



EVALUATION OF WOVEN FIBER MEMBRANE BIOREACTOR EFFICIENCY FOR DOMESTIC WASTEWATER TREATMENT

Vo Thi Dao Chi¹, Nguyen Tran Thien Khanh¹

¹An Giang University, VNU-HCM

Information:

Received: 28/7/2025

Accepted: 02/10/2025

Published: 12/2025

Keywords:

Domestic wastewater, membrane, Woven Fiber Microfiltration, septic tank

ABSTRACT

In this research, Woven Fiber Microfiltration system (WFMF) replacing conventional septic system is the modification of septic tanks to improve the quality of the effluent. A pilot scale study of Woven Fiber Microfiltration (WFMF) with pore size from 1 – 3 μm in form of flat sheets was applied in the last compartment of a septic tank to improve the quality of the effluent of the septic tank, but not modify the structure of the septic tank that was already built before. The flux of 4 L/m².h was suggested as a sustainable flux for the working of WFMF in an anaerobic condition in a septic tank. The BOD and COD reduction was found to be over 29.17% and about 40% respectively. SS removal was high with over 90%, and the concentration of SS of effluent was under 10 mg/L. However, nitrogen and phosphate removal were not effective in anaerobic condition, under 10%. The removal efficiency of coliform was varying between 73.3 and 75.9%.

1. INTRODUCTION

Under the pressure of the rapid growth of population and urbanization, water pollution and sanitation conditions become serious challenges of Ho Chi Minh City, a largest city in Vietnam. One of reasons causing critical environmental pollution is the consequence of the less investment on sewage treatment facilities of this city in the past, and wastewater collection and treatment often received less priority than water supply and treatment (Dan,2008). Currently, over 1,579 million m³ of municipal wastewater per day from sewage systems without treatment is directly discharged into canals and rivers

(Chau,2017). Therefore, the impact of sewage contamination on surface water and groundwater is a burning issue, since sewage existing backwater from simple septic tanks installed with high concentration of coliform, organic pollutants, and nutrients is recognized as one of momentous threats to human health, economic activities, and tourism opportunities (Bui,2015) To solve this problem, there are two main choices to approach wastewater treatment for Ho Chi Minh City: centralized treatment and decentralized treatment. However, centralized treatment systems seem hardly feasible, because these treatment systems are very expensive, and

Vietnam implemented administrative restructuring on July 1, 2025, introducing significant changes to its administrative units. Nevertheless, this article continues to use the old names of provinces, cities, communes, and wards to reflect the data and context at the time of the study.

complex in terms of constructions, operations, and maintenances (Adam,2002). Conversely, decentralized treatment systems have benefits such as: simple and low-cost investment of operations. Hence, decentralized on-site treatment systems of wastewater from households, cluttered houses, and less developed communities lacking sewer systems are a suitable solution, and suite with the real social and economic situation of Ho Chi Minh City (Anh, 2016). Among on-site wastewater treatment systems, on-site anaerobic treatments were considered as a right decision because these systems employed small land use, cheap and simple design. Otherwise, its sludge production, nutrient demand, using energy is very low. On-site anaerobic treatment systems also can tolerate high loading capacity. The conventional septic tanks are the oldest anaerobic on-site treatment and are being widely employed. Dissolved organic matters in wastewater almost pass through septic tanks without significant treatment (Buuren,2010).

Ho Chi Minh has to face with problems relating to water sanitation due to excessive disposal of untreated wastewater. At present, about 75% - 80% of houses in Ho Chi Minh City are equipped with septic tanks, but rarely septic tanks were built according to the standard of Vietnamese Ministry of Construction, and some of them were built in 1870s during the French Colonial period (Anh, 2016). Most septic tanks were directly connected with sewage systems. However, many poor communities with low income are barriers for Ho Chi Minh City in upgrading wastewater treatment systems and management of domestic wastewater discharge (Thanh,2011). Diseases relating water-born such as dengue, filariasis, malaria, yellow fever, onchocerciasis, and trypanosomiasis haven't yet decreased in recent years (Buuren, 2010).

The lack of fresh water becomes scarce in Ho Chi Minh City because the surface water sources are almost heavily polluted. The problem has been getting worse while the sources of ground water are rapidly exhausted and polluted (Van,2015). Consequently, the worth of recovery and reuse of domestic wastewater are realized, and an appropriate remedy for water pollution in Ho Chi Minh City (Thomas,2017). For a long time, Vietnamese farmers still keep a strong tradition in reusing domestic effluent that was known as a water irrigation source, and the natural fertilizers for crops and aquaculture (Scott,2004). The benefits and risks of unplanned reusing wastewater depend much on the degree of pollution and kinds of each crop applied. High concentration of nitrogen and phosphorous are good benefits for water irrigation, but high concentration of pathogens remaining in wastewater is extra negative effects on human beings (FAO,1986).

An immersed membrane bioreactor (IMBR), a combination of a biological treatment and membrane filtration technology could be a suitable selection for sanitation approach in Ho Chi Minh City (Hai,2016). An IMBR includes a bioreactor and a membrane system that is together in an existing single unit, and not occupy land use (Ben,2010). According to Pillay and Jacobs (2018), IMBR can be operated with high biomass concentration ranging from 15,000 mg/L to 20,000 mg/L when it is compared to about 4000 mg/L in conventional activated sludge process. The age of sludge in IMBRs is increased, but the quantity of sludge is reduced. IMBRs have been popularly applied in isolated villages, small communities, buildings, and small industries to provide a high-quality effluent with reducing minimum pathogens (Kraume,2005).

Woven fiber microfiltration (WFMF) incorporated with a biological treatment has

been recommended as a suitable solution for local low-income communities to approach sanitation since it is simple operational procedures, robust, low level of technical skills, flexible, and cheap (Martha,2019). These systems also contribute the increase of public health when it gives a treated effluent with the significant reduction of COD, BOD, and minimizing pathogens. Satisfying friendly environment such as low using of land, construction materials, and high potential for the recovery of nutrients is benefit of WFMF (Martha,2019). Therefore, WFMF can be easy to adapt with the current conditions and requirements of Ho Chi Minh City.

In this research, upgrading septic tank by applying woven fiber microfiltration is considered as an appropriate strategy for low cost decentralized sewage treatment in Ho Chi

Minh City to have access sanitation (Thanh,2015). The goals of using WFMF are to aim highly efficient removal of suspended solids, and maximum removal of pathogens that are the risks for environment and human health. In addition, the good quality effluent with the useful nutrients could be applied as a source of natural fertilizer, and a source of water for irrigation in agriculture, and solve the decreasing fresh water sources in Ho Chi Minh City (Ahn,1999).

2. METHODOLOGY

2.1. Selection of the study area

Based on the objectives mentioned, the pilot was carried out at a septic tank of C6 cafeteria in HCMC University of Technology (figure 2.1), and the modules of woven fiber microfiltration membrane was operated at flux of 4 L/m². h.

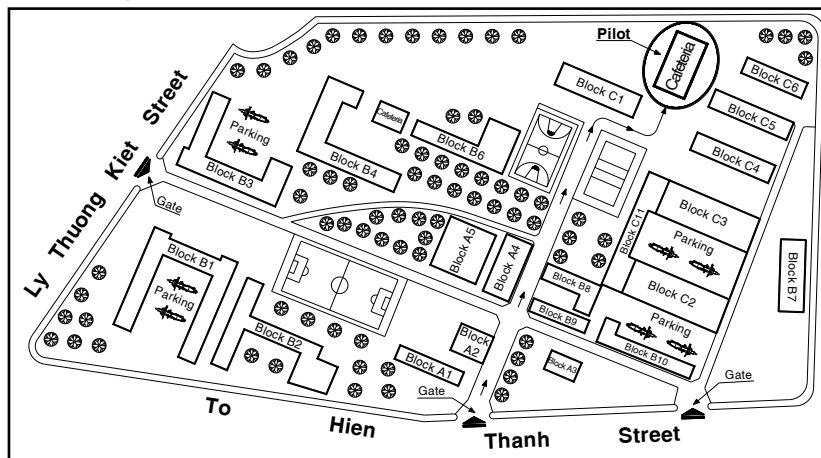


Figure 2.1. The location of the pilot in HCM University of Technology

2.2. Experimental study

2.2.1. Characteristics of C6 septic tank and its wastewater

The septic tank was installed under the ground, and its design was followed the Vietnamese regulation of septic tank construction. This septic tank includes 3 chambers (figure 2.2). Chamber 1 is largest chamber. Chamber 2 and chamber 3 have the same volume size with.

Wastewater flows from toilet to chamber 1, and then to chamber 2. Finally, it will be outside by through the chamber 3 in which no scum is on the surface of wastewater. Effluent without treatment from chamber 3 will flow into the sewage system of HCMC University before it will be directly discharged into cannel or rivers of Ho Chi Minh City. Every day, about 30 people use this toilet. Therefore, the septic tank receives about 240 liters of wastewater per day.

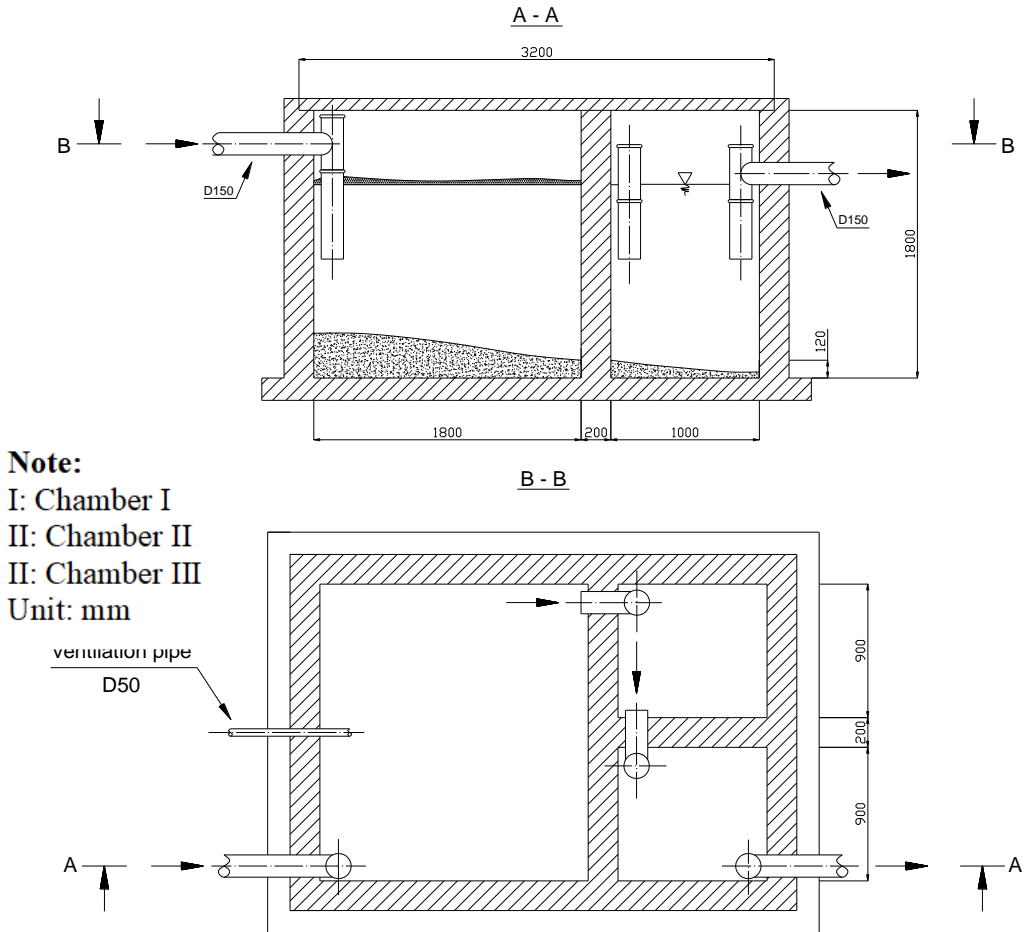


Figure 2.2. The design and dimensions of the septic tank located at C6 cafeteria

2.2.2. Woven fiber microfiltration membrane (WFMFM)

One woven fiber microfiltration membrane unit consists of flat sheets that were made by woven polyester matter with the pore size of 1 μm to 3

μm . Flat sheets were connected by a plastic rectangular frame. The specification of this membrane was expressed by table 2.1. One module included 5 units which were fixed together in parallel in row.

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

Item	Unit	Characteristic
Initial membrane resistance	L/m ² .h	6.46E+11
Operational pressure	kPa	< 80

2.2.3. Experimental set up

The installation of WFMF system (figure 2.4) includes: Connection between the module and peristaltic pump by plastic a pipe line. Pressure gauge was placed over the tank and before the peristaltic pump, and can be removed in necessary case. All connections of system were well done to avoid the leakage. Make a cover to

insert the module into this septic tank. Module was hung to septic tank cover by steel bars . Insert the module into the septic tank:Top the module was fully dept into the wastewater. Then, all connector had to be placed over the sewage to avoid accidently leaking of connectors, and easy maintenance. The experiment set up is showed in the figure 2.3.

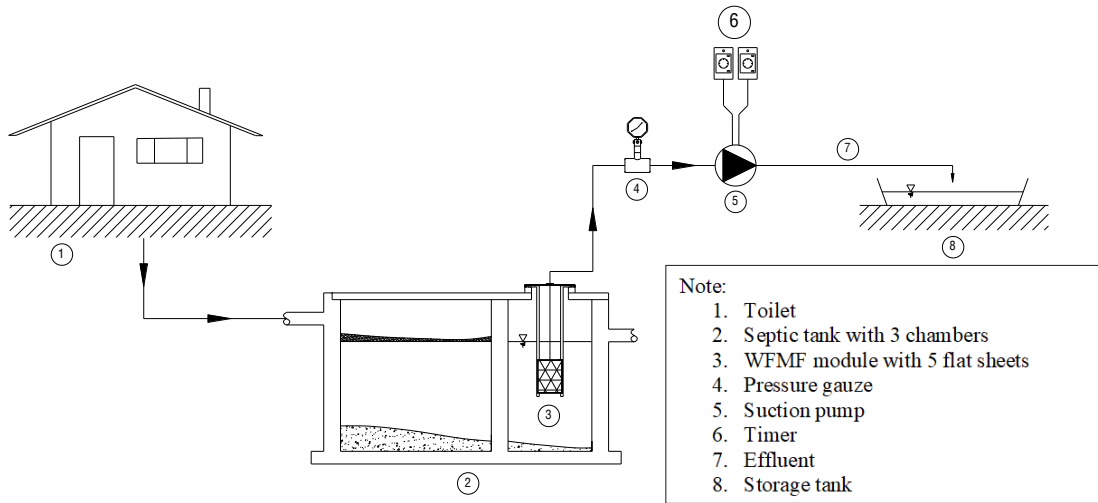


Figure 2.0. The experimental set up



Figure 2.4. Woven fiber filters system

2.2.4. Membrane operation conditions

Based on the flow rate of wastewater (240 L/day) enters this septic tank per day, the critical fluxe of 4 L/m².h were determined for the operation. The permeate flux was set at a value

(4 L/m².h), and the differential trans-membrane pressure was recorded one time per day. WFMFM module was connected to electric source, and was operated with 8 minutes in run and 2 minutes in idle. When trans-membrane

pressure reached nearly 80kPa at which membranes were completely fouling, the module was stopped and took it out this septic tank to do the cleaning. Another module running was continued.

3. Results and Discussion

3.1. Characteristics of effluent of the septic tank before upgrading WFMF

Table 3.1. Specification of the effluent of C6 septic tank

Parameter	Unit	Effluent	QCVN 14:2008/BTNMT
pH	-	8.21	5 – 9
TSS	mg/L	65	100
COD	mg/L	102	-
BOD ₅	mg/L	63	50
TKN	mg/L	86.8	-
N-NH ₄	mg/L	103	10
P-PO ₄ ⁻	mg/L	7	10
Coliform	MPN/100 mL	6*10 ³	5*10 ³

3.2. BOD removal

BOD removal was presented in figure 3.1.

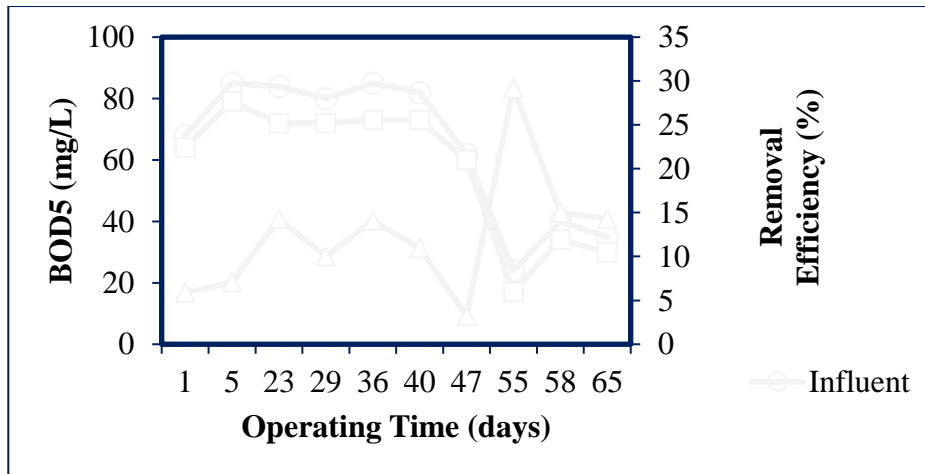


Figure 3.1. BOD removal

The BOD removal was about 29.17% for 55 days, and the BOD removal had the trend in increasing with the time. This can explain the concentration of MLSS (Mixed Liquor Suspended Solid) in the third chamber increased with the time. The trends were expected and consistent with theory of Fane and Ndinisa, 2006. However, the BOD removal efficiency

was not stable, it depended on the unstable influent flow rate and a part of MLSS drained out of the septic tank when wastewater reached the hydraulic retention time in the septic tank. These were similar to the research of Pillay et al (2018).

3.3. COD removal

COD removal was presented in figure 3.2. After one week, COD removal was about 40%. However, the COD removal in the fluctuation was due to rainfall. However, the COD removal

of septic tank in 68 days of experiment increased with the time. Therefore, the results in the figure 3.2 also were in agreement with literature of Chang (2002).

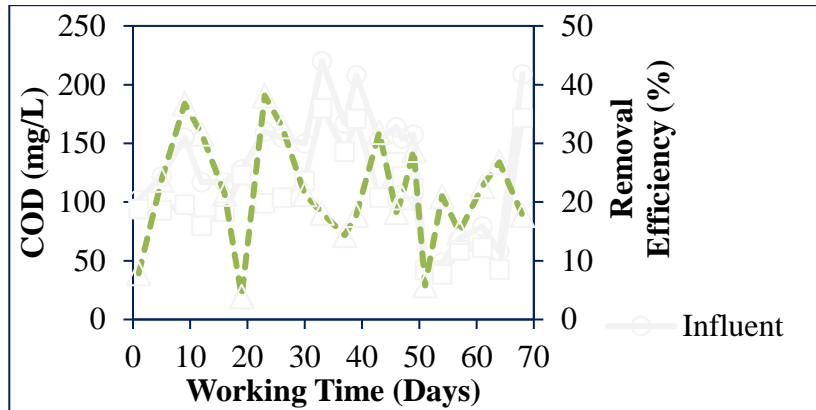


Figure 3.2. COD variations and removal efficiency

3.4. SS removal

After 21 days of the operation, the average SS removal efficiency of flux of 4 L/m².h (figure 3.3) was 90.2%. Similar to COD, average SS in the third chamber also increased with the time.

According to Huong,(2012), IMBR remove above 90% of solids and SS after through WFMF was under 10 mg/L and met the standard of discharge. Therefore, the data represented above in figure 3.3 was in agreement with that study.

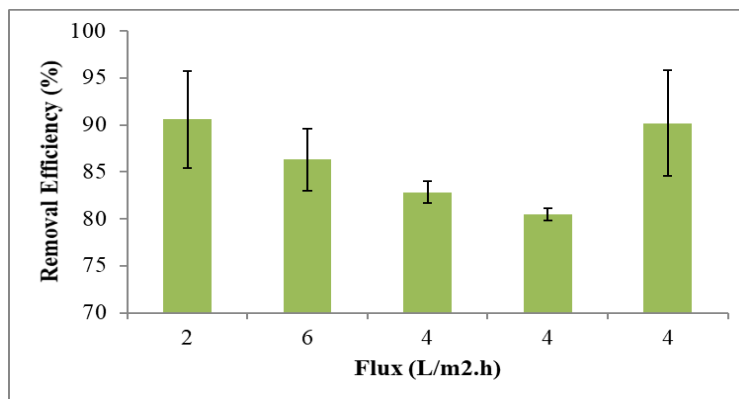


Figure 3.3. Average SS of wastewater in the effluent

3.5. Coliform removal

The efficiency of coliform removal with flux 4 L/m².h was varying between 73.3 and 75.9% (figure 3.4). Based on figure 3.4, coliform 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. Percentage coliform removal was in agreement with literature especially to that demonstrated by the following authors: Soriano et al. (2003) and Rosenberger and Kraume (2002).

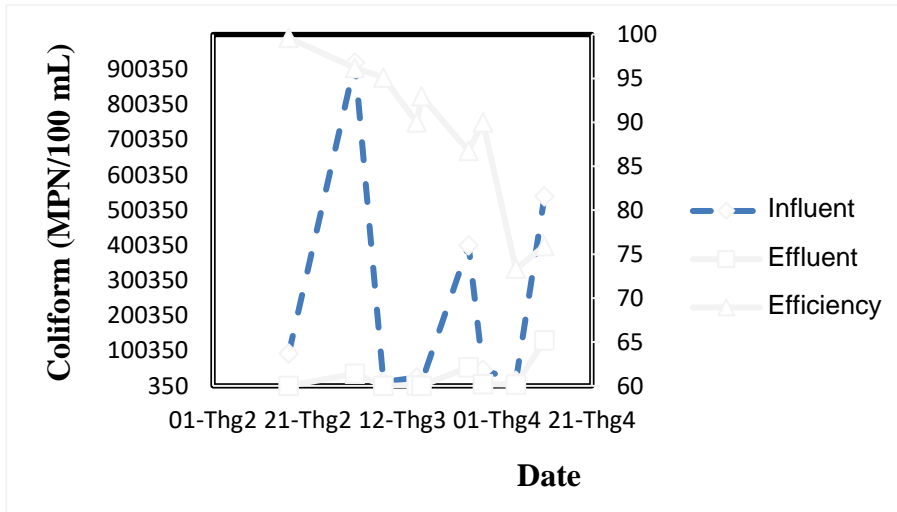


Figure 3.4 Coliform variations and removal efficiency

3.7. Nitrogen removal

Average TKN in the effluent was from 80 mg/L to 131 mg/L (figure 3.5). Average TKN removal efficiency was from 5% to fewer than 5% because nitrification did not happen in anaerobic condition. Ammonia concentration in the effluent was in range of 69-116 mg/L (figure 3.5). These results were similar to the study of

Huong (2012). The average efficiency of ammonia removal was low and not stable, less than 6%. According to Visvanathan (1997), nitrogen removal in anaerobic condition almost does not happen, and the decreasing of nitrogen in effluent because a part of nitrogen in the chamber 3 was used to synthesize biomass and nitrogen of organic compounds in form of suspended solids eliminated by membrane.

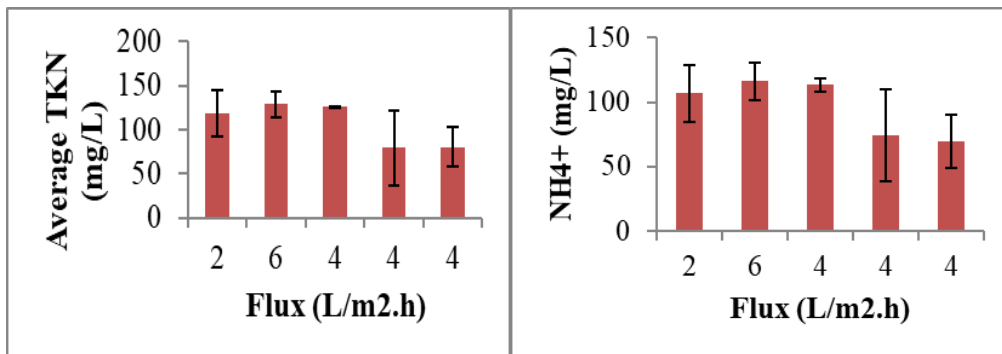


Figure 3.5. The Average TKN and ammonia in the effluent

3.8. Phosphate removal

Average phosphate of effluent also was high from 5.5 mg/L to 9.2 mg/L and the average efficiency of phosphate removal was too low, under 6.5% (figure 3.6). The ANOVA ONE

WAY analyzed that there was no significant difference of phosphate removal in range of three fluxes studied. the results in the study also were in agreement with the study of Visvanathan (1997).

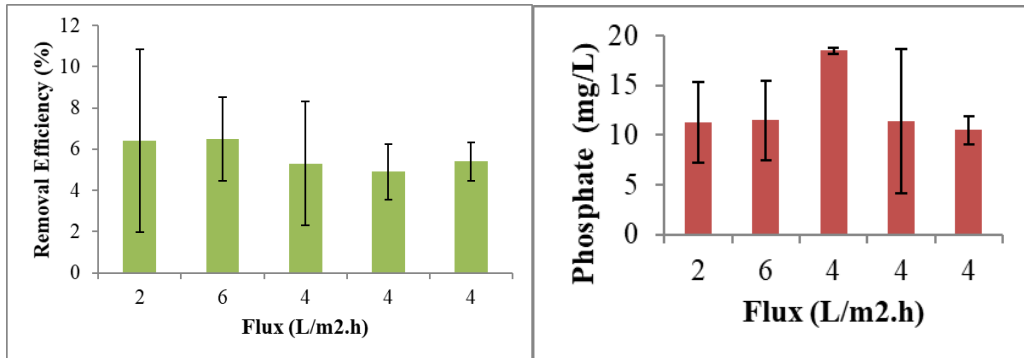


Figure 3.6. Average phosphate removals

4. CONCLUSION AND RECOMMENDATIONS

The study demonstrated that the septic tank modified by submerging a woven fiber microfiltration is feasible to improve the quality of the effluent. The efficiency of BOD removal increased from 3.23% to 29.17% in 55 days. However, BOD of effluent did not meet Vietnamese standard of discharge. There were two reasons to explain this fact. First, the biomass production in anaerobic condition was slowly, and a part of them was washed out when wastewater in septic tank reached its hydraulic retention time. Second, a big storm diluted wastewater in the third chamber. However, BOD removal efficiency increased up 56% if lasting the presence of WFMF in septic tank for 6 months, and BOD in effluent often met the Vietnamese standard of discharge. This demonstrated by the experiment was done from June 2011 to December 2012 at A5 building of HCMC University of Technology (Huong, 2012). After 7 days, the COD removal was about 40% also increased with the time. Similar to the BOD removal, the results of COD removal were not stable because of storm, its value was often over 60 mg/L in the effluent. The SS through WFMF was under 10 mg/L, and met the Vietnamese of discharge. The efficiency of SS removal had the trend in increasing when TMP was higher. For this study, the SS removal

efficiency was above 90% and total coliforms in the effluent was high even though the removal efficiency achieved from 73.3 to 75.9%.

The assessment of water reuse can be based on the demand of water use for different object. For this study, the concentration of nitrogen and phosphate is too high in the effluent. So, the effluent cannot be discharged into the water body. It should be reused for irrigation in agriculture. 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 BOD, COD and Coliforms.

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.
- Anh.N.V. (2016). *Improved septic tank, a promising decentralized wastewater treatment alternative in Vietnam*. Revised in December 2019 from <https://www.researchgate.net/publication/237377189>.
- Ben Aim, R. (2010). *Membrane bioreactor, present status, recent advances and research*

- trends. France: Technology specialized group.
- Bui, T. V., Le, H. N. and Phan, N. L. 2015. Groundwater sustainability of Ho Chi Minh City, Viet Nam. *Int. Symp. and Exhib.of Vietnam Water Coop. Initiative*, Ha Noi, Viet Nam.
- Buuren, V.J.C.L. (2010). *A participatory multi-criteria method for drainage and sanitation system selection in developing cities- Applied in Ho Chi Minh City, Vietnam*. (Doctor's research study, Wageningen Univeristy, 2010). Wageningen City, Netherland.
- Chang, I., S., Clech, P., L., Jefferson, B., & Judd, S. (2002). Membrane fouling in membrane bioreactors for wastewater treatment. *Journal of Environmental Engineering*, 128, 1018- 1029.
- Chau.H., (2017). *Improve the quality of water in Ho Chi Minh Cityfrom 2010 to 2020*. (Master's research study, Ho Chi Minh University of Technology, 2012). Ho Chi Minh City: Ho Chi Minh University of Technology.
- Dan, N., P. (2008). *Reuse domestic wastewater in Ho Chi Minh City*. HCM: HCMC University of Technology.
- Dan, N, P.N., P. (2008). *Reuse domestic wastewater in Ho Chi Minh City*. HCM: HCMC University of Technology.
- Fan, F., Zhou, H. and Husain, H. (2006). Identification of wastewater sludge characteristics to predict critical flux for membrane bioreactor processes. *Water Research*, 40, 205-212.
- FAO. (1986). *Wastewater quality guidelines for agricultural use*. Food Agricultural Organization. Retrieved January, 2020, from website: <http://www.fao.org/docrep/t0551e/t0551e04.htm>.
- Hai, V., P., Dan, N., P. & Thanh., B., X. (2016). *Membrane Bioreactor for Decentralized Wastewater*. Retrieved in Jan.2020 from https://link.springer.com/referenceworkentry/10.1007%2F978-3-642-40872-4_2006-1
- 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). Nutrients 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., Cele, M., X., & Deelie, M. and Jacobs, EP. (2018). *Development of a membrane pack for immersed membrane bioreactors*. Water Research Commission. Retrieved on FebAugust 2020011 from <http://www.wrc.org.za/wp-content/uploads/mdocs/TT%20750-18.pdf> <http://www.wrc.org.za/Pages/DisplayItem.aspx?ItemID=7814>.
- Rosenberger, S. and Kraume, M. 2002. Filterability of activated sludge in membrane bioreactors. *Desalination*, 146 (1): 373-379.
- Scott C.A.& Faruqui, N. (2004). *Wastewater Use in Irrigated Agriculture-Coordinating the Livelihood and Environmental Realities*. International Development Research Centre (IDRC), Ottawa, Canada.

- Soriano, G. A., Erb, M., Garel, C. and Audic, J. M. 2003. A comparative pilot-scale study of the performance of conventional activated sludge and membrane bioreactors under limiting operating conditions. *Water Environmental research*, 75, 225-231.
- Thanh, B., X. (2011). *Report on the sanitation of Ho Chi Minh City*. HCMC: HCMC University of Technology.
- Thanh, C., N., D., Thanh, T., Xuan, T., B. & Thi., D., H., V (2015). *Low-cost spiral membrane for improving effluent quality of septictank*. *Journal Desalination and Water Treatment* Volume 57, 2016 - Issue 27.
- Thomas. S., Siraj. T., Jennifer M., Justin, A., & Lu Y. (2017). *Viet Nam Hydro-Economic Framework for Assessing Water Sector Challenges*. Resources Group.
- Van.D.T.B. (2015). *Impacts of water stress on ho chi minh city, Vietnam*. German University.
- Visvanathan, C. 1997. Application of air backwashing technique in membrane bioreactor. *Water Science and Technology*, 36: 256-366.