Letters in Applied NanoBioScience
Open-Access Journal (ISSN: 2284-6808)

Article
Volume 12, Issue 4, 2023, 169
https://doi.org/10.33263/LIANBS124.169

Peat Water Color Purification Using Tubular Ceramic Membrane by Crossflow Filtration at Various Pressures and Operating Times

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Scopus Author ID 57201851635
Received: 3.08.2022; Accepted: 3.10.2022; Published: 27.12.2022

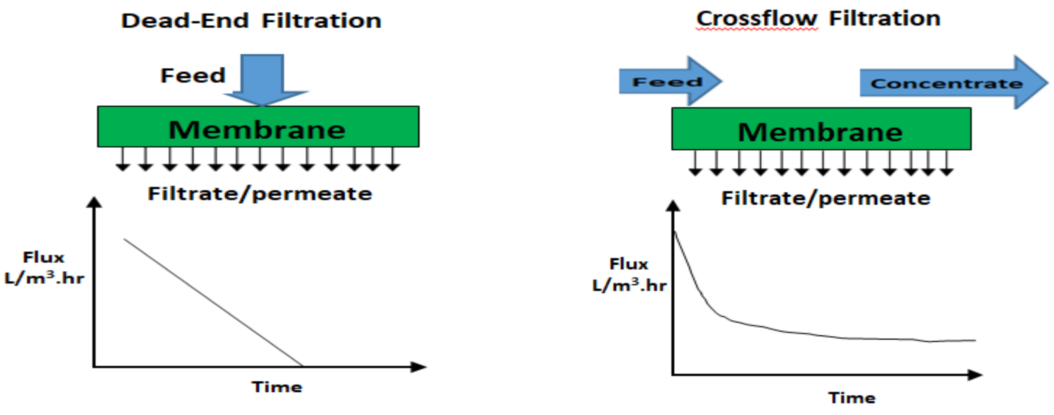
Abstract: The goal of using tubular ceramic membrane technology in water purification is to preserve the color quality of peat water, which is determined by comparing the color concentration of peat water before and after treatment. This study intends to examine the influence of filtration time (15–75 minutes) on membrane selectivity based on the rejection coefficient of decreasing color concentration at varying pressures (0.5–2.0 bar). Tubular ceramic membranes are comprised of natural ingredients such as zeolite (Z), clay (CL), activated carbon (CA), white Portland cement (ZW), and Polyvinyl Alcohol (PVA) in varying proportions: Z: CL = 10%: 50% (M1), 30%: 30% (M2), and 50%: 10% (M3); 25% CA, 10% CW, and 5% PVA. The membrane was produced by sintering at 8000°C for 6 hours. Results indicated a rejection coefficient of peat watercolor of up to 98.44% during a filtration period of 30 minutes and an operating pressure of 1.0 bar, with flux and permeability of 352.69 L/m^2/hr and 352.69 L/m^2/hr.bar for an M3 membrane. The results of the membrane's characterization indicate that its density is 0.6849 g/cm3, its porosity is 31.091%, and its pore size ranges from 2.702 to 4.909 m. The increased pressure might cause the flux membrane to expand and the permeability to decrease, lowering the selectivity membrane and rejection coefficient.

Keywords: cross-flow filtration; peat water; rejection coefficient of color; sintering method; variation of zeolite and clay.

1. Introduction

Peat water is the surface water found in marshy and lowland environments. The quantity of peat water is substantial, but in terms of quality, it is insufficient for human use. The presence of iron (Fe) and manganese (Mn) elements, which generate a high turbidity, gives peat water its reddish-brown hue, acidic flavor, and pungent odor. According to Regulation No. 32/2017 of the Minister of Health of the Republic of Indonesia, peat water treatment technology was needed to adhere to the clean water quality requirements. Few products are capable of purifying peat water. Membrane technology is the best option for clean water treatment since it is practical, effective, energy-efficient, chemical-free, and applicable. Membranes are unpopular among the larger population due to the high cost of commercial membranes. Therefore, innovation is required to manufacture economical and suitable membranes [1,2]. Utilization of natural elements such as zeolite, kaolin, and activated charcoal from coconut shells must be incorporated into membrane goods.

As a catalyst, zeolite has been widely applied as an adsorbent, an ion exchanger, a molecular filter, and a drying agent [3]. Kaolin is widely used in ceramic, pharmaceutical, rubber, and water purification because it has low permeability and is highly cohesive [4]. Activated carbon from coconut shell charcoal is widely used as an impurity-absorbing material, purifying water and absorbing odors. Instead of causing fouling on the filtration membrane, powdered activated carbon enhanced the absorption of organic and inorganic substances in the filtered liquid. [5]. White Portland cement is an adhesive material made up of hydrated calcium silicate compounds that, when mixed with water, bind to other solid materials to form a compact, dense, and hard mass unit [6]. Polyvinyl alcohol (PVA) is an organic compound soluble in water, functions as an adhesive (adhesive), and burns at high temperatures. The nature of PVA can be easily soluble in water, flexible, and easy to form. White Portland cement and PVA have been used as adhesives for inorganic or ceramic membranes [3-5]. The success of the water purification process with membranes also depends on the quality of a membrane product which is determined by the type, composition, particle size, and sintering temperature. The separation process with the membrane can move one of the components based on the physical and chemical properties of the membrane as well as the separated components. Clean water that can pass through the membrane surface area in a certain time is expressed by flux. Displacement occurs due to the driving force in the feed in the form of pressure difference (ΔP), concentration difference (ΔC), electric potential difference, and temperature difference, as well as membrane selectivity, which is expressed by rejection. Applying zeolite-based ceramic membranes and variations of clay-activated carbon and white portland cement adhesive and PVA reduced 83.78% of Fe metal and 90.40% of Mn metal in groundwater by cross-flow filtration for 15 minutes at a pressure variation of 0.5 - 2.0 bars. The membrane is classified as a microfilter with a membrane flux of 200-500 L/m/hour and a membrane permeability of 150-750 L/m^2.hour.bar. Permselectivity of the membrane is more selective to the removal of manganese (Mn). The best membrane composition is the M3 membrane (10% zeolite, 50% clay, 25% activated carbon, 10% white Portland cement, and 5% PVA).



(a) (b)

Figure 1. Membrane operating systems as: (a) dead-end filtration; (b) cross-flow filtration.

This study continued the composition of the membrane by varying the zeolite and kaolin (10%, 30%, and 50%) while the activated carbon, white Portland cement, and PVA remained at the compositions of 25%, 10%, and 5%, respectively. The membrane was applied to clarify the color of peat water in Tempok Teungoh Village, Lhokseumawe City, by observing changes in color and TDS for 15-75 minutes by cross-flow filtration at pressure variations of 0.5-2.0 bar. A tubular ceramic membrane is a porous medium shaped like a tube, semipermeable, and separates particles of molecular size (species) in a solution system. The membrane functions as a selective barrier between the two phases, which can only pass certain components and restrain other fluid flow components that are passed through the membrane [7]. The feed or concentrate phase contains retained components, while the permeate phase contains components that pass through the membrane. There are two membrane operating systems, namely dead-end and cross-flow systems [8], as shown in Figure 1.

Membrane performance can be measured from several parameters, including membrane flux, membrane permeability, and membrane selectivity. Flux (J_x) is the amount of permeate volume that passes through one unit surface area of the membrane at a certain time in the presence of a pushing force in the form of pressure. Membrane permeability (Q_x) is the amount of permeate flow that passes through the membrane surface area in the presence of a pushing force in the form of pressure. Permselectivity is a measure of the ability of a porous membrane to hold a species or pass through a certain species, expressed by the rejection coefficient (%R) of the membrane. The purpose of this study was to determine the influence of cross-cross-flow filtration system filtration duration at varying pressures.

2. Materials and Methods

2.1. Materials.

Peat water was obtained from Teumpok Teungoh Village, Banda Sakti District, Lhokseumawe City, Aceh, Indonesia. The peat water has a pH of 2-4, measured using universal litmus paper. The membrane is made from a mixture of zeolite (Z), kaolin (CL), activated carbon (CA), white portland cement (CW), and polyvinyl alcohol (PVA). All these materials have been cleaned and were supplied by CV. Rudang Jaya Medan, South Sumatera, Indonesia, with an average particle size of 100-120 mesh. A standard solution of 500 units of Pt.Co was used for color water analysis. The solution was a mixture of 1,246 grams of K_2PtCl_6 and 1.00 grams of $CoCl_2$ dissolved in 100 ml of concentrated HCl, then diluted to 1 L with aquadest. This standard solution of PtCo was prepared in the testing laboratory of the Department of Chemical Engineering, Politeknik Negeri Lhokseumawe, Aceh, Indonesia. The Litmus paper was used to measure the acidity of peat water before and after the treatment. Tubular ceramic membranes are made using aluminum and stainless steel. The membrane is a hollow cylindrical tube with an outer diameter of 69.83 mm, an inner diameter of 27.5 mm, a thickness of 21.165 mm, and a membrane height of 250 mm. The membrane mold was made at the Mechanical Engineering Laboratory, Politeknik Negeri Lhokseumawe Aceh, Indonesia.

2.1. Synthesis of tubular ceramic membranes.

The process of synthesis of tubular ceramic membranes uses the sintering method at a temperature of 8000 °C. Then, a 1000-gram total amount of zeolite (Z) and kaolin (CL) mixture with various compositions (10%:50%), (30%:30%), and (50%:10%) was filled into the container. Then, about 250 grams of activated carbon (CA), 100 grams of cement white Portland (CW), and 50 grams of polyvinyl alcohol (PVA). Then the mixture is stirred evenly, and 700 ml of mineral water is added little by a little while stirring evenly with a mixer until it is homogeneous and the dough is in the form of a paste. Then the dough is put into the mold and compacted by applying pressure until it is compressed. Wait until the dough hardens and can be removed from the mold, then dry it in the sun for 3x24 hours, then dry it in an oven at 70°C for 4 hours. The membrane was sintered using a furnace at a temperature of 8000°C for 6 hours. After that, the membrane is tested for the characteristics and performance of the process. The membrane quality test was carried out at the Chemical Engineering Testing Laboratory of the Lhokseumawe State Polytechnic, Aceh, Indonesia. Testing parameters include density tests using the gravimetric method, porosity tests using the air bubble method, and membrane morphology tests to obtain membrane pore size using SEM (Scanning Electron Microscopy) equipment.

2.2. The removal process of color peat water using tubular ceramic membrane.

In this study, the removal process of colored peat water using a prototype made in a previous study is shown in Figure 2. The equipment consists of a feed tank, membrane housing, pump, pressure gauge on the feed stream, retented, and permeate. The membrane is inserted into the membrane housing, and its performance is tested based on changes in the color concentration of peat water in the permeate flow. Peat water that has been characterized is filled into a feed water tank, then pumped into a membrane housing that already contains a tubular microfiltration ceramic membrane. Operations are carried out at a pressure variation of 0.5–2.0 bar by adjusting the retented faucet. The filtering process was carried out using a cross-flow filtration system at various times of 15, 30, 45, 60, and 75 minutes. The water in the permeate flow is stored, and the volume is measured every time it changes to determine the membrane flux.

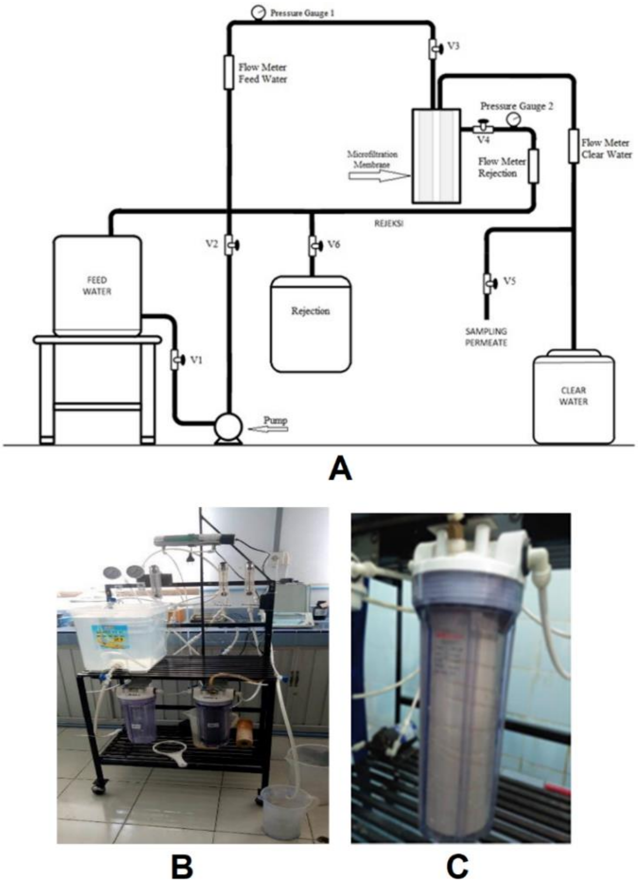


Figure 2. Prototype of unit tubular ceramic membrane microfiltration process [5] as (a) schema prototype; (b) unit process; (c) housing membrane.

To determine the selectivity membrane base on the membrane rejection coefficient, each time variation for each pressure variation is 0.5; 1.0; 1.5, and 2.0 bar samples of water in the permeate stream were taken and analyzed for changes in pH and color concentration. So that the membrane rejection coefficient (%R_{color}) is obtained using the formula:

$$R(\%) = \left(1 - \frac{C_{permeate}}{C_{feed}}\right) x\ 100\% \quad (1)$$

where %R is percentage of rejection, $C_{permeate}$ is the concentration of particles in permeate, and C_{feed} is particle concentration in the feed.

2.3. Flux and permeability test.

Membrane permeability is also measured in every flux test and every change in operating pressure. The permeability tubular ceramic membrane was tested by streaming the pure water (aquades) through the membrane module by varying the operating pressure 0,50; 1,0; 1,5, and 2,0 bar in cross-flow filtration. The flux and membrane permeability can be calculated using the following equation [9]:

$$J_x = \frac{V}{A.t} \quad \text{and} \quad Q_x = \frac{J_x}{\Delta P} \quad (2)$$

where J_x are a flux (L/m^2.hr); Q_x is membrane permeability (L/m^2.hr.bar); V is permeate volume (L); A is membrane surface area (m^2); t is time (hr); and P are operating pressure.

2.4. Color peat water analysis.

Peat watercolor analysis was carried out according to SNI 6989.80:2011. The color test was carried out to see the final result of the permeate produced using a UV-Vis spectrophotometer tool. The reddish-brown color in peat water results from the high content of dissolved organic matter (humus), especially the form of humic acid that comes from the decomposition of organic matter such as leaves, trees, grass, and wood. The presence of iron ions causes the water to turn red, while manganese oxide causes the water to turn brown. Color analysis is carried out in the testing laboratory by the Chemical Engineering Department of Politeknk Negeri Lhokseumawe.

2.5. Test of membrane characteristics.

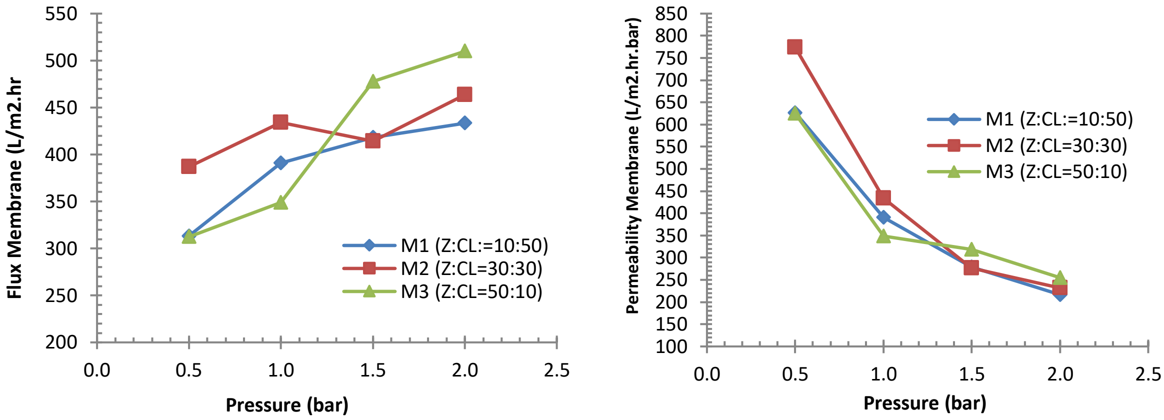
Tests were carried out to determine membrane morphology and pore size, membrane porosity, and membrane density. The membrane pore size analysis used SEM JEOL JSM-651OLA brand, the porosity test used the air bubble method, and the density test used the gravimetric method.

3. Results and Discussion

In principle, the membrane serves as a medium to separate the material based on the molecule's size and shape and holds the bait's components that have a larger size than the membrane's pores. In this research, the membrane was made using a mixture of zeolite (Z), clay (CL), activated carbon (CA), as well as white portland cement (CW), and PVA as an adhesive. The membrane was made using the sintering method [10,11] at a temperature of 8000°C [12]. The membrane formed from a mixture of these materials is expected to be able to act not only to separate materials based on the size of the molecule, which is larger than the pore size of the membrane, but it is hoped that the surface area of the membrane is capable of adsorption and ion exchange processes between negative ions of zeolite, clay, and activated carbon materials. Materials in swamp water, such as Fe and Mn ions, cause the swamp water to be colored.To prove the proposed hypothesis, it is necessary to know the performance of the resulting membrane by looking at how the pressure affects the membrane permeability based on the rejection coefficient of the color of the peat water produced. To determine the performance of the tubular ceramic membrane produced, it was required to know the pressure affects the membrane flux (Jv), membrane permeability (QP), and membrane rejection coefficient (% R) of each membrane material composition. Flux states the amount of permeate that can pass through the membrane surface area, while membrane permeability is the flow rate of permeate that passes through the membrane in the presence of a pushing force in the form of pressure [12-16]. Meanwhile, permselectivity is described by the membrane rejection coefficient (% R), which is a measure of the ability of a tubular ceramic membrane to withstand a particular species or pass through a particular species [11].

3.1. Effect of Pressure on membrane flux and membrane permeability.

The effect of pressure on the membrane flux and permeability of various compositions of membrane materials is shown in Figure 4.



(**a**) (**b**)

Figure 3. Effect of pressure on various membrane composition variations on (a) membrane flux, (b) permeability membrane.

Figure 3(a) shows that the greater the pressure, the greater the membrane flux obtained for all variations of membrane composition. This is because the greater the pressure, the greater the thrust. The greater the fluid thrust into the system, the larger the species in the fluid that are smaller than the membrane pores are missed, and the larger the species that are larger than the membrane pores are pushed through the membrane and accommodated in the permeate flow. So that at the same time of cross-flow filtration, the greater the pressure, the greater the thrust, and the greater the volume of fluid accommodated in the permeate flow. Figure 3(a) shows that the largest flux was 509.89 L/m^2/hr on the M3 membrane composition and the smallest flux was 312.38 L/m^2/hr. The membrane flux values obtained for all variations in the composition of the M1, M2, and M3 membranes, can be stated that the membrane is classified as a microfiltration membrane type which has a membrane flux requirement of > 50 L/m^2/hr. If the membrane flux states the amount of permeate that can pass through the membrane surface area, then the membrane permeability is the permeate flow rate that passes through the membrane in the presence of a pushing force in the form of pressure. So, the greater the pressure, the greater the flux, and the smaller the permeability. The effect of pressure on membrane permeability is shown graphically in Figure 3(b). Figure 3(b) shows that the greater the cross-flow filtration pressure, the lower the membrane permeability obtained for each variation in the membrane material M1, M2, and M3 composition. This is because membrane permeability is the permeate flow rate that passes through the membrane surface area, whose value is inversely proportional to the thrust of the applied pressure. So, the greater the pressure, the greater the membrane flux and the smaller the membrane permeability. Figure 4(b) shows that the highest membrane permeability at M2 membrane composition and 0.5 bar pressure is 773.90 L/m^2.hr.bar.The smallest membrane permeability was 216.65 L/m^2.hr.bar at M1 membrane composition and 2.0 bar pressure.

3.2. Effect of filtration time on rejection coefficient.

Based on the results of research that has been conducted shows that the ability of the membrane to purify water almost always gives perfect results. The sample of peat water before passing through the membrane was 22,239.5 PtCo. The efficiency of decreasing the color concentration of peat water is expressed by the rejection coefficient (%Rcolor) obtained for each composition of the M1, M2, and M3 membranes, which are operated at a filtration time of 15-75 minutes and a pressure variation of 0.5-2.0 bar. This is graphically shown in Figure 5.

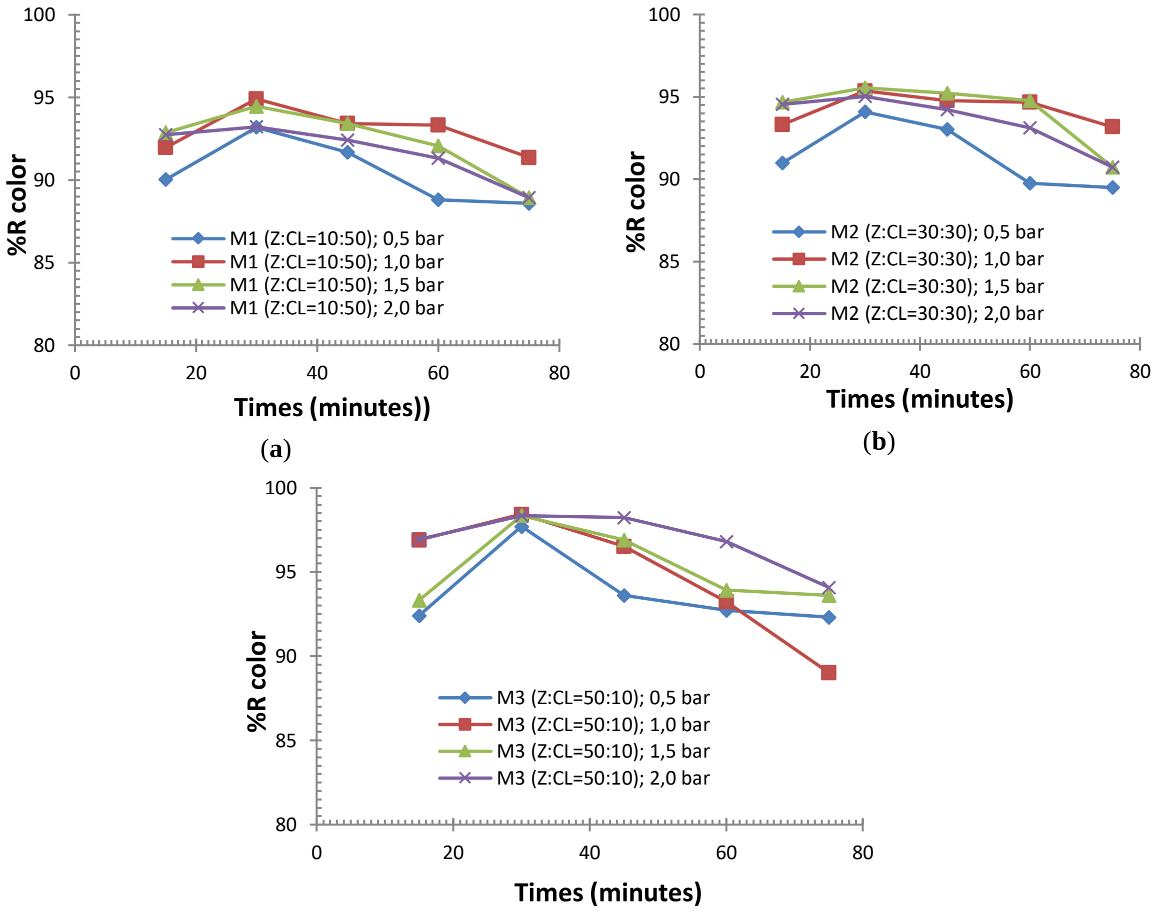
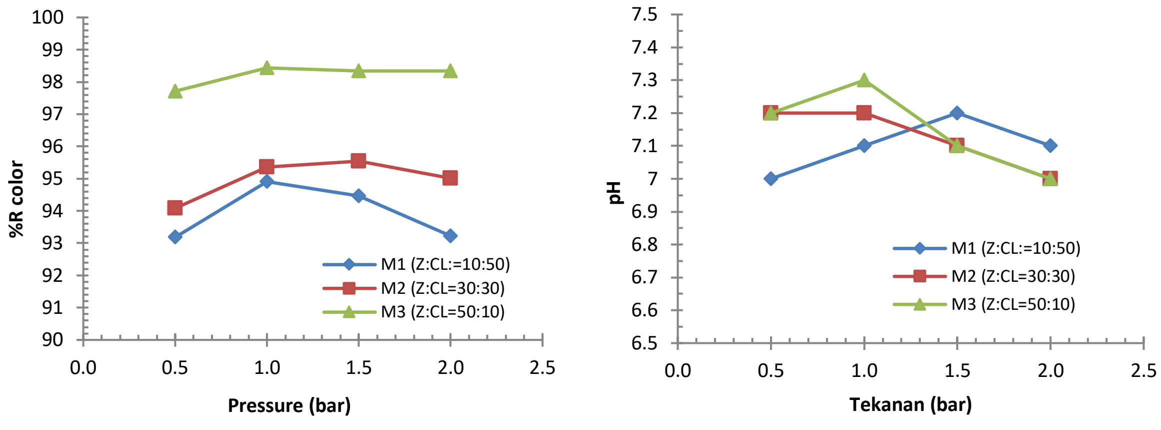


Figure 4. Effect of time of cross-flow filtration system on color rejection coefficient at various pressure variations for (a) M1 membrane; (b) M2 membrane; and (c) M3 membrane.

From Figure 4, it can be seen that from time to time, in the range of 75 minutes, the removal of the dye concentration at each pressure is best at 30 minutes, which causes the color rejection coefficient to increase. Rejection ability is different at each pressure. Filtering, which has a large rejection coefficient at 30 minutes, is at a pressure of 1.0 bar. Changes in the color concentration of peat water after passing through the membrane as permeate indicate that there has been a selection of particles causing the color of peat water that is unable to penetrate the membrane so that the particles are separated and ejected into the retented flow (concentrate). With increasing pressure, it will cause an increase in the thrust of the particles through the membrane so that the concentration of peat watercolor is relatively small, and there is a decrease in the permeate flow. The longer filtering time also does not indicate an increase in the rejection coefficient in the permeate flow. Instead, it causes saturation on the surface of the membrane pores so that the particles retained on the membrane surface will be pushed through the pores, causing the rejection coefficient in the permeate flow to be small. The results showed the effectiveness of the optimum filtration time of 30 minutes for all types of M1, M2, and M3 membranes. The membrane's selectivity depends on the interfacial interaction of the membrane with the species that will pass through and the pore size of the membrane [11]. The highest color rejection coefficient, referred to as color removal efficiency for membrane performance, was 98.44%, obtained at a filtration time of 30 minutes and an operating pressure of 1.0 bar for the M3 membrane, 95.36% for the M2 membrane, and 94.91% for the M1 membrane. The greater the amount of zeolite, the better the membrane performance.

3.3. Effect of pressure on membrane permselectivity based on rejection coefficient (%R) and pH.

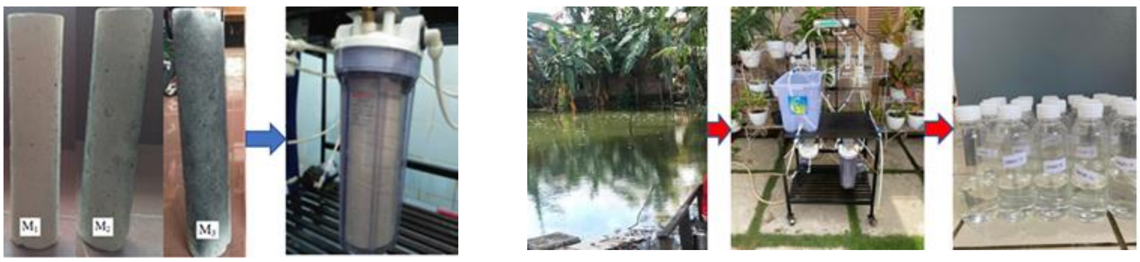
Factors that affect the permselectivity are the size of the particles that will pass through it, the interaction between the membrane and the feed solution, and the membrane's pore size. The rejection coefficient (%R), which describes membrane permeselectivity, is the concentration fraction of solutes that do not penetrate the membrane. In general, the R value varies between 0 and 100%, where R = 100% means a perfect separation. In this case, the semipermeable membrane is ideal, while the R-value of 0% means that all particles pass from the membrane [15,16]. Therefore, the membrane's permeability is described by the rejection coefficient (%R) of the membrane, which is a measure of the ability of the ceramic membrane to withstand a particular species or pass through a certain species. In this study, the color of the swamp water is meant. In this study, the peat water used came from pond water in Lhokseumawe City, Indonesia. The results of laboratory tests showed that the peat water in the area had a color concentration of 22,239.50 Pt.Co. This concentration value exceeds the value of the quality standard of clean water standards by referring to environmental health quality standards and water health requirements of the Minister of Health of the Republic of Indonesia's. Therefore, applying tubular ceramic membranes of various compositions of M1, M2, and M3 membranes were tested for their performance by looking at the rejection coefficient of the color of peat water that passes through each membrane by cross-flow filtration. A common phenomenon that often occurs in a separation process with membranes is that if the membrane flux produced is large, the membrane permeability is low, and if the flux produced is low, the membrane permeability is high. Likewise, if the permselectivity is high, the flux will also be low. The results of membrane permselectivity based on the rejection coefficient of peat watercolor and peat water pH at the end of the filtration operation are shown in Figure 5.



(a) (b)

Figure 5. Effect of operating pressure on variations in membrane composition on (a) the rejection coefficient of peat watercolor, (b) pH of peat water.

From the graphs in Figure 6 (a) and 6 (b), it can be seen that for each variation in the composition of the M1, M2, and M3 membranes, the best color rejection coefficient (% R_{color}) is at a pressure of 1.0 bar. This is because the smaller the pressure and thrust, the fewer particles can pass through the membrane pores because they are stuck on the membrane surface and are released along with the retained flow. With the small number of particles that can pass through the membrane, the concentration of color in the permeate stream is small. The smaller the concentration of color in the water that is accommodated as permeate, the greater the rejection coefficient. The greater the rejection coefficient, the better the membrane performance. The greater the rejection coefficient, the more selective the membrane is for certain species that cannot pass through the membrane. Therefore, applying tubular ceramic membranes from various compositions of M1, M2, and M3 membranes were tested for their performance by looking at the rejection coefficient of the color of peat water that passes through each membrane by cross-flow filtration. From the graph in Figure 6, for all M1, M2, and M3 membranes operated by cross-flow filtration, the best operating pressure is 1.0 bar, where the largest color rejection coefficient for M1 membranes is 94.91%, 95.36% (for M2 membranes), and 98.44% (for M3 membranes). Figure 6(b) shows that the pH of the clean water obtained from the peat water that has passed through the membrane as permeate is in the range of 7.0–7.3, which is neutral from the previous acid at pH 2.6. This is because water's degree of acidity (pH) is strongly influenced by the particles dissolved in the peat water. When the color-causing water particles have been able to separate after passing through the membrane, it causes the particle content in the permeate flow decreases so that the water's pH is neutral. The membrane products and permeate flow water are shown in Figure 6.



(a) (b)

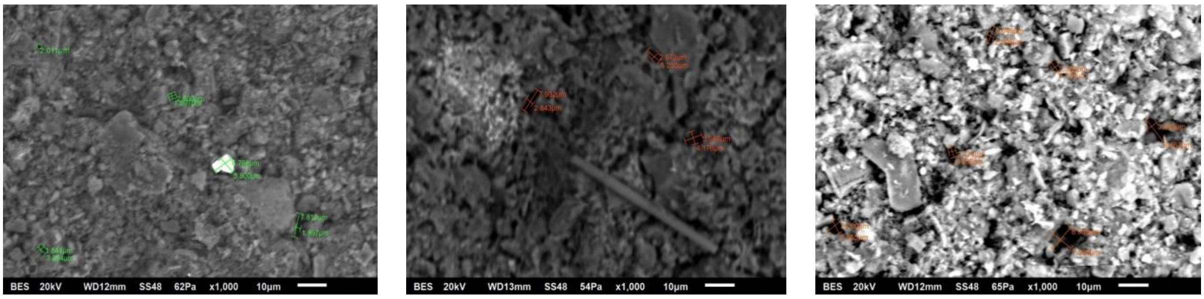
Figure 6. The membrane products and permeate flow water as (a) M1, M2, and M3 membranes, and the housing that already contains the M3 membrane; (b).

The M3 membrane is a membrane consisting of a mixture of 50% zeolite, 10% clay, 25% activated carbon, 10% white Portland cement, and 5% PVA. While the M2 membrane consists of a mixture of 30% zeolite, 30% clay, 25% activated carbon, 10% white Portland cement, and 5% PVA, While the M1 membrane consists of a mixture of 10% zeolite, 50% clay, 25% activated carbon, 10% white Portland cement and 5% PVA, Based on this composition, it can be seen that the amount of zeolite greatly affects the rejection coefficient of the color of the peat water and the optimum M3 membrane. The greater the amount of zeolite, the better the membrane performance. This is because zeolite can exchange ions that cause the color of peat water, such as organic compounds, iron ions, and Mn ions. This can also be seen from the indication that the pH of the swamp water has increased from 2.6 to 7.3.

3.4. Effect of membrane composition on membrane characteristics.

3.4.1. Morphology membrane test.

The morphological structure of the membrane is strongly influenced by several factors, such as the constituent materials, the success of the dough process, the molding process, compaction, and the sintering process. To determine the characteristics of the resulting membrane, it is necessary to test the physical properties of the membrane, such as the density test by the gravimetric method, the porosity test using the air bubble method, and the membrane pore size test using SEM (Scanning Electron Microscopy). SEM (Scanning Electron Microscope) analysis aims to be able to determine the characteristics of ceramic membranes, to be able to see the morphology, which includes the structure and cross-section, as well as to determine the pore statistics, namely the distribution of pores and pore sizes of ceramic membranes [17-21]. Concerning the results of the porosity, density, and flux values obtained, the analysis of ceramic membranes with these parameters in the variation of composition analyzed the morphological structure of the membrane using SEM. The results of tire analysis using SEM can be seen in Figure 8. The results of the morphological structure testing of the membrane were magnified 1000x, resulting in a dark color indicating the membrane pores. It can be seen in the picture that the pore membrane formed has a diameter that is not uniform. This can be caused by incomplete combustion [22-26]. The average pore diameter size formed was M1 of 4.909 m, M2 of 4.425 m, and M3 of 2.702 m. From the results of the pore size obtained, the greater the amount of zeolite, the smaller the pore size obtained and the greater the rejection coefficient obtained. Based on the pore size obtained, it can be concluded that the M1, M2, and M3 ceramic membranes meet the standard of microfiltration ceramic membranes (0.05–10 m).



(**a**) (**b**) (**c**)

Figure 8. Membrane morphology test results using SEM; (a) M1 Membrane; (b) M2 Membrane; (c) M3 Membrane.

In the picture, it can be seen that the number of membrane cavities is still irregular. The pore size is at the microfiltration standard, but the number of pores is irregular, and the density of the material is not uniform. This can be caused by several factors, among which: compaction is not carried out properly, and when sintering is not complete, the combustion is uneven. The results of the membrane characteristics test are shown in Table 1. Figure 8 shows that the M3 membrane has a more uniform pore size and a smaller size of 2.702 m compared to the M1 and M2 membranes. However, the three membranes, M1, M2, and M3 had pore sizes below 10 m, so the three membranes were types of microfiltration membranes.

3.4.1. Determining the density of the membrane using the gravimetric method.

The density of ceramic membranes was obtained by weighing each membrane's weight and measuring the membrane's diameter and thickness. This results in the mass and volume of the membrane. The greater the density, the smaller the pore size of the membrane. In the sintering process, bonding occurs between the powder surfaces to determine the density of the resulting membrane. The results of the membrane density test are shown in Table 1.

3.4.2. Determining the density of the membrane using the gravimetric method.

The porosity of the membrane indicates the amount of free space between the pores to store water. Porosity measurements on each membrane composition were carried out to determine the distance between pores after the sintering process. The percentage of membrane porosity can be obtained using the porosity formula. Determination of membrane porosity can be done using the air bubble method using the principle of Arhimedes' law as follows [9]:

$$\varepsilon = \frac{W_2 - W_1}{W_1} \text{ x } 100\% \tag{4}$$

where ε is membrane porosity, W_1 is dry membrane weight, and W_2 is the weight of the wet membrane soaked for 48 hours.

Based on the results of the calculation of the porosity values of the three membranes, it was concluded that the more zeolite composition, the greater the porosity value [27-33]. The zeolite pore structure is often used as a tool to separate a substance from other substances whose molecules are smaller so that the separation can be accommodated by the zeolite pore structure [34-37]. In its use as a separator, the zeolite structure has been modified to filter and separate substances with large molecular differences. The following important properties of zeolites make this substance quite widely used: Zeolite can be a selector in ion exchange [38-40]. Zeolite pores can store several molecules and can select certain molecular sizes. Zeolite can be an acidic solid catalyst, and zeolite is a metastable substance under certain conditions (pH and temperature). The results of the three membrane porosity values, M1, M2, and M3, are shown in Table 1.

Table 1. The test results for the characteristics of the M1, M2, and M3 membranes at a Sintering Temperature of 800^0C for 6 hours.

No	Composition (Z:CL:CA:CW:PVA)	Membrane	Membrane size pore (μm)	Density (g/cm^3)	Porosity (%)
1	10:50:25:10:5	M_1	4.909	0.6886	30.251
2	30:30:25:10:5	M_2	4.425	0.6799	31.588
3	50:10:25:10:5	M_3	2.702	0.6849	31.091

4. Conclusions

The study concluded that the tubular ceramic membrane comprised of zeolite, clay, activated carbon, white Portland cement, and PVA had a membrane flux performance of 352,69 L/m^2/hr and a membrane permeability of 352,69 L/m^2.bar. At a filtration period of 30 minutes and a pressure of 1.0 bar, the best color rejection coefficient of 98.44% was obtained on the M3 membrane. Using SEM, the findings of the membrane's characteristic test determined that the M3 membrane had a density of 0.6849 g/cm3, a porosity of 31.091%, and a pore size ranging from 2.702 to 4.909 m. Based on the membrane characteristics test findings, the zeolite, clay, activated carbon, white Portland cement, and PVA tubular ceramic membrane qualifies as a microfiltration membrane.

Funding

This research received no external funding.

Acknowledgments

Acknowledgment to the Director of Politeknik Negeri Lhokseumawe, who has provided Applied Research Grant Funds sourced from Politeknik Negeri Lhokseumawe DIPA fund for the 2021 Fiscal Year.

Conflicts of Interest

There are no conflicts to declare. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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