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Treatment Of Bagasse Based Pulp And Paper Industry Effluent Using Moving Bed Biofilm Reactor

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Abstract: 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 MBBR 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 different filling percentages of 40%, 50%, 60%, and 70%. During the different filling percentage, the removal efficiencies of COD & BOD were monitored at the HRT period of 2h, 4h, 6h and 8h. The result showed that the maximum COD and BOD removal of 87% were achieved for 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, Moving bed biofilm reactor, Biocarriers, Proflextype.

1. Introduction

The pulp and paper industry is a mix of large integrated plants based on wood based raw material and medium and small size paper plants based on agro residues or waste paper. The wastewater from this industry may be organic or inorganic in nature or a combination of both. It 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[32]. 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[20]. 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[4,9,2].

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[14].

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 objective of this study was to treat the bagasse based pulp and paper industry effluent using laboratory-scale MBBR and study the performance of Moving Bed Biofilm Reactor for various operating conditions.

2. Materials And Methods

2.1 Reactor

A laboratory scale reactor with a total liquid volume of 5 L was used in this study. The outer and inner diameters of the reactor were 160 mm and 150 mm respectively. The reactor was filled with carrier elements 0.95 g /cm^3 density, occupying 11% of the reactor's liquid volume. The feed was filled in the influent tank and it pumped to the reactor by 'Watson 3l3' model pump with minimum capacity of 0.25 Hp through inlet. The treated wastewater from the outlet was collected in the effluent tank for settling. 'Mixing and aeration were provided by pressurised air through (BOYU ACQ-001) aerators in the bottom of the reactor. 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.

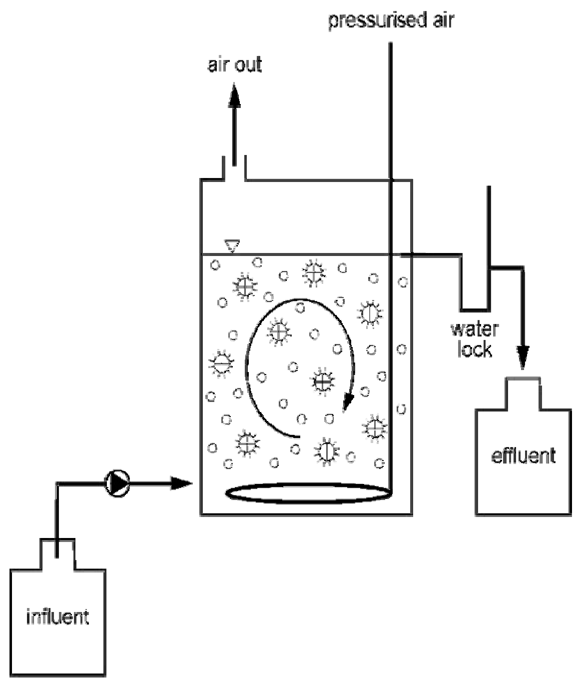

Fig 2.1: Experimental set-up.

2.2 Inoculum

The reactor was inoculated with activated sludge from a full-scale plant treating pulp and paper mill wastewater for acclimatization process

2.3 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.

2.4 Biocarriers

Proflex type biocarriers were used as the supporting medium. It is made of polyethylene material. It has fins and internal cross members. The

carrier media for the growth of microorganisms are shown below figure 2.2.

Fig 2.2: Biocarriers

2.5 Analysis

Pollutant removal in the reactor was studied by optimize the operating parameters such as biocarrier filling ratio, hydraulic retention time, and maintaining MLSS concentration. The effluent was treated for the following:

Operating conditions filling ratio of biocarriers to reactor volume – 40, 50, 60 and 70%.Hydraulic retention time – 2 hr, 4 hr, 6hr and 8hr.

Table 2.1 Biocarrier specification

Material type	Proflex
Shape	Cylindrical with fins
Colour	Black
Density	0.95 g/cm^3
Height	16mm
Diameter	22mm
Effective surface area	450 m2/m3

3. Results and Discussion

3.1 Effect of percent filling 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.

Table 3.1 Characteristics of the collected effluent

S.NO.	Parameter	Values
1	Colour	165 Pt-Co
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 (3 day, 27°C)	1650 mg/l

Table 3.2 Effect of COD & BOD removal on 50 percent filling of biocarriers

Contact time(h)	COD remaining (mg/l)	COD removed(mg/l)	COD removal (%)	BOD (3day, 27°C) remaining (mg/l)	BOD (3day, 27°C) removed (mg/l)	BOD (3day, 27°C) removal (%)
0	3340	-	-	1650	-	-
2	1280	2060	62	660	990	60
4	1123	2217	66	420	1230	75
6	705	2263	79	360	1290	78
8	440	2900	87	220	1430	87

Using the results, a combined graph was plotted using contact time and COD removal percentage. In the graph the peak curve shows the maximum removal percentage and it was obtained for 50 percent filling of biocarrier. The COD of 2900 mg/l was removed for 50 percent filling of biocarrier with contact time of 8 h. The other curves were showed lesser percentage removal and it drawn for 40, 60 and 70 percent filling of biocarrier.

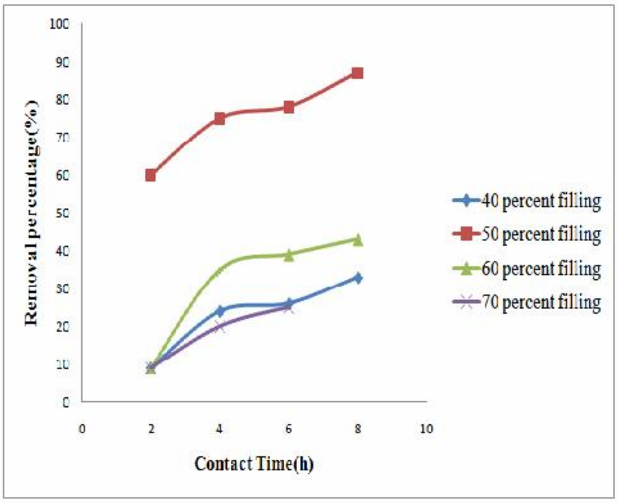

Figure 3.1 Combined graphs for BOD removal

The removal rate was increased gradually for each contact times. The results indicated that the removal efficiency of is affected by the hydraulic retention time and percentage of biocarriers to the reactor volume.

This study results proved the filling of carrier elements in reactor is important for organic removal. The reason for lower efficiency of 40 percent filling is less biomass growth in the reactor due to the less amount of biocarrier. In above 50 percent filling of the carrier the attachment of biomass is less due to restricted movement of carriers into the reactor so the removal efficiency was decreased. The filling of carrier elements in reactor is important for specific biofilm growth[14, 15]. The optimum percent filling of biocarriers achieved best performance and beyond the percent filling the efficiency started to decrease[35]. In 50 percent filling, the movement of biocarrier was effective and higher the suspended biomass concentration, the higher enzymatic hydrolysis and bio flocculation, the higher the pollutant removal. Optimum percent filling of biocarrier to remove the phenol concentration and organic matter respectively at different HRT was discussed in previous papers[4].

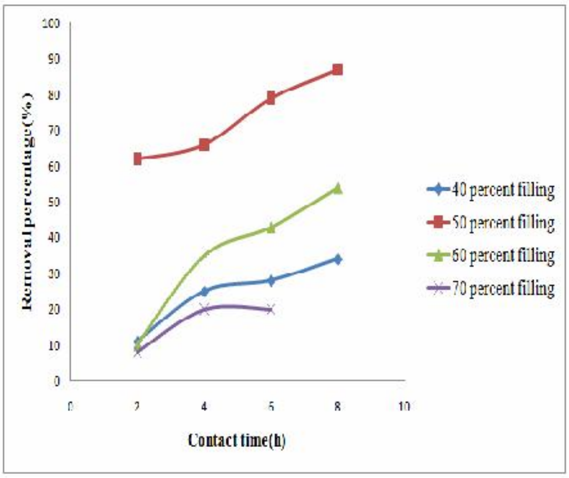

Figure 3.2 Combined graphs for COD removal

Table 3.3 Effect of Hydraulic Retention Time

S. No.	HRT (h)	COD remaining (mg/l)	COD removed (mg/l)	COD removal (%)	BOD (3day, 27°C) remaining (mg/l)	BOD (3day, 27°C) removed (mg/l)	BOD (3day, 27°C) removal (%)
1	0	3340	-	-	1650	-	-
2	2	1152	2488	66	720	930	56
3	4	979	2361	71	480	1170	70
4	6	716	2624	79	330	1320	80
5	8	213	3127	94	130	1520	93
6	10	133	3207	96	30	1620	97

3.2 Effect of Hydraulic Retention Time

The effect of hydraulic retention time was evaluated by varying the HRT values for the optimum percent filling of biocarrier. 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 10 h HRT. 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 Retention times are shown in Table 3.3.

4. 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 [2, 22].

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References

1. Afzalt. (2005), ‘Combined biological–coagulation–filtration treatments for pulp and paper effluent’, Water science and technology, Vol.41,No.4-5, pp.55 - 61.
2. Andreottola G., Foladori P., Ragazzi M. and Tatano F. (2000), ‘Experimental comparison between MBBR and activated sludge system for the treatment of municipal wastewater’, Water science and technology, Vol. 41, No. 4-5, pp. 375- 382.
3. Anurag., Naragan V S., Chaudhary.and hrichand.(2004), ‘Treatment of pulp and paper mill effluent’, Journal of scientific and industrial research, Vol.63, pp.667-621.
4. Bita., Hossein. and Maryam.(2002), ‘Phenol degradation using moving bed biofilm reactor’, Water science and technology, Vol. 43, No. 4-5, pp. 243- 250.
5. Borghei S.M., Shardatmaleki M., Pourrezai P. and Borghei G.(2008),‘Kinetics oforganic removal in fixed bed aerobic reactor’, Bioresources technology, Vol.99, pp. 1118- 1124.
6. Broch A ., Andersen R. and Opheim B.(1997), ‘ Treatment of newsprint mill wastewater in moving bed biofilm reactors’, Water science and technology, Vol.35, No. 2-3, pp. 173- 180.
7. Chinnaraj S. and Rao G. (2006), ‘Implementation of UASB digester at pulp and paper industry’, Biomass and energy, Vol.30, Issue.3, pp. 273- 277.
8. Comprehensive industry document for small scale pulp and paper industry COINDS/40/1995/CPCB
9. Dalentoft. and Thulin. (1997), ‘The use of the kaldnes suspended carrier process in treatment of wastewater from the forest industry’, Water science and technology, Vol.35, No. 2-3, pp. 123- 130.
10. U.S EPA (2002), ‘Profile of the Pulp and Paper Industry’, EPA/310-R-02-002.11. Hewell P.E.(2006),‘ Efficiently nitrify lagoon effluent using moving bed biofilm reactor treatment processes’, Water research, Vol.40, No. 2-3, pp. 130- 137.
11. Jing., Feng., Ying. and Xu.(2009),‘Removal of COD from coking-plant wastewater in the moving-bed biofilm sequencing batch reactor’,Korean journal of Chemicalengg,Vol 26, No.2, pp -564-568. 50
12. Jonoud S., Vosoughi. and Daylami.(2003),‘ Study on nitrification and denitification of high and COD load wastewater in moving bed biofilm reactor’, Iranian journal of Biotechnology ,Vol.1, No. 2, pp. 115- 120.

13. Kaldnes Moving Bed Natrix Process, Internet file; ///H:/print/Kaldnes Moving Bed (KMB) Natrix Process. Html.
14. Kermani M., Bina B., Movahedian M.M., Amin. and Nikaein M.(2008), 'Application of moving bed biofilm process for biological organics and nutrient removal from municipal wastewater', American journal of Enivronmental sciences, Vol.4, No. 6, pp. 675- 680.
15. Kermani., Bijian., Hossein Movahedian., Amin. and Nikaeen. (2009), 'Biological phosphours and nitrogen removal from wastewater usingmoving bed biofilm process', Iranian journal of Biotechnology ,Vol.7, No. 1, pp. 19- 27.
16. Lane. (2006), 'Kinetics of nitrogen and organic removal in moving bed biofilm process ', Applied mathematical modelling, Vol.32, pp. 2360 - 2377.
17. Mandavgane S A., Paradkar G D. and Subramanian D.(2006),
18. 'Desilication of agro based black liquor using bubble column reactor', Journal of scientific and industrial research, Vol.5, pp.603-607.
19. Marianne., Yues., Parent., villemur. and jolicoeur.(2006),' Design optimization of a self-cleaning moving bed bioreactor for seawater denitrification, Water research, Vol.40, pp. 249- 258.
20. Mobius., (2006), 'Water use and wastewater treatment in paper mills', Augsburg first edition D-86199.
21. Odegaard.,(1999),'The moving bed biofilm reactor', Water Environmental Engineering and Reuse of Water, Vol. 4, pp. 250- 305.
22. Odegaard H., Gisvoid G. and Strickland. (2000), 'The influence of carrier size and shape in moving bed biofilm process', Water science and technology, Vol. 41, No.4-5, pp.383 -391.
23. Odegaard H. (2006), 'Innovations in wastewater treatment: the moving Bed Biofilm processes, Water science and technology, Vol.53, No.9,pp.17 - 33.51.
24. Odegaard H., Rusten B. and Westrum T. (2006), 'A new moving Bed Biofilm process', Water science and technology', Vol. 29, No.10 -11 ,pp.157- 165.
25. Odegaard H.(2006), 'Design and operation of the kaldness MBBR',Aqua cultural Engineering', Vol.34, Issue 3, pp.3221 -3231.
26. Pastorelli G., Andreottola G., Canziani R., Darriulat C., and Rozzi A.(1997),'organic carbon and nitrogen removal in moving bed biofilmreactor, Water science and technology, Vol. 35, No 6, pp.91-99.
27. Pastorelli G., Andreottola G., Canziani R., Pascalis F., and Rozzi A. (1997), 'Pilot – plant Experiments with moving bed biofilm reactors', Water science and technology, Vol. 36, No 1, pp.43-50.
28. Rajesh K S., Singaravel M., Sankaralingam P., Subramanian S. and Subrahmanyam S V. (2009), 'Colour removal from pulp and paper mill effluent – methods and industrial application- a review', IPPTA J, Vol.21, No.1, pp.143 - 148.
29. Rouse D., Burica O., Stražar M. and Levstek M.(2006), 'A Pilot-plant study of a moving-bed biofilm reactor system using PVA gel as a biocarrier for removals of organic carbon and Nitrogen', Water science and technology, Vol.51, No.4-5, pp.675-678.
30. Rusten., Johnson., Devall., Davoren., and Bryan. (1999), ' Biological pre-treatment of a chemical plant wastewater using high rate moving bed biofilm reactor', Water science and technology, Vol. 39, No.10-11, pp.257 - 264.
31. Rusten B., Hellstrom B G., Hellostrom F., Sehested O., Skjeifoss E.and Svendsen B.(2000),'Pilot testing and preliminary design of moving bed biofilm reactor for nitrogen removal at FREVAR waste water treatment plant', Water science and technology, Vol.41, No.4-5, pp.13 -20.
32. Sigrun J., Jahern., Jukka., Rintala A. and Odegaard.(2002), ' Aerobic moving bed biofilm reactor treating thermo mechanical pulping whitewater under thermophilic conditions', Water research, Vol.36,pp.1067- 1075.
33. Tamilnadu Newsprint and Papers Limited, karur, <http://www.tnpl.com> 52
34. Technical manual for industrial pollution control for pulp and paperindustry, 1998, Japan Environment Corporation.
35. Trapani D., Mannina G., Torregrossa M. and Viviani G. (2008),'Hybrid moving bed biofilm reactor: a pilot plant experiment', Water science and technology, Vol. 57, No.10, pp.1539- 1545.

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