Moving Bed Biofilm Reactor: A Best Option for Wastewater Treatment

Mangesh Gulhane[1] Ashwini Ingale[2]
[1]Associate Professor [2]P.G. Student
[1,2]Department of Civil Engineering
[1,2]Government College of Engineering, Amravati 444604, Maharashtra, (India)

Abstract— The current paper presents an institutional analysis of wastewater using Moving Bed Biofilm Reactor (MBBR). The paper discusses more about the various options chosen for operation of Moving Bed Biofilm Reactor. The objective of the study was the evaluation of operational parameters and performance of reactor based on attached growth process by using MBBR. The results show that at rotational speed of 10 rpm removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand(COD), and total solid(TS) was 86%, 84%, and 81% respectively.

Key words: Wastewater, MBBR, Attached growth, Suspended growth

I. INTRODUCTION

Many of our daily chores such as bathing, doing laundry, flushing toilets, preparing meals, washing dishes and other activities generate wastewater. Few people give thought to where wastewater goes after it disappears down the drain. Domestic wastewater (i.e. sewage) must be properly treated because it contains excessive nutrients, harmful bacteria/viruses and household chemicals that may contaminate the land and waters of our state and threaten public health.

Wastewater facilities are closely related to the standards of living and quality of life of citizens as city infrastructures. In particular, since the wastewater facilities affect directly the environment of water quality, the national government makes many efforts with different aspects to build the systematic system to manage it as well as to improve and enhance it [1].

Wastewater with high levels of organic matter (COD), total suspended solid (TSS) cause several problems, such as, oxygen consumption and toxicity, turbidity when discharged to the environment. It is, therefore, necessary to remove these substances from wastewaters for reducing their harm to environments. Biofilm processes have proved to be reliable for organic carbon and nutrients removal without some of the problems of activated sludge processes. Moving Bed Biofilm Reactor (MBBR) is one of the promising technologies used for treatment of wastewater. The MBBR incorporate benefits provided by both fixed film and suspended growth processes. The MBBR is reliable, innovative and cost effective treatment process for the wastewater. Moving bed biofilm reactor technology was invented in Norway before 25 years [3]. The first MBBR facility became operational in 1990 in Lardnal, Norway. MBBR technology has since made significant penetration into the European market with an installed base of more than 300 MBBR systems [4].

The idea behind the development of the Kaldnes MBBR process was to adopt the best features of the activated sludge process as well as those of the biofilter processes, without including the worst. Contrary to most biofilm reactors, the MBBR utilize the whole tank volume for biomass growth. It also has a very low head-loss. Contrary to the activated sludge reactor, it does not need any sludge recycle [5]. It is a completely mixed and continuously operated biofilm reactor, where the biomass is grown on small carrier elements that have a little lighter density than water and are kept in movement along with a water stream inside the reactor. The movement inside a reactor can be caused by aeration in an aerobic reactor and by a mechanical stirrer in an anaerobic or anoxic reactor. With MBBR technology, the biofilm that is created around each carrier element protects the bacteria cultures. This makes it much more stable under load variations and less sensitive to temperature or ph variations than conventional systems. Researchers have proven that MBBR possesses have many excellent traits such as high biomass, high COD loading, strong tolerance to loading impact, relatively smaller reactor and no sludge bulking problem [6].

The process can either be used as a 1) pre-treatment system ahead of an existing activated sludge system for increased organic matter removal, 2) stand-alone biological treatment process for BOD removal, nitrification and/or denitrification or 3) a retrofit of an existing activated sludge processes to help increase overall nitrification capacity of the existing system [7].

II. AIMS AND OBJECTIVES

The objective of the study was to investigate the feasibility by using moving bed biofilm reactor with the combination with attached growth system for the treatment of domestic wastewater. Laboratory bench-scale analyses are conducted to enhance the efficiency of reactor by adopting certain modifications such as variation in type of media and introduction of oxygen during wastewater treatment. The study was carried out to analyze the performance of modified moving bed biofilm reactor consisting of three different reactor works on the principle of attached and combination of attached-suspended growth processes.

III. EXPERIMENTAL SETUP

The lab scale model was set up with overall capacity of 62 litters. The system comprises three aerobic reactors. The Inlet and outlet arrangements were provided at both ends. The reactor was operated as continuous flow reactor with varying detention time, rotational speed and type of media used. The untreated wastewater was fed to primary sedimentation tank. The performance of MBBR reactor was observed for nearly 120 days under various operating conditions for BOD, COD, and TS parameters. Artificial media such as plastic scrubbers, aerocone blocks and cellulose pads were used for growth of biofilm. Anox Kaldnes biocarriers are used in moving bed biofilm reactor with 50 % filling ratio.

Three perforated trays were provided in the first compartment. All the trays were of same dimensions. The

trays were filled with porous media such as aerocone blocks, cellulose pads and plastic scrubbers. The second reactor was Attached Growth Reactor consisting of six compartments provided with seven baffles to avoid short circuiting effect. The Upflow-down flow was maintained in the compartments with the help of baffles. The baffle walls provided between 1st and 2nd, 3rd and 4th, 5th and 6th compartment. Anox Kaldnes media was filled in the Second, Fourth & Sixth compartments. The third reactor was the Moving Bed Biofilm Reactor which followed the principal of combined attached and suspended growth system such as Moving Bed biofilm process. The reactor was filled with Patented Anox Kaldnes biofilm carriers. The MBBR media provides extra surface for microbial attachment so as to facilitate more efficient biological wastewater treatment. To keep the biofilm carriers in turbulence, vertical paddle was rotated with the help of wiper motor mounted in the reactor.

IV. RESULTS AND DISCUSSION

The influent and effluent wastewater parameters were analyzed by adopting standard methods. The parameters such as BOD, COD and TS were tested at varying detention time and rotational speed at regular intervals. The model was operated at various rotational speeds ranging from 10 rpm, 15rpm, and 20 rpm. It was observed that the maximum BOD, COD and TS removal efficiency was 86%, 84%, and 83% at rotational speed of 10 rpm and minimum of 75 %, 72% and 64% at rotational speed of 20 rpm. There was slight increase of 1% in BOD, COD and TS removal efficiency at rotational speed of 27 rpm As such rotational speed of 10 rpm is considered to be best one. The results obtained during the study are tabulated.

Sample NO	Influent BOD			Effluent BOD			Percentage Removal		
	Rotational Speed			Rotational Speed			Rotational Speed		
	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM
1	197	241	204	30	46	43	84.39	80.65	78.83
2	231	219	178	32	42	35	86.14	80.38	80.2
3	257	238	208	47	50	47	84.6	78.76	77.04
4	212	215	234	30	45	47	85.76	79.04	79.62
5	195	227	188	34	39	46	82.11	82.49	75.48

Table 1: Performance of MBBR for BOD removal for detention time of 24 hrs and varying rotational speed

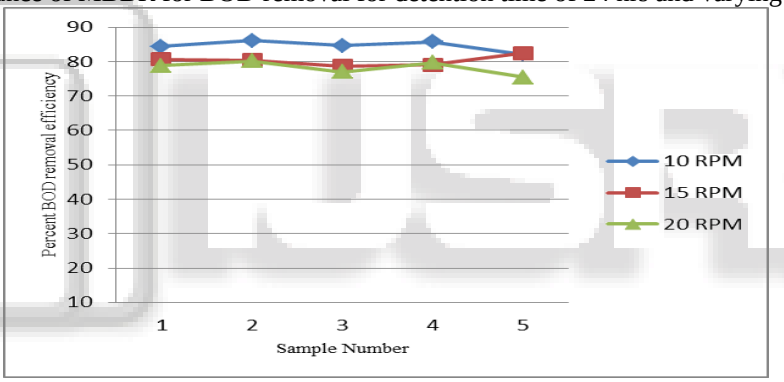

Fig. 1: Graphical representation of percent removal efficiency of BOD

Sample No	Influent COD(mg/l)			Effluent COD(mg/l)			Percentage Removal		
	Rotational Speed			Rotational Speed			Rotational Speed		
	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM
1	322	395	356	59	89	87	81.57	77.39	75.42
2	372	353	254	62	87	69	83.29	75.22	72.59
3	373	396	260	59	85	63	84.10	78.53	75.55
4	302	364	396	58	93	96	80.71	74.29	75.62
5	325	391	470	63	79	110	80.35	79.74	73.21

Table 2: Performance of MMBBR for COD removal for detention time of 24 hrs and varying rotational speed

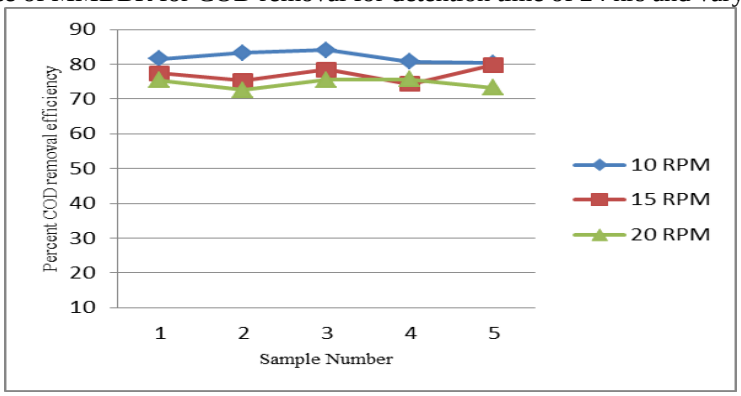

Fig. 2: Graphical representation of percent removal efficiency of COD

Sample No	Influent TS(mg/l)			Effluent TS(mg/l)			Percentage Removal		
	Rotational Speed			Rotational Speed			Rotational Speed		
	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM	10 RPM	15 RPM	20 RPM
1	345	361	255	68	107	80	80.08	70.13	68.47
2	363	347	236	70	84	84	80.54	75.68	64.38
3	407	281	274	69	80	82	82.86	71.35	69.76
4	381	276	313	71	72	107	81.22	73.9	65.80
5	374	323	217	67	83	73	81.91	74.22	66.21

Table 3: Performance of MMBBR for TS removal for detention time of 24 hrs and varying rotational speed

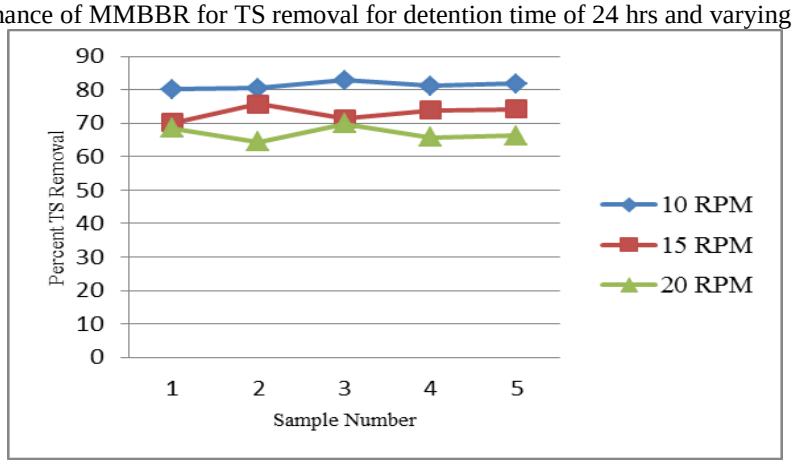

Fig. 3: Graphical representation of percent removal efficiency of TS

V. Conclusion

The Moving Bed Biofilm Reactor (MBBR) is the advance biological treatment system. It is compact, efficient and effective option for domestic wastewater treatment. It is concluded that as the rotational speed of motor decreases the biofilm formation process increases. The present study provides valuable information for further development of cost efficient treatment systems. The process is expected to require less operator intervention compared to the conventional treatment process.

VI. Acknowledgement

The authors wish to express deep sense of gratitude and indebtedness to Dr. S. P. Tatewar sir, H. O. D. , Department of Civil Engineering, for extending their valuable guidance and support to complete the study within stipulated time-line.

References

[1] Kim B. K., et al., "Wastewater Treatment in Moving-Bed Biofilm Reactor operated by Flow Reversal Intermittent Aeration System", World Academy of Science, Engineering and Technology, Vol.60, 2011
[2] Shinde P.G, Water scenario 2025, National Level Conference on Water Management Scenario 2025 Problems, Issues and Challenges, V.P.M.'s Joshi-Bedekar College, Mumbai,pp1-2,2010.
[3] Odegaard H, Compact wastewater treatment with MBBR, Norwegian university of science and technology, Norway, pp1-2, 1994.
[4] Barwal A. and Chaudhary R. To study the performance of biocarriers in moving bed bioflm reactor technology and kinetics of biofilm for retrofitting the existing aerobic treatment system, pp215-217, 2014.
[5] Rusten B., et al., "Treatment of pulp and paper industry wastewater in novel moving bed biofilm reactors", Water Sci. Technol., Vol.30, pp.150-151, 1994.
[6] Karmani M., et.al, Application of moving bed biofilm process for biological organic and nutrients removal from muncipal wastewater, American Journal of Environmental Science ,Volume 4(6), 675-678, 2008.
[7] Brinkley J., et.al, Moving bed biofilm reactor technology – A full-scale installation for treatment of pharmaceutical wastewater, pp1-3, 2007.

