Characterization of Canteen Waste Water Using External Membrane Bioreactor

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Abstract- **Many regions face shortage of water for drinking and irrigational purposes. Areas with ample water supplies face issues like nutrient eutrophication and salinity intrusion etc. To meet the increasing water demand, hollow fibre external membrane bioreactor (EMBR) with sludge retention times (SRT) 2 and 4 hours were set up for treating canteen waste water of MDIT Ulliyeri at hydraulic retention times (HRT) 6, 7 and 24 hours. The performance of MBR is investigated under different aeration rates (2.5L/min and 1.5L/min). The influence of HRT and SRT on effluent quality is also determined. Increasing HRT and SRT results in noticeable increase in the removal efficiencies of turbidity, total suspended solids, BOD and COD. A comparative analysis was carried out on the effluent quality of MBR and Sequential Batch reactor (SBR).**

I. INTRODUCTION

Membrane bioreactor as the name suggests is a combination of biological waste water treatment and filtration unit. MBR is an adaptation over activated sludge process where the sedimentation, flocculation and adsorption processes are replaced by filtration process alone. The fact behind MBR is that it works without the addition of chemicals. MBRs offer the advantage of total solids retention at all biomass concentrations, better effluent treatment quality and low sludge yield.

Organic matter removal efficiency in MBR is associated with the SRT. Increasing SRT directly results decrease in the concentration of soluble microbial products (SMP) thus improving effluent quality. High SRT produce starvation conditions in the bioreactor and thus reduces the formation extracellular polymeric substance (EPS) and low sludge production. Similarly operating at low SRTs increases membrane fouling and thus results in reduction in the MBR performance as a result of low biomass concentration.

The HRT also results in membrane fouling. As HRT decreases, the rate of membrane fouling also increases due to an increase in sludge viscosity and EPS concentration. Aeration rate also plays an important role in the treatment process. Biodegradation of organic matter in the absence of oxygen is a very slow biological process. Aeration provides oxygen to micro organisms for treating and stabilizing waste water.

MBR consists of bioreactor integrated with membrane module. Based on the location of membrane module with respect to bioreactor, there are two basic configurations, external membrane bioreactor and submerged membrane bioreactor (SMBR). In EMBR configuration the membrane component is placed outside the bioreactor where as in SMBR the membrane component is immersed in the bioreactor.

II. METHODOLOGY

A small scale EMBR was constructed and operated with HRTs of 6, 7 and 24 hours, the SRT was set to 2 and 4hours. Ultra filtration polypropylene hollow fibre membrane is used in this study. The effluent was collected from the MDIT canteen outlet. The influence of HRT and SRTs on effluent characteristics are analysed here. Bio sludge collected from the sedimentation tank of Milma diary Kunnamangalam is used as the inoculums for bioreactor. Sludge is acclimated with canteen waste water for about two weeks. Schematic diagram of external membrane bioreactor is shown below

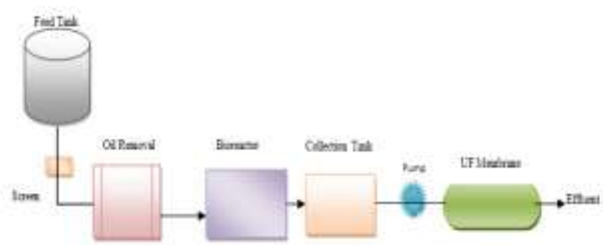

Fig. 1 Schematic diagram of Membrane Bioreactor

A. External Membrane Bioreactor Process (EMBR)

The whole process is operated in batch mode. Bar screens of size 225 micron are used, this helps to remove large particles from entering the tank. By the action of gravity canteen waste water was discharged to oil removal tank after screening. The oil being lighter in weight float on the surface of water, and the oil free water from the bottom of the tank is collected and transferred to bioreactor by using suction pump. The bioreactor was filled with 1L sludge and 6L canteen waste water and oxygen was supplied by using aerators. After the aeration time, the mixed liquor in the bioreactor was allowed to settle. The supernatant was collected and transferred to collection tank. From there water is passed through UF hollow fibre membrane by using pump. The filtration unit consists of diaphragm pump, adapter and Ultra filtration (UF) hollow fibre membrane. The effluent was collected and analyzed. This process was repeated by varying HRT and SRT. The bioreactor was operated at different aeration rates such as 2.5L/min and 1.5L/min.

Fig. 2 Experimental set up of EMBR

B. Sequential Batch Reactor process (SBR)

SBR mainly consists of four steps fill, react, settle and draw (decant). Reactor was filled with 1L of bio sludge and 6L of canteen waste water for one day HRT, within one hour. The system had to be fully aerated during the fill process. The aeration was continued for about 18 hours. After the reaction time, the aerator was shut down and the colloidal suspension was allowed to settle for about 4 hours. The supernatant was then collected within 1 hour and was analyzed. The same process was repeated for different aeration rates.

III. RESULTS AND DISCUSSIONS

The EMBR was operated at different aeration rates (2.5L/min and 1.5L/min). The effluent quality was determined for various HRTs (6hr, 7hr and 24hr) and SRTs (2hr and 4hr).

TABLE I
EFFLUENT CHARECTERISTICS OF MBR FOR 2.5L/min (2hr SRT)

2.5 L/min (2 hr SRT)									
Parameters	6 HRT			7 HRT			24 HRT		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	5.63	6.6	-	8.72	7.09	-	8.72	7.09	-
Conductivity (ms/ppt)	1.999	1.769	-	2.264	1.498	-	5.112	2.201	-
Turbidity (NTU)	125	30	76%	125	20	84%	225	30	86.7%
TSS (mg/l)	250	96	61.6%	224	56	75%	244	50	79.5%
DO (mg/l)	2.9	3.5	-	4.9	5.9	-	3.8	5.7	-
BOD (mg/l)	180	83	53.8%	190	70	63.2%	230	70	69.6%
COD (mg/l)	440	253	42.5%	464	243	47.6%	510	244	52%

TABLE II
EFFLUENT CHARECTERISTICS OF MBR FOR 1.5L/min (2hr SRT)

1.5 L/min (2 hr SRT)									
Parameters	6 HRT			7 HRT			24 HRT		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	9.16	6.90	-	6.71	6.94	-	5.68	7.10	-
Conductivity (ms/ppt)	4.667	2.345	-	2.178	1.609	-	2.402	2.227	-

Turbidity (NTU)	200	30	85%	206	27	86.8%	256	30	88%
TSS (mg/l)	221	65	70.6%	118	25	78.8%	269	51	81%
DO (mg/l)	4.9	5.9	-	5.5	7.3	-	2.9	4.9	-
BOD (mg/l)	200	86	57%	240	78	67.5%	249	69	72.3%
COD (mg/l)	440	230	47.7%	520	250	51.9%	461	219	52.3%

TABLE III
EFFLUENT CHARECTERISTICS OF MBR FOR 2.5L/min (4hr SRT)

2.5 L/min (4 hr SRT)									
Parameters	6 HRT			7 HRT			24 HRT		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	6.87	7.13	-	6.87	7.02	-	5.18	6.69	-
Conductivity (ms/ppt)	2.354	2.134	-	2.533	2.169	-	3.414	3.227	-
Turbidity (NTU)	247	30	87.85%	256	27	89.5%	266	25	90.6%
TSS (mg/l)	310	90	71%	263	49	81.3%	254	36	85.8%
DO (mg/l)	2.1	4.2	-	3.5	6.9	-	2.9	6.8	-
BOD (mg/l)	250	93	62.8%	268	86	67.9%	270	53	80.3%
COD (mg/l)	520	270	48%	460	220	52%	472	210	56%

TABLE IV
EFFLUENT CHARECTERISTICS OF MBR FOR 1.5L/min (4hr SRT)

1.5 L/min (4 hr SRT)									
Parameters	6 HRT			7 HRT			24 HRT		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	8.69	7.07	-	5.02	6.91	-	8.91	6.69	-
Conductivity (ms/ppt)	6.490	3.043	-	4.164	3.099	-	3.891	2.318	-
Turbidity (NTU)	220	26	88.18%	270	27	90%	200	9	95.5%
TSS (mg/l)	115	31	73%	300	54	82%	269	30	88.8%

DO (mg/l)	3.5	5.9	-	5.4	9.4	-	2.5	6.8	-
BOD (mg/l)	210	75	64.3%	230	70	69.57%	193	28	85.5%
COD (mg/l)	586	290	50.5%	610	230	62.3%	594	235	60.4%

From the obtained results it is clear that removal efficiency increases with increase in SRT and HRT. The better removal efficiency is obtained in the case of 24hour HRT, 4hour SRT and 1.5L/min aeration rate. The removal efficiency for BOD increased from 72.3% to 85.5% with increase in SRT, for 1.5L/min aeration rate and 24 hour HRT. In the same way, the removal efficiency for COD increased from 52.3% to 60.4% with increase in SRT, for 1.5L/min aeration rate and 24 hour HRT.

TABLE V
EFFLUENT CHARECTERISTICS OF SBR

	2.5L/m (4hr SRT)			1.5L/m (4hr SRT)		
Parameters	24 HRT			24 HRT		
	Influent	Effluent	Removal (%)	Influent	Effluent	Removal (%)
pH	6.84	6.96	-	5.59	6.84	-
Conductivity (ms/ppt)	5.082	4.875	-	2.796	1.826	-
Turbidity (NTU)	158	76	52%	244	64	73.8%
TSS (mg/l)	155	56	63.87%	210	52	75%
DO (mg/l)	2.5	5.6	-	1.9	4.5	-
BOD (mg/l)	250	76	79.6%	188	53	81.2%
COD (mg/l)	410	260	53.7%	426	243	57.6%

A. Comparison of results

MBR exhibits better removal efficiency when compared with SBR. A satisfactory organic removal of over 85% is achieved in the case of MBR.

TABLE VI
REMOVAL EFFICIENCY FOR 2.5L/min (4hr SRT)

Parameters	**MBR**	**SBR**
Turbidity (NTU)	90.6%	52%
TSS (mg/l)	85.8%	63.87%
BOD (mg/l)	80.37%	79.6%
COD (mg/l)	56%	53.7%

TABLE VII
REMOVAL EFFICIENCY FOR 1.5L/min (4hr SRT)

Parameters	**MBR**	**SBR**
Turbidity (NTU)	95.5%	73.8%
TSS (mg/l)	88.8%	75%
BOD (mg/l)	85.5%	81.2%
COD (mg/l)	60.4%	57.6%

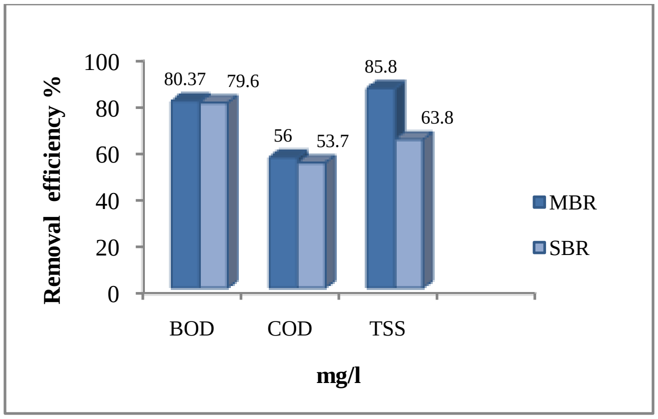

Fig. 3 Comparison graph for 24 hr HRT and 4hr SRT (2.5 l/min)

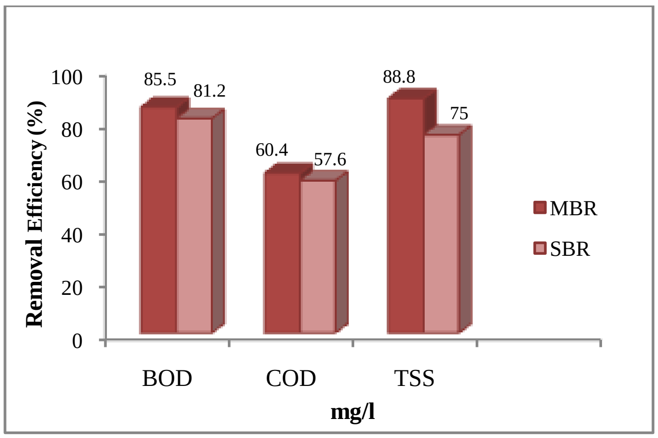

Fig. 4 Comparison graph for 24 hr HRT and 4hr SRT (1.5 l/min)

IV. CONCLUSION

Treatment of canteen waste water using Membrane bioreactor is found to be feasible. The effluent shows a great reduction in turbidity, total suspended solids, BOD, COD etc. Removal efficiency of MBR operating at 24hr HRT is chosen as the optimum when compared to 6 and 7hrs. In spite of the fact that higher HRTs offer better removal efficiency because the substrate stays more time in the bioreactor. The influence of SRT on the effluent quality was correlated. Increasing SRT results in noticeable decrease in organic matter production. The most optimum removal efficiency was achieved at 24hr HRT and 4hr SRT. Also the optimum aeration rate is 1.5L/min. Better effluent quality is achieved at low aeration rate when compared with 2.5L/min.

Finally MBR was proved to be more efficient than SBR. Better effluent quality is achieved by using MBR when compared to SBR. Hence MBR is an effective and economic method for the treatment of canteen waste water. All the values are within the irrigation standards. Hence the treated water can be used for land irrigation.

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