Bioresource Technology 240 (2017) 3–8

Contents lists available at ScienceDirect

Bioresource Technology

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

Performance evaluation of attached growth membrane bioreactor for treating polluted surface water

Lu Li, Siwaporn Suwanate, C. Visvanathan *

School of Environment, Resources and Development, Asian Institute of Technology, Pathumthani 12120, Thailand

HIGHLIGHTS

- Laboratory scale aMBR system was tested for treating polluted surface water with COD_{Mn} 10 mg/L.
- aMBR was able to remove 50% of COD_{Mn}, and largely mitigated membrane fouling.
- Modified Stover Kincannon model was able to predict aMBR system performance.

ARTICLE INFO

Article history:
Received 3 December 2016
Received in revised form 21 January 2017
Accepted 24 January 2017
Available online 25 January 2017

Keywords:
Membrane bioreactor (MBR)
Attached growth
Polluted surface water
Drinking water treatment
Modified Stover Kincannon model

ABSTRACT

Attached growth membrane bioreactor (aMBR) process was investigated for treating polluted surface water with COD_{Mn} around 10 mg/L of raw water. Lab scale reactors, aMBR with 15% PVA-gel as carrier and conventional membrane filtration reactor (MF) were tested in parallel. aMBR achieved two times higher COD_{Mn} removal than MF system. Ammonia removal occurred almost completely in both MF and aMBR system – around 94% and 96%, respectively. Permeate turbidity was almost totally removed while UV_{254} removal was around 15% in MF and 20% in aMBR system. aMBR system largely mitigated membrane fouling and prolonged the system operation time. Results showed 2 h hydraulic retention time provided relatively higher removal efficiency and stable operation performance. Modified Stover Kincannon model was able to match the aMBR system.

1. Introduction

Surface water is used worldwide as the main source of drinking water in water supply systems. The surface water resources are under immense pressure caused by human activities linked to rapid urbanization and economic growth. Deteriorating surface water quality, together with water scarcity and ever increasing water demand, brings a big challenge to drinking water treatment industries.

Continuous discharge of domestic and industrial wastewater into surface water leads to an increase in organic pollutants in surface water. Organic contamination of surface water creates complex problems to conventional water treatment processes. In general, conventional water treatment processes are not designed to remove organic pollutants from surface water. When these water treatment plants need to handle organic pollutants, excessive amounts of chemicals are used leading to production of large amount of sludge. The remaining untreated traces of organic matter lead to turbidity, odor, and taste problems and also increase formation of potential disinfection byproducts when chlorination is used. Untreated organic compounds will also increase the risk of microbial regrowth in distribution pipeline (Weinberg et al., 2002).

However, the organic matter in the surface water could be considered as substrate for microorganisms (Kang et al., 2010). Thus, biological treatment could be considered as a potential approach to treatment. The membrane bioreactor (MBR) process, which consists of biodegradation and microfiltration processes, could be an attractive solution. The MBR process is widely used in wastewater treatment where high concentration of biomass is retained in the reactor that results in efficient biodegradation and good effluent quality (Visvanathan et al., 2003). The MBR for polluted surface water treatment has been studied by Li and Chu (2003) to improve removal of organic substances; 1500 mg/L Mixed Liquor Suspended Solids (MLSS) were introduced by which 61 ± 12% Total Organic Carbon (TOC) reduction and 98 ± 1% nitrification were achieved. Tian et al. (2008) integrated powdered activated carbon (PAC) into MBR to improve removal of organic matter, by improving the adsorption processes and also provide more contact surface for microbes and substrates. It was a first attempt that used

* Corresponding author.
E-mail address: visu@ait.ac.th (C. Visvanathan).

http://dx.doi.org/10.1016/j.biortech.2017.01.043
0960-8524/

attached growth concept for treating polluted surface water. The membrane fouling was increased due to the PAC addition. PAC dosage and adding frequency has significant effect to MBR system operation and maintenance. Williams and Pirbazari (2007) studied pre -ozonation to improve MBR performance, and found it reduced membrane fouling and increased membrane permeate flux. Almost all the studies that tried to use MBR for polluted surface water treatment introduced activated sludge into MBR system, which led to membrane fouling. In order to avoid this membrane fouling problem, attached growth membrane bioreactor (aMBR) could be considered as an alternative technological solution in which the immobilized microbes on the carrier could assist to retain biomass in the reactor, providing good biodegradation rate.

This study was aimed at investigating the performance of aMBR for treating polluted surface water. Polyvinyl alcohol gel (PVA-gel) was used as bio carrier in this aMBR to enhance biodegradation performance. Performance of aMBR and MF system removal and membrane fouling at hydraulic retention times (HRT) of 1 h, 2 h and 3 h were tested and analyzed. First-order and modified Stover-Kincannon models for describing the organic removal in aMBR system were studied.

2. Materials and methods

2.1. Experiment Set-up

Lab scale system was set-up as shown in Fig. 1. Two different reactors operated in parallel namely, conventional membrane filtration system (MF-without carriers), and attached growth membrane bioreactor (aMBR-with moving carriers). Both the reactors were divided into two compartments with an acrylic baffle plate in the middle of the tank, named HRT side and membrane side in case of MF system, and carrier side and membrane side in case of aMBR system. It was fabricated to avoid the carrier getting adsorbed to hollow fiber membrane module in aMBR system, and also to control various hydraulic retention times in MF HRT side and MBR carrier side. The carrier applied in aMBR was non-biodegradable PVA-gel with an average bead diameter of 3–4 mm, specific gravity 1.03 kg/m^3 and 90% in porosity (Kuraray Aqua Co., Ltd). The filling ratio of the carrier was 15% of the water volume in carrier side. Hollow fiber Polytetrafluoroethylene UF membrane modules (Sumitomo Electric Industries, Ltd.) with pore size 0.1 μm and effective filtration area of 0.1 m^2 were submerged in both the reactors. Separated air supply lines were controlled to provide oxygen and membrane scouring. Digital pressure gauges were set between the membrane module and suction pump to monitor the transmembrane pressure (TMP) in both the reactors.

2.2. Operational conditions

HRT 1 h, 2 h and 3 h were selected and tested based on common water treatment demand. Level sensors were set in MF HRT side and aMBR carrier side to control the water level in the designated HRT. The flow rate was controlled at 2 L/h for the entire system based on membrane flux 20 LMH, together with the overflow in membrane side so as to ensure the membrane module was submerged. The (entire) system was placed under intermittent operation mode by a timer (8 min on and 2 min off).

The membranes were taken out from the reactor for physical wash by sponge cleaning and water flushing once the TMP reached 60 kPa followed by chemical wash conducted before changing the operation condition. No sludge was discharged during every cycle of test duration.

2.3. Feed water

Simulated polluted surface water was used as feed water in this system. Domestic wastewater was collected and diluted with local tap water to maintain a COD_{Mn} around 10 mg/L. Feed water temperature was 25-31 °C throughout the experiment period; the average temperature was 27.1 °C and pH was 7–8.

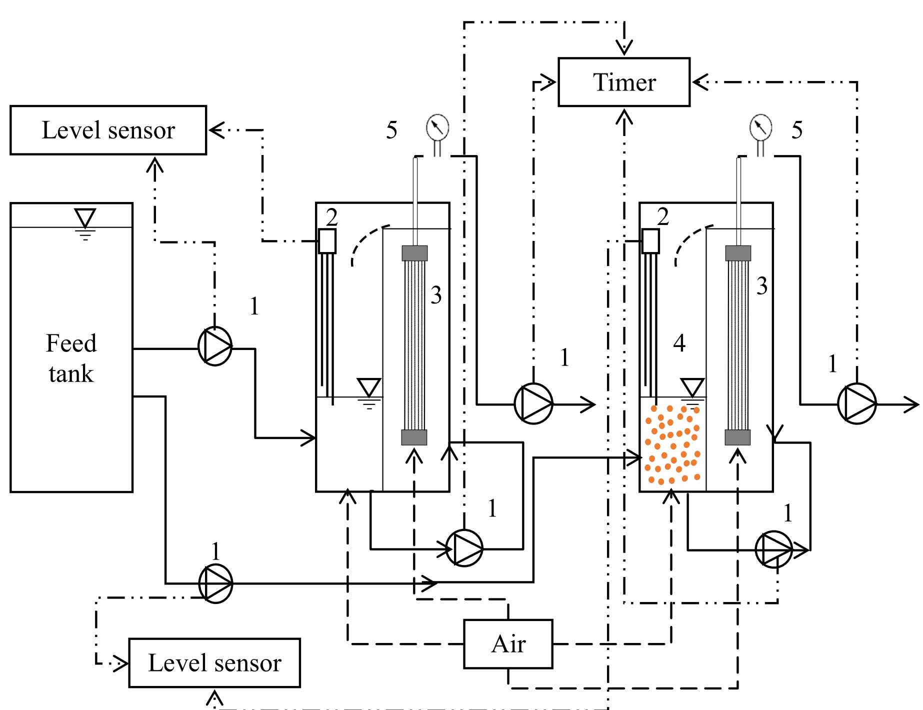

Fig. 1. Schematic of an attached growth membrane bioreactor (aMBR) and membrane filtration (MF) reactor set up. 1 – Pump, 2 – Level sensor probe, 3 – Membrane module, 4 – Bio carrier and 5 – Pressure gauge.