

Improving the Efficiency of Membrane Reactor

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ABSTRACT: The ever growing demand in water supply in many cities leads to the higher levels of treatment and reuse of wastewaters for various purposes. Membrane technologies have seen a significant growth and increase in application in the last few years. The most important consideration in the design and operation of membrane reactors is membrane fouling. It affects the pre-treatment needs, operating conditions, backwashing and performance of the reactors. This paper focuses on the control of fouling in membrane reactor by providing proper pre-treatment before passing to the membranes.

KEYWORDS: membrane reactor, dairy wastewater, pre-treatment, efficiency

I. INTRODUCTION

The rate of water pollution has increased considerably due to the continuous growth of industries and urbanization. The natural resources for water supply has reduced which has made a constraint for the demand of water. In dairy industries, water is used in all the steps. The wastewater contains high BOD, COD and dissolved/suspended solids [1-4]. In developing countries, many deaths are due to polluted drinking water. Ultrafiltration (UF) which has a relatively low cost than nanofiltration or Reverse Osmosis (RO) can be used to remove the contaminants. UF is considered as a very promising process for drinking water production because of its compactness, easy automation and high rate of turbidity removal [10]. UF technology is widely accepted in developing countries for drinking water production. One of the major limitation for the performance of membrane is membrane fouling [11]. The definition of fouling as per Terminology for membranes and membrane processes (IUPAC Recommendations 1996) is the process resulting in loss of performance of a membrane due to the deposition of suspended or dissolved substances on its external surfaces, at its pore openings, or within its pores. So by controlling the fouling the performance of the membranes can be improved.

II. WASTEWATER COMPOSITION

The wastewater used in this study was obtained from dairy industry located in Chennai, India. The wastewater was stored in refrigerator which can be used for longer periods. The characteristics of wastewater are in the Table 1.

Parameter	Average concentration
pH	6.41
Turbidity	145 NTU
Total solids	5957 mg/L
Total Dissolved Solids	3203 mg/L
Total Suspended Solids	2753 mg/L
Total Volatile Solids	377 mg/L
BOD ₅	1342 mg/L
COD	2617 mg/L

Table 1 Characteristics of wastewater

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III. EXPERIMENTAL SETUP

A lab scale setup was made with a sedimentation tank followed by aeration tank which leads to the membrane filter unit. The units were made of fibre glass material. The sedimentation tank has a total capacity of 12.5 l which has baffles at regular intervals for settling. The wastewater flow to sedimentation tank was controlled by the use of peristaltic pump. The aeration tank provides necessary aeration for the degradation of the organic matter. The carbon filter was provided before passing to the membrane. The membrane chosen was of Polyethersulfone (PES) ultrafilter membrane.

IV. EXPERIMENTAL PROCEDURE

The wastewater was filled to a tank. From the tank, the wastewater was flowed to the sedimentation tank. The influent flow was controlled by the use of peristaltic pump. The flow was limited to 10 ml/min. From the sedimentation tank, it was pumped to the aeration tank. From there it was pumped to the carbon filter module which adsorbs the solids from the wastewater and reduces the odour in it. Later it was to the membrane unit, where a part of water was permeated through the membrane. This permeated water was collected separately. The retentate from the membrane was passed back to the inlet tank. The membrane cleaning was done with tap water at regular intervals.

The samples of influent were collected once a day. The permeate samples were studied with parameters like COD (Chemical Oxygen Demand), TSS (Total Suspended Solids) and turbidity.

V. EXPERIMENTAL RESULTS

The reactor was started with low feed flow which was controlled by peristaltic pump which was necessary for the adaptation and stabilization of the reactor due to variable wastewater composition. Later, the feed flow was increased to 10 ml/min.

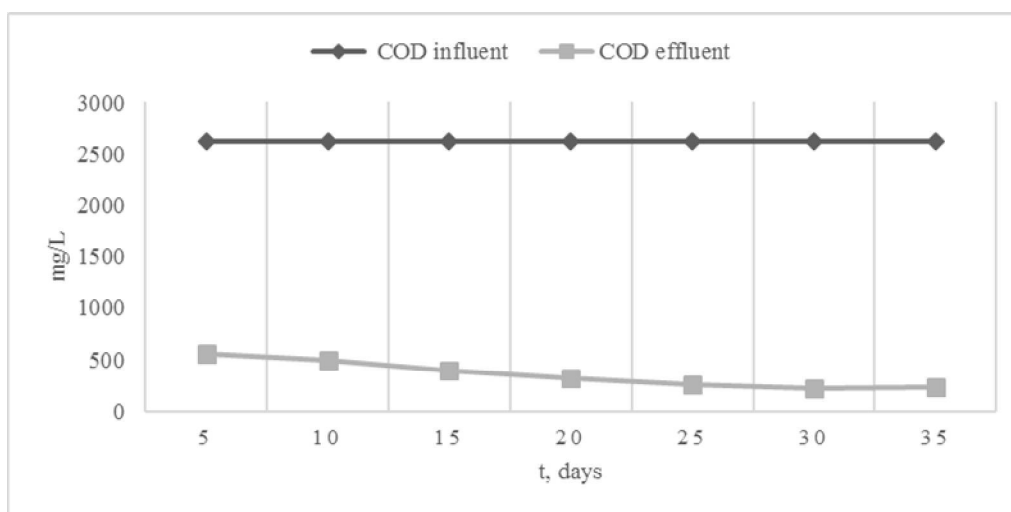


Fig. 1 COD concentrations at various days

Removal of COD was from 78% to 92% and the average was 86%. This result shows that this method can remove higher levels of COD for dairy wastewater and the quality of permeate was stable. The COD concentrations at the inlet and outlet for a period of 35 days is shown in the Fig. 1.

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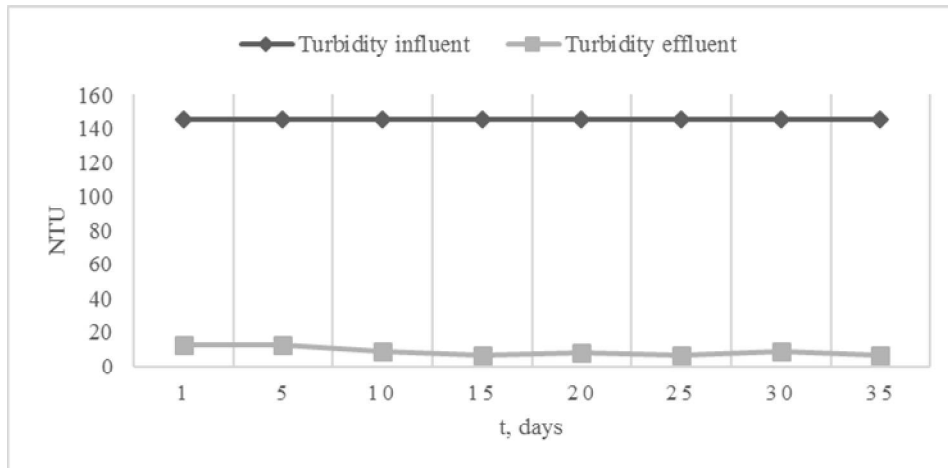


Fig. 2 Turbidity levels at various days

Turbidity concentrations at the inlet and outlet for a period of 35 days in Fig. 2. Turbidity removal was high ranging from 90% to 95% and the average was 94%. The permeate was clear. This also contributes to high level removal of suspended solids from the wastewater.

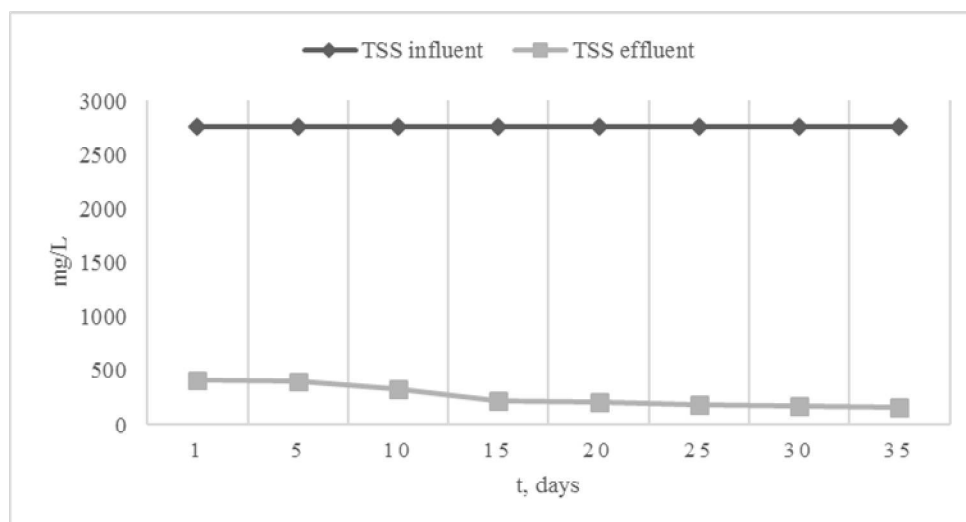


Fig. 3 TSS concentrations at various days

Removal of TSS was from 85% to 95% and the average was 91%. The TSS concentrations of inlet and outlet for a period of 35 days is shown in Fig. 3.

In order to reduce fouling, the cross flow velocity was fixed to 3 m/s. The transmembrane pressure was varied between 1 to 2 bars. Initially the permeate flux was higher with low transmembrane pressure and later with higher transmembrane pressure the flux did not attain the initial level. The rate at which fouling occurred was delayed to the pre-treatment before passing to the membrane. The carbon filter further reduced the solids loading rate to the membrane which also reduced the rate of fouling.

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VI. CONCLUSION

The result shows that ultrafiltration membrane with pre-treatment can be used for small scale dairy wastewater treatment plants. The permeate water quality and the removal efficiencies of pollutants were satisfactory. The average COD, turbidity and TSS removal was 86%, 94% and 91% respectively. The treated water was clear and no odour. This can be used for firefighting in industries and car washing.

The fouling was controlled by the use of carbon filters before the membrane separation. The membrane was also frequently cleaned with permeate which also reduced the fouling rate.

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