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Study on Pollutant Removal Efficiency and RTD of a Submerged Anaerobic Membrane Bio - Reactor

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ABSTRACT
The efficient treatment of industrial effluent is one of the serious problems for the past few decades. Since the industrial effluents contain more organic pollutants, the most favorable option to treat this by biological treatment process. In the study, a lab scale submerged anaerobic flat sheet membrane bioreactor was operated with pumping operation for the treatment of tannery effluent. Since Anaerobic Membrane Bio – Reactor (AnMBR) has many advantages over Commercial Activated Sludge process, we have opted AnMBR for the study. Fouling is the main problem faced while using Membrane Bioreactors. The reactor is setup with backwash and gas recirculation to remove the fouling phenomenon temporarily. Frequent cleaning of the membrane by chemical means is also followed to remove the clogs over the pores of the membrane that cannot be easily removed by any other physical means. The reactor is also setup to collect bio – gas that can be used as a source of alternate energy. The reactor has an efficiency of 86% in terms of pollutant removal whereas the bio – gas produced has 61% methane. The RTD study is done to evaluate the fate of the pollutants inside the reactor. The reactor is run on different Organic Loading rates and the effective Organic Loading Rate is found out by RTD analysis.

Keywords
Membrane Bio - Reactor; Residence Time Distribution; bio – gas.

1. INTRODUCTION
The main aim of the study is to study the Residence Time Distribution of the reactor for various Organic Loading Rates. RTD is to be done to know the fate of pollutants inside the reactor. But initially the reactor has to be optimized for proper treatment. This is because a treatment plant without any treatment will pay no use to what it is actually meant to be. All the analysis has been done as per American Public Health Association guidelines.
The reactor was optimized with respect to pollutant removal of 90%. The rheological parameter was studied for three different Organic Loading Rate with a specific MLSS concentration. Rheogram results will depict whether the fluid inside the reactor is Non – Newtonian fluid in all the cases. RTD studies are also conducted for three different Organic Loading Rate.

2. MATERIALS AND METHODS
2.1 Setting up of the reactor
Submerged Anaerobic Membrane Bio-Reactor with Flat sheet membrane of size 31 × 60 cm is designed and fabricated. The

body of the reactor is made is Stainless steel with two compartments with a total capacity of 80 liters. Peristaltic pumps are used for the influent and also sucking out the effluent. Provisions for gas recirculation and effluent recirculation are also provided.

2.2 Removal Efficiency of the reactor
The submerged anaerobic membrane bioreactor has to be optimized for different MLSS concentration which is the removal efficiency. This is done to fix the optimum MLSS concentration to be maintained in the reactor so that the maximum pollutant removal may be achieved. The MBR system is able to achieve low level of effluent nitrogen by adjusting the MLSS to optimize nutrient uptake. Samples are being collected and checked for removal efficiency (COD, TSS, VSS, TS, VS, NH_3) and so the check can be made whether the reactor is efficient and ready for the intended study.
The plot of tracer analysis curve can help us to study whether the reactor is in complete mixed condition.

2.3 Residence Time Distribution
RTD studies are mainly done to verify the performance of reactor by means of distribution curves. This can be done by the Tracer analysis. This study predicts the mixing characteristics of the liquor in the MBR (Wang *et al.,* 2009). RTD analysis is a very efficient diagnosis tool that can be used to inspect the malfunction of chemical reactors. The profile of RTD can vary highly due to the degree of mixing in the reactor (Shin *et al.,* 2010). Mixing characteristics are very important for MBR systems because they can affect both the organic removal and the settling of the sludge (Lopes *et al.,* 2002). Good mixing promotes heat transfer of substrate and heat to microorganisms and ensures the effective use of the entire reactor volume. Ideal mixing system predicts that real systems emphasis the Plug Flow (PFR) pattern of tracer curve in which complete mixing does not occur (Zheng *et al.,* 2011).

Although the hydrodynamics of MBR system is of critical importance to the performance of the system (Martinelli *et al.*, 2010), MBRs are usually assumed as a Completely Mixed Flow Reactors (CSTR) and designs are based mainly on the bio-kinetics and fouling potential of the treatment system. RTD studies simply emphasis that how long the pollutant can stay inside the reactor (Lopez *et al.*, 2010).

Residence Time distribution can be experimentally done by tracer analysis. Tracer used for this should be conservative (i.e.) non reactive in nature. Tracers include chemicals, biological, radioactive and mechanical types. In this study tracer used is Rhodomine B. Tracer can be injected by two methods step input and pulse input. In the pulse injection study we may obtain concentration curve, with the help of concentration curve we can plot the E curve or the RTD curve.

The plot of tracer analysis curve can help us to study whether the reactor is in complete mixed condition.

3. RESULTS AND DISCUSSION

3.1 Removal efficiency of the reactor

The removal efficiency with respect to various parameters are shown below Figure 1 shows the removal efficiency of the reactor. As of Chemical Oxygen Demand, there is an increase in removal efficiency from 66.7% to 88.9%.

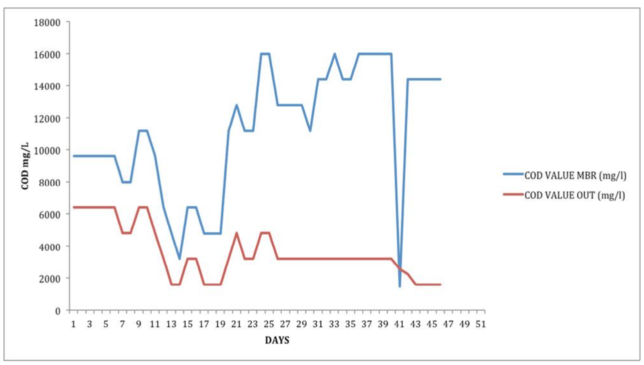

Figure 1. COD Removal

The Figure 2 shows the Total solids removal in the Anaerobic Membrane Bio – reactor. The Total Solids removal went up from 30 % to 86.34 %, which proves the efficiency of the membrane.

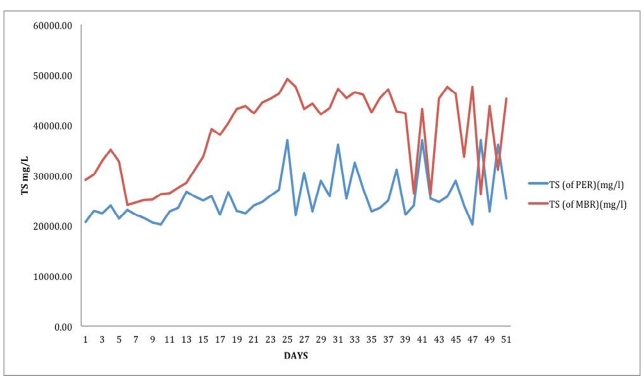

Figure 2. Total Solids Removal

Figure 3 depicts the removal in Total Suspended Solids, this is considered to be one major factor as the membrane attributes highly towards the Total Suspended solids removal.

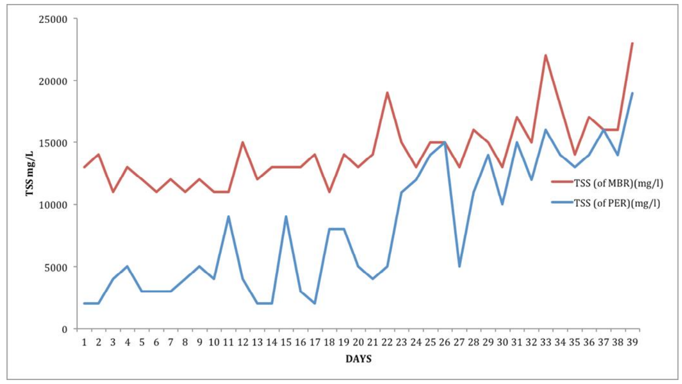

Figure 3. Total Suspended Solids Removal

Figure 4 depicts the flow variation, for the reactor to be stable, the reactor should go through constant inlet and outlet pumping operations. This is because the reactor will be operation 24/7.

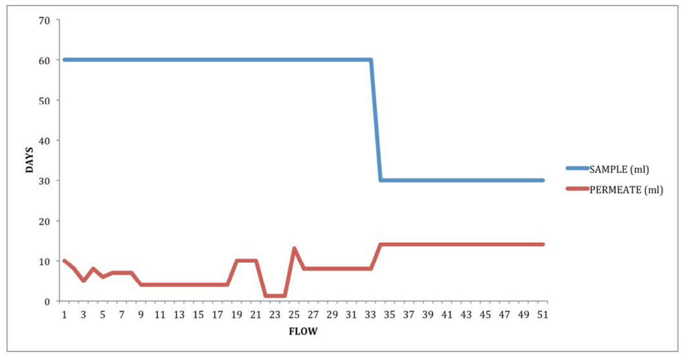

Figure 4. Flow variation

Figure 5 shows the total amount of gas production from the reactor during the optimisation process, which shows a total of 8.56 litres of gas.

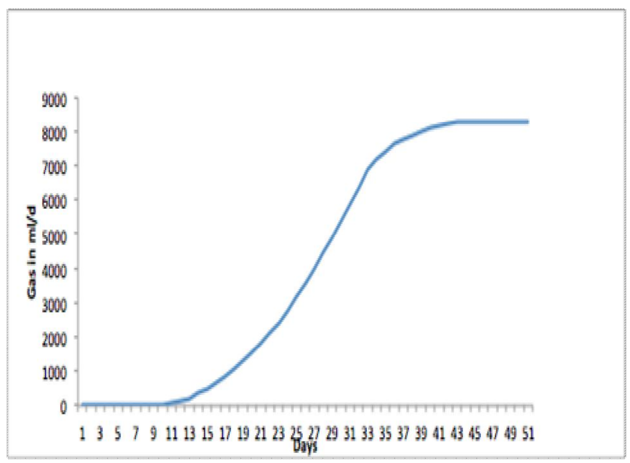

Figure 5. Cummulative gas production

The gas produced is taken to a Gas Chromatography study and the result is given in Fig 6. The methane composition is about 61% of the volume which is a highly effiecient bio – gas.

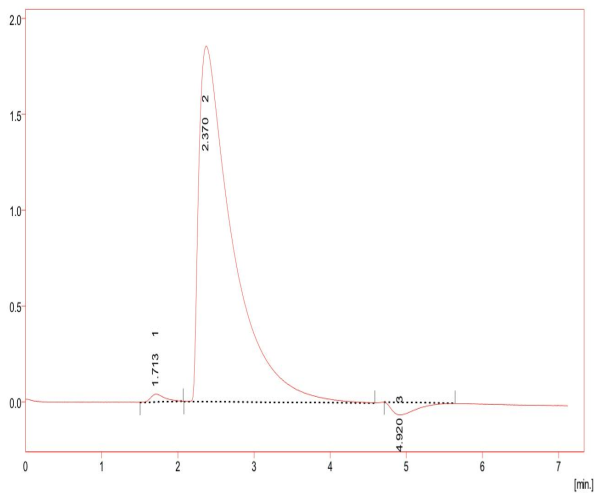

Figure 6. Gas Chromatography

3.2 Residence Time Distribution

The RTD study has been done for 3 different OLR and the results are depicted below

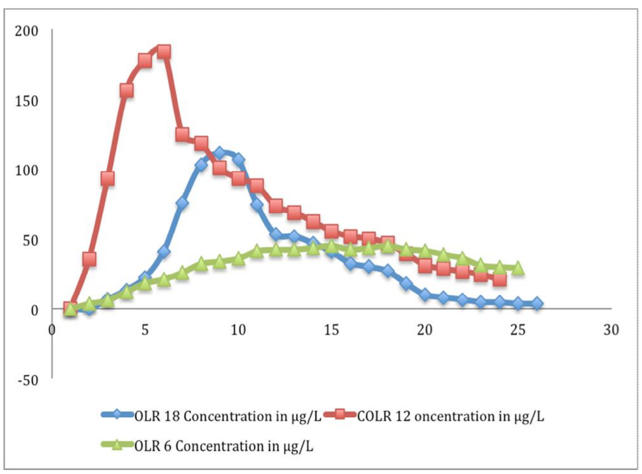

Figure 7. RTD curves

The Figure 7 shows that OLR 12 and 18 are prone to short circuiting as the concentration fall is very rapid compared to time. OLR 6 is found to be effective as the pollutant will tend to stay in the reactor for a linger duration which is indeed required in the Suspended growth process.

4. CONCLUSION

- The COD removal efficiency of the reactor was initially 66.7%, as the reactor was kept in run with proper monitoring, the efficiency sprang up to 88.9%.
- The initial volatile fatty acid production in the reactor seemed to which, which in-turn will reduce the production of biogas. With due course of time the volatile fatty acids were inhibited.
- The Total Solids removal went up from 30 % to 86.34 %, which proves the efficiency of the membrane.
- The cumulative gas production was also efficient enough, even though there was a fall in F/M ratio.
- The produced Bio – gas had a methane composition of 61 %.
- The effective OLR as per the RTD studies was found to be 6.

REFERENCES

1. “Manual on water and wastewater quality analysis” by American Public Health Administration.
2. Octave Levenspiel., “Chemical Reaction Engineering – 3rd edition”.
3. Piotr Zima., (2011) “Simulation of residence time distribution and mixing in reactors with recirculation using 2D approach”.
4. Brannock., Leslie, G., Wang, Y and Buetehorn, S., (2009). “Optimizing, mixing and nutrient removal in membrane bioreactors. Journal of Desalination, 250, 54-32.