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Dairy Wastewater Treatment Using Moving Bed Bio-Film Reactor

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ABSTRACT: The Moving Bed Biofilm Reactor (MBBR) system is considered an Advanced Wastewater Treatment (AWT), which combines the best of Activated Sludge Process (ASP) and bio filter processes, making use of suspended biomass and attached biomass. In this present study emphasis has been given to evaluate removal prospects of organic matter by Moving Bed Bio-Reactor (MBBR) media as an attached media. The effects of vital factors such as Hydraulic Retention Time (HRT) and Organic loading Rate (OLR) affecting the performance of reactor in terms of OM removal were investigated. In this study, the performance of the MBBR at a lab-scale during batch and continuous operations was addressed while changing the Organic Load Rate (OLR) and the Hydraulic Retention Time (HRT). The MBBR shows to be more stable when a FR of 40% is used, which allows a reduction of the HRT from 8 to 4 h, reaching a COD and BOD removal of 95%, allowing a reduction on the energy consumption, compared to the conventional processes.

KEYWORDS: MBBR, HRT, OLR, FR, COD, BOD

I. INTRODUCTION

The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. It is estimated that about 2% of the total milk processed is wasted into drains. The wastewater generated from milk processing can be separated into two groups—the first group concerns wastewater having high flow rates and the second concerns the effluents produced in small milk transformation units). Dairy wastewater is characterized by high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contains fats, nutrients, lactose, as well as detergents and sanitizing agents. Nutrients lead to eutrophication of receiving waters, and detergents affect the aquatic life. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated/partially treated wastewater cause serious environmental problems. Moreover, the Indian government has imposed very strict rules and Regulations for the effluent discharge to protect the environment. Thus, appropriate treatment methods are required so as to meet the effluent discharge standards.

Dairy effluent contains soluble organics, suspended solids, trace organics. All these components contribute largely towards their high biological oxygen demand (BOD) and chemical oxygen demand (COD). Dairy wastes are white in colour and usually slightly alkaline in nature and become acidic quite rapidly due to the fermentation of milk sugar to lactic acid. The suspended matter content of milk waste is considerable mainly due to fine curd found in cheese waste. The pollution effect of dairy waste is attributed to the immediate and high oxygen demand. Decomposition of casein leading to the formation of heavy black sludge's and strong butyric acid odour and characterize milk waste pollution. The characteristics of a dairy effluent contain Temperature, Color, pH (6.5-8.0), DO, BOD, COD, Dissolved solids, suspended solids, chlorides, sulphate, oil & grease. It depends largely on the quantity of milk processed and type of product manufactured. The waste water of dairy contains large quantities of milk constituentssuch as casein, inorganic salts, besides detergents and sanitizers used for washing. It has high sodium content from the use of caustic soda for cleaning.

Brinkley John carried out the study on processes that would treat variable high strength wastewater in a small footprint and provided provisions for future expansion. He selected the MBBR process due to the success the process had for treating high strength wastewater for comparable pharmaceutical applications. The 0.5 million gallon per day (mgd)

MBBR process consisted of two reactors operated in series designed to treat an influent and effluent Biochemical Oxygen Demand (BOD₅) of 3,197 mg/L and less than 75 mg/L, respectively.

Odegaard *et al.* (2000) carried out the study on the fundamental characteristic of the MBBR was the specially designed Biofilm carriers, for which the geometry, sizing and materials of construction had been considered carefully to maximize performance. This was a key difference from the activated sludge process where treatment performance was more directly tied to reactor volume. In the MBBR, surface area could be increased by designing carriers with a higher specific surface area or by adding a greater quantity of carriers to a reactor volume. This offered flexibility for future treatment capacity upgrades without requiring the construction of additional reactors.



Figure-1. Polypropylene Media

II. METHODOLOGY

2.1 Materials

MBBR media is a free-floating media which houses huge quantity of active biomass. Once submerged inside the bioreactor, the floating media operates as non-clogging media. No channels or dead spots are developed like in other technologies. The movement is caused by either aeration, or being mechanically stirred, depending on reactor design and effluent requirements. The MBBR media represents flexibility and newengineered potentials in waste water treatment plant operation.

Material	Polypropylene
Effective Specific Surface Area	400 m ² /m ³
Media Height	15 mm/ 10 mm
Media Diameter	22 mm
Weight per unit surface area	0.37 kg/m ²

Specific Gravity	0.90-0.95 g/cm ³
Density	0.93 g/cm ³
Media fill rate range	25-55% of volume

Table -1. Technical Specifications of MBBR Media

2.2 Experimental Setup

The reactor was setup at the Environmental engineering lab. A rectangular shaped tank built of glass with 0.4 m length, 0.3 m width and 0.23 m depth. Air diffusers were provided at the bottom of the reactor with a constant aeration rate of 2.5 l/min to supply oxygen to the microbial mass for biological activity and mixing the carriers.

III. RESULT AND DISCUSSION

3.1 Effect of HRT on the performances of reactor in terms of organic matter

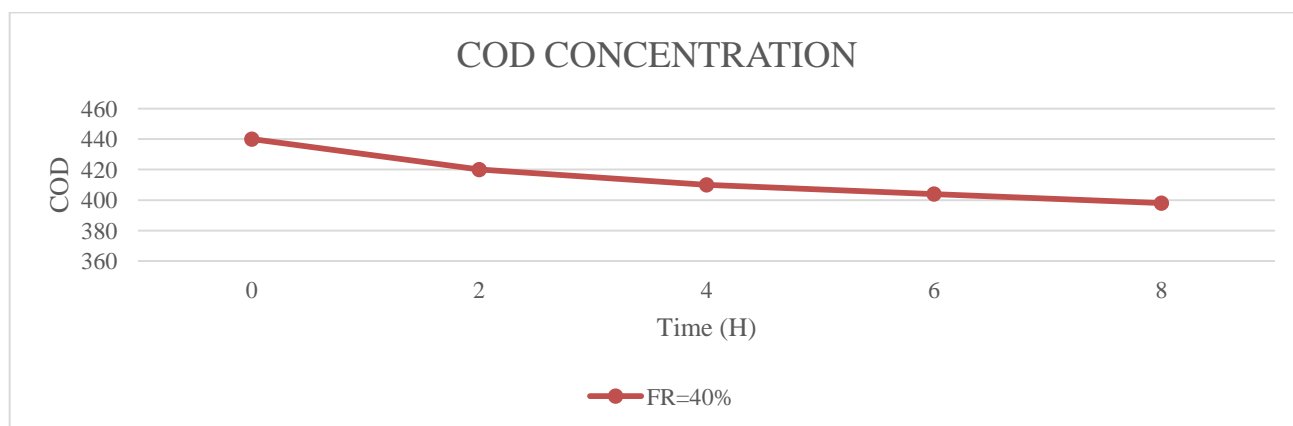
Hydraulic retention time (HRT) is an important operational variable which can be easily controlled. It is average length of time a molecule of liquid remains in the reactor and can be defined as the volume of the reactor divided by the average influent flow rate.

In terms of COD removal, although the HRT was decreased, reactor conditions became stabilized shortly within the first few days of each cycle and high removal efficiency was achieved after the stabilization days. The COD removal efficiency obtained for hydraulic retention time of 2h was 94% and for 4h was 96%.

In terms of BOD removal, although the HRT was decreased, reactor conditions became stabilized shortly within the first few days of each cycle and high removal efficiency was achieved after the stabilization days. The BOD removal efficiency obtained for hydraulic retention time of 2h was 93% and for 4h was 98%.

The MBBR operating in batch regime, was charged once a day, and samples were collected every hour during an experimental time of 8 h. Five different initial COD concentration (440, 420, 410, 404, 398 mg/L) were tested at a FR of 40%.

The MBBR operating in batch regime, was charged once a day, and samples were collected every hour during an experimental time of 8 h. Five different initial BOD concentration (210, 197, 188, 182, 168 mg/L) were tested at a FR of 40%.

**Figure-2.** Initial COD Concentration

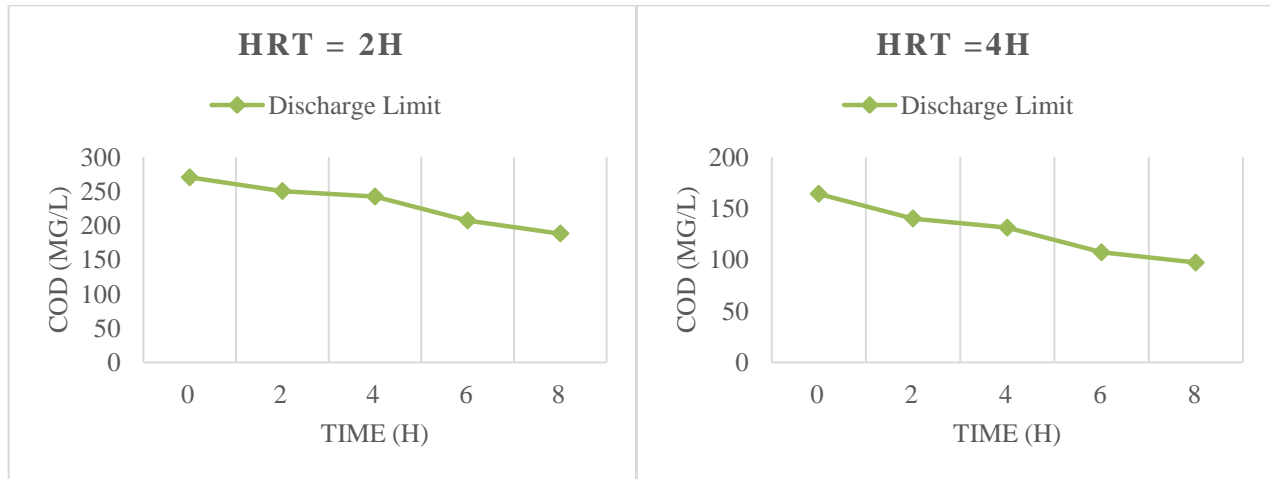


Figure-3. COD Evaluation of MBBR with HRT for 2H and 4H

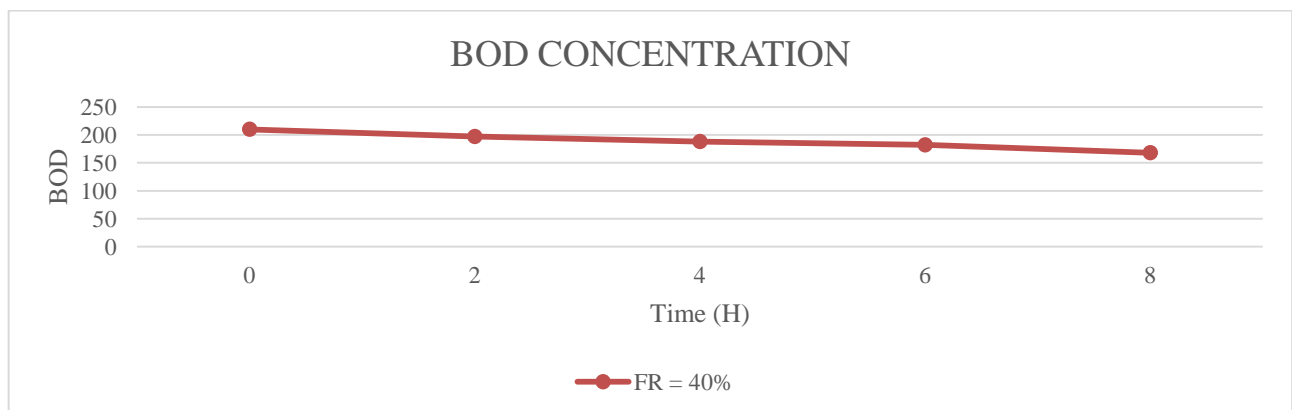


Figure-4. Initial BOD Concentration

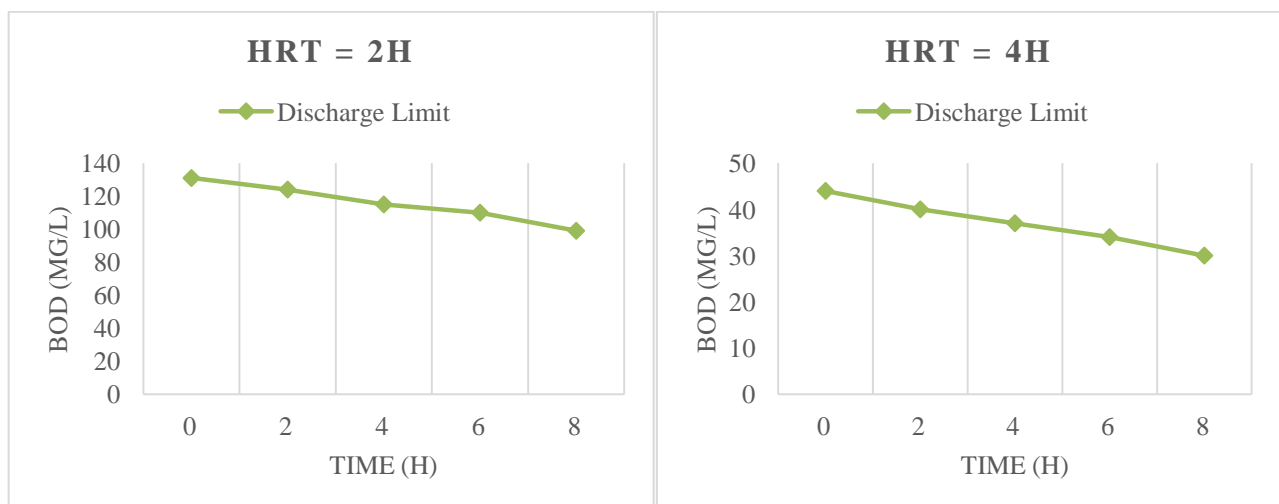


Figure-5. BOD evaluation of MBBR with HRT for 2H and 4H

Using a FR = 40% the system the able to operate with HRT lower than 6h.

IV. CONCLUSION

The MBBR shows to have a good performance to treat dairy wastewater, reaching a removal efficiency of 98% after 4h of treatment, using a FR of 40%.

After the tests carried out along this work, it is possible to conclude that a Filling Ratio of 40% reproduced better results in the COD removal efficiency in less reaction time and allows the discharge in the water environment according to the Portuguese law.

Using a FR of 40% there was achieved a great cod removal efficiency using a lower number of carriers inside the reactor, once the optimal FR can reach 70%, leading to higher energy costs. Using a FR lower than 70% and reaching a COD removal of 80% in less time than the conventional wastewaters treatments, this can be translated in lower energy requirement, consequentially the energy costs will be reduced.

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