Study on Rheology and Optimization for Treating Tannery Effluents in Submerged Aerobic Membrane Bioreactor

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Abstract - Efficient treatment of tannery effluent is one of the serious problems faced for the past few decades. Since these industrial effluents contain more organic pollutants the most favorable option to treat this is by biological treatment process. In this study a lab scale submerged aerobic flat sheet membrane bioreactor was operated under gravity drain operation for the treatment of tannery effluent. Main aim of this project is to study about the rheology of MLSS present in the reactor. The reactor was optimized for three different MLSS concentration and the optimum was fixed as 12000mg.L^{-1}with respect to pollutant removal of 90%. The main rheological parameter viscosity was found out for 3 different MLSS concentration and 5 different air flow rates

Keywords: Submerged aerobic flat sheet membrane bioreactor, gravity drain operation, membrane fouling, rheology

I. INTRODUCTION

Water is one of the valuable natural resources in Earth. It is widely distributed as fresh and salt water. The usability is based on its freshness. As per statistics only 0.5% of available water can be readily usable. Main focus of this study is to treat the industrial effluent releasing from tanning industries. Tanning is the process of treating of animal skins which is rich in toxic substance. These products do not able to decompose easily. In India pollution from tanneries is to be 50% more than the net products they produced. Treating tannery wastewater by means of bioprocess still faces some difficulties due to the presence of inhibiting and recalcitrant compounds. Activated Sludge Process is the most used biological wastewater treatment method for treating tannery effluent (Judd, 2006). Submerged Aerobic Membrane Bio Reactor treatment process is proposed in this study for treating pre-treated effluents from clarriflocculator. However no study has been done with aerobic process to treat tannery effluent. In aerobic MBR removal of organic pollutants and nutrients achieved by decomposition of microorganisms present in the sludge (Tixier ***etal.***,2003) One major problem in operating flat sheet membrane bio reactor is that is fouling of membrane. Fouling is due to the deposition of particles into the membrane pores. Membrane fouling may results in high flux decline which in turn decreases permeability (Leclech ***et al***.,2003). This problem can be minimized by the introduction of fine air bubble on the surface of membrane. One part of this study is to optimize the SMBR with respect to various MLSS concentration based on rheology. MBR optimization requires detailed knowledge about kinetics of pollutant removal (Lopes ***etal.,*** 2010).

II. MATERIALS AND METHODS

2.1 MBR setup:

Submerged Aerobic flat sheet membrane bioreactor has been designed and fabricated. The body of the reactor is made by acrylic sheet. Effective volume of aerobic membrane bioreactor was 35 liters. Aeration was given by 3 numbers of Fine bubble Diffusers with Pore size of 0.1mm. The effective Bubble size was in the range of 1 to 2mm.

Membranes:



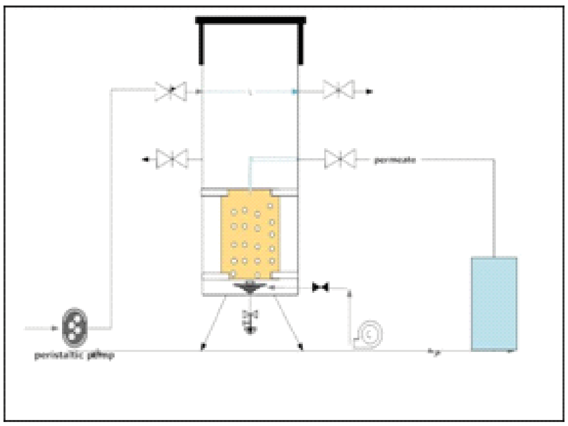


Number	4
Pore size	0.1μm
Material	PVDF
Area of filtration	0.4 sq.m

Diffusers:

Type	Fine bubble
Number	3
Pore size	0.1mm
Bubble size	1 to 2mm

Flow diagram of SMBR



2.2 Operating conditions:

MBR has been continuously operated for 24 hours HRT with constant OLR of 1.6g/L/day. The maximum air flow rate given was 45 LPM. MBR was operated at 3 different airflow rate such as 45 LPM, 25LPM, 5LPM and the respective effects on the sample and the membrane were analyzed through there rheological parameters.

2.3 Sample characteristics:

Sample has been collected from the aeration tank of Ranipet Tannery Effluent Treatment Company ltd. (Ranitec). Secondary sludge has been collected from the reactivated zone of the same plant. This sludge was inoculated by adding nutrients and given as seed (biomass) inside the reactor. Before inoculation activated sludge was tested to know about its settable property by performing Sludge Volume Index test (APHA 2710 D). SVI30was found as 54.7ml.g^{-1}indicated the good settling property. The seed sludge was continuously aerated to maintain the aerobic condition so that it enhances the multiplication of aerobic microorganism

Parameters	Concentration
pH	8.12
Total COD	4000 mg/L
Soluble COD	2800mg/L
BOD	1500mg/L
Alkalinity	2000mg/L
Total solids	19000mg/L

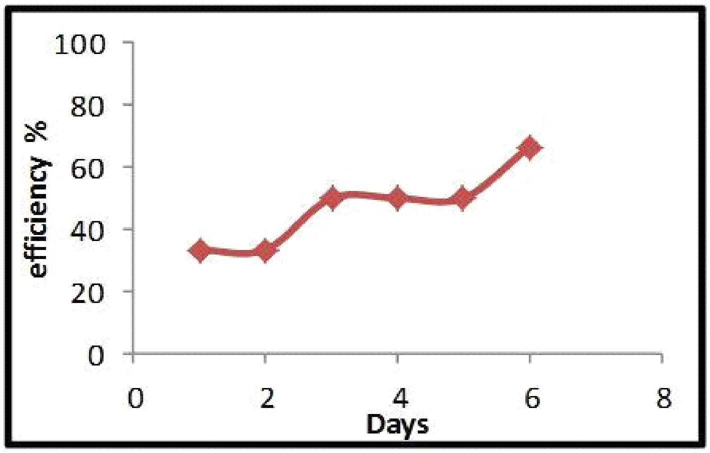
2.4 Analytical methods:

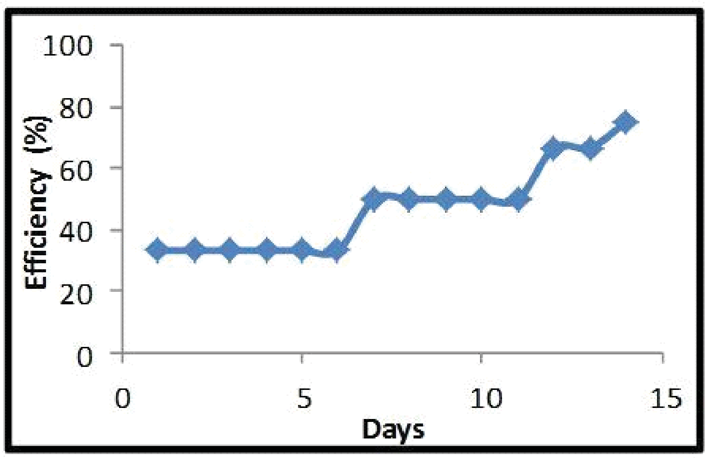
COD (APHA 5220 C), BOD (APHA 5210 B), Alkalinity (APHA 2320 B), Total solids (APHA 2540 D), MLVSS count (APHA 2540 D) and rheology (APHA 2520 C, APHA 2710 F) of sample have been determined as per APHA guidelines.

III. RESULTS AND DISCUSSIONS

3.1 Optimization of the reactor:

Reactor was optimized for three different MLSS concentration. For each MLSS concentration pollutant removal was found out. For each concentration, pollutant removal rate may gradually increase and attain its stable value. Fix it as maximum pollutant removal rate for particular MLSS concentration.





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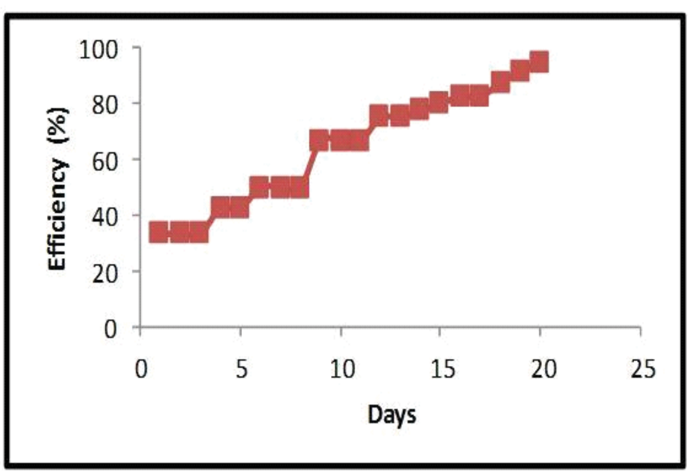

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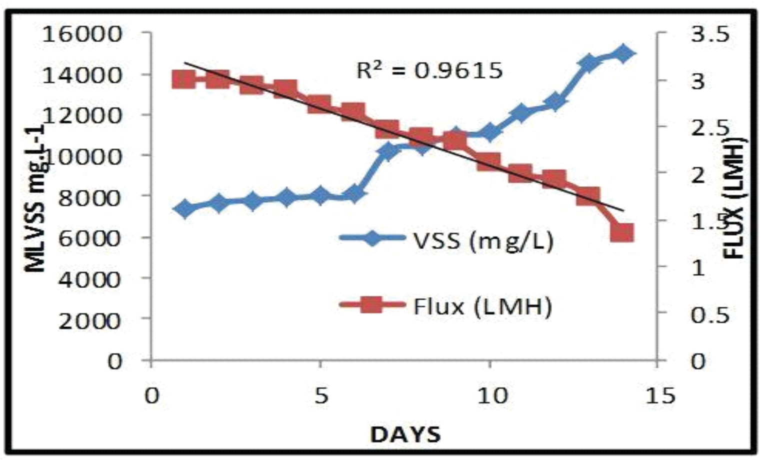
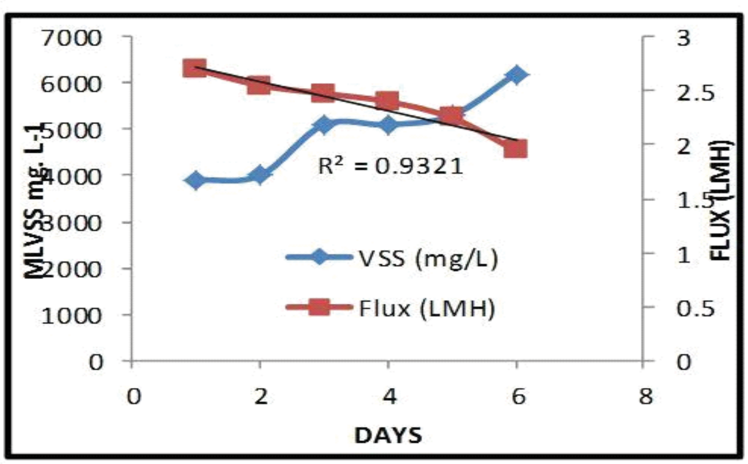
Fig 3.1 A,B,C : COD removal efficiency for 5000 mg/L, 8000mg/L and 12000mg/L respectively

Fig.3.1.A depicts the efficiency of COD removal for the MLSS concentration of 5000 mg.L^{-1}. This plot shows an increasing trend of COD removal whereas maximum COD removal obtained at 6 days of time to achieve its maximum pollutant removal efficiency of 67%. This was highly coincidental with the results of Brannock ***et al.,*** (2009). In this study the results obtained was up to 63% of removal efficiency and there was no further increase in COD removal obtained in this MLSS concentration Fig. 3.1.B depicted the COD removal for 8000mg.L^{-1}.In this stage the reactor was operated for 14 days of time period and the removal efficiency obtained was about 75%. Coherently this removal trend observed was also in increasing manner. Fig. 3.1.C shows the results for MLSS of 12000mg.L^{-1}.In this concentration the system was continually operated for about 20 days in which removal efficiency achieved about 90%. There were no further removal occurred. In this study it was also found that the biomass rate (MLVSS) inside the reactor increased exponentially with respect to the pollutant removal rate. The maximum increment in the biomass rate was found to be 19000mg.L^{-1}which was attained when the reactor was operated at the MLSS rate of 12000mg.L$^{-1.}$ The MLVSS concentration were reported to have negative impact on membrane permeability according to Ueda *etal.,*(2012)

3.2 Relation between MLVSS and Flux for various MLSS feed stock:

The above mentioned figures clearly explain about the fate of flux decrement for every increase in MLVSS concentration. All the figures are highly correlated with each other by having high R^2value, in such a way that there is a constant relation between MLVSS and flux.





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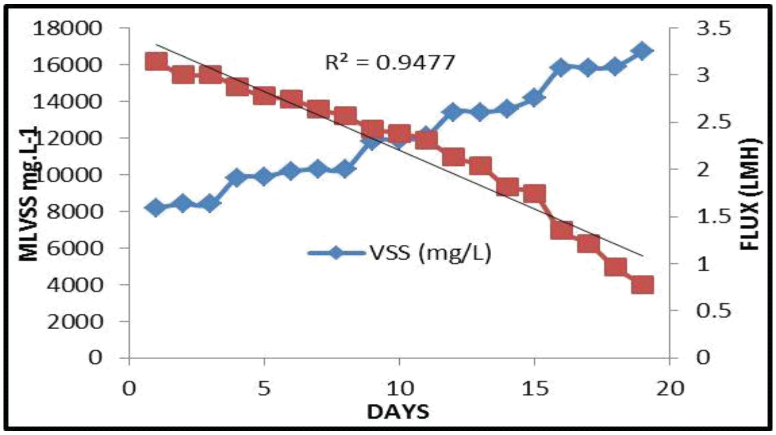

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Fig 3.1 A, B, C Flux vs MLVSS increase A) 5000 mg.L^{-1}B) 8000mg.L^{-1}C) 12000mg.L^{1}

The above mentioned figures clearly explain about the fate of flux decrement for every increase in MLVSS concentration. All the figures are highly correlated with each other by having high R^2value, in such a way that there is a constant relation between MLVSS and flux. As the flux rate decreases the membrane permeability also gets decreased. This is mainly due to the gel layer or agglomeration of sludge on the membrane surface. It can be greatly influenced by changes in MLSS concentration. The layers which deposit on the membrane surface can be removed by hydrodynamic forces (Bohm ***etal***.,2012). Coherently Meng ***etal.,*** (2007) study says, that the increment in MLVSS concentration is one of the main factors affecting membrane and causes fouling.

To overcome these difficulties it has been recommended to give proper aeration on the surface of membrane. Due to injection of air bubbles the flux rate can also get increased (Chang ***etal***.,2002) this air bubbles can act as shear stress over the surface of membrane.

3.3 Rheology of the fluid inside the reactor:

This is the study perceived to depict the impact on MLVSS on viscosity and flow and type of fluid inside the reactor. One of the main rheological parameter is viscosity of the fluid this was determined by plotting rheograms with apparent viscosity (vs) shear stress. There are two types of fluids, Newtonian (viscosity linearly proportional to shear stress) and Non Newtonian (vice versa). It has been known for many years that the activated sludge and mixed liquor are non- Newtonian and that the viscosity of the fluid increases with MLSS concentration. The most common non Newtonian behavior found in sludge is known as shear- thinning where viscosity reduces with increasing shear stress.

While maintaining in this MLSS concentration there is no change in the permeate level has been obtained so it was confirmed that there is only minimum level of cake formation due to MLSS on the membrane surface. In spite of continuous aeration mode there is also increase in viscosity obtained. The change in rheology for various air flow rates and MLSS concentration was shown in Table. 3.3 It shows an increasing trend in viscosity of fluid inside the reactor for decreasing in air flow rate. As already discussed this relation is highly coincided with the previously observed data. Table. 3.3, also shows that there is a significant change in viscosity observed with an increased

MLSS concentration of 5000 $mg.L^{-1}$to 12000 $mg.L^{-1}$.This was attributed to increased extracellular polymeric substances with an increased MLVSS inside the reactor which in turn affects the membrane flux

Table 3.3. Relation between rheology and membrane fouling:

Solids ($mg.L^{-1}$)	Aeration intensity (LMH)	45	30	25	15	5
5000	Viscosity (multiplied by 10^{-6} m^2/s)	2.947	2.981	3.00	3.045	3.186
8000		4.97	5.021	5.136	5.218	5.361
12000		6.557	6663	6.74	6.87	6.969

IV. CONCLUSION

Aerobic submerged flat sheet membrane bioreactor was designed, fabricated and experimented at various operating conditions. The following conclusions were made based on the results obtained.

● Reactor was optimized for varying MLSS ranges as 5000 $mg.L^{-1}$, 8000 $mg.L^{-1}$and 12000$mg.L^{-1}$**.**

● It has achieved its maximum efficiency of 66.67 % pollutant removal while operated at 5000mg/L, 75% removal efficiency at 8000 $mg.L^{-1}$and upto 90% at 12000$mg.L^{-1}$ respectively**.**

• Constant shear stress of 45LMH was given on membrane surface to avoid frequent cake layer formation.

Rheological analysis was carried out for three different MLSS concentration to know about the type of fluid and their effects on flux declination. The results obtained were clearly coincided with the previous studies. This reactor was operated under gravity drain operation which in turn reduces the suction cost.

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