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Membrane bioreactor for the treatment of voc laden pharmaceutical wastewater: Effect of biological treatment systems on membrane performance

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ABSTRACT

Present study evaluated the effect of effluent from submerged aerated biological filter (SABF) and activated sludge process (ASP) on the performance of membrane bioreactor (MBR). MBR was operated both in external configuration and internal configuration mode. Feeding SABF effluent to MBR resulted in a flux reduction of 2.3% and 12% under external and internal configurations, respectively. Volatile Organic Compound (VOC) removal from SABF effluent by MBR was only 13% in the external configuration mode whereas VOC was completely eliminated in the internal configuration mode. Treatment of effluent from ASP caused significant flux reduction and increase in transmembrane pressure (TMP) in the MBR. For both internal and external membrane configurations, substantial increase in extra cellular polymeric substances (EPS) and suspended solids resulted in higher membrane fouling during the treatment of ASP effluent. VOC removal from ASP effluent by MBR was achieved only while adopting internal configuration mode. Effective treatment of pharmaceutical wastewater, with less impact on membrane performance and reduced VOC emission to the atmosphere, can be achieved by coupling SABF with MBR and adopting internal configuration mode.

1. Introduction

Pharmaceutical industries consume large quantities of solvents for their operations. As a result, wastewater generated from these industries contains about 80% of organic solvents. Most of these solvents are volatile in nature. Treatment of such solvent laden wastewater results in the stripping of volatile organic compounds (VOCs) from the treatment units. Most of the earlier studies which employed aerobic and anaerobic processes for the treatment of pharmaceutical wastewater focused only on COD removal [1–3]. An important issue that is often neglected is the VOC emission during the treatment. In anaerobic treatment units, the stripped VOCs are mostly combusted along with the methane gas, whereas extensive aeration increases the stripping of VOC in an activated sludge process [4].

Several aerobic and anaerobic biological reactors such as activated sludge process [5], expanded granular sludge anaerobic filter [6] etc., were used in the past for removal of VOCs from different industrial wastewaters. Most of the earlier studies focused only on the degradation of one or a combination of two pollutants. However, the co-existence of toxic compounds like benzene, toluene, and dichloromethane in the pharmaceutical wastewater can cause inhibitory effects on the biodegradation processes. Very often, single stage treatment processes are not sufficient to meet the discharge standards with respect to chemical oxygen demand (COD) and VOC emissions to the atmosphere. This necessitates post treatment to completely remove the residual VOCs from the biologically treated wastewater.

The selection of post treatment technology to completely mineralize the VOCs in the wastewater and to reduce their emission during treatment units is a challenge. Reduced VOC emission has been reported from the treatment units which retain high biomass concentration [7–8]. Treatment technologies such as membrane bioreactors (MBR), have proven their potential to treat different industrial waters. However, the potential of MBR to treat VOC laden pharmaceutical wastewater has not been studied yet. Coupling the benefits of biological reactor with the filtration process will result in a novel hybrid treatment system, which can reduce VOC emissions during the treatment of pharmaceutical wastewater.

An inherent problem associated with MBR is membrane fouling. The fouling is mainly dependent on the effluent characteristics of the coupled bioreactor. Most of the earlier studies on membrane fouling focused only on the effect of the activated sludge process on the membrane perfromance. Not much work has been reported on

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the effect of effluent from attached growth reactors on the membrane performance. The adaptability of membrane bioreactor as a post treatment process to improve effluent quality from submerged aerated biological filter (SABF) needs to be studied. Deposition of colloids and soluble particles on the membrane surface results in flux reduction and the fouling propensity varies with the membrane configuration also.

Main objectives of this study were to evaluate: (i) the feasibility of membrane bioreactor as a post treatment unit; (ii) the suitability of various biological systems to optimize the performance of the combined treatment system and (iii) membrane performance for different membrane configurations. Performances of two biological systems, namely submerged aerated biological filter (SABF) and activated sludge process (ASP), employed for the treatment of VOC laden pharmaceutical wastewater and their impact on membrane performance were evaluated under different membrane configurations.

2. Materials and methods

2.1. Experimental setup for membrane bioreactor

MBR consisted of a hollow fiber membrane module placed in a rectangular chamber. Hollow fiber membrane module (UM 0234 L1) consisted of a bundle of hollow fiber membranes attached to the module case. Hollow fiber membrane (HFM) used for the present study was supplied by MRC, Thailand. The HFM was made of polyethylene, with a pore size of 0.4 μm and a surface area of 0.2 m^2. The membrane module consisted of approximately 800 fibers. Each fiber was 15 cm in length and 2 mm in diameter. The maximum flow rate applicable in the HFM was 0.25 $m^3/m^2/d$ and the recommended suction pressure during membrane filtration was in the range of 5–30 kPa [9]. Rectangular chamber used for immersing the membrane was made of 3 mm thick plexi glass with dimensions (L × W × H) 30 cm × 10 cm × 50 cm. The cross sectional area

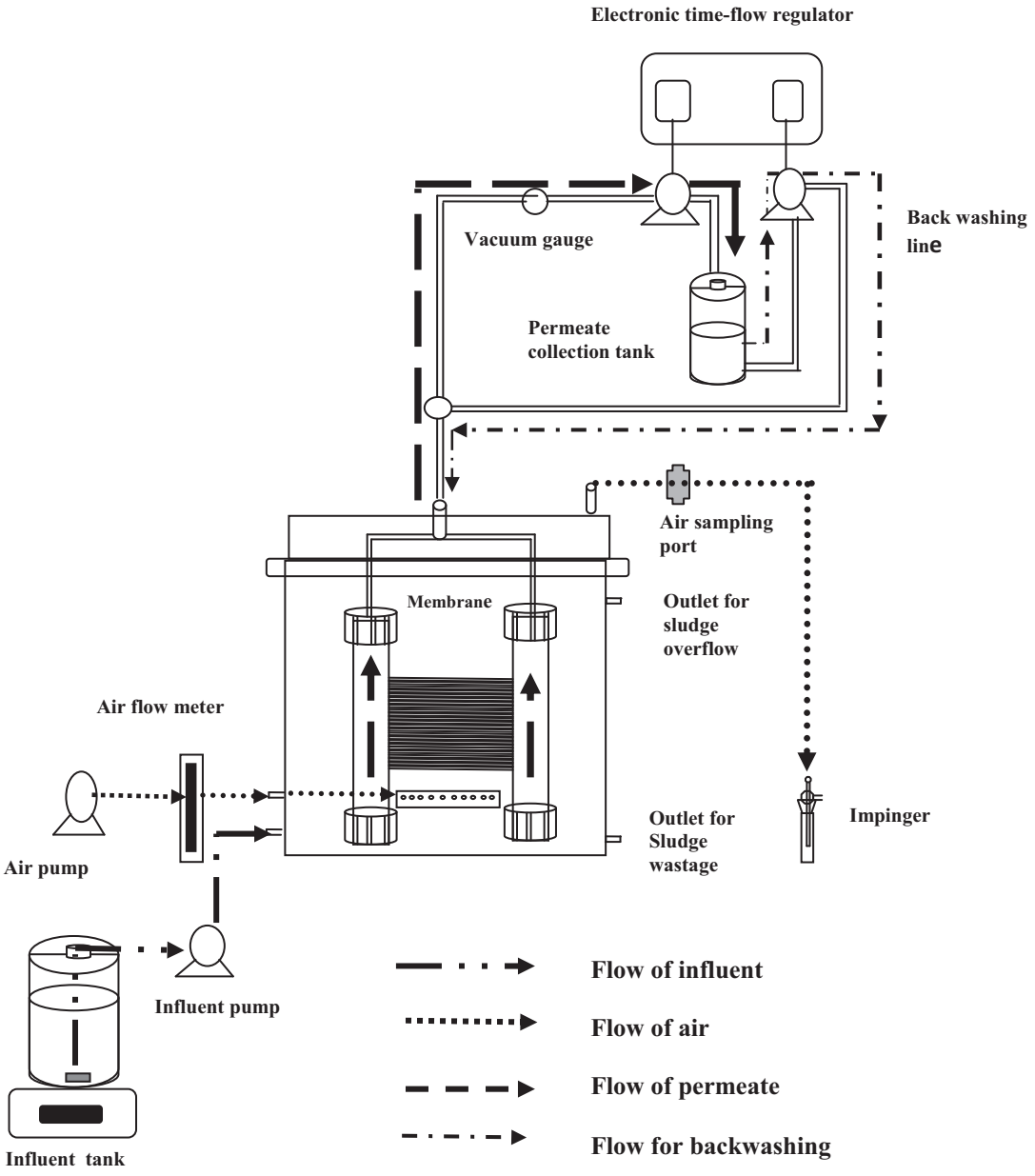

Fig. 1. Over- all flow diagrams for operations of submerged membrane bioreactor for treating wastewater.