AGU International Journal of Sciences – 2020, Vol. 8 (1), 94 – 100

AGU INTERNATIONAL JOURNAL OF SCIENCES
ISSN 0866 - 8086

THE OPTIMUM OPERATIONAL CONDITION OF WOVEN FIBER MICROFILTRATION IN A SEPTIC TANK TO IMPROVE THE QUALITY OF EFFLUENT

Vo Thi Dao Chi[1], Nguyen Tran Thien Khanh[1]
[1]An Giang University, VNU-HCM

Information:
Received: 12/03/2020
Accepted: 25/05/2020
Published: 04/2021

Keywords:
Domestic wastewater, membrane, Woven Fiber Microfiltration, septic tank, reuse

ABSTRACT

In this study, the Woven Fiber Microfiltration (WFMF) is used as a membrane material. This membrane is cheaper in price and more robust in comparison with the current other membrane materials, thus is able to withstand harsh working conditions. The research seeks optimal value of permeate flux. After doing the operations, the flux of 4 L/m^2.h was selected as a suitable value for WFMF operation. The removal efficiency of COD of this system was above 38.13%.The removal efficiency of suspended solid was from 90.33% to 95.97% and the highest coliform removal was 99.62%.

1. INTRODUCTION

The world is facing with problems relating to water sanitation due to excessive disposal of untreated wastewater. Many poor communities with low income have barriers in upgrading wastewater treatment systems and management of domestic wastewater discharge. Currently, more than one billion people do not access to safe drinking water (Roesner et al., 2006). Therefore, the reusing treated wastewater can be a part of sustainable water management (Adam, 2002).

Membrane technology is one of a physical separation process and acts as a filter to reject pollutants. The separation performance of membrane types based on the pore size and the separation driving force (Pillay, 2008). The use of membrane as a processing and separation method in manufacturing, medical, water treatment and fuel cells, i.e… is gaining a wide application of this technology due to the myriad of advantages. Despite being widely applied, the operation of membranes still requires high energy consumption and still suffer from fouling adding to the overall cost of the running (Kraume,2005).

An immersed membrane bioreactor (IMBR) is a combination of a biological treatment and membrane filtration technology. That includes a bioreactor and a membrane system together in an existing single unit, and does not occupy land use. According to Rocky (2004), IMBR can remove coliform bacteria and suspended solids are not removed completely by the conventional activated sludge process. Further, the age of sludge in IMBRs is increased, but the sludge production is low. IMBRs have been a selection to apply in isolated villages, small communities, buildings, and small industries to collect a good effluent that can be used as non-potable water. The selecting and investing IMBR to waste water treatment and reuse could be a suitable selection for sanitation approach for many countries.

In this study, the Woven Fiber Microfiltration (WFMF) was used as an IMBR that has potential advantages over current commercial membrane modules. Advantages are not destroyed under dry heat, scouring, easy to clean without chemicals, and very robust, thus able to withstand rough manhandling. Another advantage of using WFMF is that it has a permeate quality meeting national or regional drinking water quality regulations (Martha,2019).

In order to optimize the WFMF membrane performance, some parameters were evaluated, such as permeate flux, trans-membrane pressure. The quality of the permeate were conducted in the laboratory. The goals of the study were to investiagte the highly efficient removal of COD, suspended solids and pathogens.

2. MATERIALS AND METHODOLOGY

The woven fiber microfiltration membrane module consists of five flat sheets were made by woven polyester materials with the pore size of 1 µm to 3 µm. The average daily flow of wastewater entering the septic tank is about 240 liters, so the proposed total area of one unit was nearly 1 m^2 (5 flat sheets). These were fixed together in parallel in row (Figure 2.1).

Table 2.1. Specifications of woven fiber filter

Item	Unit	Characteristic
Membrane type	-	Dead-end, outside-in, flat sheet
Material	-	Polyester
Pore size	µm	1 – 3
Length	cm	38
Width	cm	25.5
Number of membranes	-	5
Total area	m^2	0.969
Initial membrane resistance	$L/m^2.h$	6.46E+11
Operational pressure	kPa	< 80

Figure 2.1. Woven fiber filters

The experiment was directly conducted in a septic tank of a public toilet in HCMC University of Technology. The woven fibre membrane experimental set up was showed in figure 2.2. The module was put in the third chamber of the septic tank.

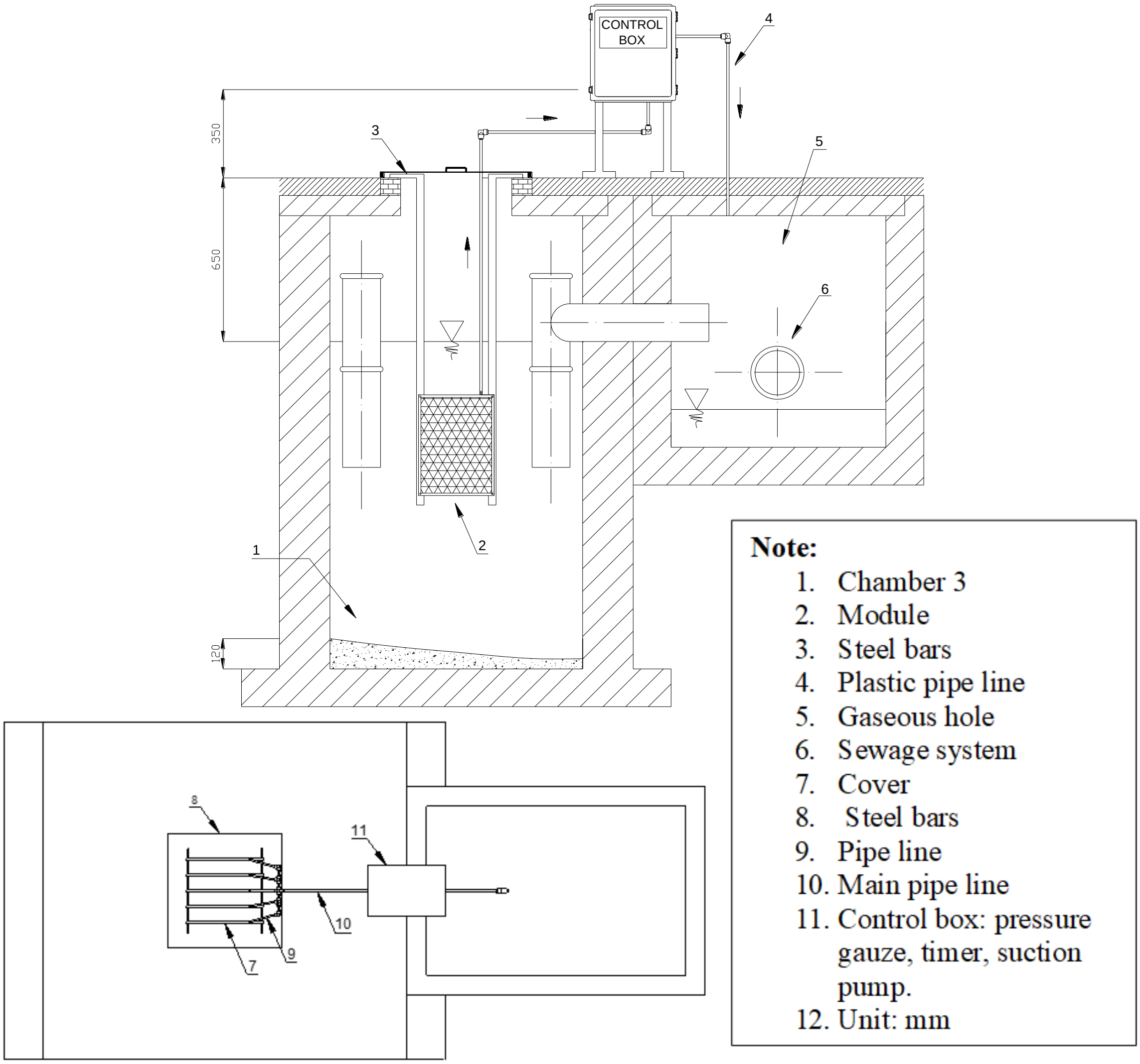

Figure 2.2. The installation of control box

The critical fluxes were determined for each operating set following the conventional procedure:

- The permeate flux was set at a low value of 2 $L/m^2.h$, and the differential trans-membrane pressure (TMP) was recorded one time per day.
- Then, when another flux was increased in higher value, and new differential trans– membrane pressure was recorded.

Table 2.1. Scenarios of membrane working

No. of operation	Operational mode	Flux (kPa)
1	8 minutes on – 2 minutes off	2
2		4
3		6

The electric source was connected to WFMF module. The unit was operated with alternating 8 min of suction with a 2-min pause. When the TMP approximately reached nearly 80kPa at which the membranes were completely fouling. At this stage, the module was stopped and taken out the septic tank to do the cleaning. After that, another running with higher flux was replaced.

For each sample that was collected, the concentration of COD, TSS and fecal coliforms were analyzed. The permeate obtained were also done the same analysis.

3. THE RESULTS OF THE EXPERIMENT

The study was carried out with 3 values of different fluxes in range of 2 L/m^2.h, 4 L/m^2.h, and 6 L/m^2.h to compare the TMP variation and fouling time of each experiment. TMP was recorded every day. The experiments were stopped when TMP reached 80 kPa. The Figure 3.1 shows the trans-membrane variation at different flux in anaerobic condition.

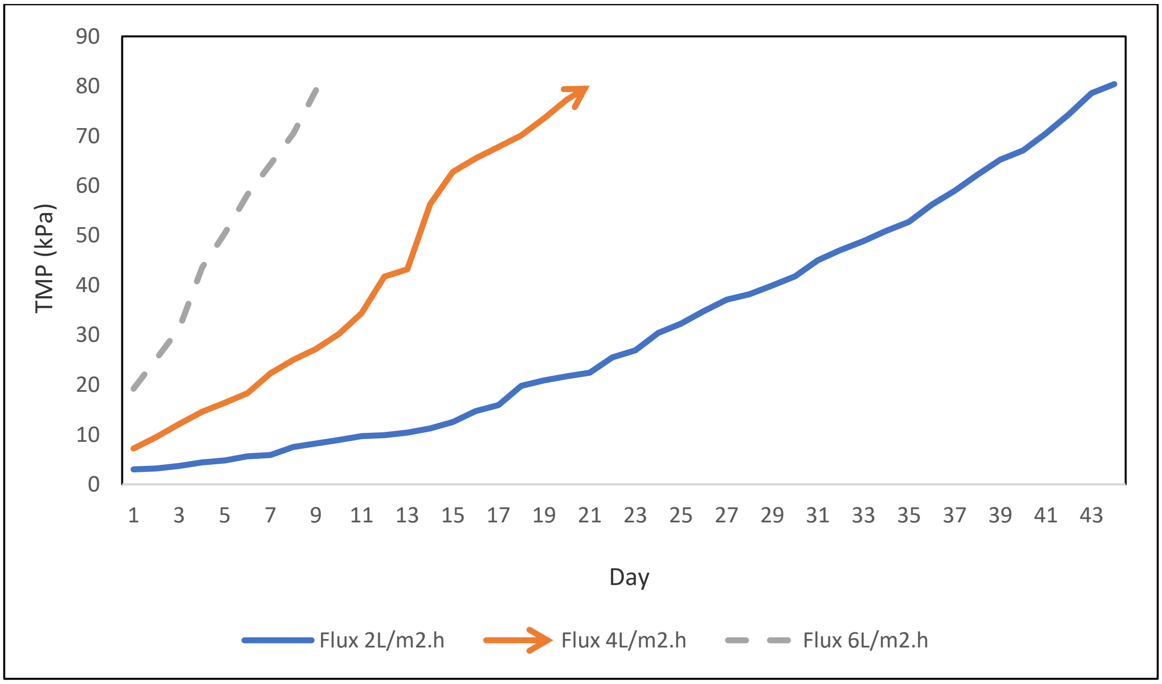

Figure 3.1. Trans-membrane pressure variations in anaerobic condition

Based on the Figure 3.1, at low flux of 2 L/m^2.h, TMP slowly increased, and no the large the TMP variation during the running period due to the slow formation of gel or deposition on the surface of membranes. Membrane module worked for 38 days and was stopped when its TMP was 78.6 kPa on the 43rd day. For the experiment of running with flux of 4

L/m^2.h, the experiment was carried out in the stable condition of wastewater in the third chamber. TMP slowly increased for the first week, and fast increased in the second week. From Figure 3.1, the progress of membrane fouling of this experiment was faster than the experiment of running with flux of 2 L/m^2. h. This experiment was stopped when TMP was 80.1 kPa, and membrane module worked for 22 days. Contrary to TMP variations of membrane running with flux of 2 L/m^2.h and flux of 4 L/m^2.h, the TMP of membrane running with 6 L/m^2.h increased fast because the fast formation of cake layer on membrane surfaces, and membrane module got clogged at 79.2 kPa on the 9th day of its working.

TMP increase of 4 L/m^2.h was faster than TMP of 2 L/m^2.h, but it was less than the increase of TMP of 6 L/m^2. h. The fouling day of 2 L/m^2.h was 43days (at 78.6 kPa). The fouling day of 4 L/m^2.h was 22 days (at 80.1 kPa), and the fouling day of 6 L/m^2.h was 9 days (at 79.2 kPa). These trends in the experiments were also in agreement with literature according to Martha, (2019). In this study, the flux of 2 L/m^2.h was not chosen the optimum flux for the real operational manual because the capacity of treated wastewater/day is too low. Therefore, the flux of 4 L/m^2.h was recommended for the sustainable flux in manual operation.

Table 3.1 shows quality performance of WFMF and activated sludge process in the septic tank.

Parameter	Activated sludge	WFMF	Removal percentage (%)
COD	160 mg/L	99 mg/L	38.13
SS	62mg/L	2.5 mg/L	95.97
Coliform	92000 MPN/100 mL	350 MPN/100mL	99.62

By ANOVA ONE WAY analysis, there was no significant difference in COD removal in range of 2 L/m^2.h, 4 L/m^2.h and 6 L/m^2.h and those were in agreement with literature of Ahn, (1999); Chang, (2002) and Huong, (2012). COD of effluent was from 132.73 mg/L to 160 mg/L. The average COD removal increased from 7.8 to 38.13% with the time.

Average SS removal efficiency of 2 L/m^2.h and 4 L/m^2.h is the same with 95.97% and 93.2% respectively. While SS removal efficiency of flux of 6 L/m^2.h was 90.33%. In fact, there was no significant difference in SS removal of 3 these fluxes by ANOVA analysis. According to Huong, (2012), WFMF remove above 93% of solids and suspended solids after through WFMF was under 10 mg/L and met the Vietnamese standard of discharge. Therefore, the result was in agreement with that research

The highest coliform removal was about 99.6% occurred with flux 2 L/m^2.h and flux 4 L/m^2. h. For flux 6 L/m^2.h, its removal was from 95.75 to 97.4%. By ANOVA ONE WAY analysis, there was no significant difference in coliform removal in range of 2 L/m^2.h, 4 L/m^2.h and 6 L/m^2.h Based on the results of analysis, coliforms removal had the trend in increase at high TMP. This could be explained when membrane nearly got clogged, the pore sizes of membrane became smaller and could prevented the pass of coliform through membrane. The results of coliform removal were in agreement with literatures demonstrated by the following authors: Soriano (2003), Kraume (2005) and Pillay (2018).

4. CONCLUSIONS AND SUGGESTIONS

Appropriate operational condition of flux was found out by carrying out 5 experiments with 3 different fluxes: 2 L/m^2.h, 4 L/m^2.h, 6 L/m^2. h. The experiment running with 2 L/m^2.h worked for 43 days, and it was stopped at 78.6 kPa. The membrane module running with 4 L/m^2.h worked for 22 days, and it was stopped at 80.1 kPa. For running 6 L/m^2.h, membrane module worked for 9 days and it was stopped at 79.2 kPa. Based on the fouling time, and the capacity of treating wastewater, flux of 4 L/m^2.h is recommended the sustainable flux for the WFMF manual operation because the time of membrane working and capacity of treating wastewater could be suitable in practice. The removal efficiency of COD of this system was above 38.13%. The values of SS in the third chamber ranged from 16mg/L to 62 mg/L, but the concentration of SS filtered by WFMF was under 10 mg/L. That met the Vietnamese regulations of discharge. The efficiency of SS removal had the trend in increasing when TMP was higher. For this research, the removal efficiency of suspended solid was from 90.33% to 95.97%. For this study, the highest coliform removal was 99.62%, because the size of coliforms is from 1-2µm, and the size of fecal coliforms are from 0.7 -1.5µm, while pore size of WFMF is 1-3µm in size. Those are reasons for the pass of coliform through from woven fibre membrane system.

In order to know the sustainable flux, the time of WFMF in the last chamber of a septic tank should be lasted more than 6 months to exactly evaluate the removal of COD.

In practice, 22 days for the working time of membrane running with 4 L/m^2.h was not effect. Therefore, should make another study to minimize the WFMF fouling. This suggestion is to combine with scouring air in the compartment installed membrane system.

The size of membrane module also is important. If WFMF has to treat a large of capacity of wastewater, big flat sheet membrane module seems not suitable. The recommendation is to should change the flat sheet form into roll form to increase the membrane surface and minimize the area that WFMF will occupy in the septic tank.

REFERENCES

Adam, C., Gnirss, R., Lesjean, B., Buisson, H., & Kraume, M. (2002). Enhance biological phosphorus removal in membrane bioreactors. *Wat. Sci. Tech, 46 (4-5)*, 281 – 286.

Ahn, K., H., & Song, K., G. (1999). Treatment of domestic wastewater using microfiltration for reuse wastewater. *Desalination,126*,7-14.

Chang, I., S., Clech, P., L., Jefferson, B., & Judd, S. (2002). Memebrane fouling in membrane bioreactors for wastewater treatment. *Journal of Environmental Engineering, 128*, 1018- 1029.

Huong, N., T. (2012). *Applying Woven Fiber Microfiltration to treat wastewater in a septic tank*. (Master's research study, Ho Chi Minh University of Technology, 2012). Ho Chi Minh City: Ho Chi Minh University of Technology.

Kraume, K., Bracklow,U., Vocks, M., and Drews, A. (2005). Nutriens removal in MBRs for municipal wastewater treatment. *Wat. Sci. Tech. 51* (6-7), 391 – 402.

Martha N., Sudesh, R., Kumnandi, P., Pillay, v., l. (2019). *Controlling fouling in a woven fibre microfiltration membrane for water treatment.* 2 Department of Process Engineering, Stellenbosch University, Private Bag X1 Matieland 7602, South Africa.

Pillay, V L., and Jacobs, EP.(2008). *Development of a memebrane pack for immersed memebrane bioreactors*. Water Research Commission. Retrieved on August

2011 from http:// www.wrc.org.za/Pages/DisplayItem.aspx?ItemID=7814.

Pillay, V L., Cele, M., X., & Deelie, M. and Jacobs, EP. (2018). Development of a memebrane pack for immersed memebrane bioreactors. Water Research Commission. Retrieved on FebAugust 2020011 from http://www.wrc.org.za/wp-content/uploads/mdocs/TT%20750-18.pdfom http:// www.wrc.org.za/Pages/DisplayItem.aspx?ItemID=7814.

Rocky Mountain Institute (2004). *Valuing Decentralized Wastewater Technologies*. November, 3-4. Revised in November 2011, from http://www.rmi.org.

Roesner , L., Qian, Y., Criswell, M., Stromberger, M., & Klein, S. (2006). *Long-term Effects of Landscape Irrigation Using Household Graywater*. Colorado: Colorado State University.

Soriano, G. A., Erb, M., Garel, C. & Audic, J. M. (2003). A comparative piot-scale study of the performance of conventional activated sludge and membrane bioreactors under limiting operating conditions. Water Environmental research, 75, 225-231.