DOI: 10.15625/vap.2019.000190

EVALUATING REMOVAL ABILITY OF MICROORGANISMS BY USING MEMBRANE

Thi-Tra-My Ngo[1, 2*], Thi-Ngoc-Hang Luong[1], Tran-Kim-Phung Nguyen[1], Hong-Hai Nguyen[1,3], Thi-Khanh-Dieu Hoang[1], Xuan-Thanh Bui[1]

[1] Faculty of Environment and Natural Resources, Ho Chi Minh City University of Technology, VNU-HCM, Vietnam. 268 Ly Thuong Kiet street, district 10, Ho Chi Minh City, Vietnam.
[2] Graduate School of Engineering, Nagasaki University, Nagasaki 852-8521, Japan.
[3] Institute for Environmental Science, Nguyen Tat Thanh University, Ho Chi Minh city, Vietnam.
**Corresponding author email: tramyngo1310@gmail.com*

ABSTRACT

The rapid growth of the population produces a massive quantity of domestic wastewater including a lot of pathogenic bacteria. Hence, removing bacteria in wastewater is becoming a large environmental problem. Membrane bioreactor (MBR) was considered as an effective method to remove microorganisms without creating dangerous substances. In this study, the removal efficiency of lab-scale membrane bioreactor (MBR) was compared with that of pilot-scale. The number of *Escherichia coli (E. coli)* and *Staphylococcus aureus (S. aureus)* in the feed solution were 10^7-10^8CFU/100Ml for each special on the lab-scale system. While the number of coliforms of the pilot-scale one was around 1.76×10^8 CFU/100mL. The MBR process was able to achieve 7.3 and 8.4 log10 higher reductions of bacteria compared to the lab-scale system (5.6 log10 for coliform). The effluent of both two systems qualified the standard QCVN 14-MT: 2015/BTNMT. Therefore, MBR proved to be a potential technology to remove the microorganisms in wastewater, avoiding their impacts on the environment.

Keywords: Escherichia coli, Staphylococcus aureus, microorganism removal, MF filtration.

1. INTRODUCTION

With rapid economic development, the impacts of climate change and population growth have led to the extremely serious degradation of water resources. In particular, domestic wastewater includes water from toilets, washing baths, leftovers, etc., containing lots of pathogenic bacteria which were stinky, dirty and impacts to especially serious human health (*Khan et al., 2018*). Therefore, removing these harmful bacteria is essential. For this purpose, some conventional treatment methods such as using the activated sludge, adsorption, forward osmosis, and advanced oxidation have been proved to be effective only in removing the common biodegradable compounds or a certain type of pollutant. Moreover, some conventional disinfection methods like chlorination, ozone or peracetic acid (*Khan et al., 2018*) could create harmful by-products (for example, Trihalomethanes- TMH). Therefore, it is necessary to focus on developing alternative technologies.

The membrane bioreactor (MBR), an advanced biological method, was considered to be effective to remove microorganisms without creating dangerous substances. Moreover, the development of membrane bioreactor (MBR) technology reduced the operating and maintenance cost (*Chen et al., 2017*). Therefore, evaluating the removal ability of microorganism by membrane was conducted in this research at 2 scales. Study on the laboratory-scale system was carried out first to evaluate the removal efficiency of *E. coli* and *S. aureus*. Another system was conducted to removal Escherichia coli and Coliform bacteria on a pilot scale. This study aimed to determine the removal ability of microorganisms by microfiltration (MF) membrane, to meet the discharge standards to the environment.

2. METHODS

2.1. Experimental membrane system

2.1.1. The lab-scale system

The lab-scale system was described in **Figure 1**. Each tube contained 4 fibers. A hollow-fiber polyvinylidene fluoride (PVDF) membrane was installed with a pore size of 0.1 µm, the height of 240 mm, the outer diameter of 2 mm, the inner diameter of 0.6 mm. The used feed solution was a nutrient broth solution which was cultured to the concentration of bacterial of 10^7 - 10^8CFU/100mL.

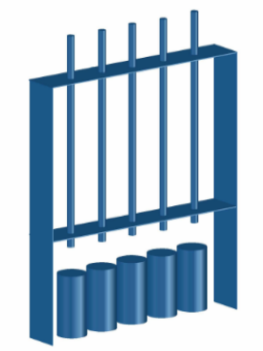

Fig.1. Lab-scale system

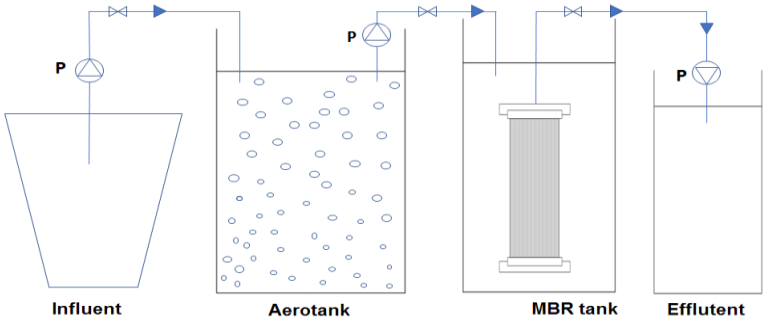

Fig. 2. Pilot-scale system submerged MBR

2.1.2. The pilot-scale MBR system

The wastewater contained in a storage tank was injected continuously into a reactor by a feeding pump. A submerged hollow-fiber polyvinylidene fluoride membrane modules (KOLON, Korean) was installed with a pore size of 0.1 µm, fibers number of 176 and the surface area of 2.2 m^2 (**Figure 2**). The influent of the system was the domestic wastewater which was collected from B4 building in Bach Khoa University on Wednesday every week. The concentration of raw domestic wastewater was presented in **Table 1.**

Table 1. Domestic wastewater characteristics

Parameter	**Value**
pH	6.7 ± 0.3
COD (mg/L)	800 ± 150
TKN (mg/L)	28 ± 15
NH_4^+-N (mg/L)	13.5 ± 4.0
NO_2^-N (mg/L)	0.1 ± 0.07
NO_3^-N (mg/L)	0.67 ± 0.15
TP (mg/L)	1.4 ± 0.5
Total Coliforms (CFU/100mL)	146×10^6

2.2. Sampling method and data processing

2.2.1. For lab-scale experiments

This research used feed solution which was cultured to the concentration of bacterial of 10^7 - 10^8 CFU/100mL. After that, it was filtered by MF.

2.2.2. For pilot-scale

Wastewater was collected daily from the collection system of B4 building. Samples were taken every morning after the normal operation model was checked. The fixed sampling time was 7:30 am to 8:30 am.

$$\text{Log removal} = \text{Log}_{10}(A) - \text{Log}_{10}(B)$$

Where:

A: the number of viable microorganisms before filtration.

B: the number of viable microorganisms after filtration.

Sample mean value:

$$X_{tb} = \frac{X_1 + X_2 + X_3}{3}$$

Where: X_1, X_2, X_3: concentration of microorganisms, CFU/100mL.

Data were processed by statistical methods using Excel 2013.

3. RESULTS AND DISCUSSION

3.1. The bacteria removal efficiency of the lab-scale system

The obtained results showed that during the membrane filtration using MF 0.1µm, almost all samples didn't have the presence of *E. coli*. This is explained by the fact that the size of the *E. coli* varies from 1 to 3µm while the pore of the membrane is 0.1µm, so *E. coli* was retained on the membrane surface. Removal efficiency calculated by log removal of E. coli and S. aureus were respectively 7.3log10 and 8.4log10. The result from this study showed that with the same feed concentration, log removal of *E. coli* was similar to the research of *Joseph et al. (1997)* (7.8 $\log_{10}$). This research proved that the MF with a membrane pore size of 0.1μm could remove most of the *E. coli*.

The obtained data showed that almost all the samples after filtering by MF 0.1µm membrane were not detected *Staphylococcus.* The results proved that this membrane could effectively filter *Staphylococcus* due to the size of *Staphylococcus* 0.5 to 1.5µm while the membrane size was 0.1µm. The result from this study showed that with the same feed concentration, log removal of *S. aureus* was similar to the research of *Joseph et al. (1997*) (8.2 $\log_{10}$) and log removal was high.

3.2. The bacteria removal efficiency of the pilot-scale system

All samples of wastewater from the *pilot-scale* system were reported to have coliform. *E. coli* rarely appeared, and only around <3 CFU/mL. In general, the number of *E. coli* and Coliform of the permeate flow met the National Technical Standards For Domestic Wastewater - QCVN 14-MT:2015/BTNMT. The average of log removal rate in this study was 5.6, lower than the previous in the laboratory-scale test. Therefore, it could be concluded that the MF membrane in the optimal conditions had better removal efficiencies than in the wastewater treatment applications. For lab-scale, the microbiological removal efficiency was optimal, because samples were analyzed in completely sterilization conditions, so the permeate on lab-scale almost no bacteria detected, leading to very high efficiency.

4. CONCLUSION

After operating two systems, the results of this study showed that on the lab-scale system, MF membrane could remove 1.95×10^7 CFU/100mL of *E. coli* and 2.60×10^8 CFU/100mL of *S. aureus.* Removal efficiency calculated by log removal of *E. coli* and *S. aureus* were respectively 7.3log10 and 8.4log10.

On pilot-scale, the number of *E. coli* and Coliforms which collected from B4 building wastewater was 1.76×10^8 CFU/100mL, when treated by the MBR system, the removal efficiency was 5.6log. From the results, the research on the two systems had some significant differences due to the research and sterilization conditions.

REFERENCES

[1]. Chen, W., Luo, J., Cao, R., Li, Y., Liu, J., (2017). Effect of macroporous adsorption resin-membrane bioreactor hybrid system against fouling for municipal wastewater treatment. *Bioresource Technology*, 224, 112-117.

[2]. Hirani, Z.M., Decarolis, J.F., Adham, S.S., Jacangelo, J.G., (2010). Peak flux performance and microbial removal by selected membrane bioreactor systems, *Water Research*, 44(8), 2431-2440.

[3]. Joseph G., Jacangelo, Samer, A., Laîné, J.M., (1997). Membrane Filtration for Microbial Removal, 39 - 45.

[4]. Khan, M.A., Ngo, H.H., Guo, W., Liu, Y., Chang, S.W., Nguyen, D.D., Nghiem, L.D., Liang, H., (2018). Can membrane bioreactor be a smart option for water treatment? *Bioresource Technology Reports*.

[5]. Kim, Y., Li, S., Chekli, L., Woo, Y.C., Wei, C.H., Phuntsho, S., Shon, H.K., (2017). Assessing the removal of organic micro-pollutants from anaerobic membrane bioreactor effluent by fertilizer-drawn forward osmosis. *Journal of Membrane Science*, 533, 84-95.

[6]. Luca, D.G., Sacchetti, R., Leoni, E., Zanetti, F. (2013). Removal of indicator bacteriophages from municipal wastewater by a full-scale membrane bioreactor and a conventional activated sludge process: Implications to water reuse. *Bioresource Technology*, 129, 526-531.

[7]. Marti, E., Monclús, H., Jofre, J., Rodriguez-Roda, I., Comas, J., Balcázar, J. L. 2011. Removal of microbial indicators from municipal wastewater by a membrane bioreactor (MBR), *Bioresource Technology*, 102(8), 5004-5009.

[8]. Zhang, K., Farahbakhsh, K., (2007). Removal of native coliphages and coliform bacteria from municipal wastewater by various wastewater treatment processes: Implications to water reuse. *Water Research*, 41, 2816-28