WASTEWATER TREATMENT USING MEMBRANE BIOREACTOR

by

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DEPARTMENT OF CHEMICAL ENGINEERING

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Dedicated

to

My Loving Parents,

Renu and Rohan

CERTIFICATE

This is to certify that the thesis entitled, **"Wastewater Treatment using Membrane Bioreactor",** being submitted by **Mr. Vikrant Sarin**, to the Indian Institute of Technology, Delhi, for the award of degree of '**Doctor of philosophy in Chemical Engineering**', is a record of bonafide research work carried out by him. **Mr. Vikrant Sarin** has worked under our guidance and supervision and has fulfilled all the requirements for the submission of this thesis, which to our knowledge has reached the requisite standard. The results embodied in this thesis have not been submitted in part or in full, to any other University or Institute for award of any degree or diploma.

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ABSTRACT

Membrane bioreactor (MBR) combines membranes with biological processes for treatment of waste water. MBR provides high quality of treated water with complete solid removal and disinfection capability, combined with high rate and efficiency of organic and nutrient removal in one unit, small foot print low or near zero sludge production, high loading rate capability, rapid start up, modular and retrofit. It is free from sludge bulking problem thus, has high performance and low maintenance. This research work involves studying the treatability of municipal wastewater, industrial effluent taken from Juice processing unit and examines the bio kinetics and fouling characteristics. The operational conditions during the experimental trials had prolonged sludge age upto 50 days, recirculation ratio as 5, hydraulic retention time as 16 (h) – 7.7 (h), organic volumetric load as 0.691 – 3.17 Kg COD m^3 d^{-1} and food/microorganisms ratio as 0.0864 – 0.845. The contaminants removal efficiency in both the cases was observed for COD removal as always higher than 90% the mean effluent COD being as 21 ppm, ammonical nitrogen and Total Kjeldah Nitrogen (TKN) removal efficiency observed as higher than 90% with mean in the effluent as 1.5 and 2.8 ppm respectively, total phosphorus removal was low upto 31% and TSS removal observed was always above 98.5% with mean of 99.6%. Respirometric tests were carried out to verify microbial activity during growth, stationary and decay phase. Specific oxygen uptake rate (SOUR) was determined for biomass samples having 5, 10, 18 and 25 days SRT and was found as 19.35, 4.6, 2.82 and 3.15 mg O_2 /g VSS/ h respectively.

Further, this research work investigated the fouling of membranes which is one of the major factors affecting the performance of MBR, thus, limiting the use of application of MBR. The experimental assessment of flux criticality was carried out by flux – stepping tests. The reliability of short term tests trial were verified over a long period by determining the time of sustainability, t_{sust} of four different sub critical fluxes ranging between 14 and

$32\,l\,m^{-2}h^{-1}$. Coefficient of fouling propensity was determined from the model. An exponential fitting was observed in terms of fouling rate both before and after t_{sust}, though fouling after t_{sust} is likely to be ascribed not only to cake formation. A comprehensive mathematical formulation was proposed according to the local flux approach to model the sub-critical TMP (Trans Membrane Pressure) transients. The model involved both bound and free form of EPS and provided a fair prediction of the sustainable time duration and TMP jump.

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