Applied Research in Science and Technology 02 (01): 36-42 2022

Contents lists available at openscie.com

Applied Research in Science and Technology

Journal homepage: https://areste.org/index.php/oai

Performance of Pretreatment Materials on Hospital Wastewater Before Microfiltration Membrane Filtration Process

Imam Santosa[1]*, Daria Br Ginting[1], Enro Sujito[1]

[1] Jurusan Kesehatan Lingkungan, Poltekkes Kemenkes Tanjungkarang, Lampung, Indonesia

*Correspondence: E-mail: imamsantosa2811@gmail.com

ARTICLE INFO

Article History:
Received 26 May 2022
Revised 17 July 2022
Accepted 12 August 2022

Keywords:
Hospital wastewater,
Microfiltration membrane,
Pretreatment materials.

ABSTRACT

An alternative method of treating hospital wastewater can use a microfiltration membrane, where the results showed that the disposal of oily wastewater reached 82.5%, BOD 90%, COD 85%, and total Coli up to 70%. In addition, it can remove particles from wastewater from 0.04 to 100 microns in size. The problem with using microfiltration membranes is the rapid occurrence of fouling/saturation on the surface of the microfiltration membrane, causing the wastewater treatment operation time to be short. The length of this treatment causes the problem of less amount of wastewater being treated and another problem, namely faster membrane replacement. This study aims to determine the performance of pretreatment of microfiltration membranes made of alum, silica sand, and activated carbon for parameters pH, BOD, COD, TSS, Ammonia, Fatty Oil, and Total Coliform. The results of the study were as follows: 1) the average quality of hospital wastewater was temperature 28.8°C, pH 7, BOD 79 mg/l, COD 167.05 mg/l, Total Suspended Solid 68 mg/l, Ammonia 4 mg/l, Phosphate 0.745 mg/l, Fatty Oil 1.64 mg/l, Coliform 2.200 MPN/100 ml. 2) Comparison analysis of the most effective materials on the parameters, for BOD Silica Sand 78.24%, COD 56.25% Silica Sand, Total Suspended Solids 83.42% Activated Carbon, Ammonia Silica Sand 56.49%, Phosphate 80.43 % Activated Carbon, Fat Oil is 80.43% Alum, Coliform is Microfiltration Membrane 40.91%.

1. Introduction

The hospital is one health care facility that produces large amounts of wastewater in operational activities. Wastewater comes from bathing, washing, patient toilets, laundry, kitchens, laboratories, and other sanitation activities. Generally, hospitals in Indonesia manage wastewater using a biological method, namely an aerobic anaerobic biofilter system.

The wastewater treatment method with an aerobic anaerobic biofilter system has weaknesses because it requires expensive investment, a large area of land, and uses biofilters, pumps, blowers, and expensive chemicals to operate. The aerobic anaerobic biofilter wastewater treatment plant (WWTP) system consists of a screen, fat capture tank, initial settling tank, anaerobic biofilter tank, aerobic biofilter and final settling tank, chlorination tank, and indicator pond **(Ministry of Health Republic of Indonesia, 2011)**.

Currently, water purification and wastewater treatment technology can use a microfiltration membrane. The microfiltration membrane is 0.05 m in size and is used for oily liquid waste with an absorption capacity of up to 82.5% **(Widyasmara et al. 2013)**. **Novalina et al. (2016)** describe microfiltration as an alternative to wastewater treatment which results in the removal of 90% BOD, 85% COD, and up to 70% total Coli. According to **Agustina (2016)** a microfiltration membrane is the separation of micron or sub-micron-sized particles. The general shape is like a cartridge, and the point is to remove particles from water with a size of 0.04 to 100 microns.

The problem faced is the occurrence of fouling/saturation on the surface of the microfiltration membrane, which causes the wastewater treatment operation time to be short. This lack of time for treatment causes problems with less wastewater being generated and membrane replacement faster. Membrane fouling is a problem that often occurs on the membrane surface. Fouling is the deposition of particles on the surface of a membrane. Fouling on the membrane depends on the effectiveness of the pretreatment and the current flowing on the membrane surface. Therefore, preliminary treatment is needed to overcome the rapid occurrence of fouling.

Materials used for pre-treatment where the function materials to extend the operating hours of the microfiltration membrane can be an alum, silica sand, and activated carbon, all of which can function to purify wastewater, so it is expected that the operating time of the microfiltration membrane can last a long time in treating wastewater of hospital.

Filtering using silica sand and activated carbon in hospital wastewater can reduce BOD levels by39.97% and COD levels by 41.19% **(Ronny and Syam, 2018)**. Coagulation carried out with optimum alum concentration was able to remove turbidity up to 94.98%, TSS 93.87%, and COD 57.43% **(Nurlina et al. 2015)**. Therefore, analyzing the performance of preliminary treatment made from alum, silica sand, and activated carbon in treating hospital wastewater using a microfiltration membrane is necessary. In addition, this study aims to determine the initial parameters of the concentration of pH, BOD, COD, TSS, ammonia, oils and fats, total Coliform of hospital wastewater, analyze the comparison of the effect of alum, silica sand filter, and activated carbon filter on the quality of pH parameters, BOD, COD, TSS, ammonia, oils and fats, total Coliform.

2. Methods

2.1 Research Design

This research is experimental with a pre-test and post-test design for the object under study. The research conducted from March to September 2021, where thelocation of the study was in the laboratory/workshop of the environmental health department, Tanjungkarang Health Polytechnic (Poltekkes Tanjungkarang. The hospital wastewater samples came from the wastewater treatment plant (WWTP/ IPAL) of RSIA Puri Adhya Paramita (Hospital) in Bandar Jaya, Central Lampung Regency, Lampung Province. The quality of hospital wastewater examined was parameters of pH, BOD, COD, TSS, ammonia, fatty oil, and total Coliform **(Ministry of Environment, 2016)**.

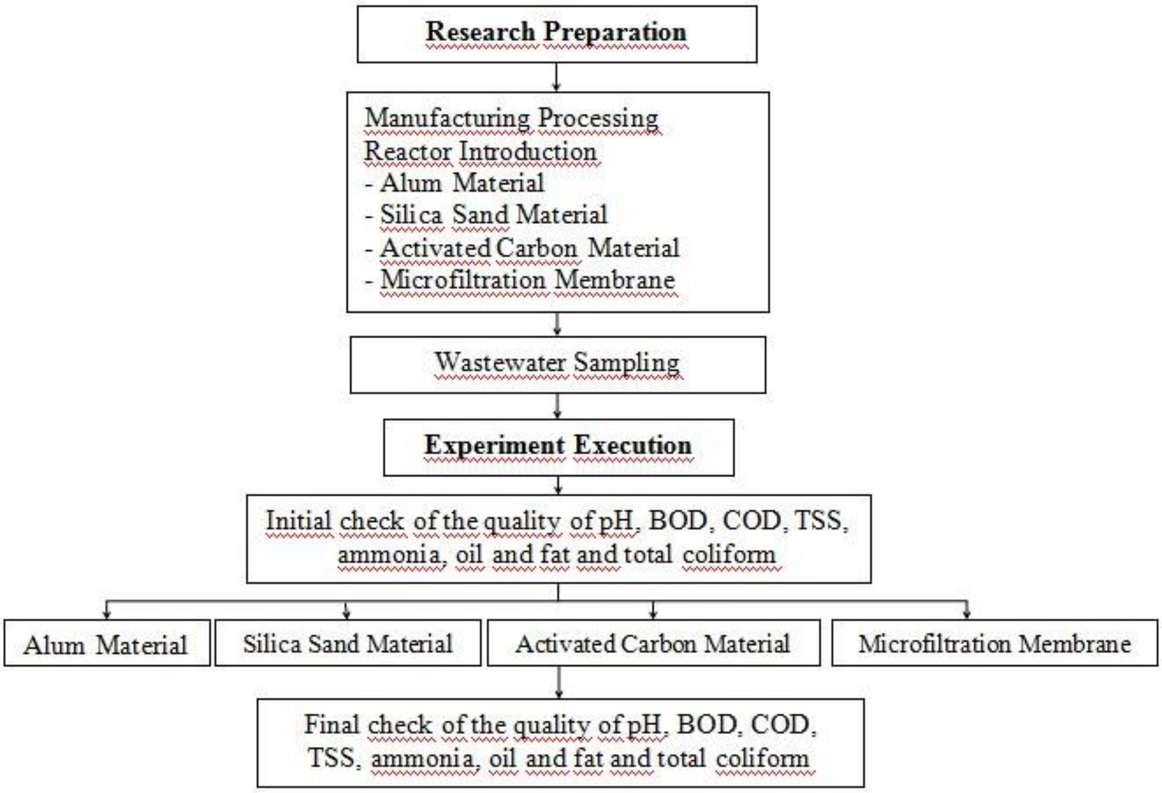

Figure 1. Research Design Fow chart

2.2 Reactor Design

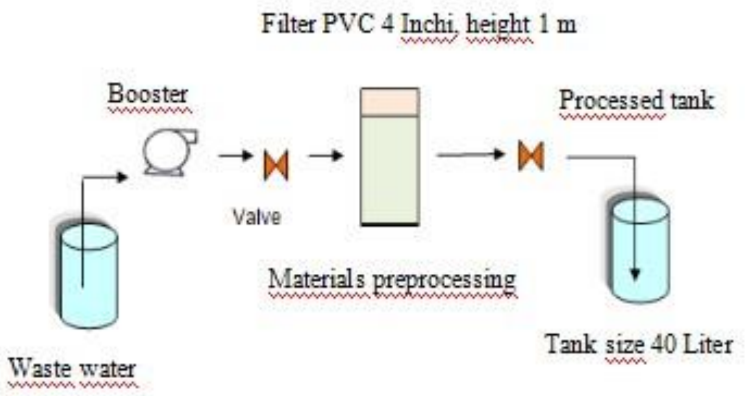

Figure 2. Reactor Design

Hospital wastewater is accommodated in a 40-liter plastic tub, pumped with a Booster Pump with a capacity of 1 liter per minute. The pumped wastewater individually flows into a filter containing silica sand, activated carbon, alum, and microfiltration membrane material. The processed water is accommodated in a 40 liter plastic tub. The treated water is then examined at the Lampung Provincial Health Laboratory. According to **Ronanda and Marsono (2021)**, the use of the reactor requires a fast sand filter as a preliminary treatment to treat clean water using a microfiltration membrane.

3. Results and dicussion

3.1 Hospital Wastewater Quality

Based on Table 1, it is known that the average quality of wastewater at wastewater are temperature is 28.8 C, pH 7, BOD 79 mg/l, COD 167.05 mg/l, Total Solid Suspended 68 mg/l, Ammonia 4, Phosphate 0.745 mg/l, Oils and Fats 1.64 mg/l and Coliform 2.200 MPN/100 ml.

The study results were compared with the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No.P.68/Menlhk/Setjen/2016 concerning Domestic Wastewater Quality Standards; several parameters did not meet the requirements, namely BOD, COD, and TSS. According to domestic wastewater quality standards for hospitals, the pH parameters range from 6-9, the maximum level of BOD is 30 mg/l, the maximum level of COD is 100mg/l, the maximum level of TSS is 30mg/l, the maximum level of Fatty Oil is 5 mg/l, maximum Ammonia 10 mg/l, Total Coliform 3000 MPN/100ml **(Ministry of Environment, 2016)**.

Table 1. Hospital Raw Wastewater Quality

No	Parameters	Sample Replications 1	Sample Replications 2	Average	Unit
1	Temperatur	27,9	29,7	28,8	°C
2	pH	6,80	7,20	7	-
3	BOD	76,0	82,0	79	mg/l
4	COD	161,7	172,4	167,05	mg/l
5	Total Solid Suspended	65	71	68	mg/l
6	Ammonia	3,70	4,30	4	mg/l
7	Phosphate	0,23	1,26	0,745	mg/l
8	Fat Oil	0,16	3,12	1,64	mg/l
9	Coliform	2,200	2,200	2,200	MPN/100 ml sample

The cause of this discrepancy is that the hospital wastewater used comes directly from wastewater sources, such as treatment rooms, laundry installations, kitchens, operating rooms, and laboratories. The wastewater source has not been treated at the wastewater treatment plant, so the wastewater does not meet the quality standard requirements according to PERMENLHK number 68 of 2016.

3.2 Performance pretreatment media on BOD, COD, TSS, Ammonia, Phosphate, Fat Oil, and Total Coliform

Tabel 2. Effect of pretreatment media on BOD, COD, TSS, Ammonia, Phosphate, Fat Oil and Total Coliform

Pretreatment Media Type	BOD	COD	TSS	Ammonia	Phosphate	Fat Oil	Total Coliform
	Percentage (%)						
Activated Carbon	58.85	49.06	62.31	49.19	80.43	62.50	27.27
Silica Sand	78.27	56.25	75.85	56.49	39.13	34.38	27.27
Alum	69.54	55.94	74.27	47.84	39.13	87.50	27.27
Membrane Microfiltration	75.82	53.01	83.42	50.41	54.35	62.50	40.91

Based on Table 2. Biological Oxygen Demand (BOD) obtained the results of a Pretreatment Media Type comparison, activated carbon 58,85%, silica sand 78,24%, alum 69.54%, and microfiltration membrane 75.82%. BOD indicates the presence of liquid waste organic matter. BOD is the amount of oxygen needed by bacteria to decompose all organic matter in water within 5 days and at a temperature of 20°C **(Irianto, 2016)**. In this study, the comparison results of the most effective BOD parameter media were silica sand preliminary media, namely 78.24%. This is because silica sand results from weathering rocks containing major minerals such as quartz and feldspar. Silica sand removes the physical properties of water, such as turbidity / cloudy water, and eliminates odors in water. In general, silica sand is used in the early stages as a filter in processing dirty water into clean water **(Artiyani and Firmansyah, 2016)**.

Based on Table 2. Chemical oxygen demand (COD) parameters were obtained from the comparison of media, 49.06% activated carbon, 56.25% silica sand, 55.94% alum, and 53.01% microfiltration membrane. COD shows the amount of oxygen needed by oxidizing materials such as Potassium bichromate to decompose organic matter into CO2 and H2O gases. COD is the amount of oxygen needed to oxidize organic and inorganic substances in water **(Irianto, 2016)**.

In this study, the results of comparing the most effective media for COD parameters were silica sand preliminary media, which was 56.25%. According to **Darmono (2005)** this is because silica sand with a size larger than 1 mm can reduce COD levels by 34.1%, silica sand with a size of 1-0.5 mm has the ability to reduce COD levels by 37.97%, and silica sand with a size of less than 0.5 mm has the ability to reduce COD levels by 41.51%. The higher the porosity of silica sand, the higher the sorption rate. The best silica sand used as a filter is silica sand with a size of 0.5 mm, which is the most optimum silica sand as a water filter media in this study.

Based on Table 2. the measurement of total suspended solids obtained the results of a media comparison, 62.31% activated carbon, 75.85% silica sand, 74.27% alum, and 83.42% microfiltration membrane. TSS indicates the presence of suspended carbohydrates greater than 1 m. According to **Irianto (2016)**, TSS is a suspended material with a diameter of > 1 m which is retained on a millipore sieve with a pore diameter of 0.45 m.

In this study, the result of the comparison of the most effective TSS (total suspended solids) parameter media was the initial medium of the microfiltration membrane, which was 83.42%. This is because the microfiltration membrane filters macromolecules of more than 500,000 g/mol or particles with a size of 0.1 – 10 m with a dissolved solids content of not more than 100 ppm. Many industrial applications are carried out in the water sterilization process to separate microorganisms (bacteria, fungi) and filter oil and water emulsions with an operating pressure of 0.5 – 2 atm **(Kurniawan and Mariadi, 2015)**.

Based on Table 2. the percentage of ammonia reduction is 49.19% activated carbon, 56.49% silica sand, 47.84% alum, and 50.41% microfiltration membrane. Ammonia showed that the protein content in the waste obtained was around 1.11 mg/l. Ammonium in the waters comes from the decomposition of organic nitrogen, such as protein. Nitrogen is found in soil and water, which comes from decomposing organic matter such as dead plants and aquatic biota. Free ammonia and free chlorine will react with each other and form an antagonistic relationship **(Irianto, 2016)**.

In this study, the comparison of the most effective ammonia-free parameter media was silica sand preliminary media, which was 56.49%. This is because the porosity of silica sand at a size > 1 mm is 34.1%; The porosity of silica sand with a size of 1 > 0.5 mm is 37.97%, and silica sand with a size of0.5 mm is 41.51%. The higher the porosity of silica sand, the higher the sorption rate. The best silica sand used as a filter is silica sand with a size of 0.5 mm, which is the most optimum silica sand as a water filter media in this study **(Darmono, 2005)**.

Based on Table 2. the percentage of phosphate reduction in the comparison of media is 80.43% activated carbon, 39.13% silica sand, 39.13% alum, and 54.35% microfiltration membrane. In waters, phosphorus is not found in the form of free elements but in the form of inorganic compounds in the form of particulates. Plant, animals, and humans need phosphate, which has the benefit of activating the work of the enzymes ATP (Adenosine Triphosphate) and ADP (Adenosine Diphosphate). Humans and animals naturally excrete phosphate in the form of feces and urine. Phosphate is widely used for fertilizers, soaps or detergents, industrial ceramic materials, lubricating oils, beverage and food products, and catalysts. Phosphate is not toxic to animals and humans **(Irianto, 2016)**.

In this study, the results of comparing the media for the most effective phosphate (PO4) parameter were 80.43% activated carbon recognition media. This is because activated charcoal or activated carbon has a positive charge. There is a difference in the positive charge of activated carbon and the negative charge of pollutants, and pollutant molecules will be binding to activated carbon (absorption of pollutant molecules) **(Nurlina et al. 2015)**.

Based on Table 2. the percentage reduction of oil and fat in the media ratio, activated carbon62.50%, silica sand 34.38%, alum 87.50%, and microfiltration membrane 62.50%. Oil and detergent are domestic waste materials that affect the penetration of organic and inorganic materials **(Irianto, 2016)**.

In this study, the results of comparing the most effective fatty oil parameter media were 87.50% preliminary alum media. This is because alum is a widely used coagulant. After all, it is economical, easy to obtain in the market, and easy to store. Alum can also precipitate organic substances faster than the coagulants of Poly Aluminum Chloride (PAC) and Ferric Chloride (FeCl3.6H2O). The use of alum depends on the turbidity and high levels of organic pollutants contained in the wastewater. **(Nurlina et al. 2015)**.

Based on Table 2. the percentage of Coliform reduction in several media, activated carbon was 27.27%, silica sand 27.27%, alum 27.27%, and microfiltration membranes 40.91%. Total coliform bacteria is the calculated value of the number of colonies of Escherichia, Citrobacter, and Enterobacter bacteria found on the filter membrane after being cultured for 18-24 hours. Coliform bacteria are types of coli bacteria that are divided into two groups: fecal coliforms, bacteria that typically live in the intestines of humans and animals, for example, Escherichia coli, and non-fecal coliforms are bacteria that live in dead animals and plants. For example, Enterobacter aerogenes **(Irianto, 2016)**.

In this study, the results of comparing the most effective media for the parameters of the MPN- Germ Coli group were found to be 40,91% microfiltration membrane recognition media. This is because the microfiltration membrane filters macromolecules of more than 500,000 g/mol or particles with a size of 0.1 – 10 m with a dissolved solids content of not more than 100 ppm. Many industrial applications are carried out in the water sterilization process to separate microorganisms (bacteria, fungi) and filter oil and water emulsions with operating pressures of 0.5 – 2 atm **(Kurniawan and Mariadi, 2015)**.

4. Conclusions

Hospital wastewater quality parameter temperature 28.8 C, pH 7, BOD 79 mg/l, COD 167.05 mg/l, Total Solid Suspended (TSS) 68 mg/l, Ammonia 4, Phosphate (PO4) 0.745 mg/l, Oils and Fats 1.64 mg/l and MPN-Coli Group Germs 2.200 Total/100 ml sample. Based on the comparison of pre-treatment materials, the best performance materials for reducing the quality of hospital wastewater, respectively, are silica sand, microfiltration membranes, alum and activated carbon. Comparison analysis of the most effective materials on the parameters, for BOD Silica Sand 78.24%, COD 56.25% Silica Sand, Total Suspended Solids 83.42% Activated Carbon, Ammonia Silica Sand 56.49%, Phosphate 80.43 % Activated Carbon, Fat Oil is 80.43% Alum, Coliform is Microfiltration Membrane 40.91%.

5. Acknowledgment

Acknowledgments are especially shown to research funders or donors. Thanks can also be conveyed to those who helped carry out the research.

6. Authors Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

7. References

Agustina, S. (2006). Membrane Technology in Industrial Liquid Waste Treatment. *Research Bulletin*, *28*(1), 18-24.

Artiyani, A. & Firmansyah, N. H. (2016). Upflow Filtration Capability Upflow Filtration Treatment With Zeolite Sand And Activated Charcoal In Reducing Phosphate And Detergent Levels In Domestic Wastewater. *Innovative Industries, 6*(1), 8–15.

Darmono, M. Y. (2005). Study of the use of silica sand as a physical filter in a water filter unit. JemberUniversity Repository. http://repository.unej.ac.id/handle/123456789/19014.

Irianto, K. (2016). Liquid Waste Management. Bali Denpasar Printing. Ministry of Environment. (2016). Permen LHK No. 68 of 2016. Domestic Wastewater Quality Standards, Jakarta.

Ministry of Health. (2011). Technical Instructions With Aerobic Anaerobic Biofilter System Wastewater Treatment Plants at Ministry of Health Service Facilities, Environmental Sanitation Series.

Kurniawan, I. & Mariadi, P. D. (2015). Review: Hybrid Membrane Profile in Wastewater Reduction Process. *Conversion Journal, 5*(1), 1-7.

Nurlina, Zahara, T. A., Gusrizal & Kartika. I.D. (2015). Semirata Proceedings of Bks-Ptn Bara Oil and Gas Sector, Effectiveness of Using Alum And Activated Carbon In Tofu Wastewater Treatment. Pontianak.

Ronanda & Marsono. (2021). Study on the Application of Submerged Microfiltration Membranes in Siwalanpanji Water Treatment Plant (IPA) PDAM Sidoarjo. *Journal of ITS Engineering, 10* F61-F67. Surabaya.

Ronny & Syam, D. M. (2018). Application of Silica Sand Filter Technology in Reducing BOD andCOD Levels of Hospital Liquid Waste. *Journal of Hygiene, 4*(2). 62-66.

Widyasmara, M., Dewi, C. K. & Aryanti, N. (2013). Potential of Microfiltration and Ultra FiltrationMembranes for Oily Liquid Waste Treatment. *Journal of Chemical and Industrial Engineering, 2*(2), 295-307.