^{-3}$ were used for inverse fluidization respectively.

### Inoculation and biofilm formation

Biofilm formation of the microbes to the surface may be brought about by various mechanisms such as surface charge, gravity, Brownian motion and chemo attraction brings the microbes to the surface. Adhesion of the bacteria after attraction occurs by a two-step process. The physical bonding by weak Vander Waal forces to hold the microbes and stronger irreversible bond by chemical forces. In a present reactor the effluent is treated in the aerobic environment. The micro organism which is used as biomass is immobilized in a beaker which contains the effluent and the packing material and inoculated for few days where it starts growing in that environment.

### Experimental Setup

The experimental setup is shown in the Figure.1.Set up consist of inner direct fluidized core of height 1 m and diameter 50 mm, outer shell of inverse fluidization is of height 0.6 m and diameter 150 mm and a disengaging section of height 0.6 m and diameter 200 m. Compressed air is sparged from the bottom with a of range 0.4- 4 lit/min. The effluent was fed into the column using mono-block pump of 0.5 HP, and the flow rate of the liquid was manipulated by using a rotameter with range 0-500 L/h.

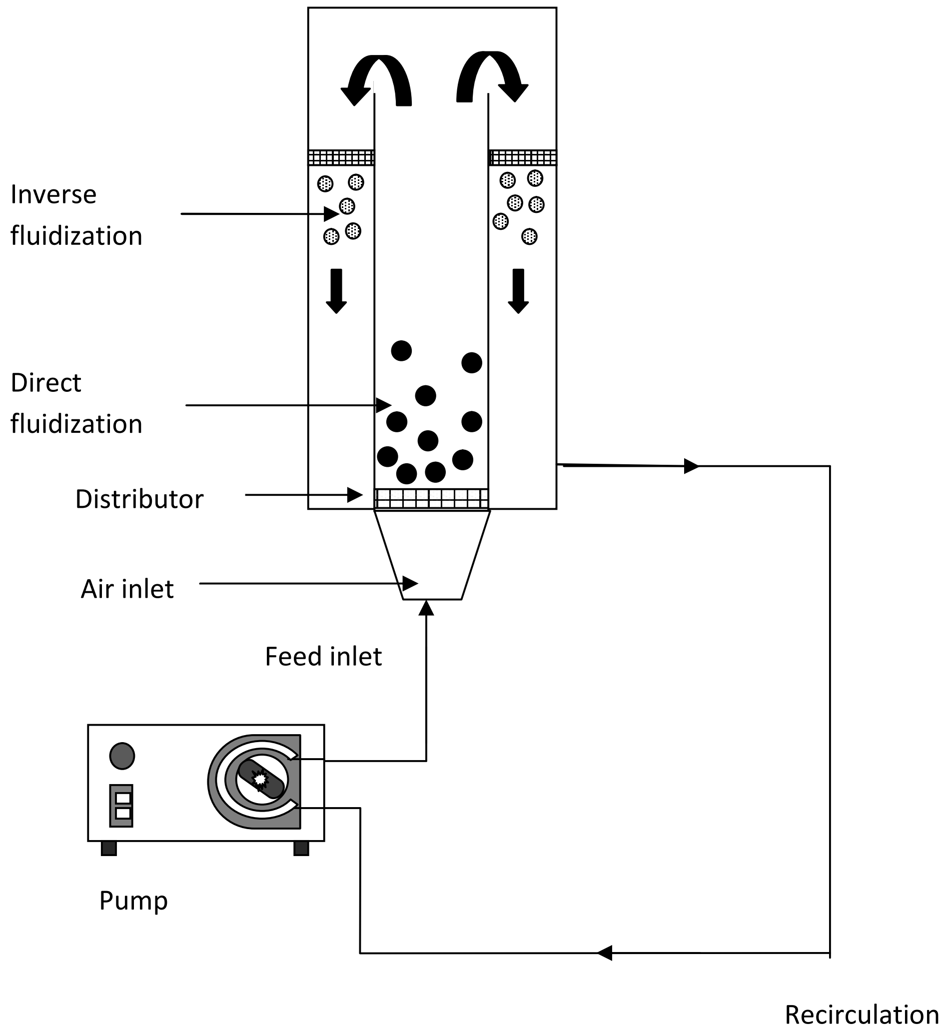


**Fig. 1. Schematic diagram of Hybrid reactor (HR).**

**Experimental Procedure**

The inoculated microorganism acts on the organic and inorganic constituent of waste water for their metabolic activity. The organisms were incubated for a time interval of 15 to 20 days for the growth of biomass. The biofilm coated support particle are then packed in the fluidizing column for 70 mm height. The effluent was pumped in to the column and the flow rate was monitored using a rotameter and the gas was fed to the column through a pressure regulator and a rotameter. The truncated cone expansion provided at the inlet of the reactor ensure minimal pressure drop and the grid provides proper mixing of gas and liquid. The inverse fluidization is achieved by the down flow current of the liquid. The parameters which influence the reduction rate of COD in the effluent are temperature, pH, concentration of the microbes, and age of immobilization. There are other parameters like liquid superficial velocity up on which the growth of the bio film depends.

## Result And Discussion

The hybrid bioreactor treating diary waste water showed high process stability, decreases the operating cost by utilizing the energy supplied for the direct fluidization to the inverse. Results presented have clearly shown that it is possible to effectively degrade dairy waste water. High surface area of the support particles assure that enough viable biomass inside the reactor is maintained during both direct and inverse fluidization.

A comparative study of hybrid reactor with equal volume of FBR for the wastewater treatment was shown in the Fig.2, maximum COD removal was seen in hybrid reactor. The hydrodynamic characteristics of hybrid reactor were studied. In case of fluidization by single phase the pressure drop across the bed increases with the flow rate. Fig.3 shows that there is a high pressure drop with low density particle compared to high density particles[7]. The experiment with different initial bed heights of 4, 5, 7 and 9 cm in both direct and inverse bed were performed. Fig.3 shows the variation of COD with different initial bed height. It was inferred that the percentage reduction in COD increases with increase in bed height[8]. From the Fig. 3 total pressure drop increased from 333.5 $N/m^2$ for 4 cm equal bed height in both inverse and direct fluidization in the column to 655 $N/m^2$ for 9 cm column. Main factor responsible for degradation was the biomass that attached to the support particles, although some degradation may occur due to suspended active cells when the reactor was operated in a mixing regime. The comparative study has proved that the hybrid reactor has high efficiency in treating the organic loads than the fluidized bed reactor (FBR). Also the time taken for degradation is less. And hence the hybrid reactor can be used to treat various other industrial wastes and the efficiencies may be articulated and the hybrid reactor may be scaled up for industrial application. For dairy effluent a maximum COD removal efficiency of 94.5% is achieved which is relatively higher than that fluidized bed reactor (FBR). Fig 4 represents the % COD removal at various hydraulic retention time (HRT). It is observed that the COD reduction decreased with HRT. Higher the HRT decreases flowrate of the waste water through the reactor and biomass supported particles thus increase the mass transfer and leads to efficient degradation of waste. This observation is in good agreement with previous reports[9,10]. When the HRT increased from 0.5 to 2 h, percentage COD removal increased from 86% to 98%[11].

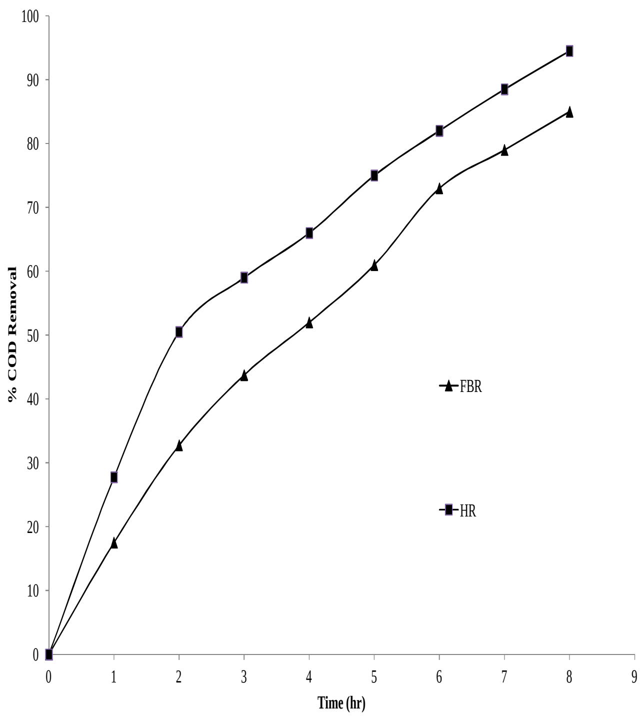


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**Figure.2. Comparison of percentage COD reduction of Hybrid reactor and FBR**

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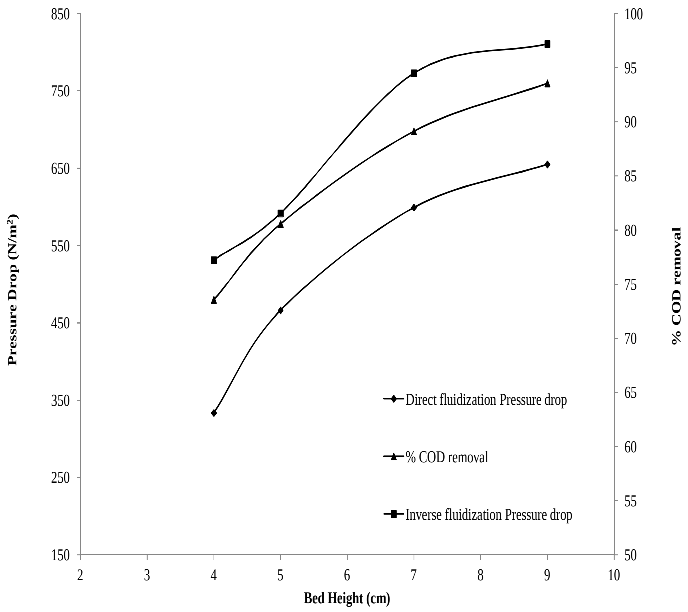


**Figure.3. Variation of pressure drop and percentage COD reduction verses different bed height.**

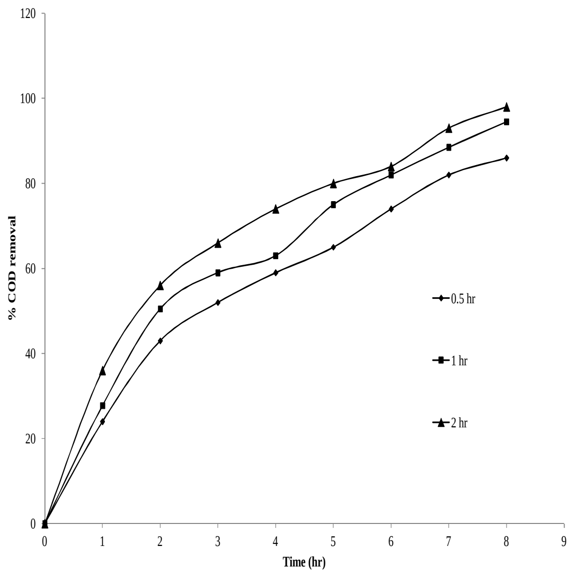


**Figure.4. Percentage COD reduction verses time with different HRT.**

## Conclusion

Based on the analysis and interpretation of the experimental results for biodegradation of dairy waste water in hybrid bioreactor the following conclusion was drawn. Results presented in this report have clearly shown that it is possible to degrade effectively dairy waste water containing high organic loads in the hybrid bioreactor, since operational conditions such as high surface area of the support particles, are assured in order to maintain enough viable biomass inside the reactor during both direct and inverse fluidization. The hydrodynamic characteristics of direct and inverse fluidized bed are experimentally determined. The comparative study has proved that the hybrid reactor has high efficiency in treating the organic loads than the fluidized bed reactor. Also the time taken for degradation is less. And hence the hybrid reactor can be used to treat various other industrial wastes and the efficiencies may be articulated and the hybrid reactor may be scaled up for industrial applications.

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