Comparative Analysis of Microfiltration Membrane Pretreatment Materials for Treating Hospital Wastewater

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Abstract. In general, hospitals in Indonesia treat wastewater using a biological method, namely an aerobic anaerobic biofilter system. The anaerobic aerobic biofilter Waste Water Treatment Plant (WWTP) system in the hospital consists of a screen tub, fat catcher tank, initial settling tank, aerobic biofilter pond, aerobic biofilter and final settling tank, chlorination tank and indicator pond. So that this wastewater treatment method has the disadvantage of requiring an expensive investment, because it requires a large area of land, uses biofilters, pumps, blowers and chemicals in its operation. Alternative methods for treating hospital wastewater can use a microfiltration membrane, where the results of the study show that the removal of oily wastewater reaches 82.5%, BOD 90%, COD 85% and total Coli up to 70%. In addition, it can remove particles from wastewater measuring 0.04 to 100 microns. The problem faced in the use of microfiltration membranes is the rapid occurrence of fouling/saturation on the surface of the microfiltration membrane causing the operation time of wastewater treatment not to be in a long time. The duration of this treatment causes the problem of a small amount of wastewater being treated and other problems, membrane replacement is faster. The purpose of the research is to determine the performance of the preliminary treatment for microfiltration membranes made from alum, silica sand and activated carbon for parameters ph, bod, cod, tss, ammonia, oil and fat, total coliform wastewater. Analyzing the effect of differences in pre-processing materials for microfiltration membranes made from alum, silica sand and activated carbon on the quality parameters of ph, bod, cod, tss, ammonia, oil and fat, total coliform. The research method carried out is a quasi-experimental, namely research that aims to explain things that will happen to the research variables through manipulation and control of variables with a design using pre test (before treatment) and post test (after treatment) to the object under study. The results of the study are as follows: 1) the average quality of hospital wastewater is 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) Analysis of the comparison of the most effective materials on the parameters, for BOD is silica sand 78.24%, COD is silica sand 56.25%, total suspended solid is 83.42% activated carbon, ammonia is silica sand 56.49%, phosphate is 80.43% activated carbon, fatty oil is 80.43% alum, coliform is a 40.91% microfiltration membrane.

Keywords: preliminary treatment · membrane · microfiltration

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1 Introduction

The hospital is one of the health care facilities that produce large amounts of wastewater in its operational activities. Waste water comes from bathing, washing and latrine activities (MCK) patients, laundry, kitchens, laboratories, places of worship and other sanitation activities,

Today in general, hospitals in Indonesia treat wastewater using a biological method, namely the anaerobic anaerobic biofilter system. This is based on the WWTP Technical Guidelines for Health Service Facilities which are the reference for hospital wastewater treatment [6].

The method of treating wastewater anaerobic aerobic biofilter system has a weakness because it requires an expensive investment, because it requires a large area of land, uses expensive biofilters, pumps, blowers and chemicals in its operation. The anaerobic aerobic biofilter WWTP system consists of a screen tub, fat catcher tank, initial settling tank, anaerobic biofilter tank, aerobic biofilter and final settling tank, chlorination tank and indicator pond.

Currently the technology for water purification and wastewater treatment can use a microfiltration membrane, the microfiltration membrane used has a size of 0.05 m and is used for oily wastewater with a removal of up to 82.5% [12].

(Novalina, et al. 2016), Describes microfiltration as an alternative to wastewater treatment which results in the removal of 90% BOD, 85% COD and up to 70% total Coli.

Micro membrane is the separation of micron or sub-micron-sized particles, the shape is common like a cartridge, the point is to remove particles from water with a size of 0.04 to 100 microns [1].

Although previous studies of microfiltration membranes have proven the success of treating wastewater, the problem faced is the occurrence of fouling/saturation on the surface of the microfiltration membrane causing the operation time of wastewater treatment to not be long. The lack of time for this treatment causes problems with the amount of wastewater produced being less and membrane replacement is faster.

Membrane fouling is a frequent problem on membrane surfaces. Fouling is the deposition of particles on the membrane surface. Fouling on the membrane depends on the effectiveness of the pretreatment and the current flowing on the membrane surface. Therefore, to overcome the rapid occurrence of fouling, preliminary processing is needed.

The materials used as preliminary treatment can be 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 hospital wastewater.

Filtering using silica sand and activated carbon in hospital wastewater can reduce BOD levels of 39.97% and COD levels of 41.19% (Ronny and Syam, 2018). Meanwhile, coagulation carried out using the optimum concentration of alum was able to remove turbidity up to 94.98%, TSS 93.87% and COD 57.43% [8].

The problem faced by the microfiltration membrane method in hospital wastewater treatment is the occurrence of fouling/saturation on the surface of the microfiltration membrane causing the operation time of the wastewater treatment not to last a long time. This treatment does not last long, causing the problem of the amount of waste water

being produced is small and membrane replacement is faster. So that the formulation of the problem is how is the performance of the preliminary treatment made from alum, silica sand and activated carbon in treating hospital wastewater using a microfiltration membrane.

Research purposes are as follows: 1) Knowing the initial parameter concentrations of pH, BOD, COD, TSS, Ammonia, Oil and Fat, Total Coliform of hospital wastewater, 2. Analyzing comparison the effect of alum, silica sand filter and activated carbon filter on the quality of the parameters pH, BOD, COD, TSS, Ammonia, Oil and Fat, Total Coliform.

2 Method

2.1 Research Design

See Fig. 1.

2.2 Experimental Reactor

Waste water is pumped with a Booster Pump with a capacity of 1 L per minute flowing into the silica materials, then the water flows into the treated water tank (Fig. 2).

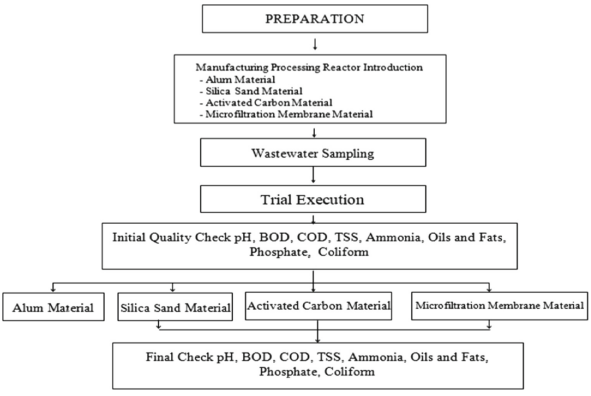

Fig. 1. Research Design

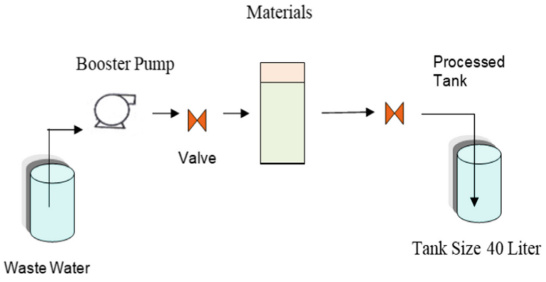

Fig. 2. Experimental Reactor

3 Result and Discussion

3.1 Hospital Preliminary Wastewater Quality

Based on the tables and graphs, the quality of hospital wastewater shows the average quality of wastewater at a wastewater temperature of 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 (Table 1).

Compared to 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, there are several parameters that do not meet the requirements, namely, BOD, COD, and Total Solid Suspended (TSS) [5].

3.2 Comparative Analysis of Material Effect on Wastewater Parameters

1) BOD Parameter

Based on the graphic data above for the temperature parameters, the results obtained are the comparison of media, 58.85% activated carbon, 78.24% silica sand, 69.54% alum, and 75.82% microfiltration membrane (Fig. 3).

BOD indicates the presence of liquid waste organic matter. Biological Oxygen Demand (BOD) is the amount of oxygen needed by bacteria to decompose all organic materials in water within 5 days and at a temperature of 20 °C [4].

In this study, the results of the comparison of the media for the most effective BOD parameter were silica sand preliminary media, which was 78.24%. This is because silica sand is the result of weathering rocks containing major minerals such as quartz and

Table 1. Hospital Preliminary Wastewater Quality

No	Parameter	Test result Repetition 1	Test result Repetition 2	Repetition Average	Unit
1	Temperature	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 sampel

Source: Research, 2021

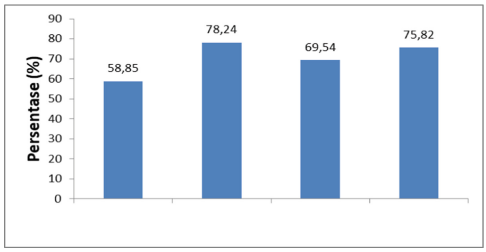

Fig. 3. Results of Comparison of BOD decrease

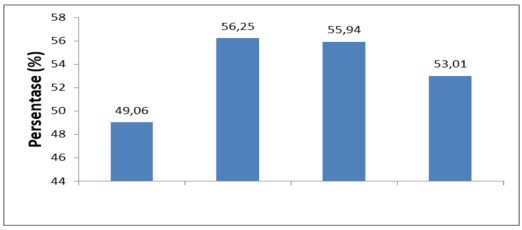

Fig. 4. Comparison Results of COD Reduction

feldspar. The use of silica sand is to remove the physical properties of water, such as turbidity/muddy water and remove odors from the water. In general, silica sand is used in the early stages as filter in processing dirty water into clean water [2].

2) COD Parameter

Based on the graphic data above for the temperature parameter, the results obtained are the comparison of media, 49.06% activated carbon, 56.25% silica sand, 55.94% alum, and 53.01% microfiltration membrane (Fig. 4).

COD shows the amount of oxygen required by oxidant materials such as: Potassium bicromate to decompose organic matter into CO_2 and H_2O gases. Chemical oxygen demand (COD) is the amount of oxygen needed for the oxidation of organic and inorganic substances in water [4].

In this study, the results of the comparison of the most effective medium for COD parameters were silica sand preliminary media, which was 56.25%. This is because the porosity of silica sand at size >1 mm is 34.1%; The porosity of silica sand with size 1 > 0.5 mm is 37.97% and silica sand with size 0.5 mm is 41.51%. The higher the porosity of the 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 [3].

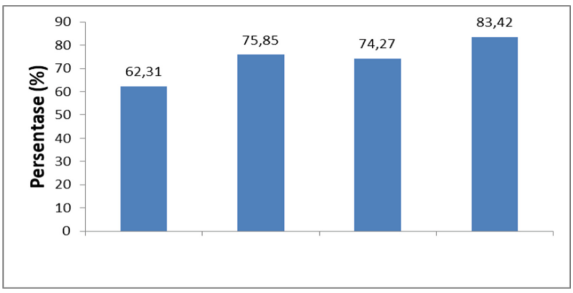

Fig. 5. Results Comparison of TSS Rduction

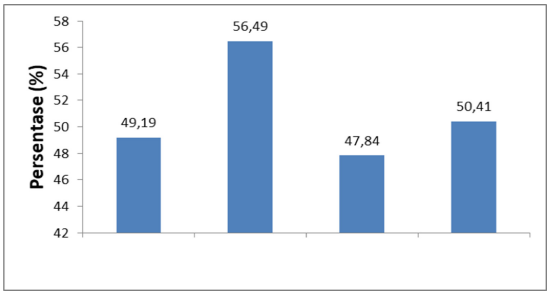

Fig. 6. Comparison Results of Free Ammonia Reduction

3.3 Total Solid Suspended Parameter

Based on the graphic data above for the temperature parameter, the results obtained are the comparison of media, 62.31% activated carbon, 75.85% silica sand, 74.27% alum, and 83.42% microfiltration membrane (Fig. 5).

TSS (total suspended solid) indicates the presence of suspended carbohydrates larger than 1 um. According to Efendi, TSS are suspended materials with a diameter of > 1 m that are retained on a millipore sieve with a pore diameter of 0.45 m [4].

In this study, the results of the comparison of media for the most effective TSS (total suspended solid) parameter was the microfiltration membrane preliminary medium, which was 83.42%. This is because the microfiltration membrane functions to filter macromolecules of more than 500,000 g/mol or particles that have a size of 0.1–10 m with a dissolved solids content of not more than 100 ppm. Applications in industry are mostly carried out in the water sterilization process with the aim of separating microorganisms (bacteria, fungi) and filtration of oil and water emulsions with operating pressures of 0.5–2 atm [7].

4) Ammonia Parameter

Based on the graphic data above for the temperature parameters, the results obtained are the comparison of media, 49.19% activated carbon, 56.49% silica sand, 47.84% alum, and 50.41% microfiltration membrane (Fig. 6).

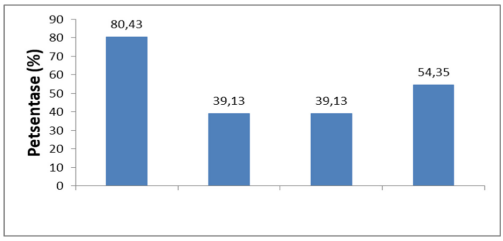

Fig. 7. Results Comparison of Phosphate Reduction

Ammonia indicates the presence of protein content in the waste obtained around 1.11 mg/l. Ammonium in waters comes from the decomposition of organic nitrogen such as protein. Nitrogen found in soil and water, which comes from the decomposition of organic matter such as dead plants and aquatic biota. Free ammonia and free chlorine will react with each other and form an antagonistic relationship [4].

In this study, the results of the comparison of the media for the most effective free ammonia parameter was the preliminary medium of silica sand, which was 56.49%. This is because the porosity of silica sand at size $>$ 1 mm is 34.1%; The porosity of silica sand with size 1 $\theta > 0.5$ mm is 37.97% and silica sand with size 0.5 mm is 41.51%. The higher the porosity of the 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 [3].

5) Phosphate Parameter

Based on the graphic data above for temperature parameters, the results obtained are comparisons of media, 80.43% activated carbon, 39.13% silica sand, 39.13% alum, and 54.35% microfiltration membrane (Fig. 7).

In waters, phosphorus is not found in the form of free elements but in the form of inorganic compounds in the form of particulates. Phosphate is needed by plants, animals and humans which has the benefit of activating the work of the enzymes ATP (Adenosine Triphosphate) and ADP (Adenosine Diphosphat). Phosphate is naturally excreted by humans and animals in the form of feces and urine. Phosphate is widely used for fertilizers, soaps or detergents and industrial ceramic materials, lubricating oils, beverage and food products, catalysts. Phosphate is not toxic to animals and humans [4].

In this study, the results of the comparison of the media for the most effective phosphate (PO_4) parameter is 80.43% activated carbon introduction medium. 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 the pollutant, there will be binding of pollutant molecules to the activated carbon (absorption of pollutant molecules) [8].

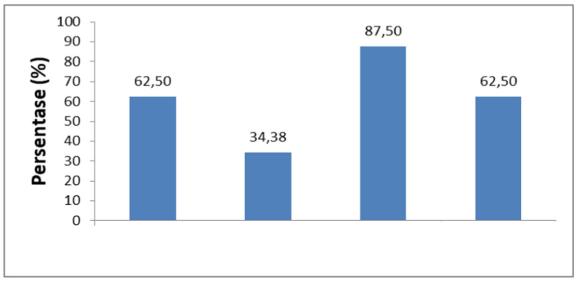

Fig. 8. Comparative Results of Fat Oil Reduction

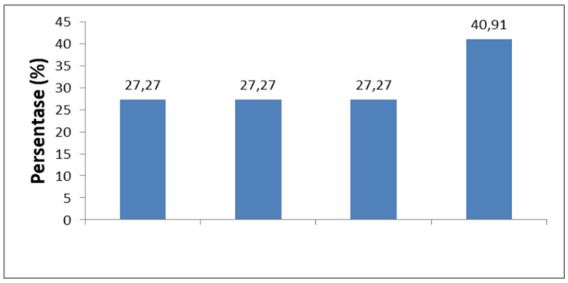

Fig. 9. Results of Comparison of Fat Oil Reduction

6) Fat Oil Parameter

Based on the graphic data above for the temperature parameter, the results obtained are the comparison of media, 62.50% activated carbon, 34.38% silica sand, 87.50% alum, and 62.50% microfiltration membrane (Fig. 8).

Oil and detergent are domestic waste materials that affect the penetration of organic and inorganic materials [4].

In this study, the results of the comparison of the media for the most effective fatty oil parameters were 87.50% alum preliminary media. This is because alum is a coagulant that is widely used because it is economical, easy to obtain in the market and easy to store. Alum is also able to precipitate organic substances faster than Poly Aluminum Cloride (PAC) and Ferric Chloride ($FeCl_3.6H_2O$) coagulants. The use of alum depends on the turbidity (turbidity) and the high level of organic pollutants contained in the wastewater [8].

7) Coliform Parameter

Based on the graphic data above for the temperature parameters, the results obtained are the comparison of media, 27.27% activated carbon, 27.27% silica sand, 27.27% alum, and 40.91% microfiltration membrane (Fig. 9).

Total coliform bacteria is the calculated value of the number of colonies of Escherichia, Citobacter, and enterobacter bacteria found on the filter membrane after

being cultured for 18–24 h. Coliform bacteria are types of coli bacteria that are divided into two groups, namely fecal coliforms, namely bacteria that live normally 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 [4].

In this study, the results of the comparison of the most effective media for MPN-Germ Coli group parameters were 40.91% microfiltration membrane introduction media. This is because the microfiltration membrane functions to filter macromolecules of more than 500,000 g/mol or particles that have 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 with the aim of separating microorganisms (bacteria, fungi) and filtration of oil and water emulsions with operating pressures of 0.5–2 atm, [7].

4 Conclusion and Sugestion

4.1 Conclusion

1) Average concentration of wastewater parameters, temperature 28.8 °C, pH (degree of acidity) 7, BOD 79 mg/l, COD 167.05 mg/l, Total Solid Suspended (TSS) 68 mg/l, Free Ammonia 4, Phosphate (PO4) 0.745 mg/l, Oil and Fat 1.64 mg/l and MPN-Germ Golonga Coli 2.200 Total/100 ml sample.
2) Analysis Comparatif of media materials to decrease parameters, for parameters BOD parameter is silica sand which is 78.24%, COD parameter is silica sand which is 56.25%, total suspended solid parameter is microfiltration membrane which is 83.42%, parameter free ammonia is silica sand which is 56.49%, phosphate parameter is activated carbon that is 80.43%, fatty oil parameter is alum which is 87.50%, Coliform parameter is microfiltration membrane which is 40.91%.

4.2 Sugestion

Carry out further research on the application of preliminary treatment on field-scale microfiltration membranes at research partner hospitals.

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