Physical Characteristics of Bangkok Domestic Wastewater Treatment Using a Pilot Scale Membrane Bioreactor

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Abstract

Submerged membrane bioreactor (MBR) is a high efficient technology for domestic wastewater treatment and reuse. Physical characteristic of a pilot scale MBR for Bangkok domestic wastewater treatment was investigated in this study. The results showed that pH kept on in neutral range and dissolved oxygen (DO) remained stable around 3 mg/L. Temperature, conductivity, oxidation-reduction potential (ORP) were reasonably stable with small fluctuation across a 45 day test period. The MBR displayed excellent filterability with no significant turbidity in the effluent. With constant flux, the membrane showed a considerable development of a fouling growth rate in the system.

1. Introduction

A membrane bioreactor (MBR) was first used to treat wastewater by Smith et al. over 30 years ago [1]. Later, membrane bioreactors (MBR) that are characterized by immersing the membrane modules as separation units directly in the bioreactor were developed for wastewater treatment in the 1990s [2]. The MBR incorporates a submerged membrane process for liquid–solid separation instead of the more usual gravity sedimentation.

Due to the absence of secondary clarifiers, the overall size of treatment plant can be greatly reduced [3]. In addition, many advantages of common MBR systems have been reported such as complete solid removal from effluent, effluent disinfection, high loading rate capability, low/zero sludge production, rapid start-up and more compact size [4]. The MBR has been proved to be used for treating a variety of wastewaters such as tannery wastewater [2], industrial wastewater and oily wastewater [5]. However, practical application of membrane bioreactors in Bangkok domestic wastewater treatment has not been reported in literature. Therefore, the purpose of this paper was to explore the physical characteristic experience of a MBR system for Bangkok domestic wastewater treatment.

2. Experimental Materials and Method

A pilot scale MBR used in this study was consisted of a 45 liter aerobic unit fitted with a submerged flat-sheet membranes. The membrane material is chlorinated polyethylene with nominal pore size 0.4 μm. Bangkok domestic wastewater from Chongnonsi cannel was collected and pumped to the bioreactor from the feed tank, passing through a fine screen. Effluent was removed through the membrane with a suction pump passing through permeate line. Pressure gauge was also

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located on the permeate line. The aeration process was conducted using a blower and controlled using air rota-meter.

The coarse bubble aeration was supplied to the membrane tank in order to prevent membrane clogging as well as to provide oxygen for microbial growth. Samples were collected once a week at the following 3 different positions: inlet the system, within the MBR and permeate outlet. Turbidity was measured using a turbidity meter. Dissolved oxygen (DO) and pH were measured using DO electrode and a pH meter, respectively. Ammonia, nitrate and phosphate were determined by Hach colorimeter (model DR/890, Hach Company).

3. Results and discussion

3.1 pH

From Fig. 1, the inlet wastewater pH displayed higher average level (7.1–7.6) than that of MBR (6.9-7.4) and permeate (6.9–7.3) due to a high ammonia loading in the coming stream.

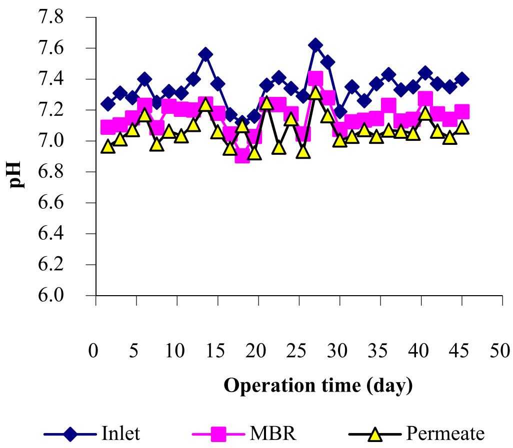

Fig. 1 Variation of pH in the MBR system

However, it can be concluded that the average pH in all samples of the MBR system are fluctuating in the neutral range (6.9-7.4). Moreover, optimum pH ranges strongly impact the microbial growth and a suitable range of pH for microbial activity is suggested at 6 to 9 [6]. At these pH ranges, the microbes in an activated sludge reactor can grow and function properly.

3.2 Oxidation-reduction potential (ORP)

From Fig. 2, a negative ORP value occurred at a very high organic loading in the inlet sample. The higher oxidizing agent in water, the higher ORP will be obtained.

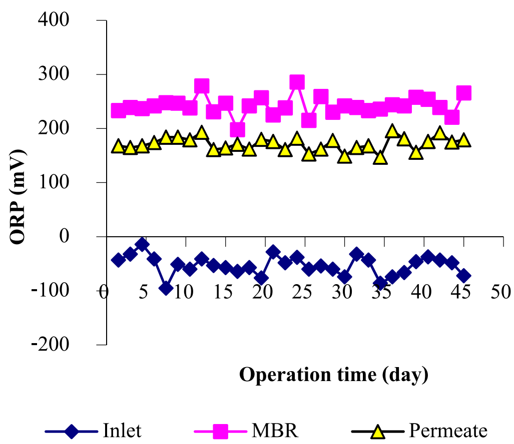

Fig. 2 Variation of ORP in the MBR system

Li and Pual [7] indicated that ORP values can clearly show the chemical oxygen demand (COD) removal occurring along the length of an aeration wastewater treatment with a good linear relationship. In fact, ORP values increased dramatically as organic matter was removed. A high enough ORP (650+ mV) can kill most bacteria, which is suitable even for drinking water purification [8].

3.3 Temperature

The MBR system was kept in the climatic conditions with average temperatures between 24 and 29 degree centigrade (Fig. 3). From Fig. 3, the inlet stream has a little lower average temperature than other sections. Aeration in the aerobic membrane unit can help to reduce temperature 1-2 degree in membrane tank and permeate stream.

Temperature impacts on membrane filtration through its influence on permeate fluid viscosity [9]. The greater filtration resistances observed at low temperature (below 17 ^{0}C) were explained by the increasing of sludge viscosity resulting in less the shear stress generated by coarse bubbles and less particle back transport velocity [10]. All these factors are directly linked to membrane fouling, so it is expected to observe greater deposition of materials on the membrane surface at lower temperatures [11].

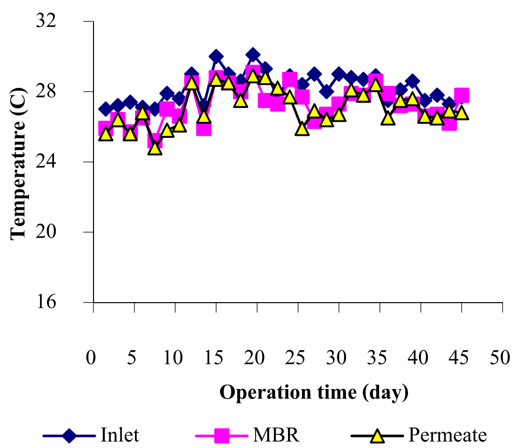

Fig. 3 Variation of temperature in the MBR system

3.4 Dissolved oxygen (DO)

Coarse bubble aeration was provided in the MBR system in order to scrub and prevent biofouling on membrane surface. Hence, DO concentration (Fig. 4) in the membrane tank and permeate are higher than the inlet stream. As seen, the DO concentration in the membrane unit is always greater than 2.0 mg/L which means the real aerobic stage can happen properly as expected. As a general trend, higher DO tends to lead to better filterability, and lower fouling rate [12]. The effect of oxygen limitation causing a lowering of the cell surface hydrophobicity, and consecutive floc deterioration, was concluded to be the main reason for the worsen MBR fouling [13].

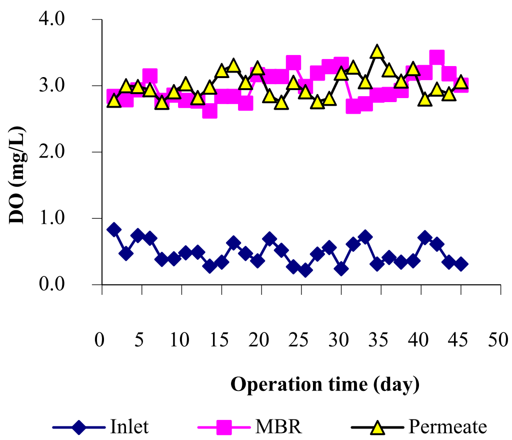

Fig. 4 Variation of DO in the MBR system

3.5 Conductivity

From Fig. 5, the highest conductivity from the inlet stream sharply decreased in the membrane and permeate section respectively. A slightly increase of conductivity occurred in the membrane unit probably due to soluble microbial products produced in the aerobic system and also some dead cells decayed to become a readily biodegradable substance.

Conductivity is considered as a convenient express method for determining the solution mineralization and concentration of metal ions of solutions. In some studies, conductivity can be used to determine the weight fraction of certain particles in solution, the total content of solid substance, and the content of ionized solid substance by multiplying the conductivity values with an empirical factor varying from 0.55 to 0.99, depending on the nature of dissolved components and temperature [14].

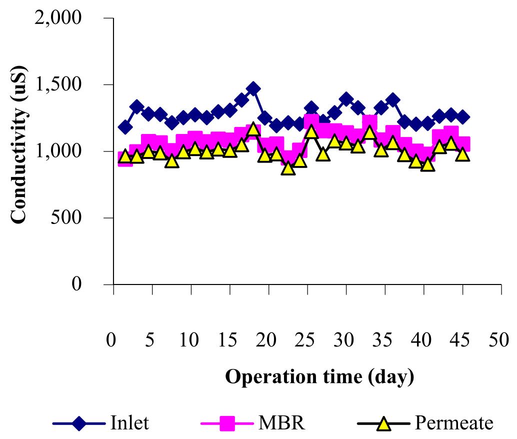

Fig. 5 Variation of conductivity in the MBR system

3.6 Turbidity

From Fig. 6, the inlet wastewater has lower turbidity than that of the membrane unit.

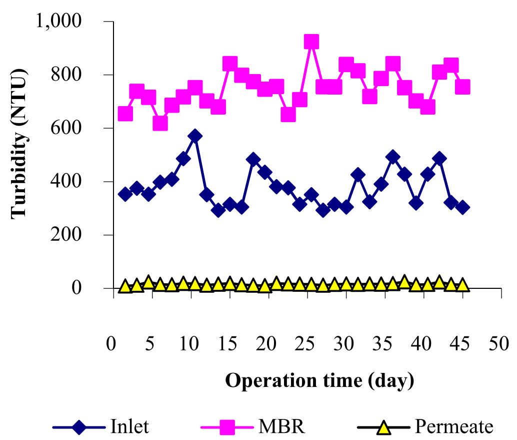

Fig. 6 Variation of turbidity in the MBR system

Turbidity is related with the amount of suspended solids present in the system. Therefore, the highest MLSS concentration in the membrane unit gives the highest turbidity value. As expected, this submerged microfiltration membrane can separate sludge cells from wastewater very well and it can be seen from Fig. 6 that the membrane shows a nearly 100% filterability with no significant turbidity in permeate.

3.7 Membrane performance

The MBR was continuously operated for 45 days. During the operation, MLSS concentration in the MBR was continued at about 5-7 g/L. The variation of trans-membrane pressure (TMP) with operation time was demonstrated in Fig. 7.

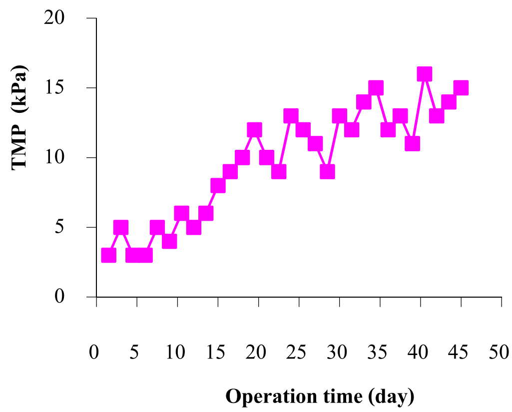

Fig. 7 Variation of TMP in the MBR system

It can be observed that the TMP increased with operation time as the membrane flux was kept at about 10 L/(m^2.h) during the experiment. In Fig. 7 membrane showed a fouling growth rate within 45 days maybe due to un-stabilization of activated sludge in the initial stage. Moreover, the TMP variations of the two membranes exhibited a two-step fouling phenomenon, i.e., a slow increase of TMP followed by a rapid increase [15].

4. Conclusions

The physical characteristic performance of the MBR was measured for 45 days. The physical measurement results in the MBR system showed that the average pH, ORP, temperature, DO and conductivity were about 6.9-.7.3, 200-300 mV, 24-29 ^{0}C, 2.6-3.5 mg/L and 900-1200 µS, respectively. The effluent showed turbidity less than 10 NTU which can be implied to outstanding membrane filterability. The constant flux 10 L/(m^{2}.h) was maintained all over the experimental period and the fouling was found to be developed during this time.

5. Acknowledgement

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6. References

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