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PERFORMANCE STUDY OF MOVING BIOFILM AEROBIC SEQUENCING BATCH REACTOR (MBASBR) FOR THE TREATMENT OF PAPER AND PULP MILL EFFLUENT

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ABSTRACT

In this study the experiments are conducted to remove the Chemical oxygen demand (COD),Total suspended solids (TSS) and Lignin from paper and pulp mill wastewater using Moving biofilm aerobic sequencing batch reactor (MBASBR) .The laboratory scale reactor of working volume 20 liters used for the study. In addition to the conventional reactor the plastic carrier is used as the moving biomedia for the suspended and attached growth treatment in the reactor. Microbial culture of Phenerochetes chrysosporium and Pseudomonas alcaligens is used for the treatment. These microbes show good attachment with the carrier for the biochemical degradation of the paper and pulp mill wastewater during the treatment process. The average removal efficiencies for COD, TSS and lignin are found to be 96%, 98% and 84 % respectively.

Keywords

Biocarrier, CODremoval, TSS removal, Ligninremoval, sequencing batch rector

Introduction

Paper and pulp industry is the largest water and wood consuming industry in the world and it pollute the environment due to stringent legislative action the impacts reduced by 80-90% [1]Wood is the primary raw material used to production of paper. To prevent the activity of deforestation and reduce the natural resource conservation now days the secondary material like sugarcane bagasse and recycled paper is used for the production. The waste water characteristic is depend on the manufacturing process and the type of material used for the production no similar characteristic discharge is found in the industries[2]The manufacturing processes involves pulping, bleaching in the pulping black liquor is produced which is the most polluted. Wastewater contains chlorinated lignin phenols resin acids which cause highBOD, COD, TDS, TSS, colour etc.which cause various problems to the environment[3].To treat the wastewater various existing treatment methods like trickling filter, aerobic lagoons, Activated Sludge Process (ASP) are used but the removal efficiencies are less. The electro-chemical treatment shows better removal efficiencies but these methods are expensive.Fed batch reactor is used to remove COD and BOD by coagulation and sand filtration combination treatment [4].Among the above ASP is mostly used biological treatment but poor settling ability and sludge bulking problems occurs due to Filamentous growth [5] To overcome these problems Sequencing batch reactors used for the treatment it is similar to ASP but in the SBR the return sludge activity will not be there. To improve the biological treatment efficiencies particular species of microorganisms are used for the biodegradation. The SBR having the following steps fill, react, settle, draw and ideal [6]. Biomassloss is happen during the draw phase of the SBR. In this present study to overcome the biomass loss the novel modified reactor MBASBR is designed by using sphere shape plastic material as the biocarrier in the reactor. This material provides region for themultiplication of microbes and forms biofilm on the it.These biocarrier increase the retention of biomass and enhance both suspended and attached growth degradation.

Materials and methods

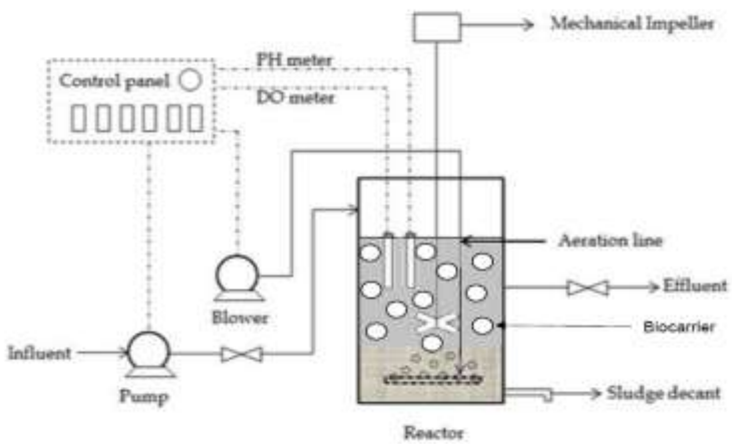


Fig 1: Moving Biofilm Aerobic Sequencing Batch Reactor Setup

Sample wastewater from paper mill plant

Paper and pulp wastewater were collected from the secondary clarifier of the pulp & paper plant in Coimbatore, India and transported to an environmental engineering laboratory in Coimbatore Institute of Technology. The collected samples were stored in a refrigerator at 4°C for further investigation.

Moving Biofilm Aerobic Sequencing Batch Reactor

The bench-scale MBASBR reactors with 20 L (mixtures of substrate and inoculums) of working volume were used in this study for treating pulp and paper mill wastewater. The reactor is made using acrylic plastic of 280 mm diameter, 400 mm height and 5 mm thick. The schematic view of experimental setup is shown in **Fig.1.**Low speed gear motor is used for driving the paddle shape impeller and maintained at a speed of 80-100 rpm to agitate the working volume. The influent from the feed tank (l) is injected into the reactor using a peristaltic pump. The pH meter and DO meter are attached with the reactor to monitor the pH value and dissolved oxygen concentration in the reactor. Immersion water heater rod is connected with PID controller to maintain the specific temperature in the reactor.

Bio carrier

Polypropylene spheres shape biocarrier showed in **Fig.2.**were used as the moving media for the attachment of the microbial biomass in the reactor it facilitate the both suspended and attached growth degradation.

Fig 2: Image of Bio carriers

Culture isolation and identification

Phenerochetes chrysosporium and Pseudomonas alcaligens were isolated in the paper and pulp mill wastewater. These strains were kept in potato dextrose agar (PDA) medium at 30^{o}C for six days for cultivation.Total micro-organism in the culture is 10^{9} cell/ml. The scanning electron microscopic image of the microbes is shown in **Fig. 2** and **Fig.3**.

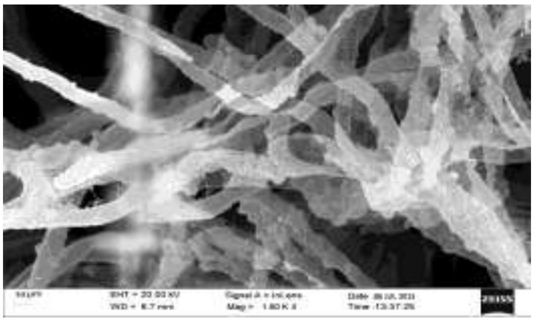


Fig3: SEM Image of Phenerochetes chrysosporium (Fungi)

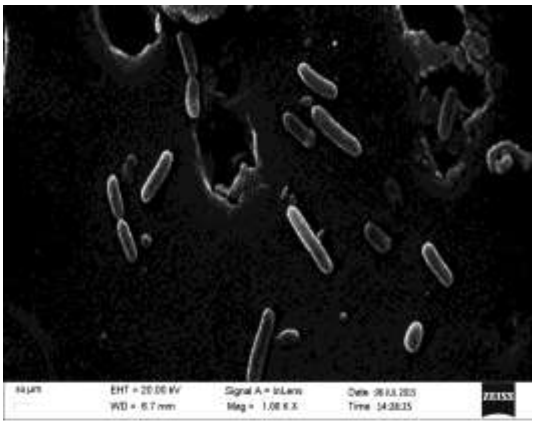


Fig 4: SEM Image of Pseudomonas alcaligens (Bacteria)

Reactoroperating strategy

The reactor is run for the period of 35 days in that initial two weeks is taken for the preliminary growth of the microbes on the surface of the plastic biocarrier during this period the constant volume of effluent is exchanged as fill and draw principle . In the reactor 20 liters of wastewater is take in addition to this plastic carrier is added. The cycle time is maintained as 8 hours in this period fill, react, settle, draw,and ideal phase were taken place during the initial days is shown in Table 1. In each cycle the 8 liters of wastewater is exchanged in the mean while 8 liters of supernatant water is drawn as effluent for the characterization. After the biofilm development on the carrier operating parameters OLR, HRT, Aeration rate, Temperature, Bio carrier volume varied to increase the performance of the reactor.

The dissolved oxygen level around 3 mg/l is maintained in the rector by the diffused aerator excess dissolved oxygen greater than 4 mg/l causes foaming in the reactors [7] .The aeration time is adjusted in the reactor based on the DO level and waste sludge is removed at the end of the day. The initial MLSS concentration is around 1400 mg/l and it attains 3500-4000 mg/l it shows the biomass level is increased in the reactor with increase in days. Urea and trisodium phosphate is used during the initialstartup period of treatment to maintain the ratio approximately 100:5:1 of COD: N: P (Metcalf and Eddy, 2003) [8].

Table 1 Initial Operating Conditions in the reactor

Initial Operating Conditions			
Phase	**Phase Period in hours**	**Cycle time in hours**	**No. of cycles per day**
Fill	0.5		
React	4.5		
Settle	1.5	08	03
Draw	0.5		
Ideal	1.0		

Result and discussion

Characteristics of the paper and pulp mill wastewater

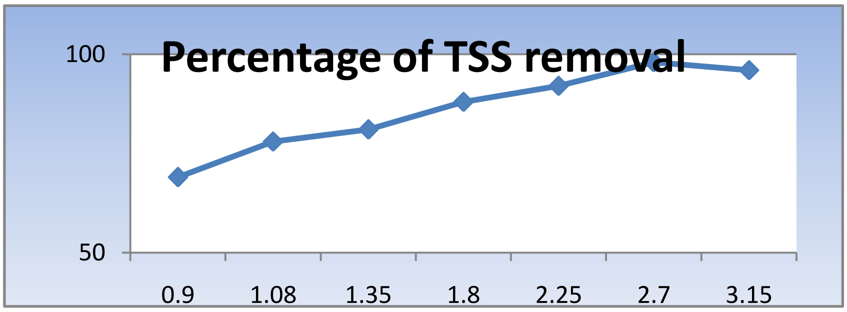
The Physio-chemical characteristic were analyzed according to the standard methods for the examination of wastewater (APHA, 2005) [9] for the effluent shows Chemical oxygen demand (COD), Total suspended solids (TSS) and Lignin, 3420 mg/l, 1314 mg/l and 643 mg/l respectively.

Effect of OLR variation on COD removal

The organic loading rate is varied in terms of COD concentration from 1000mg/l to 3420mg/l at the steady state condition the optimum operating parameter is maintained to run the reactor for the COD removal. Initially the reactor is fed with the low concentration wastewater and gradually increased the loading rate to monitor the performance of the reactor. During the low organic loading it shows less removal of COD it is due to less utilization of organics by the biomass .The removal of organic pollutants by sequencing batch reactor is upto 90% based on characteristics of the wastewater and operating parameter by Pokhrel and Viraraghavan [10].The MBASBR shows the similar response low loading rates at 0.9 OLR kg COD m^3 d^{-1}it shows 67 % of COD removal and it attains maximum COD removal of 96% at 2.7 OLR kg COD m^3 d^{-1} it is shown in Fig.6.

OLRkg COD m^3 d^{-1}

Percentage of COD removal



OLR kg COD m^3 d^{-1}

Fig 5: Effects of OLR on COD removal

Effect ofOLR variationon TSS removal

The suspended particle is direct over the percentage of turbidity according to Pavanelli and Bigi [11].The higher flocc formation and the longer settling time will makes the TSS removal higher. Both values of TSS and turbidity are similar by Ariffinl et al[12].In the MBASBR various OLR is maintained from 0.9 to 3.15 kg COD m^3 d^{-1}.IT shows 69% removal of TSS atOLR 0.9 and it gradually increases and reaches 98% of removal at 2.7 kg COD m^3 d^{-1}it is shown in Fig.6.The higher removal is due to the biofilm which increase surface area for the attachment of the suspended particles is due to the bio carrier present in suspension.

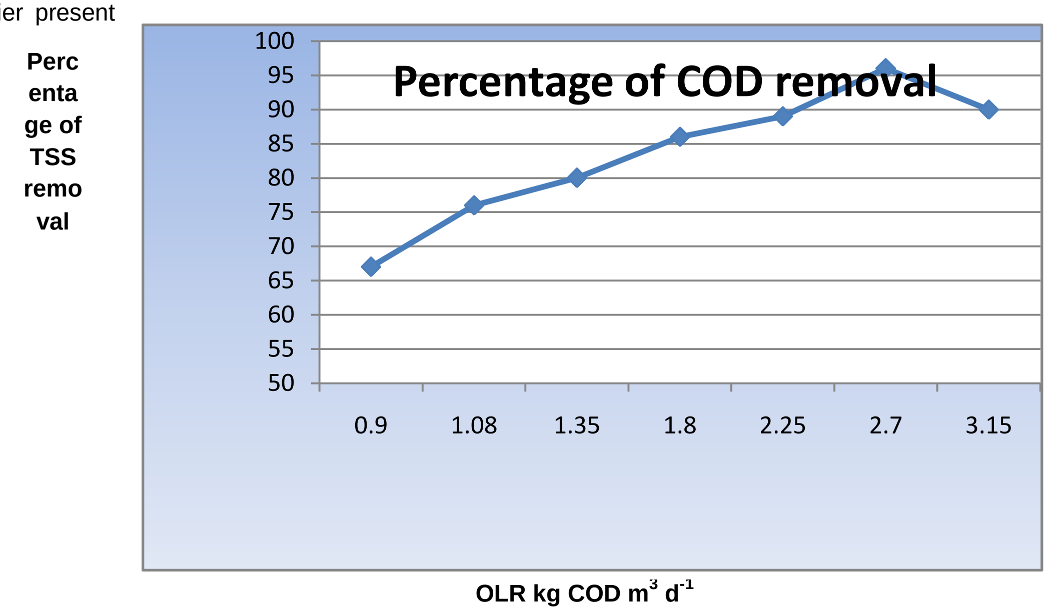


Fig 6: Effect of OLR on TSS removal

Effect of OLR variation on Lignin removal

In the present reactor the initial degradation is less showed 55% removal of lignin and the P. chrysosporiumgot attached with the biocarrier acts as the degrading agent to remove the lignin and shows higher removal of 84% at the OLR 2.7 kg COD m^3 d^{-1} it is shown in Fig.7.Lignin degradation gets lower at higher loading it is due to the depletion of biomass with increase in time. Fungus assimilates the lignin before it is decomposed into starch and sugar by biological treatment by DA Bocchini et al [13].In MBASBR biocarrier act as moving biofilm which shows better performance in the degradation of lignin.

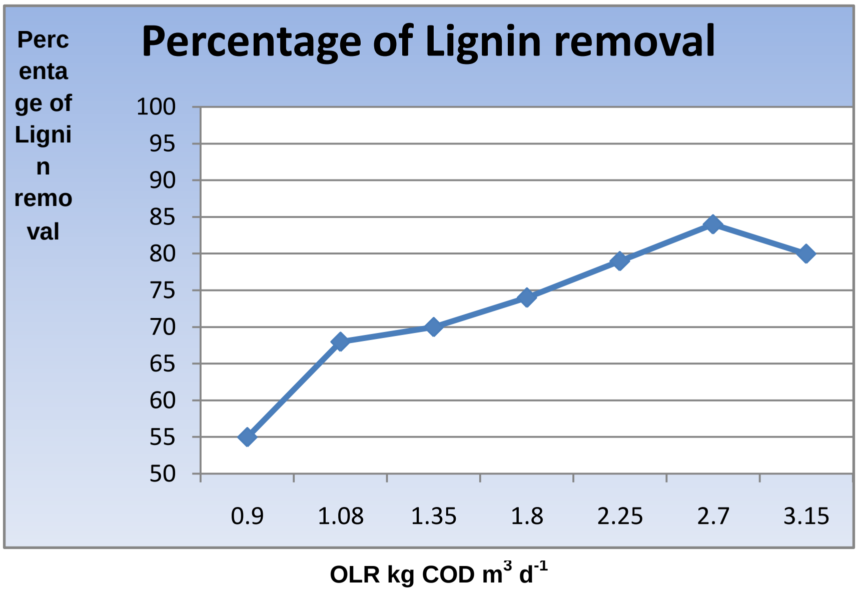


Fig 7: Effect of OLR on Lignin removal

Conclusion

The MABSBR shows very higher removal efficiencies of COD, TSS and Lignin of 96%, 98%, and 84% respectively. Combined effect of microbes and the biocarrrier media enhance the performances considerablyin the MABSBR. The biocarrier provides better attachment for the growth of micro-organisms and prevents the loss of biomass during the draw phase of the treatment. The biocarriers helps in retain the sludge and increase the biomass retention .It shows that using of biocarrier in the conventional Sequencing batch Reactor will enhance the removal efficiencies of the contaminants present in the effluent of paper and pulp mill.

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Author' biography with Photo

I R. Ranjith Kumar, completed my Bachelors at St. Peters Engineering college affiliated to Anna University, completed my Master of Engineering in Environmental Engineering and Management at Coimbatore Institute of Technology affiliated to Anna University and currently pursuing my research in Waste Water Management. I have published several research papers and attended national and international conferences related to Environmental Engineering.