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Performance evaluation of hybrid membrane bioreactor for low strength wastewater treatment

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Abstract— **The present study deals with the performance of submerged hydride membrane bioreactor. The application of membrane bioreactors is advancing rapidly for both industrial and municipal wastewater treatment. The experimental set-up is made up of Poly (methyl methacrylate). The seed sludge was obtained from anaerobic digester. Synthetic wastewater was used as the feed for the Anaerobic Membrane Bioreactor. The COD of the synthetic wastewater was maintained at 1000 mg/l . The anaerobic reactor is started with feeding flow of 10L/Day. The total removal of suspended solid is obtained by the membrane. The average COD removals were 90-95%. Initial organic matter is represented by an average COD & TOC concentration of 850-950mg/l and 300-350 mg/l while the average COD & TOC Concentration in permeate were 30-50mg/l and 10-20mg/l resp. As the system gets stabilized there is an increase in biogas production occurred. The bioreactor produced up to 4L of biogas per day. The VFA production was insignificant in the reactor, but in permeates it was less than 40mg/l. This low VFA concentration indicates the incoming COD was transformed into biomass, CH4 & CO2. Backwash is given to permeate using NaOCl to recover the flux. In this system anaerobic reactor is act as UASB reactor. Membrane fouling in AnMBRs is more intense than in aerobic MBRs as AnMBRs experiences lower sludge filterability. The major reduction in organic matter in terms of COD & TOC from synthetic wastewater to final permeate are 850-950 to 35-45 mg/l and 300-350 to 10-22 mg/l.**

Index Terms— **COD, TOC, VFA, CH4, UASB, LMH, AnMBR**

I. INTRODUCTION

Now is time to recall some facts we learnt on the way- water supports the intricate and interdependent web of life on earth; upto 60% of human body is water; and water cools down temperatures on this planet. Water that we took for granted, through its nearness or absence, shared use or wanton waste, today warns us of a future, arid and bleak. In order to obtain maximum utilization of the available water resources, used water or wastewater must be returned to its original condition or standard. The quality of wastewater must be of such a standard so as not to negatively affect the quality of the body of water into which it is returned. The three main components that must be removed from wastewater are carbon, nitrogen and phosphorous. The application of membrane bioreactors (MBRs) is advancing rapidly around the world for both municipal And industrial wastewater treatment[1]. The membrane bioreactor (MBR), an innovative combination of membrane technology and biological process for wastewater treatment, has been exhibiting great advantages over the conventional activated sludge process owing to its higher efficiency for solid–liquid separation than that of secondary sedimentation tank. Initially, MBRs were developed in the late 1980s for industrial and commercial applications in an attempt to generate high-quality water that could be reused in gray water applications. Recently, MBRs have been incorporated into municipal wastewater treatment to meet more stringent environmental regulations for water reuse or discharge that need effluent of consistent quality with low chemical oxygen demand (COD) and total suspended solids (TSS)[2]. Anaerobic biological treatment systems can offer a number of advantages over their aerobic counterparts. The operational costs associated with anaerobic systems are typically lower than with aerobic systems, and anaerobic systems also generate less waste sludge. In addition, the energy associated with the biogas produced during anaerobic biological treatment can be recovered. However, to date, the use of conventional anaerobic biological systems for the treatment of wastewaters has been relatively limited. In aerobic biological treatment processes organic pollutants in wastewater are removed by the bacteria that require oxygen to work. Worldwide commonly aerobic treatment processes are used for treatment of wastewater than anaerobic treatment processes[3].Here we used both aerobic and anaerobic treatment process in combination with membrane unit. Anaerobic reactor is used as an UASB reactor where biological reactions takes place and the outlet water stream is sent to the aerobic reactor in which membrane is submerged.

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II. PROCEDURE FOR PAPER SUBMISSION

A. Synthetic Wastewater

Synthetic wastewater was used as the feed for the Anaerobic Membrane Bioreactor. The COD of the synthetic wastewater was maintained at 1000 mg/L by adding Glucose, Urea, DAP and other micronutrient.

B.Experimental Apparatus

The experimental set-up is made of Poly(methyl methacrylate) (PMMA). The schematic diagram of the experimental set-up is shown in fig.1. The Anaerobic Bioreactor is constructed of Poly (methyl methacrylate) having a working volume of 5 liters. Anaerobic Bioreactor is followed by Aerobic Bioreactor which is made up of mild steel having a working volume of 2.5 liters. The anaerobic bioreactor is fed by gravity flow from the synthetic

Table 1: composition of synthetic wastewater for 30 liter of water

Composition	**gm/L**
Glucose	28.3
Urea	1.316
DAP	0.6387
NaCl	18
MgCl2	9.0
CaCl2	2.4
MnSO4	0.3
FeSO4	0.3
NaHCO3	9.0

wastewater storage tank. Mitsubishi Hollow fiber membrane module is submerged in the Aerobic Bioreactor. Membrane is having pore size of 0.1micron, and area 0.078m2. Permeate is withdrawn by using vacuum pump.The seed sludge was obtained from a PCMC, Pune's anaerobic digester.

C. Analytical Methods

The COD was measured according to APHA standard methods. TOC of the samples were measured using Total organic carbon analyzer (TOC-V CPH, SHIMADZU). Volatile fatty acids were determined using standard distillation method of APHA[4]. The percentage of methane in biogas was determined using Gas Chromatograph, Thermo Scientific, (CHEMITO, CERES 800 PLUS). pH was determined using pH meter JENCO (6320M).

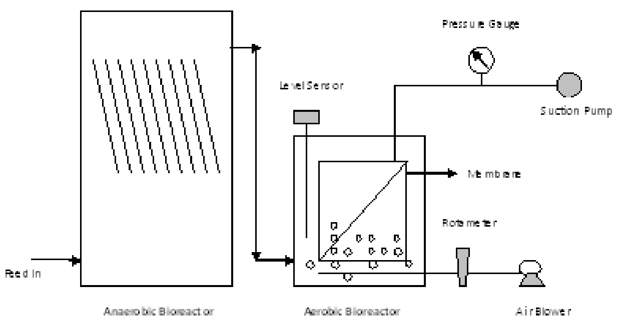

Figure 1: Experimental set up

III. RESULT AND DISCUSSION

The Anaerobic reactor is started with feeding flow of 12 L/Day. The COD of the synthetic wastewater is maintained at 1000mg/L. Feed flow was increased to 15L/day after stabilization of the Anaerobic reactor. The total removal of suspended solid is obtained by the very low pore size of the membrane. The average COD removals were 90-95%.
Initial organic matter is represented by an average COD and TOC concentrations of 850-950mg/L and 300-350mg/l respectively. Average residual COD and TOC concentrations in permeate were 30-50mg/L and 10-20mg/L respectively.

After stabilization of the system the increase of the applied loading rates allowed an increase of the biogas production in the AnMBR. In this stable period, the bioreactor produced up

Table 2: Composition of COD in the reactor

COD				
Feed	Anaerobic Reactor		Aerobic Reactor	
	In	Top	Bio	Permeate
800	1766.5	529.34	124.3	58.73
910	1600.58	394.4	55.68	32.48
975	470	245.252	64.77	45.8
890	298.9	427.72	95.06	41.49
934.99	537.58	582.008	45.08	24.41
869.55	266	437.48	67.99	30.56
780	180	105.62	56.21	11.3
847.21	142.09	81.93	41.283	25.82
771.4	198.17	171.35	87.78	34.63
852.2	185.6	145.32	84.87	29.12
864.3	174.52	155.53	79.25	29.52

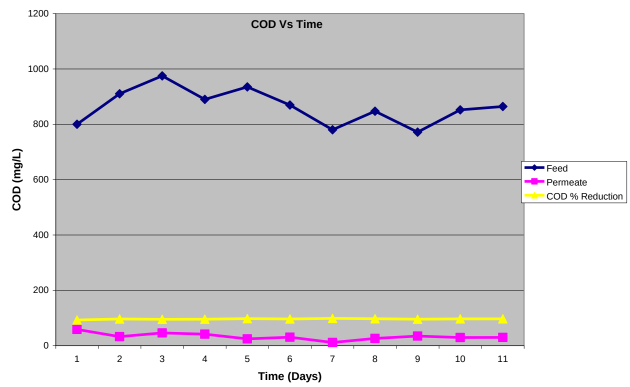

Fig 2: Evolution of the COD in the feed and in the permeate and percentage of COD reduction

Table 3: Composition of TOC in Feed and Permeate

TOC		
Feed	Permeate	% TOC Removal
300.7519	22.07895	92.65875
342.1053	12.21053	96.43076923
366.5414	17.21805	95.3025641
334.5865	15.59774	95.33820225
351.5	9.176692	97.38927689
326.8985	11.48872	96.4855385
293.2331	4.24812	98.55128205
318.5	9.706767	96.95234948
290	13.0188	95.51075966
320.3759	10.94737	96.58296175
324.9248	11.09774	96.58451926

to 4L of biogas per day. VFA concentration was monitored in the bioreactor and in permeates. The VFA production was insignificant in the reactor. It was below the inhibitory limits permitting the stability of the methanogenic process. In the permeate, the VFA concentration was less than 40mg/L. This low VFA concentration in the permeate indicated that the incoming COD was transformed into biomass, CH4 and CO2.

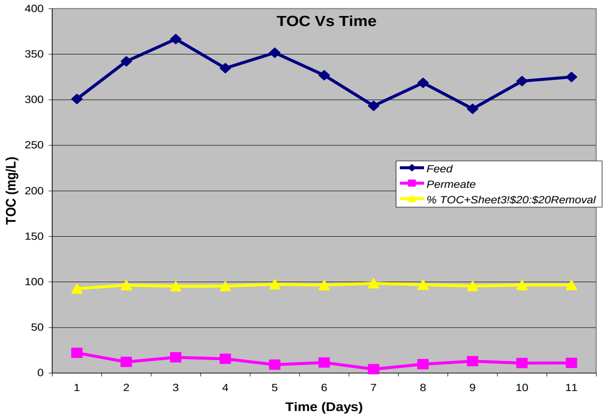

Fig 3: Evolution of the TOC in the feed and in the permeate and TOC removal as a function of time

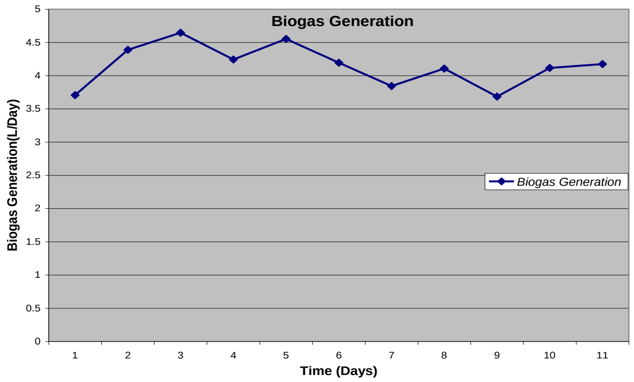

Fig 4: Evolution of the biogas generation

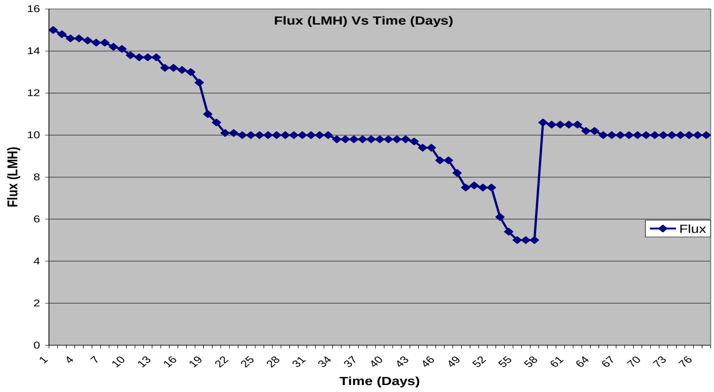

Fig 5: Flux evolution during the treatment period

The permeate flux evaluated during the experimental period. It decreased from 15 to 10 LMH till 22 days of working. From day 23 to day 49, the permeate flux was maintained constant at 10LMH. After this period, the permeate flux decreased progressively and reached 5 LMH on day 59. Although the trans-membrane pressure was increased to 2 KPa, the permeate flux did not recover its initial value. Backwash is given to the membrane using sodium hypochlorite to recover the flux[5,6,7,8].

IV. Conclusion

The Submerged hybride membrane bioreactor shows low process efficiency. Membrane fouling in AnMBRs is more intense than in aerobic MBRs as AnMBRs experience lower sludge filterabilities[8]. In this system Anaerobic reactor act as UASB reactor but reduction of COD in Anaerobic reactor is very low. Remaining COD is consumed in Aerobic reactor. In this Submerged Hybride membrane bioreactor fouling control is very difficult. Also more energy is needed for scouring of the membrane i.e. cost of air increases.

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