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# Effect of percentage fill media on performance of moving bed biofilm reactor for dairy wastewater treatment

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## Abstract

*Dairy industries are among the most polluting food industries as it requires large amount of fresh water and generate large amount of wastewater that may contrary affect the environment, if it is discharged untreated. The current paper assesses the performance of Moving Bed Biofilm Reactor (MBBR) process for primary treated dairy wastewater. MBBR is an attached growth biological treatment process technique, where suspended plastic media is used as biofilm carriers. The experimental investigation includes the characterization of dairy wastewater for parameters pH, COD, BOD, TDS and TSS. It also includes an optimization of percentage fill of biofilm carrier media from 60% to 30% in MBBR process for dairy wastewater treatment to achieve the disposal standards. It was investigated that the reduction in percentage fill of carrier media resulted out in decrease in microbial content of reactor thereby decreasing the removal efficiencies with decreased percentage fill of carrier media. 50% fill of biofilm carrier media was observed to be optimum percentage fill for achieving disposal standards. The average removal efficiencies observed at HRT of 44 hours for 50% carrier fill for the parameters COD, BOD, TDS and TSS are 92.64%, 98.69%, 17.18% and 85.77% respectively.*

**Keywords:** MBBR, attached growth, wastewater, Biofilm, microbial content.

## Introduction

Dairy industries are an important sector in India as there is very high demand of milk and milk products. In India, dairy industries contribute nearly about one fourth of India's national income. Dairy industries also contribute to the nation's socio-economic development and play a major role for the rural economy. In order to balance increasing demand of milk and milk products, the dairy industry sector is spreading rapidly. Dairy industry specializes in the processing, procurement, production, storage and distribution of milk and milk products. The dairy industries include processing of milk and production of different milk products such as cheese, butter, yogurt, whey, milk powder, ice-cream etc.

With regard to all the food industries, the dairy industry has the highest consumption of water and is one of the highest wastewater producers per unit of its production. The demand of fresh water is very high in the dairy industries. It is estimated that the water requirement in dairy industry is 1.6 liters per liter of milk processed[1]. Water is one of the main utility in dairy industries as water is used almost in each processing step in industry such as milk processing, sanitization, washing and cleaning of various processing equipment, cooling and heating[1]. The remaining water after its use in milk processing and other different activities is termed as dairy wastewater.

Large amount of wastewater gets generated during starting, stopping and rinsing of the processing equipments in the dairy industry. Most of the wastewater gets generated during cleaning and washing operation of cans, piping systems, containers, tanks. Dairy wastewater includes missed out milk and milk products, cleaning agents and detergents. Also proteins, fats, lactose as well as sodium, potassium and chlorides are main constituents of dairy wastewater. The dairy wastewater is characterized by high demand of COD, BOD, nutrients and fatty acids[2]. Dairy wastewater is organic in nature thus decomposes rapidly results in decreasing the DO level of the receiving water bodies which creating anaerobic conditions and producing strong foul odor, receiving water bodies becomes place for mosquitoes and flies which convey diseases like malaria, dengue fever. Dairy wastewater also contains soluble organics and suspended solids which deplete the DO in present water, helps to release gasses and lead to eutrophication. Toxic contents present in wastewater become harmful for some species of fishes and algae. Thus to avoid such pollution effects, appropriate treatment should be given to the dairy wastewater to achieve disposal standards before sent into the environment[3].

The dairy wastewater is organic in nature and the contents of wastewater are easily bio-degradable, hence the dairy wastewater is amenable for biological wastewater treatment processes[4]. In this project study, Moving Bed Biofilm Reactor (MBBR) is adopted for the treatment of primary treated dairy wastewater. MBBR technology is established itself as a well proven, compact and strong technique for wastewater treatment. MBBR is an attached growth biological treatment process technique, where suspended plastic media is used as biofilm

carriers. Free floating plastic media is termed as MBBR media[3]. Specially designed biofilm carriers provide large specific surface area for growth of microorganisms on carrier media. The microorganisms attached on the surface of the carriers utilize organic matter from wastewater in existence of diffused air and converting it into the biomass. According to media specifications like size, shape, specific surface area, density different low cost and naturally available carrier media could be used in MBBR process[6]. Biofilm carrier fill percentage is one of the important considerations while designing the MBBR. It is suggested that biofilm carrier fill percentage in the reactor should be less than 70%, in order to keep carrier movement in suspension in the reactor[7].

**Aim and objectives:** The aim of this project study was to examine the suitability of Moving Bed Biofilm Reactor (MBBR) for the treatment of primary treated dairy wastewater. Laboratory scale study was conducted to characterize the dairy wastewater and to determine the removal efficiency of reactor by using certain moderations such as variation in biofilm carrier fill percentage while keeping same HRT. The results were compared in terms of average removal efficiencies for parameters pH, COD, BOD, TDS and TSS to determine the optimum percentage fill rate of biofilm carriers while achieving disposal standards.

## Materials and methods

Study area: One of the prominent dairy industries in Kolhapur region was selected as the source of collection of dairy wastewater samples throughout this project study. Primary treated dairy wastewater sample was collected from the existing Effluent Treatment Plant (ETP) of industry. Primary treated dairy wastewater was collected from equalization tank of ETP.

**Biofilm Carrier Media:** Biofilm carrier media is freely floating plastic media which provides more surface area for microorganisms to attach and grow. The attached microorganisms consume the organic matter from the wastewater. The increased surface area reduces the size footprint of reactor tank required to treat the wastewater. The biofilm carrier media within the reactor was kept in suspension by providing diffused aeration[2]. For this study, polypropylene media was used as biofilm carriers.

**Reactor set up:** For this study MBBR model was designed as continuously operated aerobic system. The reactor tank proposed for this project study was made up of acrylic sheet having dimensions 25cm x 20cm x 40cm. Reactor was made as rectangular shaped for efficient movement of biofilm carriers within the reactor tank. The reactor had total capacity of 20 Liters, with working volume of 17 Liters. The carrier media was introduced in the reactor in proportion to percentage volume of working volume of reactor. Primarily the development of biomass on the carriers and in the reactor was started by addition of sewage. For the acclimatization of microorganisms in the reactor, primary treated dairy wastewater was stepwise introduced with sewage in the reactor. The dairy wastewater was treated in the MBBR process with an optimization of carrier fill percentage from 60% to 30% at common HRT of 44 hours and flow rate of 9.2 Lit/Day. The treated effluent from reactor was then collected into sedimentation container (5 Lit capacity) provided next to the reactor. In the sedimentation container, suspended biomass was settled from treated effluent and supernatant was analyzed. In this project study the peristaltic pump was used to pump the dairy wastewater from inlet tank to the reactor.

**Figure-1:** Biofilm Carrier Media.

Technical specifications of biofilm carrier media:

**Table-1:** Technical specifications of biofilm carrier media.

| | |
|---|---|
| Material used | Polypropylene |
| Colour | Black |
| Effective specific surface area | 400 $m^2/m^3$ |
| Specific gravity | 0.90 to 0.95 $gm/cm^3$ |
| Structure | Cylindrical with external fins |
| density | 0.93 $gm/cm^3$ |
| Biofilm carrier percentage fill rate | 60% to 30% |

## Results and discussion

**Characteristics of dairy wastewater:** Preliminary analysis of primary treated dairy wastewater was carried out for parameters pH, COD, BOD, TDS and TSS to understand the variations in the characteristics.

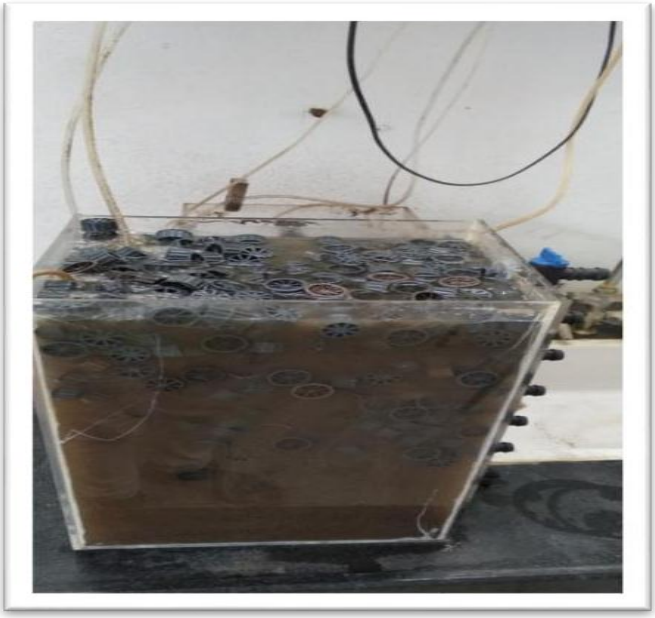

**Figure-2:** MBBR reactor.

**Figure-3:** Developed biofilm on the surface of carrier media**.**

**Table-2:** Characteristics of dairy wastewater.

| Parameter | Concentration | Disposal standards |
|---|---|---|
| pH | 7.1-8.5 | 5.5-9.0 |
| COD | 1200-1860 mg/lit | 250 mg/lit |
| BOD | 1027-1526 mg/lit | 100 mg/lit |
| TDS | 1135-1914 mg/lit | 2100 mg/lit |
| TSS | 354-652 mg/lit | 100 mg/lit |

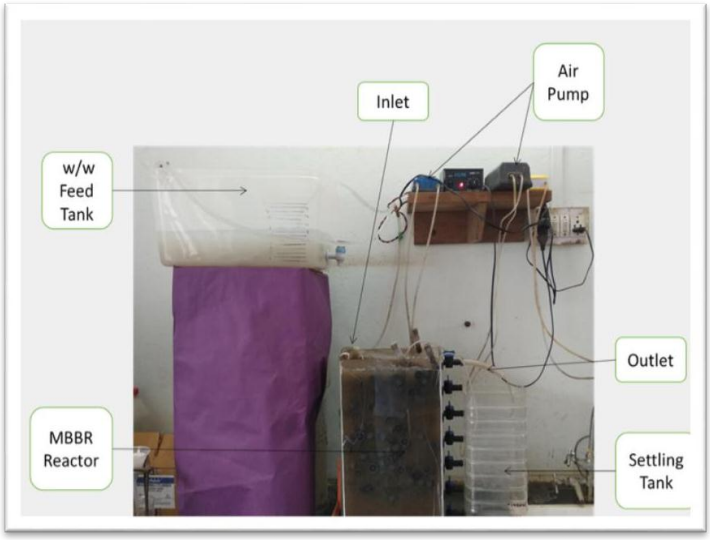


**Figure-4:** Experimental laboratory MBBR model setup.

**Performance effect of varying percentage fill rate of biofilm carriers on reactor:** The experimental analysis was divided into four stages. With a constant inflow rate of dairy wastewater of 9.2 Lit/ day into reactor percentage fill of carrier media was varied from 60% to 30%.

**Observations for 60% biofilm carrier fill:** The pH of treated wastewater was analyzed to vary from 7.8-8.4. The average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 133 mg/lit, 16 mg/lit, 759 mg/lit and 46 mg/lit respectively. The average removal efficiencies were observed for parameters COD, BOD, TDS and TSS as 93.79%, 99.01%, 19.21% and 91.14% respectively.

**Observations for 50% biofilm carrier fill:** The pH of treated wastewater was analyzed to vary from 7.7-8.4. The average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 140 mg/lit, 19 mg/lit, 688 mg/lit and 72 mg/lit respectively. The average removal efficiencies were observed for parameters COD, BOD, TDS and TSS as 92.64%, 98.69%, 17.18% and 85.77% respectively.

**Observations for 50% biofilm carrier fill:** The pH of treated wastewater was analyzed to vary from 7.7-8.4. The average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 140 mg/lit, 19 mg/lit, 688 mg/lit and 72 mg/lit respectively. The average removal efficiencies were observed for parameters COD, BOD, TDS and TSS as 92.64%, 98.69%, 17.18% and 85.77% respectively.

**Observations for 40% biofilm carrier fill:** The pH of treated wastewater was analyzed to vary from 7.8-8.7. The average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 260 mg/lit, 49 mg/lit, 779 mg/lit and 187 mg/lit respectively. The average removal

efficiencies were observed for parameters COD, BOD, TDS and TSS as 87.78%, 96.75%, 18.13% and 72.02% respectively.

**Observations for 30% biofilm carrier fill:** The pH of treated wastewater was analyzed to vary from 8.1-8.7. The average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 308 mg/lit, 67 mg/lit, 798 mg/lit and 145 mg/lit respectively. The average removal efficiencies were observed for parameters COD, BOD, TDS and TSS as 85.12%, 95.16%, 16.18% and 68.17% respectively.

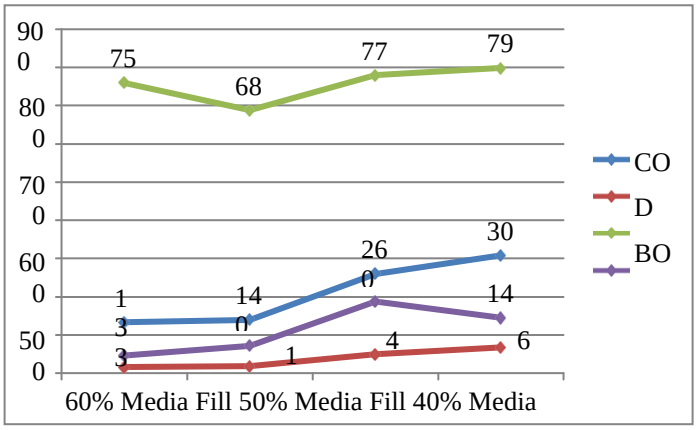


**Figure-5:** Performance of MBBR for varying percentage fill.

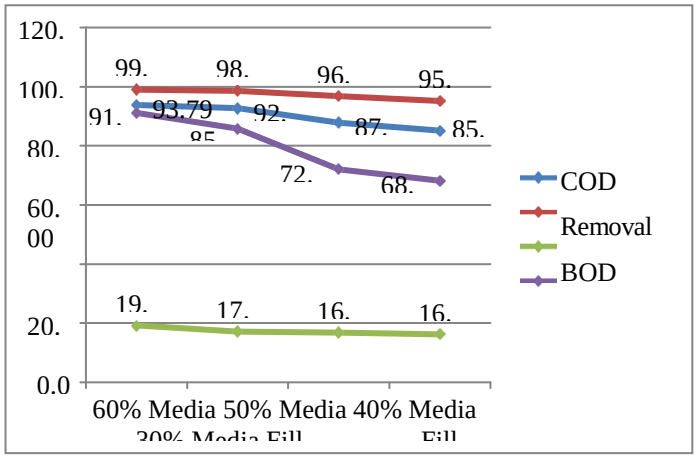


**Figure-6:** Average removal efficiencies for different percentage fill.

**Optimum Percent Fill of Media:** It was observed after comparing removal efficiencies of different percentage carrier fill of media, that maximum removal efficiencies was observed for 60% carrier fill. It was investigated that the reduction in percentage fill of media resulted out in decrease in microbial content of reactor thereby decreasing the removal efficiencies with decreased percentage fill of carrier media.

For percentage fill of 60% and 50%, average concentrations of parameters were observed to meet with disposal standards. However for percentage fill of 40% and 30%, these disposal standards were not achieved. Also for percentage fill of 60% and 50% there are no considerable differences were observed in removal efficiencies. Hence 50% carrier fill was observed to be optimum percentage fill.

## Conclusion

It was observed that percentage fill of carrier has greater impact on the performance of reactor. 50% carrier fill media in reactor was observed to be optimum percentage fill to achieve the disposal standards. It was investigated that the reduction in percentage fill of carrier media resulted out in decrease in microbial content of reactor thereby decreasing the removal efficiencies with decreased percentage fill of carrier media. With 50% carrier fill, the average concentrations of treated wastewater for parameters COD, BOD, TDS and TSS were observed as 140mg/lit, 19mg/lit, 688mg/lit and 72mg/lit respectively. All these average treated wastewater concentrations are complied with the disposal standards. The average removal efficiencies were observed for parameters COD, BOD, TDS and TSS are 92.64%, 98.69%, 17.18% and 85.77% respectively. The decreased carrier fill percentage reduces cost of operation and maintenance as well as the reactors footprint. The Moving Bed Biofilm Reactor (MBBR) technology is proved to be suitable for treatment of dairy wastewater.

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