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PERFORMANCE OF A THREE-PHASE FLUIDIZED BED REACTOR WITH DIFFERENT SUPPORT PARTICLES IN TREATMENT OF DAIRY WASTEWATER

A. Arumugam and P. L. Sabarethinam
School of Chemical and Biotechnology, Sastra University, Thanjavur, Tamilnadu, India
E-mail: venkat_25121980@yahoo.com

ABSTRACT

The aerobic treatment of dairy wastewater was performed experimentally in a three phase fluidized-bed bioreactor (FBBR) using culture of living cells immobilized on support particles. The characteristics of dairy wastewater were studied. The performance of a three phase fluidized bed bioreactor with ceramic, Teflon, glass supports was studied and compared. Pure culture of immobilized cells of *Candida haemulonii* was used. It was observed that increase in surface roughness of support particle increases the degradation rate of the wastewater. The optimum bed height for the maximum COD reduction for ceramic particle was found to be 7cm. The results showed that percentage reduction in COD for ceramic, Teflon and glass particles are 91%, 85% and 78%, respectively.

Keywords: dairy, wastewater, reactor, biodegradation, biofilm, aerobic, performance.

INTRODUCTION

Rapid growth of industries has not only enhanced the productivity but also resulted in the production and release of toxic substances into the environment, creating health hazards and affected normal operations, flora and fauna. These wastes are potential pollutants when they produce harmful effects on the environment and generally released in the form of solids, liquid effluents and slurries containing a spectrum of organic and inorganic chemicals. Thus pollution is a necessary evil of all development. To combat the plethora of environmental evils of present day society, efficient and environmentally safe organic waste treatment technologies are needed for industrial countries. Thus bioengineered technologies adapted for each type of organic and toxic wastes are required to achieve high treatment efficiencies at low capital costs. The major pollutant and waste discharged from dairy plants is organic material. This is milk diluted with water discharged as wastewater. When dumped untreated into a stream or river, organic material is decomposed by Microorganisms in the river. When breaking down the organic pollution, the microorganisms consume oxygen in the water [1]. That action can degrade the water by depleting its oxygen content. Oxygen depletion, in turn, can have a catastrophic impact on life in the water body for fish or which must have dissolved oxygen to survive. When all oxygen in a water body is used up, as frequently happens, the decay of organic matter continues without the oxygen. As a result, noxious gases such as hydrogen sulfide and methane are produced and result in an odor much like that of a septic tank. Waste control is an important aspect of resource management control and an essential part of dairy food plant operations. Waste control (quantity control) should be recognized as equal in significance to quality control. Fluidized bed bioreactor has several advantages over other conventional reactors for the treatment of wastewater. The limitation of the fluidized bed reactor in wastewater treatment is the biofilm thickness. There is a problem of increase in biofilm thickness when the microorganisms in the biofilm multiply; there is a need to select a suitable support particle for the optimum performance of the fluidized bed bio reactor. In the present study the performance of a three phase fluidized bed bioreactor with ceramic, Teflon, glass supports was studied and compared. Experiments were also conducted to find out the suitable support particle and optimum bed height to obtain the maximum biodegradation.

MATERIALS AND METHODS

The Reactor setup

The fluidizing column is made up of acrylic which is of 1200mm height, 60mm inner diameter and 70mm outer diameter. Air is sparged using a compressor and the flow rate is controlled by rotameter which is of range 0.4- 4 lit/min [2]. Similarly the effluent is fed into the column by using mono-block motor of 0.5 Hp, and the liquid flow rate is controlled by using a rotameter which is of range 0-500 lit/hr. The pressure head variation is calculated using a U-tube manometer. Carbon tetra chloride mixed with iodine pellets were used for indicating the pressure head. The treated effluent is recycled through an outlet vent which is located at the top of the column. The inlet and outlet pressure head were correspondingly calculated using the manometer. The support particle along with the biofilm is packed inside the fluidizing column for 5, 6, 7, 8 cm different heights [3]. The biomass support particles were 2mm spherical shape made of ceramic 2400kg/m^3, Teflon 1980 kg/m^3, glass 1700 kg/m^3 were used.

Characteristics of diary industry wastewater

pH	: 7-8
Chemical oxygen demand	: 2100 ppm
Biological oxygen demand	: 1040 ppm
Total solids	: 2500 ppm
Total dissolved solids	: 1200 ppm

Figure-1. Experimental setup.

Microbial culture

A strain of microorganism *Candida haemulonii* MTCC Number 1966 was obtained from Institute of Microbial Technology, Chandigarh, India.

Culture preparation

The Malt yeast agar medium is used for culturing the microorganism is composed of Glucose 12.0 g/l, Malt extract 4.0 g/l, Yeast extract 3.0g/l, Peptone 5.0g/l, Agar 15.0g/l.Incubation at appropriate temperature(30°C) and growth conditions(aerobic) are recommended for the culture [10]. The cultivated bacteria are taken up and for further culture to obtain pure bacteria.

Experimental procedure

The dairy effluent is treated in an aerobic environment using three phase fluidized bed bioreactor. Microorganisms were coated on the support particle by incubating it along with the culture media for few days. The organic and inorganic materials present in the waste water acts as the substrate for the metabolic activity of the microorganism [7]. The organisms were incubated for 5 days. The microorganism coated on the surface of ceramic, Teflon, glass beads are then packed in the fluidizing column for 5, 6, 7, 8 cm height. The support particle acts as the solid phase while the dairy waste water is used as the liquid phase and the air which is sparged acts as gas phase. The dairy effluent and the air are sparged from the bottom of the fluidizing column. The gas and liquid flow rate is controlled by the rotameter. The air thus supplied would improve fluidization and in turn supplies oxygen for the growth of organisms [1]. As a result efficient removal rate is obtained.

RESULTS AND DISCUSSIONS

Effect of support particle

The selection of suitable support particles with high surface area and rough surface which is easy for microbial attachment is necessary. The biomass growth on support particles does not change the density of bioparticles assuring homogeneous distribution of bioparticles within the bioreactor. Spherical shape support particles are optimum support for biological growth. Spherical rough ceramic, Teflon, glass particles were used in this work. The diameter and density of particles were 2mm and 2400, 1980, 1700 kgm^{-3}, respectively. Figure-2 shows the performance of the fluidized bed for various support particles [4,5]. Ceramic support particle show the high degradation rate compared to Teflon and glass. The percentage reduction in cod for ceramic, Teflon and glass particles 91%, 85% and 71%, respectively. The highest reduction is obtained with ceramic particle. This is due to high growth of microbes on the ceramic surface compared to other particle. Teflon particle have fairly rough surface so it shows the intermediate performance among the other. But cost of Teflon is the hurdle in using it as the support medium. Glass particle have the less density among the three hence at operating liquid and gas flow rate the collision among the particle was high hence there is a chance of detachment of biofilm from the surface. Hence choosing the support particle has shown a large deviation in the reactor performance.

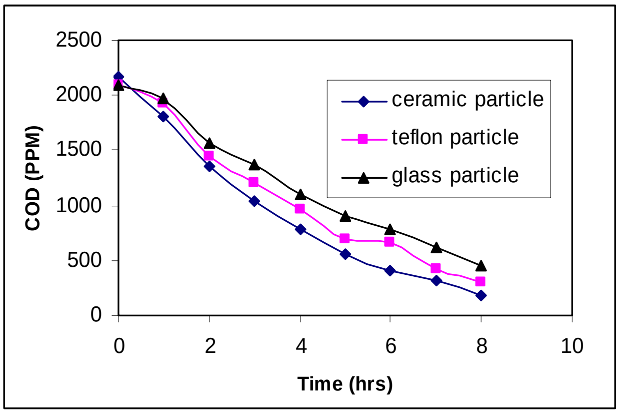

Figure-2. Chemical oxygen demand vs. time for different biomass support particle.

Bed height optimization

The hydrodynamics studies are important in designing the reactor for application of wastewater treatment. The variation of COD reduction with time for different initial bed height is shown in Figure-3. It was inferred that the reduction in COD increases with increase in bed height [6]. The increase in COD reduction with bed height was due to increase in volume of biomass support particles which lead to increase in biomass concentration for the degradation of wastewater .Increase in bed height in turn increase the pressure drop in the column so optimum bed height is chosen for the operation.

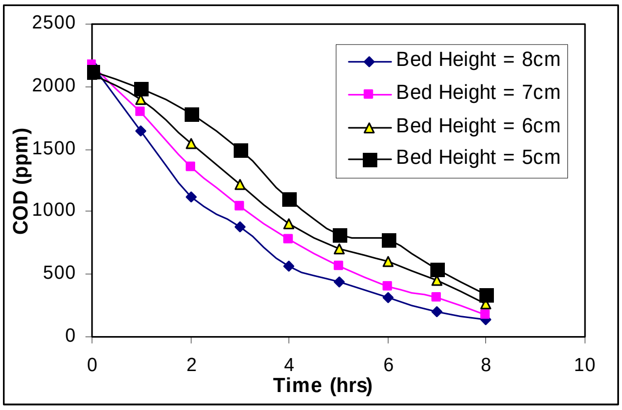

Figure-3. Chemical oxygen demand vs. time for different initial bed height of the reactor.

CONCLUSIONS

The experiments were conducted in a fluidized bed reactor with ceramic, Teflon and glass biomass support particles. It was found that this bioreactor with ceramic particles shown a maximum degradation compared to Teflon and glass particle. It was inferred that the reduction in COD increases with increase in bed height. Increase in bed height in turn increases the pressure drop in the column so optimum bed height 7cm is chosen for the operation.

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