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Comparison between Continuous and Intermittent Model on the Performance of a Pilot-Scale Anoxic/Oxic Membrane Bioreactor for Toilet Wastewater Reuse System

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Abstract

Membrane bioreactor (MBR) is a novel and effective technology, which is widely applied in wastewater treatment and water reuse. A pilot-scale anoxic/oxic MBR (A/O-MBR) was set up to reuse toilet wastewater for a 5-floor lab building. Because of low volume wastewater generation, continuous and intermittent models were applied, respectively, for this reuse system. This study aimed to identify the comparison between continuous and intermittent model on the performance of A/O-MBR for toilet wastewater reuse system. Due to remaining sludge and high DO, both continuous and intermittent model showed a great performance on COD_{Cr} and NH_4+-N removal. However, because of low COD, continuous model was hard to remain stable and high MLSS during operation, and also inhibited TN removal. Additionally, TP removal mainly relied on the bacterial growth in both models. Therefore, intermittent model had the better performance for this toilet wastewater reuse system.

Keywords: Membrane bioreactor; Continuous model; Intermittent model; Toilet wastewater reuse; Performance

Introduction

Wastewater stress has been a severe reality in many countries, especially China. Wastewater reuse thereby has been considered as one of the positive ways to relieve the stress. With population increasing in Chinese cities, toilet wastewater has become an attracted problem [1], but also been regarded as the main reuse water source for grey water [2]. Toilet wastewater contains high concentration of organic matter, NH_4+-N and phosphorus. Toilet wastewater contributes 80-90% NH_4+-N and phosphorus, and approximately 54% organic pollutants for municipal waste water [1,3,4]. Therefore, toilet wastewater needs a highly effective biological water treatment system for its reuse.

Membrane bioreactor (MBR) is a novel technology for wastewater treatment and water reuse, which combines effectively physical separation and biological degradation [5]. Comparing with conventional activated sludge, MBR contains many outstanding advantages, such as remaining sludge, low footprint, less sludge production, high quality of effluent, etc [6]. Consequently, MBR is regarded as the promising wastewater reuse technology, especially for building wastewater reuse system [7,8]. MBR has already been widely applied in wastewater reuse system, especially toilet wastewater reuse [9]. Fountoulakis et al. [3] reported that submerged MBR could effectively remove over 87% COD in toilet wastewater reuse system. Boehler et al. [1] also showed that toilet wastewater reuse system with MBR reused close to 100% wastewater, and 80% of phosphorus was removed. Therefore, a pilot-scale anoxic/oxic MBR (A/O-MBR) was built up to reuse toilet wastewater from a 5-floor lab building as flushing water (Figure 1).

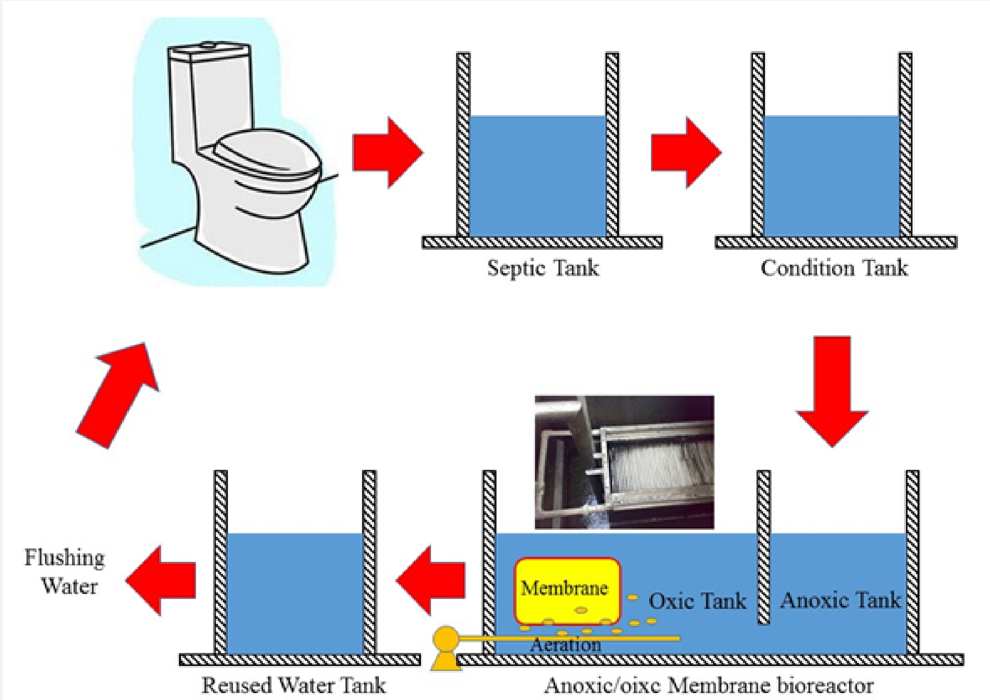

Figure 1: The schematic of the pilot A/O-MBR for toilet wastewater reuse system.

However, during the toilet wastewater reuse system operation, it was found that operational toilet wastewater was only part of the designed volume, and wastewater needed water refill to maintain the designed flux for MBR (call "Continuous model"). In addition, another model, intermittent model, was also carried out with accumulating toilet wastewater in condition tank for flux adjustion. In many studies [7,10-12], wastewater reuse system with MBR was normally in the continuous model. Therefore, this study aimed to discuss the comparison between continuous and intermittent model on the performance of MBR for toilet wastewater reuse system.

Materials and Methods

Set-up and operation

A toilet wastewater reuse system (Figure 1) was built up for a 5-floor lab building (approximate 40-80 people in weekday, and only 10-30 people during weekend) to reuse wastewater as flushing water. The system contained septic tank (24m^3 of working volume), condition tank (18m^3 of working volume), A/O-MBR (5.2m^3 of total working volume with 1.9m^3 anoxic tank and 3.3m^3 oxic tank) and reused water tank (24m^3 of working volume). Toilet wastewater firstly flew into septic tank for anaerobic digestion, then was transferred into condition tank for flux adjustion. Secondly, wastewater was pumped into anoxic tank of A/O-MBR. Last, the treated wastewater was pumped into reused water tank as flushing water. A PE hollow fiber membrane module (total surface 120m^2; pore size 0.4μm) (Mitsubishi, Japan) was installed at the middle of oxic zone, and constant flux was in an intermittent suction mode (10min ON/5min OFF). The flux was set at 20-40m^3/d. The recycle rate from oxic to anoxic zone was kept at 200%. Trans-membrane pressure (TMP) was detected with a pressure gauge. The inoculating biomass was drawn from the return activated sludge stream in Quyang WWTP (Shanghai, China). No sludge was discarded during operation.

Based on the original design, the reuse system would treat approximate 30m3 toilet wastewater every day. However, due to low volume toilet wastewater generation, only about 10-15m3 wastewater could be pumped into this reuse system. Therefore, MBR was applied with continuous and intermittent model, respectively. Continuous model (con-MBR) was that wastewater was continuously pumped into MBR from condition tank with treated wastewater refill to maintain the designed flux. Intermittent model (int-MBR) was that toilet wastewater would be pumped into MBR when reaching approximate 15m3, without treated wastewater refill.

Analytical methods

Determination of chemical oxygen demand (CODCr), ammonia nitrogen (NH_4+-N), total phosphorus (TP), total nitrogen (TN) and mixed liquor suspended sloid (MLSS) were conducted in accordance with Standard Methods [13]. Dissolved oxygen (DO) and pH were measured with a DO-and-pH meter (HQ4d, HACH, USA).

Results and Discussion

Figure 2 shows the removal CODCr of con-MBR and int-MBR. Because of the treated wastewater refill, CODCr of con-MBR was obviously lowerin the influent than that of int-MBR. But, con-MBR

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and int-MBR both had the high-quality effluent, and CODCr removal rates of MBRs were approximate 90%. This result indicated that both continuous and intermittent model for the reuse system could achieve a perfect CODCr removal. It might be because MBR could effectively maintained activated sludge in the reactor, and also supply enough oxygen for bacterial degradation. Additionally, Figure 3 shows MLSS variations between con-MBR and int-MBR. During 60 days operation, con-MBR had an obvious decrease of MLSS from 3.5g/L to 1.4g/L, but int-MBR could maintain a stable MLSS around 2.6g/L. Due to no sludge discard, MLSS variation was depended on the growth and death of bacteria. MLSS results predicted that bacterial death were over than the bacterial growth in con-MBR during operation, which was mainly because of low CODCr. Therefore, because of the low CODCr, con-MBR was difficult to maintain the stable and high MLSS during operation, meaning that con-MBR needed a regular activated sludge addition for long-time operation.

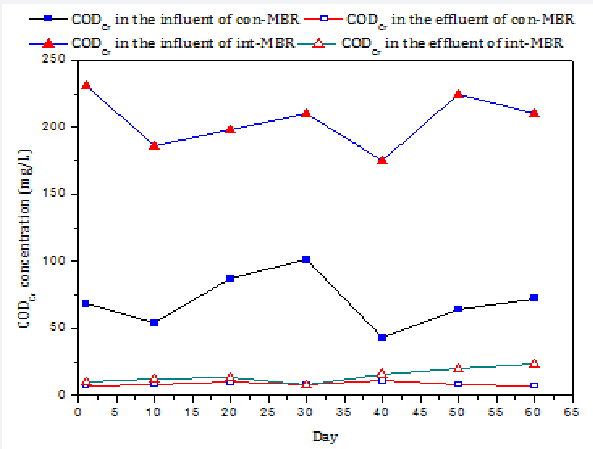

Figure 2: COD removal of con-MBR and int-MBR.

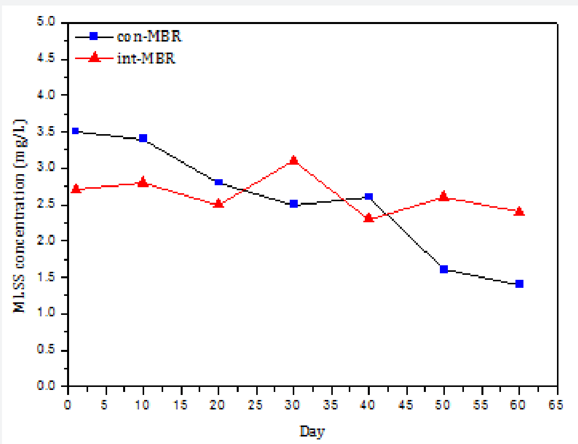

Figure 3: MLSS variations of con-MBR and int-MBR.

NH_4+-N was the one of majority pollutant in the municipal wastewater, especially toilet waste water [1,3]. As Figure 3 & 4 shows, NH_4+-N also presented a lower concentration in con-MBR due to treated wastewater refill. Although NH_4+-N in the influent of int-MBR was approximate 2-3 times of that of con-MBR, two MBRs both had excellent NH_4+-N removal during operation, indicating operational model had no obvious effect on the NH_4+-N removal. Nitrification is the biological conversion of NH_4+-N to NO_3--N under aerobic condition [14] (Eq. 1):

$$NH_4^+ + 2O_2 = NO_3^- + 2H^+ + H_2O \quad (1)$$

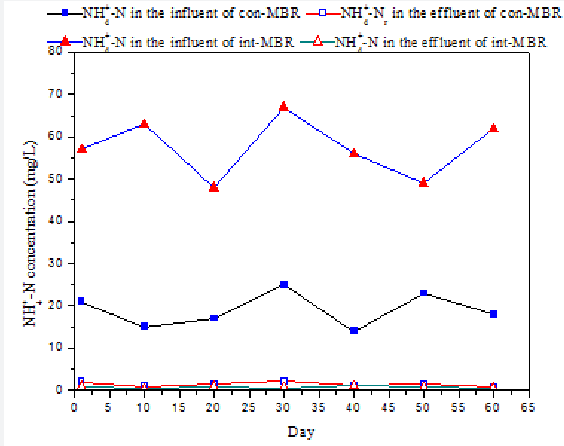

Figure 4: NH_4+-N removal of con-MBR and int-MBR.

Therefore, high DO promoted NH_4+-N transferring into NO_3--N. Additionally, previous literatures [15-18] showed that MBR was a perfect wastewater treatment for NH_4+-N removal. Consequently, high oxygen supply was the key for NH_4+-N removal, no matter in what operational model.

At addition, Figure 5 presents TN removal variation between con-MBR and int-MBR. Although there is no obvious TN variation in the effluent between con-MBR and int-MBR, int-MBR had a higher TN in the influent than con-MBR, meaning that int-MBR had better TN removal than con-MBR. During denitrification, NO_3-was the electron acceptor and organic carbon worked as the carbon source [19], and CODCr consuming of denitrification was normally 2.86g CODCr/g NO_3-N [20]. Therefore, in this reuse system, con-MBR had low CODCr for TN degradation, finally leading to low TN removal. Figure 6 also shows TP removal performance of con-MBR and int-MBR. For traditional wastewater treatment, TP removal was contributed with bacterial growth and phosphate accumulating organism. However, this reuse system had no sludge discard, and TP removal was mainly depended on the bacterial growth. Consequently, int-MBR had a great TP removal due to better bacterial growth (Figure 3). But considering long-time operation, regular sludge discard is needed for MBR to remove TP and re-fresh activated sludge. Additionally, operational cost for int-MBR was only 0.6-0.7 of that for con-MBR. Therefore, int-MBR presented a better performance for this toilet wastewater reuse system.

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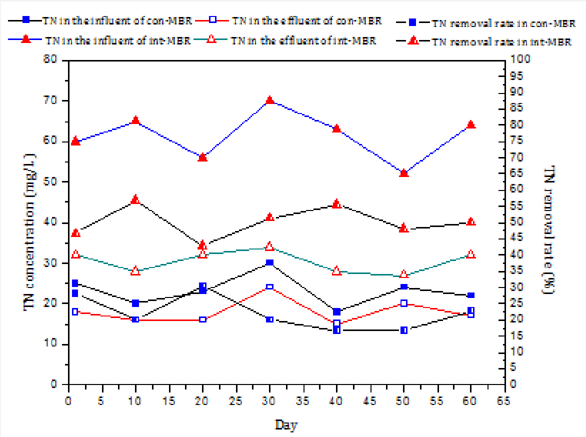

Figure 5: TN removal of con-MBR and int-MBR.

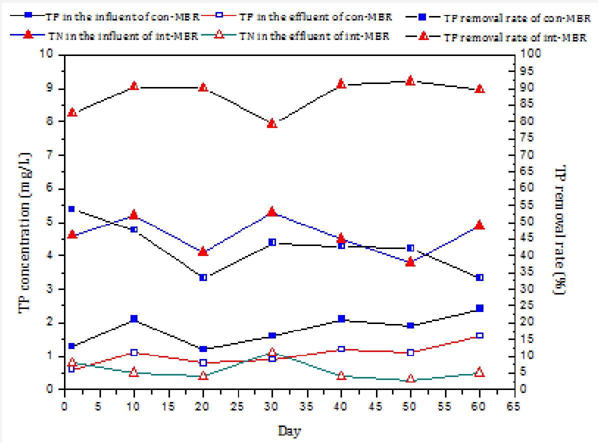

Figure 6: TP removal of con-MBR and int-MBR.

Conclusion

This study mainly presented the comparison between continuous and intermittent model on the performance of a pilot-scale A/O-MBR for toilet wastewater reuse system. Because of remaining sludge and high DO, both continuous and intermittent model showed a great performance on CODCr and NH_4+-N removal. But because of low COD, continuous model was difficult to maintain stable and high MLSS during operation, and also inhibited TN removal. Additionally, TP removal mainly relied on the bacterial growth in both models. Therefore, intermittent model presented a better performance for this toilet wastewater reuse system.

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References

1. Boehler M, Joss A, Buetzer S, Holzapfel M, Mooser H, et al. (2007) Treatment of toilet wastewater for reuse in a membrane bioreactor. Water Sci Technol 56(5): 63-70.
2. Abu Ghunmi L, Zeeman G, Fayyad M, van Lier JB (2011) Grey Water Treatment Systems: A Review Crit Rev Environ Sci Technol 41(7): 657-698.
3. Fountoulakis MS, Markakis N, Petousi I, Manios T (2016) Single house on-site grey water treatment using a submerged membrane bioreactor for toilet flushing. Sci Total Environ 551-552: 706-711.
4. Fan YB, Li G, Wu LL, Yang WB, Dong CS, et al. (2006) Treatment and reuse of toilet wastewater by an airlift external circulation membrane bioreactor. Process Biochem 41(6): 1364-1370.
5. Zhou L, Zhang Z, Jiang W, Guo W, Ngo HH, et al. (2014) Effects of low-concentration Cr (VI) on the performance and the membrane fouling of a submerged membrane bioreactor in the treatment of municipal wastewater. Biofouling 30(1): 105-114.
6. Abegglen C, Siegrist H (2006) Domestic wastewater treatment with a small-scale membrane bioreactor. Water Sci Technol 53(3): 69-78.
7. Yeom IT, Nah YM, Ahn KH (1999) Treatment of household wastewater using an intermittently aerated membrane bioreactor. Desalination 124(1-3): 193-203.
8. Wisniewski C (2007) Membrane bioreactor for water reuse. Desalination 203(1-3): 15-19.
9. Wang ZW, ZC Wu, Mai SH, Yang CF, Wang XH, et al. (2008) Research and applications of membrane bioreactors in China: Progress and prospect. Sep Purif Technol 62(2): 249-263.
10. Zuo JL, Xu YP, Zhao Y, Cui FY (2005) Study on the treatment of food wastewater by MBR for reuse in local factory.
11. Santasmasas C, Rovira M, Clarens F, Valderrama C (2013) Grey water reclamation by decentralized MBR prototype. Resources Conservation and Recycling 72: 102-107.
12. Ratanatamskul C, Suksusieng N, Yamamoto K (2014) A prototype IT/BF-MBR (inclined tube/biofilm-membrane bioreactor) for high-rise building wastewater recycling. Desalination and Water Treatment 52(4-6): 719-726.
13. China-NEPA (2002) Water and Wastewater Monitoring Methods, in, Chinese Enviromental Science Publishing House, Beijing, China.
14. (2006) Biological Nutrient Removal (BNR) Operation in Wastewater Treatment Plants, McGraw-Hill Professional, ISBN: 0-0714-6415-8.
15. Xia SQ, Li JX, Wang RC, Li JY, Zhang ZQ (2010) Tracking composition and dynamics of nitrification and denitrification microbial community in a biofilm reactor by PCR-DGGE and combining FISH with flow cytometry. Biochem Eng J 49(3): 370-378.
16. Xia S, Guo J, Wang R (2008) Performance of a pilot-scale submerged membrane bioreactor (MBR) in treating bathing wastewater. Bioresour Technol 99(15): 6834-6843.
17. Nah YM, Ahn KH, Yeom IT (2000) Nitrogen removal in household wastewater treatment using an intermittently aerated membrane bioreactor. Environ Technol 21(1): 107-114.
18. Li G, Wu LL, Dong CS, Wu GX, Fan YB (2007) Inorganic nitrogen removal of toilet wastewater with an airlift external circulation membrane bioreactor. Journal of Environmental Sciences 19(1): 12-17.
19. Metcalf I, Eddy H (2003) Wastewater engineering; treatment and reuse. (4th edn), McGraw-Hill, New York, USA.
20. Zhou LJ, Zhao M, Feng L, Wang X, Xu XY, et al. (2016) Performance and bacterial community structure of an anoxic/oxic membrane bioreactor treating anaerobically digested piggery wastewater. Desalination and Water Treatment 57(59): 28581-28591.

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