Jurnal Matriks Teknik Sipil
DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

DETERMINATION OF RECYCLE WATER TECHNOLOGY FOR WASTEWATER TREATMENT AT UNIVERSITAS PERTAMINA AREA WITH ANALYTICAL HIRACHY PROCESS (AHP)

[1)]Hafizha Hasnaningrum, [2)]Betanti Ridhosari, and [3)]I Wayan Koko Suryawan
[1),2),3)]Department of Environmental Engineering, Faculty of Infrastructure Planning,
Universitas Pertamina, Jl. Teuku Nyak Arief, RT.7/RW.8, Simprug, Kota Jakarta Selatan 12220, Indonesia.
Email : i.suryawan@universitaspertamina.ac.id

Abstract
The wastewater treatment plant (WWTP) at the Universitas Pertamina area is one of the campus's efforts to reduce the environmental impact of wastewater production. The processed WWTP can be processed into ready-to-drink water as an effort to reduce plastic waste. This plastic waste is usually produced by the consumption of mineral water products. The availability of ready-to-drink water in the campus complex is expected to increase the interest of campus residents to use tumblers and reduce the generation of plastic waste as well as university proactive efforts. The purpose of this study was to analyze the units needed to process WWTP effluent into ready-to-drink water by looking at various alternatives. This study uses the analytical hierarchy process (AHP) in determining the best alternative. The units required for each alternative are equalization tub, slow sand filter, and disinfection. Meanwhile, for processing, there are three alternatives, namely microfiltration (MF), ultrafiltration (UF), and combined microfiltration – ultra-filtration (MF-UF). The selection of these alternatives was adjusted to the criteria of cost, required membrane area, flux recovery after backwashing, and the effectiveness of total coliform removal. MF filtration technology is the largest weight, which is 0.381. Where the use of MF in the Universitas Pertamina area is cheaper and requires better area than UF and MF-UF technology.

Keywords: *AHP, Membrane, WWTP*

Abstrak
Instalasi pengolahan air limbah (IPAL) di Kompleks Universitas Pertamina merupakan salah satu upaya kampus untuk mengurangi dampak lingkungan terhadap produksi air limbah. Hasil olahan IPAL ini dapat diolah menjadi air siap minum sebagai salah satu upaya penurunan sampah plastik. Sampah plastik ini biasanya dihasilkan oleh konsumsi produk air mineral. Adanya air siap minum di kompleks kampus diharapkan dapat meningkatkan minat warga kampus untuk menggunakan tumbler dan menurunkan timbulan sampah plastik sekaligus upaya proaktif universitas. Tujuan penelitian ini adalah untuk menganalisa unit yang dibutuhkan dalam pengolahan effluent IPAL menjadi air siap minum dengan melihat berbagai alternatif. Penelitian ini menggunakan *analytical hierarchy process* (AHP) dalam penentuan alternatif terbaik. Unit yang dibutuhkan untuk setiap alternatif adalah bak equalisasi, slow sand filter, dan desinfeksi. Sedangkan untuk pengolahan terdapat tiga alternatif yaitu microfiltration (MF), ultrafiltration (UF), dan gabungan microfiltration – ultrafiltration (MF-UF). Pemilihan alternatif tersebut disesuaikan dengan kriteria biaya, luas membran yang dibutuhkan, pemulihan fluks setelah backwash, dan efektivitas penghilangan *total coliform*. Teknologi filtrasi MF merupakan bobot terbesar yaitu 0,381. Dimana penggunaan MF di kompleks Universitas Pertamina lebih murah dan membutuhkan luas area yang lebih baik dibandingkan teknologi UF dan MF-UF.

Kata Kunci : AHP, IPAL, Membran

INTRODUCTION

Water is one of the most essential sources of life for all living things, especially humans. Humans need water for bathing, washing, and cooking (Widyaningsih et al., 2016). However, from these various activities, humans most need water to meet body fluids, namely drinking water. The need for drinking water for each individual is different, depending on factors such as age, weight, energy intake, nitrogen intake, body surface area, and the amount of energy expended (Briawan et al., 2011). Even so, humans need eight glasses or 2 liters of drinking water per day so that the body's metabolism goes well (Jami'ah & Hadi, 2014). The total amount of water needed will continue to increase and the increasing number of people will give environmental impact (Sofiyah et al., 2021; Fadhilah et al., 2020; Afifah et al., 2020). If this happens, then what is threatened is the availability of drinking water itself, but it will also impact increasing the generation of plastic bottle waste.

The need for drinking water is relatively high, and human nature tends to be consumptive, encouraging them to fulfill their drinking water needs, one of which is by buying plastic bottled drinking water. Consumable plastic bottles are often judged as objects of less value, so most plastic bottled water consumers will consider the bottles as trash. Citing data reported by the Wardiyanto et al. (2018), states that 168 plastic bottles can be produced from each individual per year. In addition, of the 100 million plastic bottle waste the world produces, around 1,500

Submitted : Juni 2021
Reviewed : Juli 2021
Accepted : Juli 2021

DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

bottles end up in the oceans every day. Indonesia ranks 2nd in the world as a producer of plastic bottle waste into the sea, reaching 187.2 million tons (Wardiyanto et al., 2018). If this is not addressed immediately, it will threaten environmental sustainability. The Universitas Pertamina area also experiences the problem of plastic bottle waste. In October 2020, the survey team for Upstract 3.0 has collected data on waste generation in the Universitas Pertamina area (Hilmi et al., 2021). The results of the data processing state that plastic bottle waste ranks first as the most significant volume of waste, which is 26% of the total waste. The root of the high amount of plastic bottle waste is the high demand for drinking water in the Universitas Pertamina area . So, efforts that can be made to overcome the root of the problem are by providing ready-to-drink water in the Universitas Pertamina area. An alternative solution to meet the demand for ready-to-drink water is to recycle the effluent of the Wastewater Treatment Plant (WWTP) in the Universitas Pertamina area into drinking water.

Based on the description above, it can be concluded that the Universitas Pertamina area has a great opportunity to make efforts to reduce the amount of plastic bottle waste by recycling the WWTP effluent into ready-to-drink water. With the availability of ready-to-drink water facilities in the Universitas Pertamina area, it is hoped that the generation of plastic bottle waste will also be reduced. Recycling WWTP effluent into drinking water can also help realize the Sustainable Development Goals (SDGs) number 6 program, ensuring the availability and sustainable management of clean water and sanitation. One of the SDGs, program number 6 which is closely related to water recycling, is by 2030, improving water quality by reducing pollution, eliminating waste disposal, and minimizing the disposal of chemicals and hazardous materials, halving the proportion of untreated wastewater. and substantially increase recycling and safe reuse globally. Therefore, a study will be conducted on the design of the WWTP effluent further treatment unit to meet drinking water needs in the Universitas Pertaminaarea following Minister of Health Regulation number 492 of 2010 concerning drinking water quality requirements.

METHODS

Literature study is used as a guide in realizing the design idea. In addition, literature studies can also be used to increase understanding of the ideas that have been initiated. The literature study will also be compared with the results of data analysis and discussion. Sources that can be used as literature studies are international journals, national journals, regulations and quality standards, proceedings, textbooks, and final projects related to this research.

Field surveys are used to support the design by knowing the existing conditions of the existing locations. By conducting a field survey, it is hoped that the implementation of the design idea can be carried out more quickly. Field surveys can be carried out by coming directly to the design location or by asking related matters to the WWTP officer. Testing the characteristics of the WWTP effluent was taken using the rapid sampling method (grab sampling). In contrast to discharge sampling, water samples are only taken in 1 day at peak hours. The selection of days is based on days with the same peak hour characteristics and represents other days. The guidelines used in sampling for the characteristic test are SNI 6989.59:2008 regarding the method of sampling wastewater.

Pre-design is a preparatory stage carried out before design activities are carried out. Three alternative processing will be determined at this stage used in the design process based on quantity and quality data. After that, the three alternatives will be compared, and one alternative processing will be selected using the Analytical Hierarchy Process (AHP) selection method following research conducted by Ramadan (2014). In planning, of course, there are several things to consider. The main component that must be considered in carrying out this design is debit. Discharge is an essential consideration because the processing capacity will depend on the amount of water discharge to be treated. Moreover, the discharge generated from the treatment of WWTP in the area of the Universitas Pertamina is not continuous every hour. This is due to the operational hours of the Universitas Pertamina area, which only lasts for approximately 14 hours per day. Therefore, it is necessary to take a sample of the WWTP effluent discharge to determine the amount of discharge to be processed.

Another consideration of concern is the characteristics of the WWTP effluent. This is as important as discharge, considering the features of the effluent will affect the selection of processing units. Inappropriate choice of processing units will reduce the efficiency of the unit and the effectiveness of the removal of related parameters by the processing unit. The characteristics that will be considered in this design are pH, residual chlorine, solute (TDS),

DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

organic matter ($KMnO_4$), ammonia (NH_3-N), and total coliform. In addition to discharge and effluent characteristics, several other things to consider are design criteria, land availability, and costs.

RESULT AND DISCUSSION

The wastewater that has arrived at the WWTP will then enter sedimentation tank 1 to settle the mud and other solids that are still carried away from the settling basin. Then, the waste will flow in overflow to the equalization tank to homogenize the characteristics and discharge of the wastewater. This is important because other units in the WWTP will not work optimally if the release and parts of the wastewater entering the WWTP are not uniform. The equalization tank also functions as sediment for solids that are still carried away from the settling basin. Therefore, it is necessary to check periodically to remove the solids that settle in the equalization tank. In addition, the equalization tank also functions as a container for decomposing organic compounds in the form of solids, decomposing sludge, and collecting sludge. From the equalization tank, the wastewater will then be channeled to sedimentation tank 2 using a pump. Like sedimentation tank 1, sedimentation tank 2 also functions to precipitate solids that are still carried away by the flow. Then, from sedimentation tank 2 there will be an overflow to anaerobic tank 1. In this case, 3 anaerobic tanks are used to treat waste biologically. Waste from sedimentation tank 2 will be flowed to anaerobic tank 1, then from anaerobic tank 1 the wastewater will flow to anaerobic tank 2 and continued with anaerobic tank 3. In this unit, microorganisms will decompose organic content under anaerobic conditions.
After the waste is treated anaerobically in an anaerobic tank, the wastewater will be channeled through a transfer tank to aeration tank 1 or aerobic biofilter reactor 1. In this tank, a microorganism growth medium made of PVC in the form of a wasp's nest is installed so that after a few days of operation, the surface of the media will be covered with dirt. -form a biofilm layer. In this unit, microorganisms need oxygen to decompose organic matter. Therefore, in this reactor, a diffuser is installed to supply oxygen needs for microorganisms. In addition to the diffuser, oxygen is also supplied utilizing a waterfall. The plunge is made by flowing water from the outlet tunk to the aeration tank using a piping system. The reuse of water from the outlet tank to jump into the aeration tank is also known as recycling. Then, from aeration tank 1, the waste will then flow into aeration tank 2, which has the same treatment system as aeration tank 1. After the wastewater is treated in the aeration tank, the wastewater will then enter the bioindicator tank. Bioindicators are living things that represent the condition of an ecosystem and the environment (Han et al., 2015). The bio-indicators used in the WWTP area of Universitas Pertamina are carp and tilapia. After that, the water will flow to the outlet tub. On its way to the outlet tank, the water will be given a disinfectant in the form of chlorine. The purpose of applying disinfectant is to kill pathogenic bacteria in treated recycle water (Hasnaningrum et al., 2021). After that, the effluent that has reached the outlet tub will be discharged into a body of water. However, not all of the effluent will be discharged into water bodies, and some will be recycled to make a plunge in aeration tank 1. The discharge in the design is needed to determine the processing capacity. Therefore, it is necessary to take a discharge sample to decide on the quantity of discharge that will be used in the design. The results of sampling the WWTP effluent discharge can be seen in figure 1.

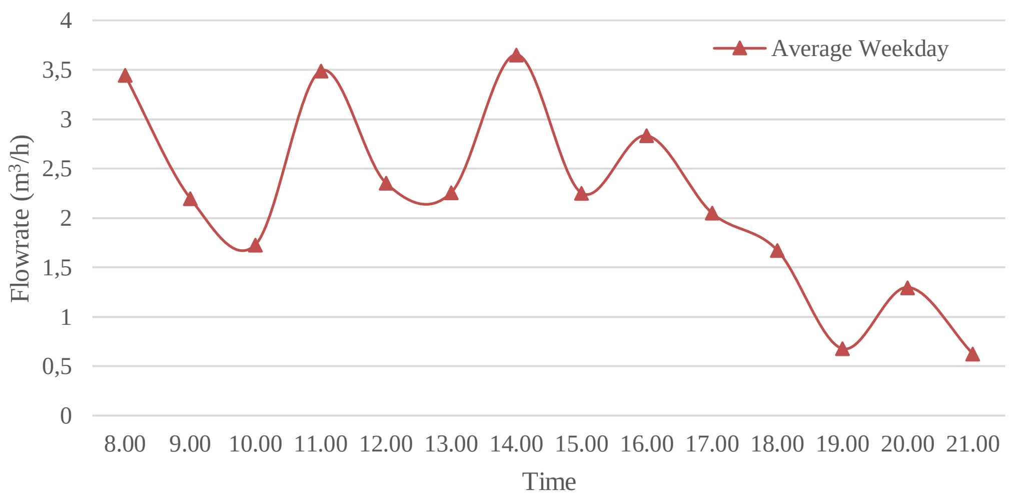


Figure 1. Calculation results of average discharge fluctuations during weekday

Jurnal Matriks Teknik Sipil
DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

Table 1 shows the results of measuring the quality of wastewater effluent in 2019. The design of the treatment unit is based on the goal to be achieved, namely processing WWTP effluent in the Universitas Pertamin aarea into drinking water following the quality standards stated in the Minister of Health Regulation (Permenkes) number 492 of 2010. Based on the results of laboratory tests, the total coliform parameter does not meet the quality standard of the Minister of Environment and Forestry Regulation number 68 of 2016 and the results of the effluent test against the Permenkes quality standard number 492 of 2010. However, other parameters do not meet the quality standard of the Minister of Health Regulation number 492 of 2010, namely ammonia and residual chlorine, which still need to be added to the chlorine level. Therefore, these three parameters will be the main focus of the design. However, other parameters that have been mentioned in the problem definition, such as TDS, pH, and organic matter, will still be a reference for considering which unit to choose.

Table 1. Results of wastewater quality measurement in 2019

Parameters	Units	1	2	3	4	5	6	7	8	9
pH	-	7.3	4.9	6.8	6.8	6.4	7.6	7.6	6.6	7.3
TSS	mg/L	6	2	4	4	1	3	6	3	15
Ammonia	mg/L	0.08	0.26	0.33	0.33	0.15	0.14	0.06	2.7	7.92
Oil and Grace	mg/L	0.54	0.54	0.87	0.87	0.54	0.54	0.56	0.54	0.65
COD	mg/L	4	10	10	10	10	4	10	13	34
BOD5	mg/L	2.87	1.19	2.14	2.14	1.77	2.46	3.86	4.42	12.05
Total Coliform	mg/L	2000	0	2300	2300	3100	1000	3800	1400	480000

The selection of units for the three alternatives is based on several things as shown in Table 2. Therefore, there are three alternatives given for further processing, namely:

1. Alternative 1 includes equalization tank – slow sand filter – microfiltration – disinfection.
2. Alternative 2 includes equalization tank – slow sand filter – ultrafiltration – disinfection.
3. Alternative 3 includes equalization tank – slow sand filter – microfiltration – ultrafiltration – disinfection.

Table 2. Description of the need for advanced treatment units for drinking water at Universitas Pertamina area

Unit	Description
Equalization Tank	The equalization tank is used to uniform the water discharge to be treated. The effluent discharge produced by the WWTP tends to fluctuate and is not continuous every hour. In addition, the equalization tank will also increase the operating effectiveness of the sand filter unit to be used.
Slow sand filter	The equalization tank is used to uniform the water discharge to be treated. The effluent discharge produced by the WWTP tends to fluctuate and is not continuous every hour. In addition, the equalization tank will also increase the operating effectiveness of the sand filter unit to be used.
Membrane	The filter membrane in the advanced treatment unit aims to remove organic and inorganic materials, viruses, and bacteria that are still left in the treated water. The alternative membrane filters used in the design of further processing of WWTP are microfiltration membranes and ultrafiltration membranes.
Disinfection	Disinfection in the advanced treatment unit removes pathogenic bacteria that are still left in the treated water. The disinfection unit in the design of this advanced treatment is quite important because, as stated in the Permenkes quality standard number 492 of 2010, water can be fit for drinking if it has a total coliform level of 0/100 ml of the sample. In addition, according to the World Health Organization (WHO), there must be residual chlorine of 0.2 mg/l – 0.5 mg/l in the treated water that reaches the customer so that the water remains safe from pathogenic bacteria after the distribution process takes place. The type of disinfectant that will be used in this design is sodium hypochlorite (NaOCl).

Preliminary sizing is used to describe the initial dimensions of each unit to be designed (Table 3). Preliminary sizing is also used as a consideration in the selection of design alternatives. The following is a preliminary sizing of each unit that will be designed. The design criteria in the design are used as an essential reference for unit development.

Jurnal Matriks Teknik Sipil
DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

Table 3. Calculation of Preliminary sizing of Each Advanced Processing Unit

Unit	Design	Design Criteria
Equalization Tank	Discharge (Q) = 2,347 l/s Detention time (td) = 2 hours Body length (P) = 3.5 m Body width (L) = 3 m Guard height = 1 m Volume of the tub = Q x td = 2,347 l/s x (1 m3/1000 l) x (3600 s/1 hour) x 2 hours = 16.9 m3 Body height = Body volume/L x W = 16.9 m3/ (3.5 m x 3 m) = 1.6 m Total body depth = Body height + free board = 1.6 m + 1 m = 2.6 m	Minimum depth: 1.5 - 2 m Freeboard: 1 m (Metcalf & Eddy, 2003)
Slow Sand Filter	Discharge (Q) = 2,347 l/s x (1 m3/1000 l) x (3600 s/1 hour) = 8.45 m3/hour Filtration speed = 0.4 m/hour Filter basin area (A) = Q/Filtration speed = 8.45 m3/hour / 0.4 m/hour = 21.125 m Assuming length: the width of the tub is 1: 1, then the length of the tank A = 21,125 m = 4,596 m 5 m Width of the tank= 5 m	Filtration speed = 0.1 - 0.4 m/hour (SNI 3981:2008).
Microfiltration Membrane	Flux (J) = 5 – 20 GFD = 0.008-0.034 m^3/m^2.hour Diameter (D) = 3.9 cm = 0.039 m Length (L) = 1.016 m Membrane area (A) = 5.8 m2 Volume (V) = 10 L = 0.01 m	-
Ultrafiltration Membrane	Membrane unit specifications: Brand = DOW type SFD-2660 Flux (J) = 24 – 70 GFD = 0.04 - 0.12m^3/m^2.hour Diameter (D) = 165 mm = 0.165 m Length (L) = 1.86 m Membrane area (A) = 33 m^2 Volume (V) = 16 L = 0.016 m^3	-
Microfiltration Membrane – Ultrafiltration	In this combined treatment, the microfiltration and ultrafiltration membranes are planned to have the exact specifications as the previously planned microfiltration and ultrafiltration membranes.	-
Disinfection	Discharge (Q) = 2,347 l/s Contact time (t) = 30 minutes = 0.5 hours Contact tank volume = 2,347 l/s x (1 m3/1000 l) x (3600 s/1 hour) x 0.5 hours = 4,225 m^3	-

Four criteria form the basis for the assessment to choose one of the three alternatives. The assessment criteria include cost, required membrane area, flux recovery after backwash, and total coliform removal effectiveness. Although the discharge is one of the critical aspects in the design considerations, the discharge is not included in the assessment criteria because the selected membrane has been adjusted to the discharge capacity and specifications of the membrane itself. Furthermore, the four criteria will be compared for each alternative with the assessment reference as follows (Saaty, 1988):

1. Just as important as the others
2. Moderate importance than others
3. Strong in importance than others
4. Very strong in importance than others
5. Extreme/absolute importance over others

The comparison of each assessment point or criteria can be seen in Table 4. The comparison table of criteria is read by reading the criteria column versus the criteria row. An example of reading for the cost criteria is carried out as follows:
Cost: cost = 1:1
Cost: required membrane area = 2 : 1
Cost: flux recovery after backwash = 1: 3
Cost: effectiveness of total coliform removal = 1: 3

DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

Table 4. Criteria assessment matrix in AHP

Criteria	Cost	Required membrane area	Flux recovery after backwash	Total coli-form removal effectiveness
Cost	1	2	1/3	1/3
Required membrane area	1/2	1	1/3	1/3
Flux recovery after backwash	3	3	1	1/3
Total coli-form removal effectiveness	3	3	3	1

Comparisons will be made for the membrane units of each alternative, namely microfiltration (MF), ultrafiltration (UF), and microfiltration – ultrafiltration (MF-UF). The comparison value between all alternatives for each criterion can be seen in Table 2. MF occupies the highest value in terms of cost, and MF – UF occupies the lowest value. Reporting from several marketplaces in June 2020, the price of MF membranes tends to be cheaper than UF membranes. So, MF has a higher value than UF. MF – UF occupies the lowest value because the unit requires 2 different membranes, and of course, it will be more expensive in terms of price. Then for the criteria for evaluating the required membrane area, each membrane brand being compared has its membrane area specifications. The use of membranes with a certain area depends on the processing capacity of each membrane. The MF membrane has a membrane area specification of 5.8 m^2, while the UF membrane has 33 m^2. The membrane area will also affect the required land area because the larger the membrane area, the larger the diameter of the tool will be. Therefore, from the necessary membrane area criteria, MF occupies the highest value. Flux recovery after backwash is one of the most essential things in choosing the type of membrane because flux recovery will affect the service life of the membrane. The smaller the flux recovery, the more likely the membrane will be clogging.

Table 5. Matrix for each criteria for alternative advance treatment

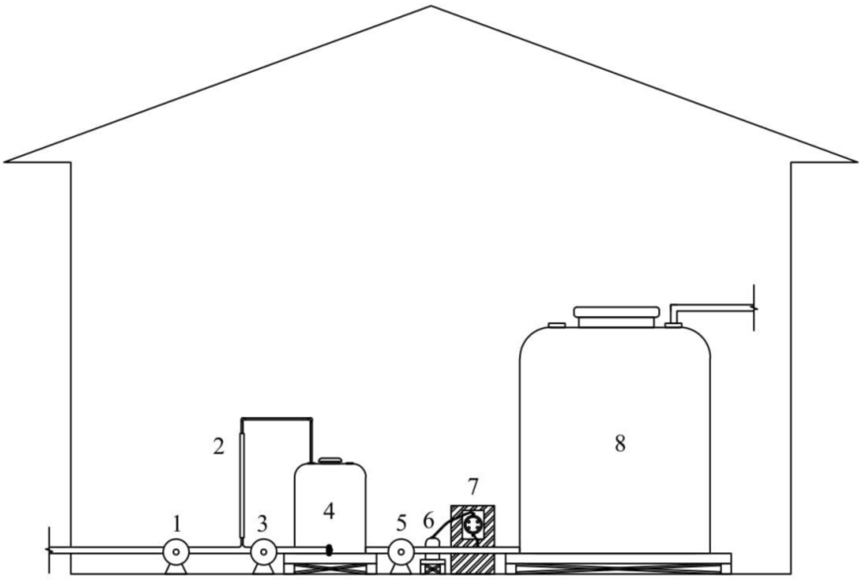
Criteria	Alternative	MF	UF	MF-UF
Cost	MF	1	3	5
	UF	1/3	1	5
	MF-UF	1/5	1/5	1
Required membrane area	MF	1	3	5
	UF	1/3	1	5
	MF-UF	1/5	1/5	1
Flux recovery after backwash	MF	1	1/2	1
	UF	2	1	2
	MF-UF	1	1/2	1
Total coli-form removal effectiveness	MF	1	1	1
	UF	1	1	1
	MF-UF	1	1	1

MF has the same flux recovery value as MF – UF, 80% (Gao et al., 2019), while UF has a flux recovery value of 90% (Mahmud, 2005). Therefore, for this criterion, UF has the highest value compared to other alternatives. The last selection criteria is the effectiveness of total coliform removal. This point is included in the most important selection criteria because from the results of laboratory tests carried out, the total coliform in the WWTP effluent sample is quite high, namely 160,000/100 ml of the sample, while the requirement for water to be consumed as drinking water according to PERMENKES number 492 of 2010 is 0/100 ml of sample. Based on Hidayah (2018) research, it is stated that MF, UF, and MF – UF can remove total coliforms up to 100%. Therefore, the values for all alternatives on this criterion are the same. From the calculation results, the final value obtained by each alternative is MF of 0.381; UF of 0.376; and MF-UF of 0.2422. The chosen alternative is the alternative with the highest final score. Therefore, the chosen alternative is alternative 1 which includes equalization basin – slow sand filter – microfiltration membrane – disinfection. Alternative weighting for the other assessment criteria is also carried out in the same way. Comparison and alternative weighting for membrane area criteria, respectively. The final weighting is done by multiplying the matrix between the weights of each alternative with the criteria. The following is the final weighting calculation (equation 1). These results indicate that MF is the best alternative that can be

DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

applied according to the criteria specified in the AHP. Overall, the concept of recycle water in Universitas Pertamina with MF can be seen in Figure 2.

$$\begin{pmatrix} MF \\ UF \\ MF-UF \end{pmatrix} = \begin{pmatrix} 0,607 & 0,607 & 0,258 & 0,333 \\ 0,303 & 0,303 & 0,515 & 0,333 \\ 0,09 & 0,09 & 0,227 & 0,333 \end{pmatrix} = \begin{pmatrix} 0,14 \\ 0,104 \\ 0,279 \\ 0,469 \end{pmatrix} = \begin{pmatrix} 0,381 \\ 0,376 \\ 0,242 \end{pmatrix} \ldots[1]$$



Information
1. Pump feed
2. Membrane Unit
3. Backwash pump
4. Backwash tank
5. Disinfection pump
6. Clorine tank
7. Dosing pump
8. Reservoir and chlorination

Figure 2. Wastewater recycle system into ready-to-drink water based on selected alternatives

CONCLUSION

Based on the criteria of cost, required membrane area, flux recovery after backwash, and total coliform removal effectiveness, the biggest criterion is total coliform removal. This is because of the high value of this parameter in the existing conditions. Alternative processing that is suitable to be applied is MF, UF, and the combination of MF-UF. However, the best unit in making decisions based on the criteria made is MF. This MF unit must also be supported by complementary buildings such as equalization tanks, slow sand filters, and the application of disinfectants.

REFERENCE

Afifah A. S., Suryawan I. W. K., & Sarwono A., 2020). "Microalgae production using photo-bioreactor with intermittent aeration for municipal wastewater substrate and nutrient removal", *Communications in Science and Technology,* Vol. 5 No. 2, pp. 107-111.

Standar Nasional Indonesia, 2008, "(SNI) 3981-2008 : Perencanaan Instalasi Saringan Pasir Lambat".

Briawan D., Sedayu T. R., & Ekayanti I., 2011, "Kebiasaan Minum Dan Asupan Cairan Remaja di Perkotaan", *Jurnal Gizi Klinik Indonesia*, Vol. 8 No.1, pp. 36-41.

Fadhilah N., Vembrio L. A. W., Safira R. H., Amiruddin A., Sofiyah E. S., & Suryawan I. W. K., 2020, "Modifikasi Unit Proses dalam Peningkatan Efisiensi Penyisihan Amonium", *Jurnal Sumberdaya Alam dan Lingkungan*. Vol. 7 No. 2, pp. 1-10.

Gao Y., Qin J., Wang Z., & Østerhus S. W., 2019, "Backpulsing technology applied in MF and UF processes for membrane fouling mitigation: A review ". *Journal of Membrane Science.* Vol. 587 No. 117136.

Hadi W. ,2014, "Penggunaan Unit Slow Sand Filter, Ozon Generator dan Rapid Sand Filter Untuk Meningkatkan Kualitas Air Sumur Dangkal Menjadi Air Layak Minum dengan Parameter Kekeruhan, Fe, dan Mn", *Jurnal Teknik ITS*, Vol. 3 No.2, pp. F256 - F259.

Han Y. G., Kwon O., & Cho Y., 2015, "A Study of Bioindicator Selection for Long-Term Ecological Monitoring", *Journal of Ecology and Environment*, Vol. 38 No. 1, pp. 119-122.

DOI: https://dx.doi.org/10.20961/mateksi.v9i3.52739
ISSN: 2354-8630
E-ISSN: 2723-4223
Vol 9, No 3 (2021): September

Hasnaningrum H., Ridhosari B., & Suryawan I. W. K., 2021, "Planning Advanced Treatment of Tap Water Consumption in Universitas Pertamina". *Jurnal Teknik Kimia dan Lingkungan*, Vol. 5 No. 1, pp. 1-11.

Hilmi F. M., Khairan A. N., Jatmoko M., Rini M. A., Putri Y. N. K., Lestari S. P., Hardi N. H. P., Rahman A. & Suryawan I. W. K., 2021, "Universitas Pertamina Starting Act (UPSTRACT) 3.0 Sebagai Edukasi Pengelolaan dan Pengolahan Limbah Padat", *Surya Abdimas*, pp. 193-197.

Kementerian Kesehatan Republik Indonesia. "Peraturan Menteri Kesehatan Republik Indonesia Nomor 492/ Menkes/Per/Iv/2010 : Persyaratan Kualitas Air Minum".

Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia. "Permen LHK No 68 tahun 2016 : Baku Mutu Air Limbah Domestik".

Metcalf & Eddy Inc., Tchobanoglous G., Burton F.L., & Stensel H.D., 2003, "Wastewater Engineering Treatment and Reuse (4th ed.)", Mc. Graw Hill. Singapore.

Saaty T. L., 1988," What is The Analytic Hierarchy Process? In Mathematical Models for Decision Support", pp. 109-121.

Sofiyah E. S., Septiariva I. Y., & Suryawan I. W. K., 2021, "Domestic Wastewater Treatment Using Various Microalgae for Lipid Production". *Annals of the Romanian Society for Cell Biology*, pp. 15156 - 15163.

Wardiyanto B., Sucipto T. L. A., & Rahmawati A., 2019, "Pengaruh Jumlah Lapisan Botol Plastik Sebagai Alat Sambung Terhadap Kuat Lentur Kayu Sambungan", *Indonesian Journal Of Civil Engineering Education*. Vol. 4 No. 2.

Widyaningsih W., Supriharyon, S., & Widyorini N., 2016, "Analisis Total Bakteri Coliform di Perairan Muara Kali Wiso Jepara". *Management of Aquatic Resources Journal (MAQUARES)*. Vol. 5 No. 3, pp. 157-164.