



Membrane bioreactor vs. oxidation ditch: full-scale long-term performance related with mixed liquor seasonal characteristics



Jianyu Sun^a, Kang Xiao^{a,b}, Xiaoxu Yan^a, Peng Liang^{a,**}, Yue-xiao Shen^a, Ningwei Zhu^a, Xia Huang^{a,*}

^a State Key Joint Laboratory of Environmental Simulation and Pollution Control, THU-Beijing Origin Water Joint Research Center for Environmental Membrane Technology, School of Environment, Tsinghua University, Beijing 100084, China

^b College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China

ARTICLE INFO

Article history:

Received 22 July 2015

Received in revised form 3 September 2015

Accepted 7 September 2015

Available online 10 September 2015

Keywords:

Membrane bioreactor

Conventional activated sludge

Wastewater treatment performance

Mixed liquor characteristics

Seasonal variation

ABSTRACT

The relative strengths of membrane bioreactors (MBR) versus conventional activated sludge (CAS) processes have long been debated, but never compared systematically at full scale. To this end, we monitored full-scale wastewater treatment performance and mixed-liquor characteristics (sludge biomass, extracellular polymeric substances (EPS), supernatant with molecular weight and hydrophilic/hydrophobic distribution) for parallel MBR and CAS (via oxidation ditch–OD), for a year. Ammonia and suspended solids were better removed by MBR; temperature affected ammonia removal in OD. At low temperatures, sludge settlement declined in both processes, but solid–liquid separation via membrane filtration continued, although the membrane fouled. EPS characteristics were similar, and organic components in EPS and supernatant varied seasonally, in both processes. MBR had a lower production rate, but higher concentration, of supernatant organics and accumulated large molecular-weight polysaccharides. Ammonia removal was correlated with tightly bound proteinaceous EPS. Polysaccharides, in loosely bound EPS and supernatant, were responsible for effective settlement (OD), and membrane fouling (MBR). These results demonstrate how mixed liquor intermediates process and performance, and that performance depends on effective solid–liquid separation. MBRs excel when stringent requirements for pollutant-removal and extreme environmental conditions exist. The much cheaper OD remains competitive under less demanding conditions.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Membrane bioreactors (MBRs) have increasingly been applied in municipal wastewater treatment engineering during the past decade, and accounted for over 2% of the municipal wastewater treatment capacity in China by 2014 [1,2]. Compared with conventional activated sludge processes (CAS), MBR uses membrane filtration for solid–liquid separation, ensuring higher effluent quality for wastewater reclamation and reuse. In spite of its alleged benefits of better treatment performance and occupation of much less land, broader application of MBRs is still hindered by their relatively high construction cost and energy consumption. Choosing between MBR and CAS for wastewater treatment remains unset-

tled, even some researchers and engineers now reconsider whether MBR has been the best choice for various engineering cases [3,4]. An exact knowledge of the advantages and disadvantages of MBR (and CAS) for specific uses, might even reshape the map of future application fields of both [2]. In this context, a well-defined and systematic comparison of MBR and CAS, especially based on full-scale engineering, must be of fundamental importance and extremely required.

Some comparative studies have presented evidence indicating that MBR has better removal efficiency for suspended solids (SS) and dissolved organics due to membrane filtration [5,6], better ammonia nitrogen removal efficiency due to abundant nitrifying bacteria [7,8]; distinguished physicochemical characteristics of biomass and supernatant [9–11]. Even so, three major issues remain unresolved. First, what are the actual differences between MBR and CAS in the context of full-scale engineering? The scale of system studied might substantially affect wastewater treatment performance, as well as mixed liquor characteristics [12,13]. However, most previous studies employed laboratory or pilot-scale

* Corresponding author.

** Corresponding author.

E-mail addresses: liangpeng@tsinghua.edu.cn (P. Liang), xhuang@tsinghua.edu.cn (X. Huang).

MBRs for their comparisons [5–11,14]. A few studies were conducted using separate full-scale MBRs and CASs under different influent conditions [15], but the use of nonparallel systems likely results in some inaccuracy of comparison. The second issue involves the differences between MBR and CAS during long-term operation, which was significant for practical engineering. Temperature was a critical variable during long-term operation of both MBR and CAS, and influenced both pollutant removal [16] and membrane fouling behavior [17,18]. Because previous comparison studies were generally conducted within a single season, they neglected potential differences in response to temperature change between MBR and CAS. Third, is the need to know the exact mechanisms of the two different types of solid–liquid separation, and how they might lead to differences in performance of MBR and CAS? Mixed liquor was a key linkage between process configuration and performance, since it directly participated in pollutant degradation and solid–liquid separation. The physicochemical characteristics of the mixed liquor (e.g., distributions of species, hydrophobicity, size/molecular weight) could be indicative of performance in pollutant removal and solid–liquid separation. Nonetheless, previous studies did not include adequate attention to the role of mixed liquor in their comparisons of MBR and CAS. For all these reasons, a systematic investigation of mixed liquor characteristics, and comparison of their impact on MBR and CAS performance; in the context of full-scale, long-term operation should be well worth undertaking.

This study is based on parallel, full-scale MBR and CAS (herein via oxidation ditch—OD) wastewater treatment streams, each with capacity of 50,000 m³/d. Their performance was monitored for one year, along with the characteristics of the mixed liquors of each process. The relationship among seasonal temperature change, treatment performance, and mixed liquor characteristics was systematically investigated to provide rational bases for selection of MBR or CAS for long-term, full-scale applications. This was accomplished by analyzing biomass, extracellular polymeric substances (EPS), and supernatant characteristics. These included components, concentration, hydrophilic/hydrophobic distribution, and the distribution of molecular weight.

2. Material and methods

2.1. Full-scale MBR and OD

The full-scale MBR and OD processes investigated in this study, each with capacity of 50,000 m³/d, were constructed in a full-scale municipal wastewater treatment plant (WWTP). The WWTP is located in Wuxi (30°36' N, 120°19' E, Jiangsu Province, China), collecting and treating domestic and industrial wastewater, and has an overall capacity of 200,000 m³/d. The effluent of this WWTP reached the I-A national standard (GB18918–2002), and provides reclaimed water for industrial facilities, or was discharged into natural rivers.

The process flow of the MBR and OD are depicted in Fig. S1, and the operational parameters of both processes were listed in Table S1. The MBR consists of eight parallel membrane tanks after an anaerobic/anoxic/anoxic/aerobic (A1/A2/A2/O) process. The hollow fiber membrane (Origin Water, China) in use was of hydrophilic polyvinylidene fluoride material with a nominal pore size of 0.1 μm. The OD was of Orbal configuration, with a secondary sedimentation tank installed between the outer and inner channels. Polymeric Al–Fe was dosed as coagulant in both processes to enhance P removal. The proportion of Al and Fe in the coagulant was 7~8% and 2~3%, respectively. The monthly dosage of coagulant in MBR and OD was 78 ± 24 t and 83 ± 27 t, respectively. As to external carbon source for N removal, sodium acetate (net con-

tent: 20~30%) was used in MBR, and acetic acid (net content: 90%) was used in OD. The dosage of external carbon source was adjusted to ensure that effluent TN concentration could reach the discharge standard. The monthly dosage of external carbon in MBR and OD (in terms of C) was 2.7 ± 2.2 t and 11.0 ± 7.8 t, respectively. Since sludge with high concentration in MBR process might promote nitrogen removal through simultaneous nitrification and denitrification or endogenous denitrification, less external carbon was needed, compared to that in OD process.

2.2. Assessment of wastewater treatment performance

Chemical oxygen demand (COD), ammonia nitrogen, total nitrogen (TN), total phosphorus (TP), and suspended solids (SS) of the influent and effluent of both processes were determined daily according to standard methods [19].

The permeate flux and transmembrane pressure (TMP) of the MBR were automatically recorded each day. The actual specific flux (L/(m² h), or LMH/kPa) of the MBR, which indicates the permeability of the mixed liquor with the membrane, was calculated by dividing the flux by the TMP.

2.3. Characterization of the mixed liquor

Samples of mixed liquor were taken from the membrane tank (MBR) and out of the aerobic zone (right after the aeration brush, OD) immediately after in-situ measurement of temperature, pH, and dissolved oxygen (DO). The suspended solids (MLSS), volatile suspended solids (MLVSS) concentration, and sludge volume (SV30) of the mixed liquor samples were measured according to standard methods [19]. The sludge volume index (SVI) was calculated by dividing the SV30 by the MLSS concentration. Supernatant was obtained by filtering mixed liquor first through a filter paper, and then through a glass-fiber membrane (0.7 μm, GF/F, Whatman, UK). EPS was extracted from the residual sludge using sodium chloride solution, into loosely bound EPS (LB-EPS) and tightly bound EPS (TB-EPS), according to a heat extraction method [20]. All samples were temporarily stored in a sealed container at 4 °C, and transported to the laboratory within 24 h for subsequent analyses.

The molecular weight distribution of the supernatant was characterized by filtering the supernatant using ultrafiltration membranes with different molecular weight cutoffs (MWCO). Three regenerated cellulose ultrafiltration membranes (MWCOs of 100 kDa, 10 kDa and 1 kDa; PLHK&PLAC, Millipore, USA) were used in this study, thus four fractions with different molecular weight intervals were obtained. Hydrophilic/hydrophobic fractionation of the supernatant was performed according to a column chromatographic procedure [21]. Hydrophobic basic substances (HOB), hydrophilic substances (HIS), hydrophobic acidic substances (HOA), and hydrophobic neutral substances (HON) were successively isolated from the supernatant.

The supernatant of each fraction and the LB/TB-EPS were characterized in terms of total organic carbon (TOC; TOC-V CPH, Shimadzu, Japan), polysaccharides [22], and proteins and humic substances [13]. Glucose (Beijing Chemical Works, China), bovine serum albumin (Sigma, USA), and humic substances (Fluka, Switzerland) were used as standard for the measurements of polysaccharides, proteins, and humic substances, respectively. Before measurement of proteins and humic substances using the modified Lowry method, divalent cations were removed using gel-type cation exchange resins (Amberlite IR-120 Na, Acros Organics, Belgium) to exclude the interference of calcium and magnesium ions [13].

The fouling potential of MBR supernatant was determined according to a dead-end filtration test. The initial decreasing rate of filtration flux, as a function of specific permeate volume, was

Download English Version:

<https://daneshyari.com/en/article/34217>

Download Persian Version:

<https://daneshyari.com/article/34217>

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