Desalination and Water Treatment
www.deswater.com
doi: 10.1080/19443994.2013.774127

51 (2013) 4825–4828
July

Taylor & Francis
Taylor & Francis Group

Engineering application of MBR in treating the fiberglass wastewater

Ming-Chien Su[a], Nien-Hsin Kao[b,*], Wen-Chun Huang[b]

[a]*Department of Natural Resources and Environmental Studies, National Dong Hwa University, No. 1, Sec.2, Da Hsueh Rd., Shoufeng, Hualien 97401, Taiwan*
[b]*Department of Environmental Engineering, Kun Shan University, No. 949, Da-Wan Road, Yun Kan District, Tainan City 710, Taiwan*
Tel. +886 6 2050494; Fax: +886 6 2050540; email: kaon@mail.ksu.edu.tw

Received 20 August 2012; Accepted 15 January 2013

ABSTRACT

A 100- L pilot Membrane Bioreactor (MBR) in situ experimental facility was used to study the treating ability of fiberglass plant wastewater. Fiberglass wastewater has the characteristic of high Chemical oxygen demand (COD) concentration after the processes of mixing, desizing, dyeing and snag under high-temperature condition. The object of the study was to improve the existing wastewater treatment process by applying the MBR system. The study was conducted in a six months period and an engineering scale up MBR system with 800 CMD of treating capacity was built into the wastewater treatment plant and had improve the quality of discharged wastewater and achieved the purpose of wastewater reclamation. The results showed that at 12 h of HRT (Hydraulic Retention Time) for the MBR system, the COD concentration was reduced from original 900 to 1300 mg/L to under 50 mg/L with the COD removal efficiency at 94 to 96%.

Keywords: MBR (Membrane bioreactor); Fiberglass wastewater; Engineering application

1. Introduction

Fiberglass is the base material for making the printed circuit board and other essential electronic composition. Generally, wastewater generated by the fiberglass industry consists of high chemical oxygen demand (COD) materials, such as polyvinyl alcohol, starch, and other inorganic composition. To treat this kind of wastewater, a process of removing inorganic matter before the organic composition in the wastewater is necessary [1]. The application of Membrane Bioreactor Reactor (MBR) in treating various kinds of wastewater and module design has been reported by various researchers [2–7]. Combination of MBR with other treatment unit or a hybrid system is also necessary to reach better treatment efficiency for certain

*Corresponding author.

Presented at the Conference on Membranes in Drinking and Industrial Water Production.
Leeuwarden, The Netherlands, 10–12 September 2012.
Organized by the European Desalination Society and Wetsus Centre for Sustainable Water Technology

1944-3994/1944-3986

kind of wastewater. Application of ozonation, adsorption, coagulation, flotation, and MBR to enhance the removal of organic or heavy metal in wastewater was reported and could reach good removal efficiency [8–11]. Due to the strengthener wastewater discharge standard, improve or upgrade treatment process is necessary and MBR is one of technology to meet a higher regulation and can be applied in wastewater reuse [12–14]. Researchers also reported that the characteristic of different membrane was related to its performance and subjected to different flux range in treating industrial wastewater [15]. However, there were few reported cases about engineering application of a pilot MBR study into the actual treatment process. In our study, we applied the results of a pilot-scale MBR reactor as the design data to build an engineering scale MBR system to improve an existing wastewater treatment process and achieved the goal of wastewater reclamation. The applied N-MBR® in the study has the characteristics of large strength, high flux, low-pressure head loss, energy saving in cleaning, easy of replacement, and operation.

2. Materials and methods

An in situ MBR reactor was used to study the biological treatment efficiency in treating the wastewater, and the results were used as the engineering design parameters in setting up an 800 CMD MBR unit. In the beginning, a MBR pilot reactor with treatment capacity of 50 to 100 L/day was used to treat the targeted fiberglass wastewater. Fig. 1 shows the schematic of the facility which included the necessary auxiliary devices and the main 70- L plexiglass tank that contains the PTFE N-MBR® with the dimension of 30 cm(L) × 20 cm(W) and pore size of 0.3 μm. The adjustment of negative transmembrane pressure (TMP), routinely backwash cleaning with 50 ppm of NaOCl, pH controller, and the combination of ultrasonic water lever sensor and influent peristaltic pump were used to achieve the optimum and stable flux conditions. Seeding activated sludge for the MBR was taken from a wine and brew plant. The initial sludge concentration (mixed liquor volatile suspended solids [MLVSS]) in the reactor was starting from 3,500 mg/L in the day 1 to the steady state of biomass in the reactor was reached and the concentration was maintained around 12,000 mg/L. The influent wastewater to the MBR was come from the effluent of Dissolved Air Flotation (DAF) unit after a chemical coagulation treatment unit. The operated inflow rate was started from 25 L/day in day 1 and raised by a 5 L/day increment for each step until reached constant flow rate and which was 100 L/day. Simultaneously, the negative TMP was also set at 0.1 cmHg in the beginning and adjusted step by step until steady state was reached. COD and SS were analyzed according to published standard methods of Taiwan EPA which are NIEA W514.21B and NIEA W210.57A, respectively.

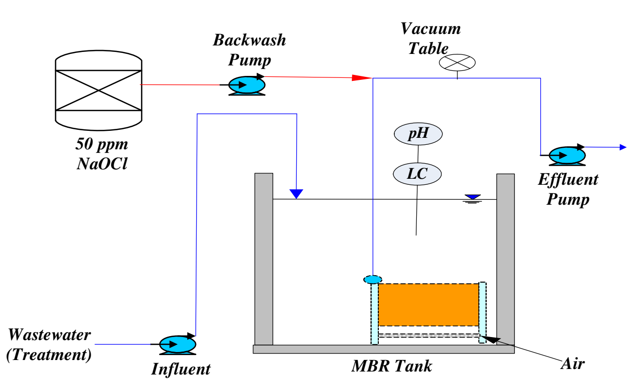

Fig. 1. Schematic diagram of the MBR pilot reactor.

3. Results and discussion

3.1. Pilot MBR study

During the incubation phase of the sludge in the reactor, a clear color change from original brown to the steady yellow orange was observed and which indicated that advantage microorganism was the dominated population in the reactor. Fig. 2 shows at the operation day of 130, the biomass had reached a designed stable concentration that was around 12,000 mg/L and the ratio of biomass (MLVSS/mixed liquor suspended solids [MLSS]) was greater than 0.90 which indicated a good composition of the microorganism population. Fig. 3 shows the fluctuation of influent COD was around 900 to 1,300 mg/L and

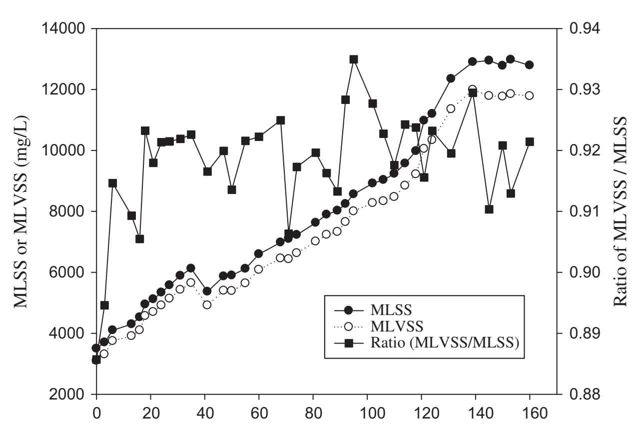

Fig. 2. Variation of biomass concentration in the MBR system.

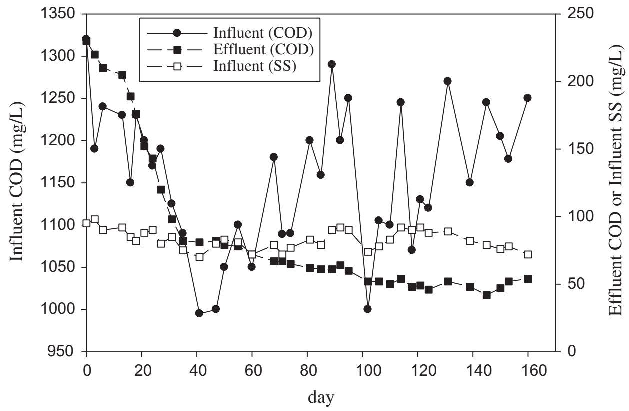

Fig. 3. Variation of COD and SS concentration in the MBR system.

influent SS was between 70 to 90 mg/L range. However, the treated effluent COD could reach below 50 mg/L with the treatment efficiency of greater than 96% and the SS in the effluent were all under 1 mg/L. The major operation parameters of the MBR system was showed in Fig. 4 which indicated that HRT, Flux, TMP, and F/M ratio were gradually adjusted to fit the respected conditions in each step. At steady state of day 130, the best removal efficiency was achieved, and the Flux, F/M ratio, HRT and TMP were set at 0.42 m^3/m^2-day, 0.2 ± 0.05 kgCOD/kgMLVSS-day, 12 h, and 0.25 cmHg, respectively.

3.2. Engineering application

Based on the results of the pilot MBR study, an engineering scale MBR treatment unit was designed, built, and operated into the existed wastewater treatment plant. The treatment plant is owned and operated by the FL fiberglass manufacture factory that is located within the MH industrial park. According to our governmental regulations, for factory that is located within an industrial park, wastewater discharge permit and water pollution fees are required based on their discharge flow rate and quality. Thus, the FL factory wished to improve their wastewater treatment process to reduce the regulatory fees. The upgraded overall treatment units of the in situ process are in the order of fine screening, equalization, chemical coagulation, DAF, pH adjustment, and the MBR system. The finalized treatment process did improve the COD removal efficiency and achieved the goal of wastewater reclamation. The design parameters for the wastewater treatment plant were based on the 800 CMD inflows at the beginning with COD 2,300 mg/L, SS 250 to 400 mg/L. After the DAF unit, the COD concentration was reduced to about 900 mg/L before it inflow to the MBR system and effluent quality of COD was set at under 50 mg/L with SS under 1 mg/L. Additional, 50% of wastewater was recovered and reused after the operation of the MBR unit. Table 1 shows the major design parameters for the MBR that were based on the study results and the actual engineering requirements and the operation recorded show that it had achieved the objective. As mentioned, the FL factory is located within the MH industrial park, and the regulated pollution fees were calculated based on the flow rate and quality of the discharged wastewater. The regulated pollution fees (in NT$) are 9.33/$m^3$, 50.30/kg and 133.14/kg for discharged flow rate, COD and SS, respectively [16]. After upgrading the wastewater treatment process, the estimated cost saving can be up to 357,000/month (about 9,400€/month) which indicated that installed MBR system is worthwhile both in treatment efficiency and finance perspective (Table 2).

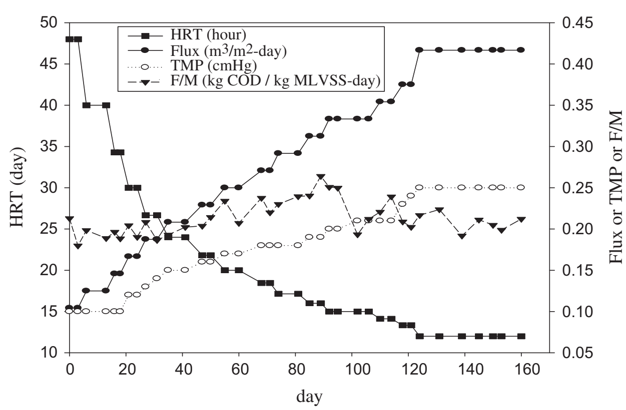

Fig. 4. Variation of operation parameters in the MBR system.

Table 1
The major design parameters of the engineering scale MBR

Membrane module	Designed parameters	Operation parameters
• Material: PTFE(outer layer)/PET (inner layer) flat with 3D structure • Pore size: 0.7 ± 0.1 μm • Submerged and suspended, parallel arrangement	• F/M ratio: 0.15 kg COD/kg MLVSS-day • MLSS: 12,000 mg/L • Reactor volume: 400 m^3 • Flux: 0.3 m^3/m^2-day • Air inflow: 16 m^3/min	• 50 cm under water level • sporadic cycle: 15 min suction/3 min break • Backwash: after 80 cycle/day • Sludge discharge: 3 m^3/day

Table 2
Estimated cost saving before and after install the MBR system

Regulatory fees based on discharged wastewater quality (in NT$/month)	COD	SS	Total amount
Before (without MBR)	320,000	70,000	390,000
After (with MBR)	30,000	3,000	33,000
Saved cost	290,000	67,000	357,000

4. Conclusions

The studied results of the MBR reactor had successfully adopted and engineering applied into upgrading an existing wastewater treatment process by installed a MBR system. The 800 CMD designed treating capacity MBR was and had improved the quality of discharged wastewater and achieved the purpose of wastewater reclamation. The results showed that at 12 h of HRT for the MBR system, the COD and SS were reduced from original 900 to 1,300 mg/L to under 50 mg/L and 1 mg/L, respectively. The removal efficiency of COD for the kind of wastewater can be up to 94 to 96% and the estimated cost saving was also shows great reducing in regulatory fees.

Acknowledgment

The project was funded by the FL factory in upgrading the wastewater treatment process.

References

[1] W. Jun-jie, H. Qin-hai, W. Meng-qing, Treatment of Fiberglass Wastewater. Environ. Sci. Technol. 06 (2004). http://en.cnki.com.cn/Article_en/CJFDTotal-FJKS200406012.htm (accessed August 16, 2012).

[2] T. Buer, J. Cumin, MBR module design and operation, Desalination 250 (2010) 1073–1077.

[3] M.C. Chang, R.Y. Horng, H. Shao, Y.J. Hu, Performance and filtration characteristics of non-woven membranes used in a submerged membrane bioreactor for synthetic wastewater treatment, Desalination 191 (2006) 8–15.

[4] W.K. Chang, A.Y.J. Hu, R.Y. Horng, W.Y. Tzou, Membrane bioreactor with nonwoven fabrics as solid-liquid separation media for wastewater treatment, Desalination 202 (2007) 122–128.

[5] A. Lim, R. Bai, Membrane fouling and cleaning in microfiltration of activated sludge wastewater, J. Membr. Sci. 216 (2003) 279–290.

[6] F. Meng, H. Zhang, F. Yang, L. Liu, Characterization of cake layer in submerged membrane bioreactor, Environ. Sci. Technol. 41 (2007) 4065–4070.

[7] M. Cheryan, N. Rajagopalan, Membrane processing of oily streams, wastewater treatment and waste reduction, J. Membr. Sci. 151 (1998) 13–28.

[8] G. Mascolo, G. Laera, A. Pollice, D. Cassano, A. Pinto, C. Salerno, A. Lopez, Effective organics degradation from pharmaceutical wastewater by an integrated process including membrane bioreactor and ozonation, Chemosphere 78 (2010) 1100–1109.

[9] V. Mavrov, T. Erwe, C. Bocher, H. Chmiel, Study of new integrated processes combining adsorption, membrane separation and flotation for heavy metal removal from wastewater, Desalination 157 (2003) 97–104.

[10] N. Lesage, M. Sperandio, C. Cabassud, Study of a hybrid process: Adsorption on activated carbon/membrane bioreactor for the treatment of an industrial wastewater, Chem. Eng. Process. 47 (2008) 303–307.

[11] D. Abdessemed, G. Nezzal, Treatment of primary effluent by coagulation–adsorptionultrafiltration for reuse, Desalination 152 (2002) 363–373.

[12] Ch. Brepols, E. Dorgeloh, F.-B. Frechen, W. Fuchs, S. Haider, A. Joss, K. de Korte, Ch. Ruiken, W. Schier, H. van der Roest, M. Wett, Th. Wozniak, Upgrading and retrofitting of municipal wastewater treatment plants by means of membrane bioreactor (MBR) technology, Desalination 231 (2008) 20–26.

[13] T. Melin, B. Jefferson, D. Bixio, C. Thoeye, W. De Wilde, J. De Koning, J. van der Graaf, T. Wintgens, Membrane bioreactor technology for wastewater treatment and reuse, Desalination 185 (2006) 271–282.

[14] J. Arévalo, L.M. Ruiz, J.A. Parada-Albarracín, D.M. González-Pérez, J. Pérez, B. Moreno, M.A. Gómez, Wastewater reuse after treatment by MBR. Microfiltration or ultrafiltration? Desalination 299 (2012) 22–27.

[15] B. Bienati, A. Bottino, G. Capannelli, A. Comite, Characterization and performance of different types of hollow fiber membranes in a laboratory-scale MBR for the treatment of industrial wastewater, Desalination 231 (2008) 133–140.

[16] Wastewater discharged pollution fees, Ministry of Economic Affairs Industrial Development Bureau, Ming Hsiung Industrial Park, http://www.moeaidb.gov.twiphwminsyong-service02.pdf (accessed August 16, 2012).