Desalination 337 (2014) 16–22

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Bio-film and bio-entrapped hybrid membrane bioreactors in wastewater treatment: Comparison of membrane fouling and removal efficiency

Bahman Rafiei [a], Fereshteh Naeimpoor [a,*], Toraj Mohammadi [b]

[a] Biotechnology Research Laboratory, School of Chemical Engineering, Iran University of Science and Technology (IUST), Narmak, Tehran, Iran
[b] Research Center for Membrane Separation Processes, School of Chemical Engineering, Iran University of Science and Technology (IUST), Narmak, Tehran, Iran

HIGHLIGHTS

- Type of immobilization affects membrane fouling and removal efficiency in H-MBRs.
- Bio-entrapped MBR performed much better than bio-film MBR.
- Protein among SMPs significantly contributed to membrane fouling.
- Cake resistance was the most significant part of the total filtration resistance.
- Bio-entrapped MBR can well retrieve its performance at shocks.

ARTICLE INFO

Article history:
Received 17 August 2013
Received in revised form 18 December 2013
Accepted 21 December 2013
Available online 1 February 2014

Keywords:
Hybrid membrane bioreactor
Bio-film
Bio-entrapment
Membrane fouling
Phenolic wastewater

ABSTRACT

Hybrid membrane bioreactors have emerged to alleviate membrane fouling, the drawback of conventional membrane. In this study immobilized acclimatized activated sludge on either polypropylene or polyurethane carriers were exploited to run two types of hybrid bioreactors and compare their performances with one conventional MBR in treatment of a synthesized phenolic wastewater at 1000 mg/L and a hydraulic retention time of 13 h. Immobilization on polyurethane foam resulted in phenol removal of 99% as compared to 72.5% for polypropylene and 70.6% for the conventional MBR. Complete membrane fouling occurring at trans-membrane pressure of 0.6 bar was observed after 5, 9 and 21 days for conventional MBR, polypropylene and polyurethane hybrid bioreactors, respectively. Additionally, analyses of soluble microbial products showed that proteins positively affect membrane fouling. The performance of hybrid bioreactor containing polyurethane foams under phenol loading shocks was also examined by sudden variations from 1000 to 1250 and 1500 mg/L in influent phenol concentration where it was found that although persistent shocks had adverse effect on phenol removal, complete retrieval of phenol removal could be achieved after elimination of shocks. Among bioreactors examined, a hybrid bioreactor using polyurethane foam is therefore proposed as a superior bioreactor considering both performance efficiency and membrane fouling for wastewater treatment.

1. Introduction

Due to the growing world population and increasing need to freshwater in urban activities, agriculture and different industries alongside the shortage of freshwater supplies, wastewater treatment has become one of the important issues in the worldwide. Various physical, chemical and biological methods have been therefore employed for wastewater treatment [1,2], among which biological methods have become the focus of many researches because of their lower cost and their potential to mineralize the contaminant. To improve the efficiency of these methods, membrane bioreactors (MBRs) emerged in 1980 by combining the conventional activated sludge and membrane processes [3,4]. MBRs have several advantages such as higher contaminant removal efficiency, lower hydraulic retention time (HRT), small footprint, ease in maintenance of high biomass concentration and less sludge production during treatment process [5–8]. However, MBRs suffer from the rapid decline in permeate flux due to the high concentration of biomass and generation of soluble microbial product (SMP) as well as extracellular polymeric substances (EPS), leading to membrane fouling [9–13]. Many studies have hence been carried out to alleviate membrane fouling by optimizing the operating conditions [14–19], modifying membrane [20–23] and evaluation of biological properties [17–19,24].

To further reduce membrane fouling, hybrid membrane bioreactors (H-MBRs) have been recently introduced where MBRs are combined with other wastewater treatment systems [25,26]. Freely suspended carriers have been used in MBRs to generate a kind of H-MBR. Carriers could be used as mechanical agents that perform continuous cleaning of membrane by striking the formed fouling on the surface of the membrane [27]. Carriers can also be applied as immobilizing matrix/support

* Corresponding author. Tel./fax: +98 21 77240495.
E-mail address: fnaeim@iust.ac.ir (F. Naeimpoor).

0011-9164/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.desal.2013.12.025

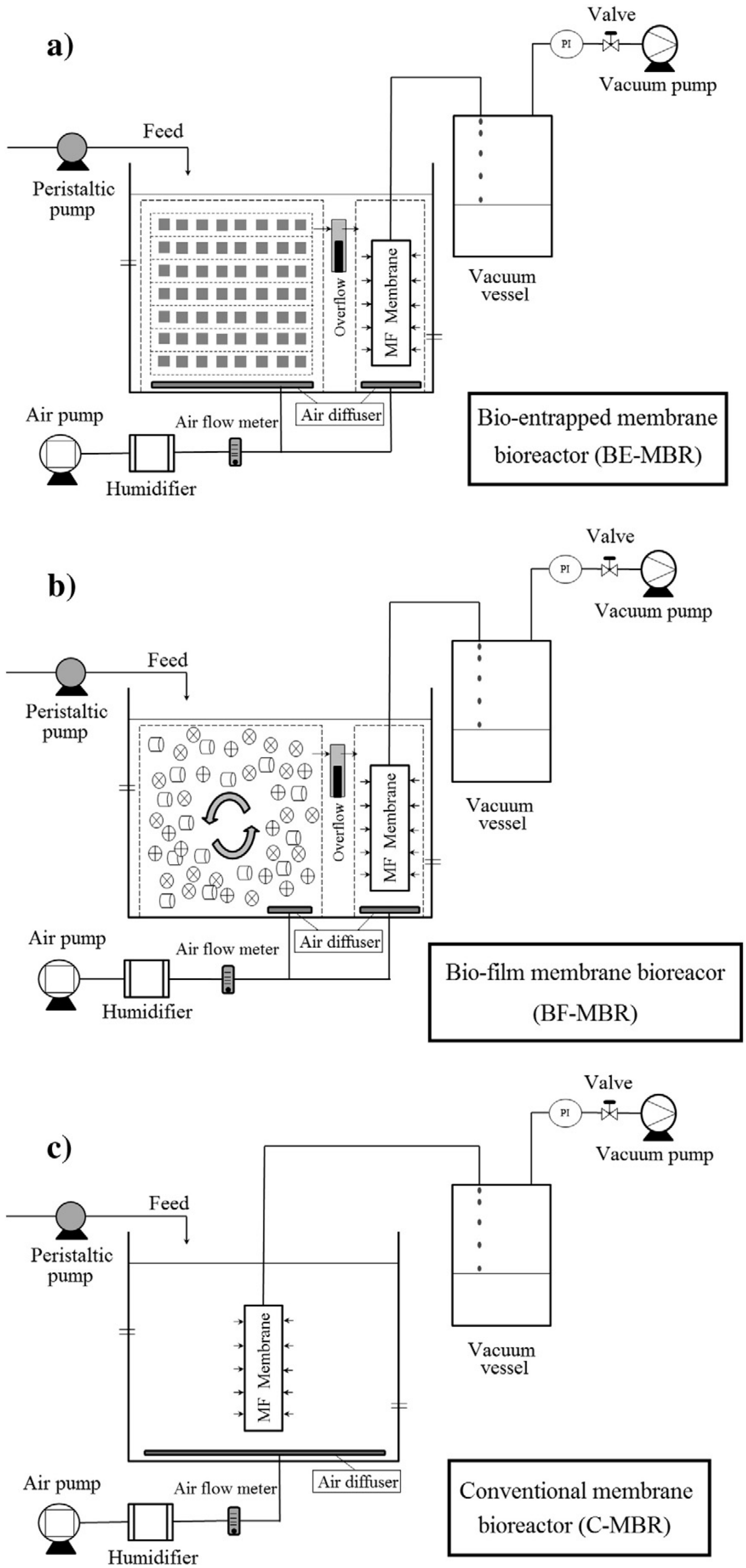

Fig. 1. Schematic set-up of bioreactors (a): BE-MBR (b): BF-MBR (c): C-MBR.