

# Modified Biofilm Reactor System for Domestic Wastewater Treatment

M. L. Gulhane<sup>1</sup> K. G. Padwekar<sup>2</sup>

<sup>1</sup>Associate Professor <sup>2</sup>P.G. Student

<sup>1,2</sup>Department of Civil Engineering

<sup>1,2</sup>Government College of Engineering, Amravati, Maharashtra (India)

**Abstract**— The treatment of wastewater using biofilm technologies has been established to be an efficient and proven technology to obtain the desirable quality of effluent. A study was carried out to increase the effluent quality by treating domestic wastewater with biofilm system with the provision of some modification in the conventional Rotating Biological Contactor. To bring about the effective treatment and to check the feasibility of treatment process a lab scale model was developed. The model consists of drums and paddles attached to the shafts with the media filled in it and was operated at varying detention time and varying rotational speed. It was observed that there was remarkable reduction in wastewater parameters and it was because of consumption of organic matter by biofilm growth formed on media filled in rotating paddles and drums. The experimental study of Modified Biofilm Reactor revealed that, the maximum removal efficiency for BOD, COD and TS was observed to be 81%, 76% and 73% at rotational speed of 3 rpm and detention time of 24 hours.

**Key words:** Biofilm, Paddles, Rotating Biological Contactor, Treatment, Wastewater

## I. INTRODUCTION

There are many problems in the treatment of both municipal and industrial wastewater treatment plants which are the result of insufficient oxygen, high BOD and COD. As community awareness of the impacts of discharging treated effluent to the environment increases, so is the need to improve the performance of existing treatment plants with the modification in the conventional treatment units. Not only does a high effluent quality reduce negative impacts of discharging a treated effluent to inland water bodies, but the range of possible reuse options is wider when a high quality effluent is available. Fixed-film treatment systems are probably the oldest used wastewater treatment processes. One such type of fixed-film treatment is the rotating biological contactor (RBC) system, where the support surface moves through the wastewater. [7] Rotating Biological Contactor (RBC) system represents an excellent option for sewage and industrial wastewater treatment. [3], [12] It has gained attention due to better chemical oxygen demand (COD) removal efficiency, because of the large amount of biomass present and low operating food (substrate) to microorganism (F/M) ratio, the system can withstand large hydraulic and organic surges. It is also an attractive engineering alternative for low cost wastewater treatment because of its short process detention time, excellent shock and toxic loading capabilities, simple process control and low energy requirements.

RBC has been widely used for providing secondary treatment as it is configured as attached growth process for effective removal of organic matter from wastewater. [4] RBC usually consists of rotating packs of discs which are contained in a tank. The shaft is aligned with the flow of wastewater so that the discs rotate at right angles to the flow

with several packs usually combined to make up a treatment train. About 40% to 60% of the disc area is immersed in the wastewater depending upon the type of treatment to be obtained. The submerged discs are rotated at desired rpm through the motor attached to the shaft to bring about the treatment of wastewater. Biological growth is attached to the surface of the disc and forms a slime layer. [6] The microorganisms attached on the rotating disks as 'biofilms', degrade organic matter and nitrogen containing compounds in the wastewater. The discs contacts wastewater and air for oxidation as it rotates and helps to slough off excess solids. Considering the action of biological growth on the disks to treat wastewater various modifications have been carried out to increase the efficiency of the RBC.

An advanced technique for treatment of wastewater was developed for effective removal of organic matter and increases the effluent quality with the modification in existing Rotating Biological Contactor. A lab scale model was fabricated with the modification involving introduction of paddles and drums attached to the shafts instead of discs. The paddles and drums were filled with media (plastic scrubber). The model was operated for varying conditions such as different detention time and different rpm and the performance of model was checked for the parameters such as BOD, COD and TS.

## II. AIM AND OBJECTIVES

The study aimed to develop a model that has the modification over conventional Rotating Biological Contactor so as to get the higher level of efficiency. The objective behind the study was to observe the performance of Modified Biofilm Reactor System on wastewater parameter such as BOD, COD and TS. To study the effect of introduction of inclined drums and paddles, and the economic aspect of using biofilm treatment process.

## III. EXPERIMENTAL SETUP

A modified bench scale model was set up and run under standard operating conditions. The fabrication of model was carried out with the help of 25 gauge thick GI sheet. The overall capacity of model was 60 litres with the proper inlet and outlet arrangement for introduction of wastewater and withdrawal of treated effluent. A baffle wall was provided at a distance of 5 cm from the inlet arrangement. The paddles were fitted to the horizontal PVC shafts provided near to the inlet and outlet end with provision of ball bearings to bring about the rotation of shaft. The vertical shaft with the drums attached to it in inclined position was mounted centrally in the tank with provision of ball bearing. The paddles and the drums were made from GI mesh and were fixed to the shafts. The surface of the paddles and drums were perforated so as to bring the media in contact with wastewater and provide attachment for the growth of microorganisms. The paddles and drums were filled with media

(plastic scrubbers) to judge the performance of Modified Biofilm Reactor. The model was developed as a single stage reactor with the rotating paddles remaining 40% immersed. The driving mechanism was mounted at influent end directly fitted to horizontal and vertical shaft with the provision of speed control unit through regulator. The reactor was maintained as continuous flow reactor and was operated at varying detention time and varying rotational speed. The study was carried out at regular interval of time and the performance of biological reactor was observed for various parameters such as BOD, COD and TS, so as to get high quality effluent.

IV. RESULTS AND DISCUSSIONS

The Biofilm Reactor worked efficiently in obtaining the desirable level of effluent quality. Standard methods were adopted for analyzing the influent and effluent quality of wastewater. The model was operated at rotational speeds of 3 rpm, 6 rpm and 9 rpm and detention time of 12 hrs, 15 hrs, 18 hrs, 21 hrs, 24 hrs and 27 hrs. The parameters such as BOD, COD and TS were tested at regular intervals of time. The maximum percentage removal efficiency was observed at a detention time of 24 hrs and rotational speed of 3 rpm.

Sam ple No.	3 rpm				6 rpm				9 rpm			
	Influ ent	Efflu ent	% Remov al	Avg % Removal	Influ ent	Efflu ent	% Remov al	Avg % Removal	Influ ent	Efflu ent	% Remov al	Avg % Removal
1	214	47	78.22	80.91	241	48	82.18	79.41	197	48	75.92	76.46
2	178	34	81.45		219	45	79.51		231	50	78.48	
3	208	53	83.19		238	56	82.22		257	70	79.98	
4	234	49	77.37		215	47	76.71		212	58	72.76	
5	188	31	84.31		227	58	77.43		195	47	76.09	

Table 1: BOD removal efficiency at varying rotational speed and detention time of 24 hours

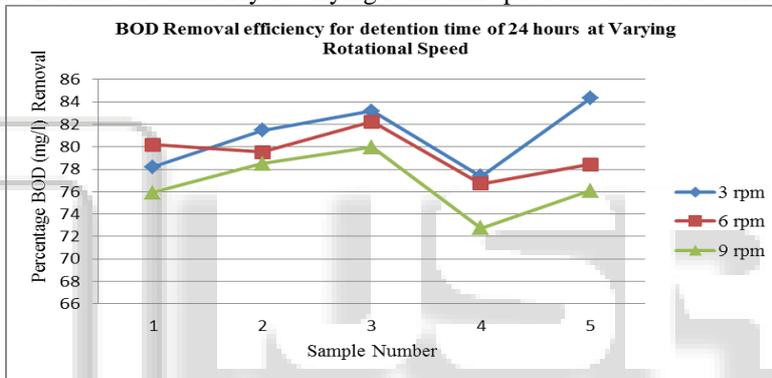


Fig. 1: BOD removal efficiency for Detention Time of 24 hours at varying Rotational Speed

From the above (table1), and (graph1) the maximum BOD removal efficiency for Detention time of 24 hours and rotational speed of 3 rpm was found to be in the

range of 77-84% and the average BOD removal efficiency was found to be 81%.

Sam ple No.	3 rpm				6 rpm				9 rpm			
	Influ ent	Efflu ent	% Remov al	Avg. % Removal	Influ ent	Efflu ent	% Remov al	Avg. % Removal	Influ ent	Efflu ent	% Remov al	Avg. % Removal
1	356	86	75.59	76.20	395	104	73.44	74.22	322	88	72.98	70.23
2	254	60	76.05		353	89	75.19		272	86	68.16	
3	260	57	78		396	122	71		325	98	70.1	
4	398	87	77.89		364	92	74.81		373	112	69.88	
5	470	124	73.48		391	94	76.68		302	97	70.07	

Table 2: COD removal efficiency at varying rotational speed and detention time of 24 hours

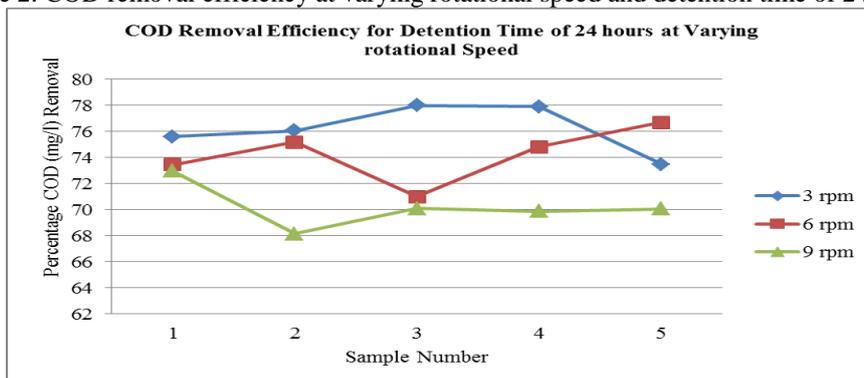


Fig. 2: COD removal efficiency for Detention Time of 24 hours at varying Rotational Speed

Sam ple No.	3 rpm				6 rpm				9 rpm			
	Influ ent	Effl uent	% Remov al	Avg. % Removal	Influ ent	Effl uent	% Remov al	Avg. % Removal	Influ ent	Effl uent	% Remov al	Avg. % Removal
1	255	71	72.07	73.17	361	96	73.3	71.64	345	88	74.52	70.8
2	235	66	76.51		347	84	75.83		363	102	71.84	
3	273	69	69.16		281	80	71.19		407	129	68.07	
4	312	78	75.1		276	97	68.01		104	122	67.77	
5	216	58	73.02		323	99	69.89		374	104	72	

Table 3: Total Solids (TS) removal efficiency at varying rotational speed and detention time of 24 hours

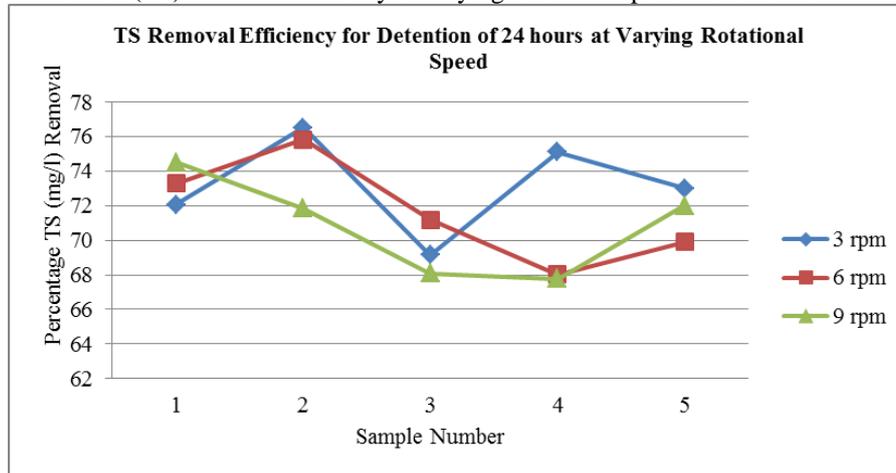


Fig. 3: TS removal efficiency for Detention Time of 24 hours at varying Rotational Speed

From the above results it was revealed that the rotational speed of 3 rpm and detention time of 24 hours was found to be optimum for various operating conditions. The COD and TS removal efficiency was found to be in the range of 73-78% and 69-77% (table 2, 3). The average BOD, COD and Total Solids (TS) removal rates were observed to be 81%, 76% and 73% (graph 1, 2, 3). It was noted that, the biological reactor with rotating paddles and drum filled with plastic scrubber showed desirable efficiency for wastewater treatment. It was noted that with the increase in detention period of the treatment, there was remarkable increase in removal efficiency.

## V. CONCLUSIONS

The study revealed that the Modified Biofilm Reactor with rotating paddles and drums filled with plastic media showed better performance for wastewater treatment. The Modified Biofilm Reactor showed higher efficiency in reducing BOD, COD and TS to a considerable extent. It is one of the promising wastewater treatment technologies suitable for treatment of domestic wastewater generated from small community as well as for the treatment of wastewater generated from industrial and agricultural activities.

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