Bioresource Technology 120 (2012) 133–139

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Anaerobic treatment of municipal wastewater with a staged anaerobic fluidized membrane bioreactor (SAF-MBR) system

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HIGHLIGHTS

- ▶ Domestic wastewater was treated with an anaerobic fluidized membrane bioreactor.
- ▶ GAC fluidization prevented membrane fouling over the 192 days of operation at 25 °C.
- ▶ A 2.3 h HRT gave effluent COD of 25 mg/L, BOD_5 of 7 mg/L, and no suspended solids.
- ▶ Biosolids production of 0.049 g VSS/g BOD_5 is much less than with aerobic systems.
- ▶ Methane energy potential was much greater than the 0.047 kWh/m^3 needed for operation.

ARTICLE INFO

Article history:
Received 13 March 2012
Received in revised form 6 May 2012
Accepted 11 June 2012
Available online 19 June 2012

Keywords:
Anaerobic
Fluidized-bed
Membrane bioreactor
Municipal wastewater
Biosolids

ABSTRACT

A laboratory-scale staged anaerobic fluidized membrane bioreactor (SAF-MBR) system was used to treat a municipal wastewater primary-clarifier effluent. It was operated continuously for 192 days at 6–11 L/m^2/h flux and trans-membrane pressure generally of 0.1 bar or less with no fouling control except the scouring effect of the fluidized granular activated carbon on membrane surfaces. With a total hydraulic retention time of 2.3 h at 25 °C, the average effluent chemical oxygen demand and biochemical oxygen demand concentrations of 25 and 7 mg/L yielded corresponding removals of 84% and 92%, respectively. Also, near complete removal of suspended solids was obtained. Biosolids production, representing 5% of the COD removed, equaled 0.049 g VSS/g BOD_5 removed, far less than the case with comparable aerobic processes. The electrical energy required for the operation of the SAF-MBR system, 0.047 kWh/m^3, could be more than satisfied by using the methane produced.

1. Introduction

With growing concerns over climate change associated with fossil-fuel utilization, anaerobic treatment of domestic wastewater is receiving increased attention (Foresti et al., 2006). Anaerobic processes not only produce methane as a renewable source of bioenergy but also consume less energy for operation than aerobic systems. In addition, the lower anaerobic waste biosolids production compared with aerobic treatment reduces the costs and difficulties associated with biosolids management. However, anaerobic treatment of domestic wastewater alone has generally not been sufficient to meet stringent effluent requirements (Gomec, 2010; Seghezzo et al., 1998; Singh et al., 1996; Takahashi et al., 2011; Yule and Anderson, 1996). To address this problem, aerobic or other post-treatment has often been used (Chan et al., 2009; Chernicharo, 2006; Khan et al., 2011; Madan et al., 2007).

An alternative treatment system is the anaerobic membrane bioreactor, which permits a long solids retention time (SRT), but a short hydraulic retention time (HRT), as microorganisms can more easily be retained within the system. In addition to allowing a smaller reactor footprint, a long SRT enhances the degradation of particulate and colloidal organics, thus improving effluent quality and reducing waste biosolids production. However, membrane fouling caused by deposition or adsorption of foulant materials on surfaces or within membrane pores is a long-standing problem. Many attempts have been made to reduce membrane fouling as the high resulting energy and operating costs have been major barriers to its application (Alan et al., 2010; Berube et al., 2006; Huang et al., 2011; Martinez-Sosa et al., 2011; Vyrides and Stuckey, 2009).

In order to reduce energy costs for membrane fouling control, a staged anaerobic fluidized membrane bioreactor (SAF-MBR) system has been proposed (Kim et al., 2011). This anaerobic system consists of an anaerobic fluidized-bed reactor (AFBR) followed by an anaerobic fluidized-bed membrane bioreactor (AFMBR). In laboratory studies with this system treating a 500 mg/L chemical

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0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.06.028