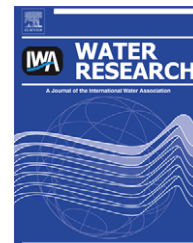


Available at www.sciencedirect.comjournal homepage: www.elsevier.com/locate/watres

The development of a novel hybrid aerating membrane-anaerobic baffled reactor for the simultaneous nitrogen and organic carbon removal from wastewater

Shaowei Hu, Fenglin Yang*, Sitong Liu, Lingqin Yu

Key Laboratory of Industrial Ecology and Environmental Engineering of National Ministry of Education, School of Environmental and Biological Science and Technology, Dalian University of Technology, Linggong Road 2, Dalian, 116024, PR China

ARTICLE INFO

Article history:

Received 22 July 2008
Received in revised form
9 October 2008
Accepted 20 October 2008
Published online 30 October 2008

Keywords:

Membrane-aerated biofilm reactor
Anaerobic baffled reactor
Hybrid bioreactor
Nitrogen removal
COD removal
Fluorescence in situ hybridization

ABSTRACT

A novel hybrid aerating membrane-anaerobic baffled reactor (HMABR), based on the installation of aerating membrane into an anaerobic baffled reactor (ABR), to achieve simultaneous removal of nitrogenous and carbonaceous organic pollutants was developed in this study. The results demonstrated that after the installation of membrane module, total VFA and COD concentration in the HMABR effluent were decreased by 68.1 and 59.5% respectively, with increased nitrogenous pollutant remove efficiency by 83.5%, at influent COD concentration of 1600 mg/L and $\text{NH}_4^+\text{-N}$ concentration of 80 mg/L. Fluorescence in situ hybridization (FISH) results of the aerating membrane biofilm showed that the biofilm stratification for the spatial profiles of ammonia-oxidizing bacteria, nitrite-oxidizing bacteria, aerobic heterotrophic bacteria, and denitrifying bacteria. The potential usage of HMABR widens the usage of aerobic-anaerobic combination technology for industrial wastewater treatment.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

In recent decades, anaerobic biological treatment of high-strength industrial wastewaters has become an established pollution control technology, and several anaerobic reactor configurations were available. Anaerobic baffled reactor (ABR) is known as a high-rate bioreactor that has a number of advantages over other reactors such as: longer biomass retention times, better resilience to organic shock loadings, and the special ability to partially separate the various phases of anaerobic catabolism (Barber and Stuckey, 1999). This system, however, still has a reputation for lower-quality effluents. The removal of nitrogenous pollutants in these anaerobic bioreactors also poses a particularly difficult challenge.

With the aim to obtain better process stability, some researchers have been focusing on combinations of the anaerobic and aerobic processes, such as: ABR-activated sludge system (Garuti et al., 1992), ABR-aerobic biofilm reactor (Bodik et al., 2003), and anaerobic-aerobic stage of a modified ABR (Barber and Stuckey, 2000), etc. These strategies mentioned above still may be problematic because of, system complex, large footprint, high operating costs as well as a requirement of extra circumfluence, etc.

Membrane-aerated biofilm reactor (MABR) represents a novel membrane treatment process, which has been drawing an increasing attention in the recent decades (Casey et al., 2000; Terada et al., 2003; Semmens et al., 2003). This system can fix biofilm onto the outside surface of a membrane,

* Corresponding author. Tel.: +86 411 8470 6172; fax: +86 411 8470 6171.

E-mail addresses: hushaowei2003@sina.com (S. Hu), yangfl@chem.dlut.edu.cn (F. Yang).
0043-1354/\$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.watres.2008.10.041

and thus, directly supply oxygen from the inner side to the biofilm. The niche close to the membrane is rich in oxygen but low in organic substrate, which creates a favorable circumstance for the development of aerobic ammonium oxidizing bacteria (AOB), nitrite oxidizing bacteria (NOB) and aerobic heterotrophic bacteria. While in the outer regions of the biofilm, high concentration of pollutant and the absence of oxygen promote denitrification and the growth of anaerobes. This unique biofilm stratification is particularly fortuitous in concomitant removal of both carbonaceous and nitrogenous pollutants in a single-stage MABR (Hibiya et al., 2003; Terada et al., 2003; Semmens et al., 2003).

In this study, aerating membrane module was installed into a compartment of anaerobic baffled bioreactor, and then hybrid MAB-ABR (HMABR) was built up. On the basis of the biological phase-separation of acidate bacteria and methanogens bacteria in ABR and the unique stratification of the aerating membrane biofilm into possibly aerobic, anoxic and anaerobic zones, the possible improved removal rate of carbonaceous and nitrogenous pollutants were expected. We examined the performance of this novel HMABR, with the aim of putting forward a high-efficiency wastewater treatment process available for simultaneous nitrogen removal technology for high-strength organic wastewater.

2. Material and methods

2.1. Synthetic wastewater

The reactor feed contained glucose and ammonium chloride, used as the primary organic and nitrogenous components. Trace elements solution CuCl_2 30 mg, H_3BO_3 50 mg, ZnCl_2 50 mg, $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$ 50 mg, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ 50 mg, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ 50 mg, EDTA 1000 mg, $\text{NaSeO}_4 \cdot 10\text{H}_2\text{O}$ 100 mg, $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ 500 per liter was added to sustain the microbial growth (Chu et al., 2006). The medium had average chemical oxygen demand (COD) concentration of approximately 1600 mg/L and ammonium–nitrogen concentration of 80 mg/L during the initial operation. On day 146, the COD concentration in the influent was increased to 2400 mg/L to further examine the treatment performance. The pH of the synthetic wastewater was controlled at 7.5 ± 0.2 by the addition of 1 M NaHCO_3 .

2.2. HMABR configuration

ABR was made of perspex with a total effective volume of 9.5 L. The reactor contained two vertical standing baffles that were divided into three separate gas tight compartments. Within each compartment, downcomer and riser regions were created, by a further slanted edge (45°) vertical baffle in order to direct the flow evenly through the riser. The ratio of the riser to downcomer was 4.5:1. Each compartment was equipped with anaerobic granular sludge. The ABR was seeded with anaerobic granule sludge collected from Municipal Wastewater Treatment Plant (Dalian, China). A large amount of granules had visible edge, colored bright black. They appeared as incompact rod-shaped or spherical-shaped with a size of 0.5 mm. The temperature was maintained at $28 \pm 1^\circ\text{C}$ by a thermostated water jacket and HRT was

controlled at 40 h. Biogas escaped from the bioreactors through wet gas flowmeter (JHL-Instrument, BSD0.5, China), which was used for the measurement of biogas volume.

The membrane module used in the experiment consisted of 16 carbon tubes and each tube had a thickness of 2.1 mm, an inner diameter of 4.7 mm, a length of 165 mm, and a pore size of $2\ \mu\text{m}$. To enhance bacteria attachment and prevent biofilm sloughing, the carbon membrane surface was covered with non-woven material to provide high, specific surface area for bacterial settlement. Air was pumped into the membrane lumen from the top of the membrane module, which partially penetrated through the membrane wall into the biofilm. Air pressure was measured by precision pressure gauge. The surplus gas was emitted also, to the gas-collection device on the top of the membrane module. The amount of oxygen supplied was controlled by the intramembrane pressure (Hu et al., 2008). The intramembrane pressure was controlled by a valve at the gas-let site. Membrane module of MABR was installed into the second compartment of ABR on day 90, and HMABR was then built up. The HMABR configuration used in these experiments is given in Fig. 1.

2.3. Experimental procedure

This experiment was divided into two approaches. For the first approach, ABR and MABR were started-up respectively. Non-woven porous polyester (thickness of 2.8 mm, porosity of $5\ \mu\text{m}$) coated with a pyridinium-type polymer (Japan Vilene, US patent 5,185,415,1993) was used as the carrier material in MABR to enhance the attachment performance for its large surface area and good adsorption characteristic. Mature anaerobic granule sludge, combined with synthesize wastewater, was inoculated into the ABR. When a pseudo-steady state with respect to effluent quality and production gas was reached, the start-up processes were considered to be successful. During this period, nitrifiers grew on the membrane surface and formed a nitrifying biofilm. With the increased ammonium nitrogen removal, the domestication of this biofilm was accomplished (Hu et al., 2008). For the second approach, the membrane coated with nitrifying biofilm from MABR was then installed into the second compartment of ABR, and the aeration of membrane aerating was initiated to examine the operation performance of this hybrid MAB-ABR (HMABR).

2.4. Analytical methods

COD, $\text{NH}_4^+\text{-N}$, $\text{NO}_2^-\text{-N}$, and $\text{NO}_3^-\text{-N}$ were measured according to the standard methods, as set out by the American Public Health Association (APHA, 1995). The effluent samples were filtered before analysis. $\text{NH}_4^+\text{-N}$ and $\text{NO}_2^-\text{-N}$ were measured by using a different colorimetric method and $\text{NO}_3^-\text{-N}$ was analyzed by using the UV spectrophotometric method. DO and pH were measured with a DO meter (YSI, Model 55, USA) and an acid meter (Sartorius, PB-10, Germany), respectively.

2.5. Gas chromatograph

Volatile fatty acids (VFA) and biogas composition (CO_2 and CH_4) were determined by gas chromatography (Shimadzu, GC-

Download English Version:

<https://daneshyari.com/en/article/4484437>

Download Persian Version:

<https://daneshyari.com/article/4484437>

[Daneshyari.com](https://daneshyari.com)