Jurnal Kesehatan
Vol. 15, No. 1, April 2024
ISSN 2086-7751 (*Print*), ISSN 2548-5695 (*Online*)
http://ejurnal.poltekkes-tjk.ac.id/index.php/JK

Performance of Microfiltration Membranes to Turn Processed Water from Hospital Wastewater Treatment Plants (WWTP) into Clean Water

Imam Santosa[1*], Daria BR Ginting[1], Bambang Murwanto[1], Mareli Telaumbanua[2]
[1]Environmental Health Department, Poltekkes Kemenkes Tanjung Karang, Bandar Lampung, Indonesia
[2]Faculty of Agriculture, Universitas Lampung, Bandar Lampung, Indonesia

ARTICLE INFO

Article history

Received date
07 Feb 2024

Revised date
16 Apr 2024

Accepted date
24 Apr 2024

Keywords:

Groundwater;
Recycle;
Sanitation.

ABSTRACT

Problems arise when there are tax fees on groundwater use by hospitals. This will, of course, burden the hospital's operational costs. The solution to reducing groundwater use is the use of microfiltration membranes. Microfiltration membranes can be used to recycle wastewater into clean water so that it can be collected and used for cleaning, washing, and watering gardens. They can reduce groundwater taxes and hospital groundwater use. The research objectives are to know the efficiency of reducing wastewater recycling equipment from the wastewater treatment plant (WWTP) outlet using a microfiltration membrane. The research methodology used was a quasi-experiment in laboratories and workshops, with a pre-test (before treatment) and post-test (after treatment) design. Stage one Microfiltration Membrane is a medium for processing wastewater into clean water in the first stage. Stage two, Microfiltration Membrane, is a medium for processing wastewater into clean water. In the second stage, it ensures that clean water quality is met. The results that the efficiency of reducing the wastewater recycling equipment from the WWTP outlet using Microfiltration Membrane for pH 7%, Temperature 6%, Turbidity 64%, Colour 85%, Dissolved Solids (TDS) 40%, Nitrate 70%, Nitrite 94%, dissolved Iron (Fe) 33%, Manganese 60%, Cadmium 50%, Lead 43%, Fluoride 46%, Cyanide 96%, Hardness (CaCO3) 11%. In conclusion, all the parameters studied experienced a decrease in concentration. This research suggests conducting further research to reduce the current research discharge and make the parameter reduction more significant.

Corresponding author:

Imam Santosa
Environmental Health Department, Poltekkes Kemenkes Tanjung Karang, Bandar Lampung, Indonesia
Email: imamsantosa@poltekkes-tjk.ac.id

INTRODUCTION

Problems in big cities currently occur due to the use of water in large land capacities, so one of the impacts is a decrease in land surface. Land subsidence can cause damage to buildings, flooding, and hamper community economic activities. Apart from that, another economic impact is that the tax costs for hospitals using groundwater have increased. This burdens hospital operational costs because the applicable regulations require a Groundwater Exploitation Permit (SIPA) for parties who utilize groundwater due to paying groundwater tax every year (Governor of Province Lampung, 2014). 80% of hospitals generally use groundwater for clean water needs for various activities, such as bathing, washing, toilets, and watering plants.

The solution to reducing groundwater use is to convert hospital wastewater into clean water using microfiltration membrane technology to collect and use it for cleaning, washing, and garden watering purposes. Previous research explained that current water purification and wastewater treatment technology can use microfiltration membranes. The microfiltration membranes used are 0.05 µm for oily wastewater, with removal reaching 82.5% (Widyasmara et al., 2013).

In other research, microfiltration is explained as an alternative to clean water. Wastewater becomes clean water with the wastewater treatment flow from the WWTP, which is channeled into a microfiltration membrane, which is then disinfected and stored in a reservoir, which results in the removal of 90% BOD, 85% COD, and a total of up to 70% Coli. % (Yudistira et al, 2016). Microfiltration membranes are the separation of micron or sub-micron-sized particles, generally shaped like a cartridge, and help remove particles from water measuring 0.04 to 100 microns (Agustina, 2016).

Apart from microfiltration membranes, filter tubes with silica sand media can also be used to reduce pollutant levels from wastewater. The average filter removal efficiency with silica sand as a pre-treatment material for microfiltration membranes resulted in a reduction in BOD 78.24%, COD 56.25%, TSS 75.85%, ammonia 56.49%, phosphate 39.13%, oil and fat 34.38%, and coliform 27.27% MPN/100ml. (Santosa, 2022).

Santosa's (2023) research stated that the quality of processed wastewater using microfiltration membranes resulted in pH 7, BOD 10mg/l, COD 64mg/l, TSS 12mg/l, Fatty Oil 0.5mg/l, NH3 1mg/l, and Total Coliform 800 Number/100ml sample, wastewater concentration in all parameters meets hospital wastewater quality standards, the suggestion from this research is to install a field-scale microfiltration membrane device.

According to Ministry of Public Works regulations, recycling wastewater into clean water must be carried out by large water users such as hotels, hospitals, and industry by building clean water installations to maintain the sustainability of water use and minimize waste discharged into the environment (Ministry of Public Works RI, 2011). Therefore, using clean water originating from hospital liquid waste is an effort to process wastewater originating from liquid waste from wastewater treatment plants (WWTP) so that it can be reused as needed.

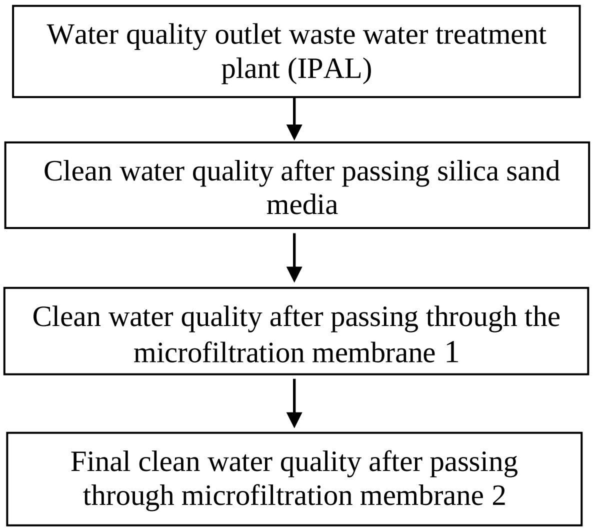
Reusing wastewater into clean water for hospital purposes requires paying attention to clean water quality requirements that comply with standards. Based on the description above, the benefit or contribution of this research is to obtain a method for processing wastewater from the WWTP outlet into clean water using silica sand media filter tubes and microfiltration membranes, the results of which can be directly used for hospital purposes.

Another benefit is that research data is obtained in the form of wastewater quality, which can be used as clean water, processing work procedures, and the efficiency of using filter tubes and microfiltration membranes, which are applied directly in hospitals.

To obtain a method for processing wastewater into clean water, the research objectives are formulated to determine the clean quality of the IPAL outlet, the clean water quality of filter tubes, the clean water quality of stage 1 microfiltration membranes, the water quality clean stage 2, and to determine the processing efficiency of the microfiltration membrane reactor.

METHOD

The research flow diagram can be seen below:



Water quality parameters examined are the parameters pH, Temperature, Taste, Odor, Turbidity, Color, Dissolved Solids (TDS), Nitrate (as dissolved NO_3), Nitrite (as dissolved NO_2), Iron (Fe) dissolved, Manganese (dissolved Mn), Cadmium (dissolved Cd), Lead (dissolved Pb), Fluoride, Cyanide, Hardness, ($CaCO_3$).

Preliminary processing with silica sand media is preliminary, so the microfiltration membrane does not experience saturation/klogging. After passing through silica sand media, clean water quality is the result of initial stage processing to show the performance of preliminary processing using silica sand media.

Stage 1 microfiltration membrane is a medium for processing clean water in the first stage. Stage 2 microfiltration membrane is a medium for processing clean water in the second stage, which ensures clean water quality is met.

The research was carried out on a field scale and used wastewater originating from the IPAL outlet of the hospital, Dr. A. Dadi Tjokro Dipo, in the city of Bandar Lampung.

In this research, the researcher prepared several things: preparation for taking samples, making a reactor, and carrying out preliminary reactor trials for hospital wastewater treatment.

Figure 1. Preparation of research

1) Equipment and Materials

In this research, we prepared the tools and materials for making the reactor. The materials needed are two water filter tubes, a 2-inch PVC pipe, a centrifugal pump of 18 liters per minute, an automatic pump sensor, a pipe, an electrical cable, silica sand 0,8-1,4 mm, a microfiltration membrane of 5 microns, a microfiltration membrane of 1 micron, dop, and cartridge tube.

2) Microfiltration Membrane Reactor Assembly

The reactor consists of a filter tube, centrifugal pump, microfiltration membrane 1, microfiltration membrane 2, and a clean water storage tank.

3) Filling Silica Sand in Tubes

The next stage is filling silica sand into the filter tube.

Figure 2. Filling silica sand in tubes

4) Reactor Testing

After constructing the reactor, a trial operation of the reactor was carried out before the reactor was used for research. This operational testing phase aims to look for deficiencies in the reactor, such as pipe leaks, so that the results obtained in this research are optimal. Wastewater pumped with a centrifugal pump with a capacity of 18 liters per minute flows into the silica sand media filter tube, microfiltration membrane 1, and microfiltration membrane 2; after that, it flows into a clean water storage tank.

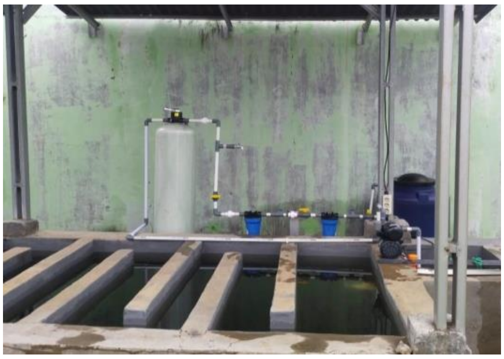


Figure 3. The reactor can now be operated

After the reactor is running, the water sample points to be examined are taken as follows:

1. Hospital WWTP Outlet
2. Filter Tube, media height 0.8 m
3. Microfiltration Membrane 1
4. Microfiltration Membrane 2

Repetition of water sampling was carried out two times, namely repetition of sample 1 and repetition 2 at each sample point. Clean water parameters examined in the laboratory are pH, Temperature, Taste, Odor, Turbidity, Color, Dissolved Solids (TDS), Nitrate (as dissolved NO3), Nitrite (as dissolved NO2), dissolved Iron (Fe), Manganese (dissolved Mn), Cadmium (dissolved Cd), Lead (dissolved Pb), Fluoride, Cyanide, Hardness (CaCO3).

After running and taking water samples in the reactor, the samples were immediately taken to the examination laboratory, and the results were waited for two weeks.

The data from clean water quality inspection results is made into a table and compared with regulations on clean water quality standards, Minister of Health Regulation Number 32 of 2017 concerning environmental health quality standards.

The data results were also made into an efficiency graph in percent units at the IPAL outlet point, filter tube, Microfiltration Membrane 1, and Microfiltration Membrane 2.

RESULTS

Table 1. Clean water quality of WWTP outlet initial hospital

Parameter	Unit	Repetition 1	Repetition 2	Average	Quality Standards Maximum**
pH	-	7	7	7	6.5-8.5
Temperature	°C	26	27	26.5	Water±3
Flavor	-	Tasteless	Tasteless	Tasteless	Tasteless
Odor	-	Odorless	Odorless	Odorless	Odorless
Turbidity	NTU	10	12	11	25
Color	TCU	121	125	123	50
Dissolved Solids (TDS)	mg/L	341	341	341	1000
Nitrate (as No_3)	mg/L	0.2	0,4	0.3	20
Nitrite (as NO2)	mg/L	1	2	1.5	3
Iron (Fe)	mg/L	0.03	0.03	0.03	1
Manganese (Mn)	mg/L	0.01	0.04	0.025	0.1
Cadmium (Cd)	mg/L	0.003	0.003	0.003	0.003
Lead (Pb)	mg/L	0.003	0.004	0.0035	0.01
Florida	mg/L	1	1.4	1.2	1.5
Cyanide	mg/L	0.02	0.028	0.024	0.1
Hardness	mg/L	244	248	246	500

Source: Research Results, 2023
Information**: Ministry of Health RI No. 32, 2017

Based on the table 1, the initial quality of clean water from the WWTP hospital outlet has concentration parameters that are still below the maximum standard for clean water and there are also quality parameters that exceed the maximum standard: pH 7, temperature 26.5°C, tasteless, odorless, turbid. 11 NTU, color 123 TCU, dissolved solids (TDS) 341mg/L, nitrate (as dissolved NO3) 0.3mg/L, Nitrite (as dissolved NO2) 1.5 mg/L, dissolved Iron (Fe) 0,03mg/L, Manganese (dissolved Mn) 0.025mg/L, Cadmium (dissolved Cd) 0.003mg/L, Lead (dissolved Pb) 0.0035mg/L, Fluoride 1.2mg/L, Cyanide 0.024mg/L, Hardness (CaCO3) 246mg/L,

Table 2. Silica filter tube clean water quality

Parameter	Unit	Repetition 1	Repetition 2	Average	Quality Standards Maximum**
pH	-	7	7	7	6.5-8.5
Temperature	°C	25	26	25,5	Water±3
Flavor	-	Tasteless	Tasteless	Tasteless	Tasteless
Odor	-	Odorless	Odorless	Odorless	Odorless
Turbidity	NTU	6	8	7	25
Color	TCU	64	68	66	50
Dissolved Solids (TDS)	mg/L	207	210	208.5	1000
Nitrate (as No_3)	mg/L	0.1	0.1	0.1	20
Nitrite (as NO2)	mg/L	0.1	0.3	0.2	3
Iron (Fe)	mg/L	0.03	0.02	0.025	1
Manganese (Mn)	mg/L	0.012	0.013	0.0125	0.1
Cadmium (Cd)	mg/L	0.003	0.003	0.003	0.003
Lead (Pb)	mg/L	0.003	0.003	0.003	0.01
Florida	mg/L	1	1	1	1.5
Cyanide	mg/L	0.001	0.023	0.012	0.1
Hardness	mg/L	224	234	229	500

Source: Research Results, 2023
Information**: Ministry of Health RI No. 32, 2017

Based on the table 2, the filter tube has quality parameters that are still below the maximum standard for clean water. There are also concentration parameters that exceed the maximum standard: pH 7, Temperature 25.5°C, Tasteless, Odorless, Turbidity 7 NTU, Color 66 TCU, Dissolved Solids (TDS) 208.5 mg/L, Nitrate (As dissolved NO3) 0.1mg/L, Nitrite (As dissolved NO2) 0.2mg/L, dissolved Iron (Fe) 0.025 mg/L, Manganese (dissolved Mn) 0.0125mg/L, Cadmium (dissolved Cd) 0.003mg/L, Lead (dissolved Pb) 0.003mg/L, Fluoride 1mg/L, Cyanide 0.012mg/L, Hardness (CaCO3) 229mg/L.

Table 3. Microfiltration membrane 1 clean water quality

Parameter	Unit	Repetition 1	Repetition 2	Average	Quality Standards Maximum**
pH	-	7	7	7	6,5-8,5
Temperature	°C	25	26	25,5	Air ±3
Flavor	-	Tasteless	Tasteless	Tasteless	Tasteless
Odor	-	Odorless	Odorless	Odorless	Odorless
Turbidity	NTU	4	6	5	25
Color	TCU	21	21	21	50
Dissolved Solids (TDS)	mg/L	207	208	207,5	1000
Nitrate (as No_3)	mg/L	0,1	0,08	0,09	20
Nitrite (as NO_3)	mg/L	0,02	0,02	0,02	3
Iron (Fe)	mg/L	0,03	0,01	0,02	1
Manganese (Mn)	mg/L	0,01	0,01	0,01	0,1
Cadmium(Cd)	mg/L	0,002	0,002	0,002	0,003
Lead (Pb)	mg/L	0,002	0,002	0,002	0,01
Florida	mg/L	0,8	0,8	0,8	1,5
Cyanide	mg/L	0,001	0,023	0,012	0,1
Hardness	mg/L	224	227	225,5	500

Source: Research Results, 2023
Information**: Ministry of Health RI No. 32, 2017

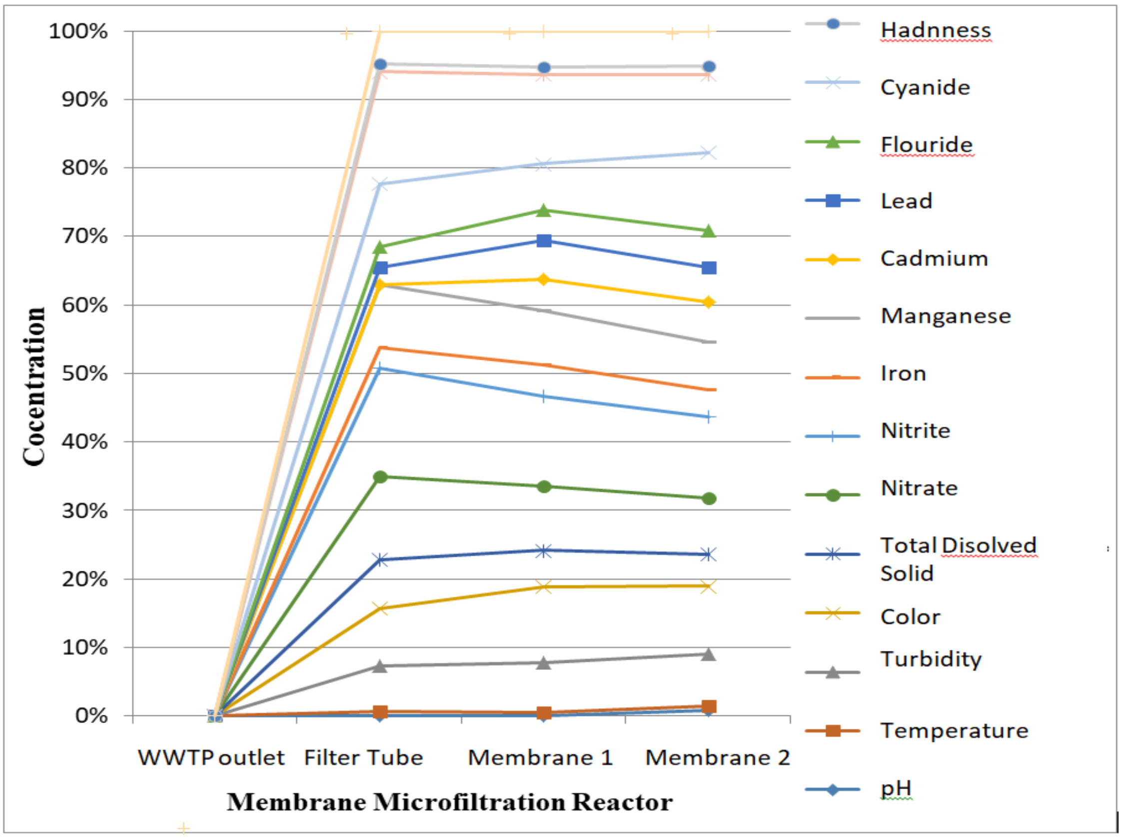
Based on the table above, the initial quality of clean water from microfiltration membrane 1 has all parameter concentrations below the maximum clean water standard: pH 7, temperature 25.5°c, tasteless, odorless, turbidity 5 NTU, Color 21 TCU, dissolved solids (TDS) 207.5mg/L, nitrate (as dissolved NO3) 0.09mg/L, nitrite (As dissolved NO2) 0.02mg/L, dissolved iron (Fe) 0.02mg/L, manganese (dissolved Mn) 0.01mg/L, cadmium (dissolved Cd) 0.002mg/L, Lead (dissolved Pb) 0.002mg/L, fluoride 0.8mg/L, cyanide 0.012mg/L, hardness (CaCO3) 225.5mg/L.

Table 4. Microfiltration membrane 2 wastewater quality

Parameter	Unit	Repetition 1	Repetition 2	Average	Quality Standards Maximum**
pH	-	7	6	6,5	6.5-8.5
Temperature	°C	25	25	25	Water±3
Flavor	-	Tasteless	Tasteless	Tasteless	Tasteless
Odor	-	Tasteless	Tasteless	Tasteless	Tasteless
Turbidity	NTU	6	2	4	25
Color	TCU	20	18	19	50
Dissolved Solids (TDS)	mg/L	208	200	204	1000
Nitrate (as No_3)	mg/L	0.1	0.08	0.09	20
Nitrite (as NO2)	mg/L	0.002	0.002	0.002	3
Iron (Fe)	mg/L	0.03	0.01	0.02	1
Manganese (Mn)	mg/L	0.01	0.01	0.01	0.1
Cadmium(Cd)	mg/L	0.002	0.001	0.0015	0.003
Lead (Pb)	mg/L	0.003	0.001	0.002	0.01
Florida	mg/L	0.4	0.9	0.65	1.5
Cyanide	mg/L	0.001	0.001	0.001	0.1
Hardness	mg/L	224	216	220	500

Source: Research Results, 2023
Information**: Ministry of Health RI No. 32, 2017

Based on the table 4, the clean water quality from microfiltration membrane 2 has all parameter concentrations below the maximum clean water quality standards: pH 6.5, temperature 25, tasteless, odorless, turbidity 4 NTU, color 19 TCU, dissolved solids (TDS) 204mg/L, nitrate (as dissolved NO_3) 0.09mg/L, nitrite (as dissolved NO2) 0.002mg/L, dissolved iron (Fe) 0.02mg/L, manganese (dissolved Mn) 0.01mg/L, cadmium (dissolved Cd) 0.0015mg/L, lead (dissolved Pb) 0.002mg/L, fluoride 0.65mg/L, cyanide 0.001mg/L, hardness (CaCO3) 216mg/L.



Graph 1. Efficiency of reducing membrane microfiltration reactor

Based on the graph 1, the reduction efficiency of filter tubes, microfiltration membrane 1 and microfiltration membrane 2, each concentration has an increasing trend, the highest concentration achieved by microfiltration membrane 2 is presented as follows: pH parameters 7%, temperature 6%, turbidity 64%, color 85%, Total Dissolved Solids (TDS) 40%, nitrate (as dissolved NO_3) 70%, nitrite (as dissolved NO_2) 94%, dissolved iron (Fe) 33%, manganese (dissolved Mn) 60%, cadmium (dissolved Cd) 50%, lead (dissolved Pb) 43%, fluoride 46%, cyanide 96%, hardness (CaCO3) 11%.

DISCUSSION

Reusing hospital wastewater is an obligation because the amount of clean water that becomes wastewater is so large. As in previous research, around 70% of domestic waste is greywater. Therefore, greywater has the potential to be reused for specific purposes (Bestari et al., 2017). This research contributes to obtaining a method for processing wastewater from the WWTP outlet into clean water using silica sand media filter tubes and microfiltration membranes, the results of which can be directly used for hospital purposes.

The filter tube with silica sand media is a preliminary processing effort so that the microfiltration membrane 1 does not experience clogging; the clean water quality after passing through the silica sand media is the result of the initial processing stage.

Stage 1 microfiltration membrane is a clean water processing medium in the first stage of producing clean water. Stage 2 microfiltration membrane is the second stage of clean water processing media, ensuring clean water quality meets standards.

Outlet WWTP

Water quality parameters examined are the parameters pH, temperature, taste, odor, turbidity, color, dissolved solids (TDS), nitrate (as dissolved NO_3), nitrite (as dissolved NO_2), iron (Fe) dissolved, manganese (dissolved Mn), cadmium (dissolved Cd), lead (dissolved Pb), fuoride, cyanide, hardness, ($CaCO_3$). The water quality parameters that come out of the WWTP that are checked are pH, temperature, taste, odor, turbidity, color, dissolved solids (TDS), nitrate (as dissolved NO3), nitrite (as dissolved NO2), dissolved iron (Fe), manganese (dissolved Mn), cadmium (dissolved Cd), lead (dissolved Pb), fluoride, cyanide, hardness (CaCO3).

Result show that the initial quality of clean water parameters has a concentration that is still below the clean water quality standard, and there are also quality parameters that exceed the maximum quality standard by Ministry of Health RI Number 32 (2017). concerning environmental health quality standards and water health requirements for hygiene purposes. sanitation, swimming pool, solus per aqua, and public baths

Filter tube

The filter tube has quality parameters that are still below the maximum quality standards for clean water, and there are also concentration parameters that exceed the maximum quality standards. Filter tubes containing silica sand media play an essential role in the preliminary process of microfiltration membranes. In this research, silica sand can reduce parameter concentrations because silica sand is the result of the weathering of rocks that contain main minerals such as quartz and feldspar. Previous research explained that silica sand is generally used in the initial stages as a filter to process dirty water into clean water. The decreasing parameter levels phenomenon was explained by the silica sand filter acting as a filtrate that can separate solid and liquid chemical compounds, where the liquid from liquid waste passes through the media. Porous so fine suspended solids can be removed (Ronny & Syam, 2018).

Other research that uses sand media in water treatment and aims to ensure that wastewater can be reused into clean water explains that slow sand filters are physical processing using sand and anthracite media. Has the best processing efficiency with COD reduction of 81.99%, 85.05%; and 86.37%, for BOD showing the efficiency of 74.84%, 82.58%; and 83.87%, for TSS 74.84%, 82.58%; and 83.87%, and the pH changed from 4, 6, and 7 (Wijaya et al., 2021).

Apart from that, based on the calculation of the reuse water unit, a carbon filter is used as a medium for utilizing wastewater into clean water for 6 carbon filter tank units and a reservoir unit with a capacity of 300 liters (Batubara, 2017). Based on the descriptions above, filter tubes with silica sand media can reduce the concentration of clean water quality parameters. They can be used as pre-treatment for the reuse process.

Microfiltration membrane 1

Result show that the initial quality of clean water from microfiltration membrane 1 has all parameter concentrations below the maximum clean water standard. Reducing the concentration of all parameters until they meet clean water quality standards is described below.

Previous research on the use of microfiltration membranes carried out by Ronanda & Marsono (2021) explained that the raw water of the Siwalanpanji Sidoarjo Water Treatment Plant (PDAM), which has a high content of organic substances and E. coli by using submerged microfiltration (MF) membranes could save chemical costs for pre-chlorination.

Additionally, membranes are the best technology available for water treatment processes. Membrane technology aims to utilize wastewater and reuse it as clean water. The key to recycling using a microfiltration membrane is that the pore size of the membrane is such that it will produce water that meets the requirements.

The function of the microfiltration membrane is to filter macromolecules weighing more than 500,000g/mol or particles measuring 0.1-10μm with a dissolved solids content of no more than 100ppm. Applications in the industry are mainly carried out in the water sterilization process to separate microorganisms (bacteria, fungi) and filtration of oil and water emulsions with operating pressures of 0.5-2 atm (Kurniawan & Mariadi, 2015).

Based on the descriptions above, the decrease in water quality concentration that meets the requirements is caused by the size of the microfiltration membrane, which is on a micron scale so that the water quality can meet standards.

Microfiltration membrane 2

Result show that the clean water quality from microfiltration membrane 2 has all parameter concentrations below the maximum clean water quality standards; this can occur due to processing with stage 1 microfiltration membranes with a membrane pore diameter of 5 microns. It is also supported by stage 2 microfiltration membrane processing, which has a pore diameter of 1 micron.

The above statement is supported by previous research that the method used using microfilter and nanofilter membranes has the best results for removing COD, TSS, Phosphate, and Detergent at a pressure of 6 bar and an operating time of 140 minutes (Clever & Cahyonugroho, 2022). The membrane's pore size is such that it will produce water that has a quality that meets the requirements for use as process water so that the concept of reuse can be achieved.

Kurniawan & Mariadi (2015) said that microfiltration membranes function to filter macromolecules weighing more than 500,000g/mol or particles measuring 0.1-10μm with a dissolved solids content of no more than 100 ppm. Applications in industry are mainly carried out in the water sterilization process to separate microorganisms (bacteria, fungi) and filtration of oil and water emulsions with an operating pressure of 0.5-2 atm. Another theory states that membrane processing is the best technology available for water treatment processes. Membrane technology can be applied directly and indirectly. In direct application, membrane technology is aimed at minimizing and reusing wastewater.

It can be concluded that the quality of processed water that meets the requirements is caused by the size of the microfiltration membrane on a micron scale, with 2-stage processing using a 5-micron porous membrane in stage 1 and using a 1-micron porous membrane in stage 2, so that the quality of all clean water can meet the requirements determined.

CONCLUSION

The initial clean water quality parameters have concentrations that are still below the clean water quality standards, and there are also quality parameters that exceed the maximum quality standards by the Minister of Health RI (2017). concerning Quality Standards for Environmental Health and Water Health. Requirements for Hygiene Purposes. Sanitation, Swimming Pool, Solus Per Aqua, and Public Baths

Filter tubes with silica sand media can reduce the concentration of clean water quality parameters but not for all test parameters and can be used as pre-treatment for reuse.

The quality of processed water that meets the requirements is caused by the size of the microfiltration membrane on a micron scale, with 2-stage processing using a 5-micron porous membrane in stage 1 and using a 1-micron porous membrane in stage 1. So that all test parameters can meet the requirements of clean water quality standards.

The reduction efficiency of microfiltration membrane recycling reactors shows an increasing trend, with the final results: pH parameters 7%, temperature 6%, turbidity 64%, color 85%, Dissolved Solids (TDS) 40%, nitrate 70%, nitrite 94%, iron 33 %, manganese 60%, cadmium 50%, lead 43%, fluoride 46%, cyanide 96%, hardness (CaCO3) 11%.

This research suggests that further research should be carried out to reduce the research discharge (centrifugal pump discharge) below the current 18 liters per minute so that each parameter can experience a more significant reduction in efficiency.

REFERENCES

Agustina, S. (2016). Teknologi Membran dalam Pengolahan Limbah Cair Industri. *Jurnal Kimia dan Kemasan*, *28*(1), 18-24. http://ejournal.kemenperin.go.id/jkk/article/view/3281/2511

Bestari, Utomo, Umar (2017). Daur Ulang Greywater Untuk Keperluan Siram Wc Dan Urinal Pada Rumah Sakit Pendidikan Universitas Tanjungpura. *Jurnal Teknologi Lingkungan Lahan Basah*, *5*(1). https://jurnal.untan.ac.id/index.php/jmtluntan/article/view/20923/17018

Batubara, Gustika O, (2017). Perencanaan Instalasi Pengolahan Air Limbah Medis Dan Daur Ulang Efluen Ipal Di Rumah Sakit Kelas C. *[Undergraduate thesis]. Surabaya: Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh November*.

Clever, M., & Cahyonugroho, O. H. (2022). Pengolahan Limbah Cair Laundry Menggunakan Membran Nanofiltrasi dengan Koagulasi dan Flokulasi, dan Mikrofiltrasi Sebagai Pretreatment. *Envirous*, *3*(1), 122-131. https://envirous.upnjatim.ac.id/index.php/envirous/article/view/76

Governor of Province Lampung. (2014). *Peraturan Daerah Provinsi Lampung Tentang Pengelolaan Air Tanah Nomor 29 Tahun 2014 Pengelolaan Air Tanah.* Lampung.

Kurniawan, I., & Mariadi, P. D. (2015). Review : Profil Hybrid Membrane Dalam Proses Reduksi Air Limbah. *Jurnal Konversi*, *5*(1), 1. https://doi.org/10.24853/Konversi.5.1.1-10

Ministry of Public Works RI. (2011). *Peraturan Menteri PU No. 6 Tentang Pedoman Penggunaan Sumber Daya Air*. Jakarta.

Ministry of Health RI. (2017). *Peraturan Menteri Kesehatan Nomor 32 Tahun 2017 Tentang Standar Baku Mutu Kesehatan Lingkungan Dan Persyaratan Kesehatan Air Untuk Keperluan Higiene Sanitasi, Kolam Renang, Solus Per Aqua, Dan Pemandian Umum*. Jakarta.

Ronny, R., & Syam, D. M. (2018). Aplikasi Teknologi Saringan Pasir Silika Dan Karbon Aktif Dalam Menurunkan Kadar BOD Dan COD Limbah Cair Rumah Sakit Mitra Husada Makassar. *HIGIENE: Jurnal Kesehatan Lingkungan*, *4*(2), 62–66

Ronanda, H. A. T., & Marsono, B. D. (2021). Kajian Penerapan Membran Mikrofiltrasi Terendam pada Instalasi Pengolahan Air (IPA) Siwalanpanji PDAM Sidoarjo. *Jurnal Teknik ITS*, *10*(2), F61-F67. http://dx.doi.org/10.12962/j23373539.v10i2.63556

Santosa, Imam. (2022). Performance Analysis Of Silica Sand As A Processing Material Introduction Microfiltration Membranes For Treating Hospital Wastewater. *IJSR Journal*, *11*(4), 1163–1165.

Santosa, I. (2023). Decreased Concentration (BOD, COD, TSS, Fatty Oil, Ammonia and Coliform) Hospital Wastewater Using Microfiltration Membranes. *Jurnal Kesehatan*, *14*(1), 117-125. http://dx.doi.org/10.26630/jk.v14i1.3491

Widyasmara, M., Dewi, C. K., & Aryanti, N. (2013). Potensi Membran Mikrofiltrasi Dan Ultrafiltrasi Untuk Pengolahan Limbah Cair Berminyak. *Jurnal Teknologi Kimia dan Industri*, 295-307. https://ejournal3.undip.ac.id/index.php/jtki/article/view/2642

Wijaya, R. A., Utomo, B., & Soeryodarundio, K. Produksi Bersih Melalui Pemanfaatan Kembali Air Limbah Pada Home Industry Tahu Menggunakan Slow Sand Filter. *Matriks Teknik Sipil*, *10*(3), 281-291. https://doi.org/10.20961/mateksi.v10i3.55343

Yudistira, Novalina A., et al. "Pemilihan Teknologi Daur Ulang Effluent Limbah Cair Rumah Sakit untuk Memenuhi Kebutuhan Air Bersih Pertamanan dan Kegiatan Non-Potable. *Jurnal Online Mahasiswa Fakultas Teknik Universitas Riau*, 3(1), 1-8. https://jom.unri.ac.id/index.php/JOMFTEKNIK/article/view/9678