RESEARCH ARTICLE OPEN ACCESS

Moving Bed Biofilm Reactor -A New Perspective In Pulp And Paper Waste Water Treatment

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Abstract: The pulp and paper mill effluent is one of the high polluting effluent amongst the effluents obtained from polluting industries. All the available methods for treatment of pulp and paper mill effluent have certain drawbacks. In this work, experiments were conducted to treat the pulp and paper mill effluent using moving bed biofilm reactor (MBBR).The wastewater generated by these industries contains high COD, BOD, colour, organic substances and toxic chemicals. This study was carried out on laboratory scale Moving Bed Biofilm Reactor with proflex type biocarriers, where the biofilm grows on small, free floating plastic elements with a large surface area and a density slightly less than 1.0 g/cm^3 . The reactor was operated continuously at 50% percentages filling of biocarriers. During the filling percentage, the removal efficiencies of COD & BOD were monitored at the time period of 2h, 4h, 6h and 8h. The result showed that the maximum COD and BOD removal of 87% were achieved for the 50 percent filling of biocarriers at the HRT of 8 h. From the experimental results, the moving bed biofilm reactor could be used as an ideal and efficient option for the organic and inorganic removal from the wastewater of pulp and paper industry.

Keywords: Bagasse, Pulp and paper, MBBR, Biocarriers, Proflextype.

I. INTRODUCTION

The wastewater from an industry may be organic or inorganic in nature or a combination of both. The pulp and paper industrial effluent contains sodium hydroxide, lignin and salts and typically, this effluent is a dark coloured liquid with small quantities of insoluble fibres. Lignin content in the fibre contributes high amount of BOD and colour to the effluent. Chemical used for bleaching of pulp and paper are non biodegradable and hence it leads to increase in the COD content.

To remove organic and inorganic substance from the wastewater, various treatments like physical, chemical and biological treatment are used. The physical treatment methods remove settable solids. Non biodegraded substances are removed by the chemical treatment. The biological treatment such as trickling filters, oxidation pond, aerated lagoon, UASB and activated sludge process are used for organic removal. At present UASB and activated sludge process is commonly used in the treatment of pulp and paper effluent.

The UASB anaerobic treatment requires more time for processing and if the ratio of COD to SO_4 is too low then the process will not work properly due to the sulphate reduction. The methanogenic bacteria reproduce slowly and they are very sensitive to toxic substances. And the gas production during winter is low when compared to summer (Mobius 2006). Wastewater discharge from UASB has some organic substance. For removal of that substance, effluent needs to be treated using a aerobic process like activated sludge which is commonly preferred.

In activated sludge process, recycling of sludge is used to maintain the reaction process and also large area is required. The composition of paper mill waste particularly high carbohydrates causes sludge bulking. Due to that poor settling will occur and high biomass will be lost with effluent. For that reasons, adopting new treatment or upgrading the existing treatment plant is essential in pulp and paper industry (Mobius 2006).

The moving bed biofilm is a process which combines the technologies of activated sludge processes and biofilm processes. In that process, reduction of COD and BOD from the effluent is high without the loss of biomasss. This technology uses media for microorganism attaching and the media are moving in water during operation. To compensate for lower performance, MBBR has a simple operational mode and it has high oxygen transfer efficiency. The land requirement is less and no recycling is required for that process.

The objectives of the study are as follows:

- To design the MBBR reactor and select the suitable biocarriers for the treatment of bagasse based pulp and paper industrial effluent.
- To study the performance of Moving Bed Biofilm Reactor for various operating conditions.
- To optimize the various operating conditions to arrive at design criteria for the treatment.

II. MATERIALS AND METHODS

2.1 Moving Bed Biofilm Reactor

Moving bed biofilm reactor (MBBR) is defined as thousands of polyethylene biofilm carriers operating in mixed motion within an aerated wastewater treatment process. Every biofilm carrier adds productivity via the provision of an active surface area sustaining bacteria within protected cells. It is this high-density population of bacteria that achieves high-rate biodegradation productivity within the system. Figure 2.1 shows the typical diagram of moving bed biofilm reactor.

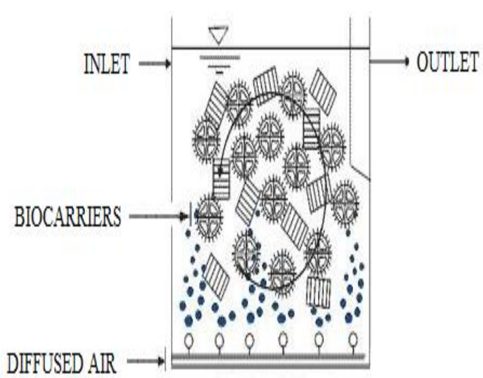


Fig 2.1 Moving Bed Biofilm Reactor

2.2 Biocarriers

Biocarriers is referred as "bed" in the moving bed biofilm process. It "carry" the microorganisms throughout the reactors. It is made up of polyethylene which has the density slightly less than water and shaped like small cylinders. Internal cross members installed in each biocarrier increase the available interior surface area for biofilm attachment. Longitudinal fins incorporated on the external surface of the biocarrier increase the external surface area available for biofilm growth. Figure 2.2

1.1 OBJECTIVES

shows the different types of biocarrier elements.

Fig 2.2 Biocarriers

Table 2.1 Biocarrrier specifications

Material type	Proflex
Shape	Cylindrical with fins
Colour	Black
Density	0.95 g/cm^3
Height	16mm
Diameter	22mm
Effective surface area	450 m^2/m^3
Max. Operating temperature	80°C
No of pieces per m^3	62000

2.3 Components of biofilm

Biofilms consist of three components. They are,Microorganisms,ExtracellularPolymericSubstances (EPS, glycolax) & Surface. Biofilms can contain many different types of microorganism, e.g. bacteria, archaea, protozoa, fungi and algae; each group performing specialized metabolic functions. EPS is an abbreviation for either extracellular polymeric substance or exopolysaccharide. This matrix protects the cells within it and facilitates communication among them through biochemical signals. Biofilms are usually found on solid substrates submerged in or exposed to some aqueous solution, although they can form as floating mats on liquid surfaces.

2.4 Mechanism Of Biofilm Process

Usually biofilms contain multiple layers of few too many µm. Nutrients and oxygen diffuse cells.

The thickness of the biofilm may vary from across the stagnant liquid layer from the moving mixed liquor to the biofilm. While nutrients (substrates) and oxygen diffuse through the stagnant layer to the biofilm, biodegradation products diffuse outward from the biofilm to the moving mixed liquor. These "back and forth" diffusion processes are continuous. As the microorganisms grow and multiply, the biomass on the biocarriers grows, or thickens. Fig 2.3 shows diffusion of nutrients through a biofilm in the oxygen through the biofilm produces aerobic, anoxic and anaerobic layers in the biofilm (Hwell 2006).

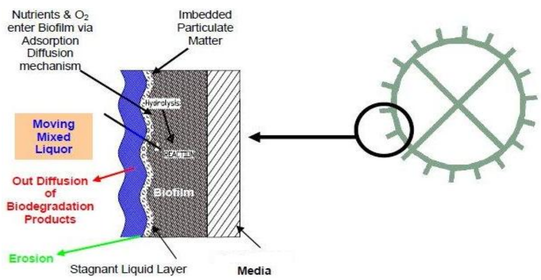


Fig 2.3 Nutrient path through Biofilm in Biocarriers

2.5 Feeding material

The effluent for this study was taken from the Tamilnadu Newsprint and Papers Limited, Karur where the industry is using bagasse as the raw material. The collection of effluent was done as per the standard sampling methods.

2.6 Seeding Material

Seeding sludge for this experiment was also obtained from the TNPL wastewater treatment plant. The sludge quantity of 5 litres was used for acclimatization process.

2.7 Compressor

Aeration was done with the help of tube diffuser fitted at the bottom through compressor (BOYU ACQ-001).The air required for biodegradation of organic material was 0.2 lpm. But the air supplied should be sufficient to keep the biocarrier in moving state. The minimum capacity of 15 lpm air was supplied and it was increased according to the requirements. A fine bubble of air was uniformly diffused throughout the liquid for the biocarrier movement and the D.O concentration of 6 to 7 mg/l was maintained in the effluent during the reaction period.

2.8 Peristaltic pump

Peristaltic pump was used to pump the effluent into the reactor. In this study, 'Watson 313' model pump with minimum capacity of 0.25 Hp was used to pump the effluent from feed tank.

biocarriers. Biomass thickening affects the ability of dissolved oxygen and substrate in the reactor to "reach" all of the biofilm microorganisms. Microorganisms in the outer layers of the biofilm have "first access" to the dissolved oxygen and substrate diffusing through the biofilm. As the dissolved oxygen and substrate diffuses through each subsequent layer in the biofilm, more and more is consumed by the microorganisms in the preceding biofilm layers. The decrease of available dissolved

III. RESULTS AND DISCUSSION

3.1 Characteristics of effluent

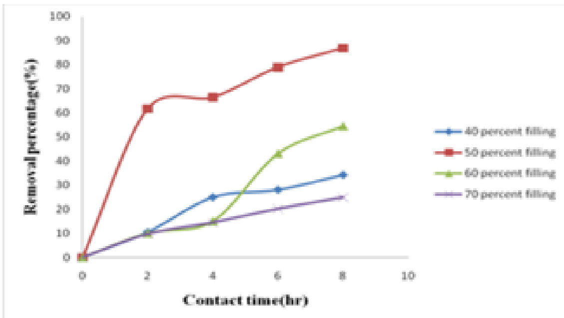
The effluent for this study was collected at the end of primary clarifier outlet from Tamilnadu Newsprint and Papers Limited, Karur where the industry is using bagasse as the raw material. The collected sample was analysed for pH, COD, BOD TS and TDS as per standard methods. Table 3.1 shows the analysed parameters and their values.

Table 3.1 Characteristics of effluent

S.NO	PARAMETER	VALUES
1	Colour	Brown
2	pH	4.4
3	Total solids	3204 mg/l
4	Suspended solids	1024 mg/l
5	Dissolved solids	2180 mg/l
6	COD	3340 mg/l
7	BOD	1650mg/l

3.2: Optimum Filling Percentage Of Biocarriers

The reactor was operated at batch mode to found the optimum percent filling of biocarriers. The percent filling of biocarriers is defined as the volume of carrier material (which includes voids) to the reactor working volume. The percent fillings were varied from 40 to 70 percent with the contact time of 2hr, 4hr, 6hr, and 8hr and the effluent was pre-settled for 1 hr before feed into the reactor. The same had been given after the treatment for the sludge settlement. The removal efficiency was monitored by periodical analyses of the parameters such BOD and COD. From the optimization study the effective percent filling of biocarrier for the treatment of pulp and paper effluent was investigated. It was observed that the removal efficiency of pollutant was high in 50 percent filling of biocarriers. In that filling COB and BOD removal were increased from 61.6% to 86.8% and 60.0% to 86.6% respectively with the contact time of 2 to 8 hr. In the other percent filling of biocarriers the removal efficiency were decreased to compare than 50 percent filling. From the above results it was concluded that 50 percent filling of biocarrier was the optimum one for effective pollutant removal.



COD removal vs contact time

Fig3.1 COD removal at various contact time for optimum filling of biocarriers

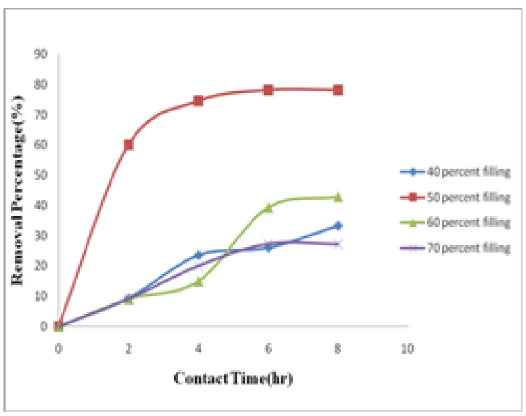


Fig 3.2 BOD removal at various contact time for optimum filling of biocarriers

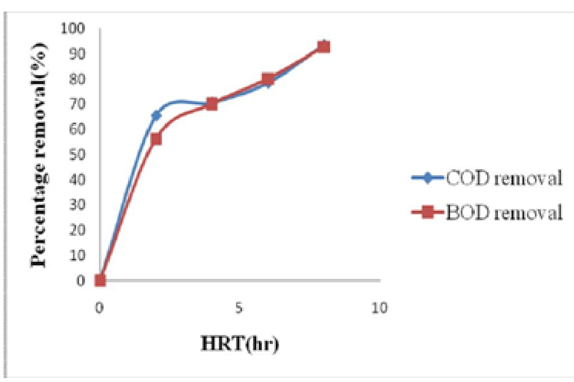


Fig 3.3 Effect of Hydraulic Retention Time

Effect of Hydraulic Retention Time The effect of hydraulic retention time was evaluated by varying the HRT values for the optimum percent filling of iocarrier. For this study the flow rate was adjusted to 2.5 l/h, 1.25 l/h, 0.8 l/h, 0.63 l/h and 0.5 l/h with the respective HRT of 2 h, 4 h, 6 h, 8 h and 10 h. From the optimization result, the reactor was filled with 50 percent of biocarrier to the reactor volume. The pre-settling time of the effluent was increased to 2 h and reactor was operated under continuous process with the above flow rates. The pollutant removal was monitored by periodical analyses of the parameters such BOD and COD. It is observed that as the HRT value increased, the COD and BOD removals also increased from 66% to 96% and 57% to 97% respectively. The maximum efficiency was obtained at 8 h HRT shown in table 3.1. The complete removal of pollutants was achieved by prolonging the HRT values. The graphs were plotted between HRT and removal percentage for BOD and COD. The BOD and COD removals at various Hydraulic

S.No	HRT (hr)	COD (mg/l)	COD removal (%)	BOD_3,27°C (mg/l)	BOD_3, 27°C removal (%)
1	0	3340	-	1650	-
2	2	1152	65.5	720	56.3
3	4	979	70.6	480	70.09
4	6	716	78.56	330	80.0
5	8	213	93.6	130	92.7

Table 3.1 Effect of Hydraulic Retention Time

IV. CONCLUSION

From the results, it is concluded that the beneficial effective HRT for pollutant removal is 2 h. But for the complete removal of BOD and COD the HRT value is to be increased. The retention time of the bioreactor influences the hydrolysis of particulate and organic matter so that removal efficiency is high. The HRT value influences the organic removal in paper industry wastewater.

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