Study of Making Clay-based Ceramic Membranes with Additional Rice Husk and Sawdust to Reduce Water Turbidity

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Abstract: There are still many people in the banks of the river in the city of Medan, especially in the Deli river, which uses river water for their daily needs. This study was conducted to reduce the water turbidity of the Deli River by using a ceramic membrane made from clay. The ceramic membrane was made by analyzing the effect of the composition and the size of the additional ingredients of rice husks and sawdust to the reduction of water turbidity in the Deli River. This ceramic membrane is made in the form of a pot (pot filter) with the height of 18 cm and the diameter of 21 cm which is burned at the temperature of 850°C - 900 °C for 8 hours.Variations in the size of the material used are range from 35-50, 50-60 and 60-100 mesh with a comparison of the composition of materials (80%: 20%), (85%: 15%) and (90%: 10%). The result of the research on clay ceramic membranes with the additional turbidity reduction efficiency is equal to 90.36%. Whereas, clay ceramic membranes with the addition of rice husk showed a decrease in turbidity with an efficiency of 88.76%.

1 INTRODUCTION

Water is one of the main requirements that must be met for the life of all living beings in order to survive and to continue living. Potable water will be decreased along with the increasing population (Furqoni et al., 2016). Increased human needs for natural resources lead to various negative impacts such as pollution and environmental damage. Various activities such as household activities, tourism, mining, and industry also contribute to water pollution (Yuniarti, 2007).

Deli River is one of the main rivers in Belawan/Belumai/Ular River Basin Unit with five tributaries. The river has an important function in various aspects of life, namely, as a source of raw materials for drinking water, bathing, irrigation, tourism and industry in Medan City. Seventy percent of pollution along the Deli River caused by solid and liquid waste from domestic activities (Dinas lingkungan hidup sumut provinsi, 2014).

Deli river is generally used by the community for household water needs. However, in the upstream area, the community in Karo and Deli Serdang Regency commonly used it for agricultural and fisheries activities.

Meanwhile, in the middle and downstream area of the Deli river, it cannot be utilized optimally due to contaminated water conditions and a decline in water quality (Bapedaldasu, 2007). The occurrence of water pollution has a risk of a waterborne disease for people who depend on these water resources (Slamet, 2000).

The decline in water quality can be indicated by an increase in the measured levels of physical parameters. For instance, an increasing level of parameter turbidity is caused by the presence of suspended substances in water such as fine sand, clay, types of compounds such as cellulose, fat, proteins that float in water or can also be microorganisms such as bacteria, algae, etc. (Effendi, 2003). In addition, turbidity also restricts the entry of light into the water (Kristanto, 2002). This phenomenon results in the process of photosynthesis not being able to take place and as a result, microorganisms are disrupted (Kasam et al., 2009).

There are several methods for treating contaminated water, such as boiling, pasteurization, chlorination, disinfectant flocculation, using ultraviolet (UV), bio-sand filters and so on (Sobsey et al, 2008). One of the appropriate technology alternatives that promise to overcome small-scale household water treatment is by using ceramic

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membranes (Furqoni et al., 2016). Ceramic membranes are filters made with a mixture of clay and combustible organic materials such as tea leaves, coffee powder, cork seeds, sawdust, corn husks, rice husks and so on (Widodo, 2015). Ceramic membrane water filter is very attractive because of their low cost, ease of fabrication and use, and their ability to filter water is very effective (Abiriga and Sam, 2014). Ceramic membrane filter is considered to be highly effective because of its easy use which is only by pouring raw water to be filtered into clean water or potable water (Nugroho, et al., 2015).

The basic ingredients used in the manufacture of ceramic membranes are clay. Natural clay is a porous material that has the ability to adsorb (Urabe, 1986). Clay is a soil that has certain mineral particles that produce plastic properties in the soil when it is mixed with water (Grim, 1953).

Meanwhile, the additional materials used in this study were sawdust and rice husk. The reason for using these additives is because sawdust and rice husk are a porous material which means that water is easily absorbed and fills the pore since the nature of sawdust and rice husks is hygroscopic or easily absorbs water (Kasam et al., 2009). Sawdust is a material that contains the main components of cellulose, hemicellulose, and lignin so that it can become an additional material in the manufacture of ceramic membranes (Slamet, 2013).

Rice husk can be found abundantly and cheap in many agricultural areas (YayasanTirta Indonesia Mandiri, 2014). Rice husk as an organic material that is burned in the combustion process, is able to increase the pores between ceramic particles. These pores allow water to flow faster through filters (Nugroho dkk, 2015) and rice husk ash contains silica as much as 86% -97% dry weight (Houston, 1972). Silica is the main raw material in the glass, ceramic and refractory industries (Krik and Othmer, 1982).

2 RESEARCH OBJECTIVES

The objectives of this study are:

1. Analyzing the effect of variations in the composition and the size of material in the production process of ceramic membranes to the reduction of water turbidity in Deli River;
2. Utilizing clay, rice husk and sawdust as material for making ceramic membranes as purifiers of river water into useful and economical potable water.

3 RESEARCH METHODS

In this study used ceramic membranes made from clay added with rice husk and sawdust in the form of pots (pot filters) with each variation of the composition of clay material and additional materials namely (80%:20%), (85%:15%) and (90%:10%). In this study also used variations of sizes of clay and additional materials by using the material that escaped in range on 35 mesh and retained on 50 mesh; passed the sieve on 50 mesh and was held in the sieve on 60 mesh; and passed the sieve on 60 mesh and was held in the sieve on 100 mesh sieve. Water samples are flowed in batches at each unit at the same time and the specified discharge between the three units is as much as 3 liters of water. Then wait until the water seeps through the media so that it is accommodated in the container.

3.1 Research Locations

The sample used in this study was water originating from the Deli river located in Aur Village, Medan Mainum District, Medan. The clay in this study came from pot craftsmen located at Jalan Darmo, Ujung Serdang, Tj. Morawa, Deli Serdang Regency, North Sumatra. Rice husk in this study was obtained from the rice husk milling industry located in Gang Turi, Pasar 7, Tj. Morawa, Deli Serdang Regency, North Sumatra. Sawdust in this study came from the property industry located in Dusun Kuini, Pasar 7 Melati II Perbaungan Village, Serdang Bedagai Regency, North Sumatra.

3.2 Fixed Variables

The fixed variables in this study are as follows:

1. Water samples of Deli River
2. Ceramic membrane media made of clay plus rice husk and added sawdust in the form of filter pots;
3. The height of the media is 18 cm with a diameter of 21 cm and 1 cm thickness;
4. Combustion temperature of 850 ^{o}C - 900 ^{o}Cfor 8 hours.

3.3 Changed Variables

The changing variables in this study are:

a. Material composition :
   - (80% : 20%)
   - (85% : 15%)
   - (90% : 10%)

b. Material Size :
- Material that passed on 35 mesh and retained on 50 mesh.
- Material that passed the sieve on 50 mesh and retained on the sieve on 60 mesh.
- Material that passed the sieve on 60 mesh and retained on the sieve on 100 mesh.

3.4 Test Parameters

The parameters examined in this study is the turbidity of the water.

3.5 Ceramic Membrane Manufacture

The making of ceramic membranes in this study are as follows:

1. Sliced the soil thinly, then dried in the sun to dry, then mashed with a ball mill machine and sifted in the size of (35-50), (50-60) and (60-100) mesh.
2. Additional ingredients, namely rice husk and sawdust that have been mashed are then sifted using a range of sizes from 35-50 mesh, 50-60 mesh and 60-100 mesh.
3. Clay and additional material, rice husk and sawdust, mixed evenly on each batter with a percent ratio by volume respectively. First treatment, clay : additional material, (80% : 20%); Second treatment, (85% : 15%) and third treatment, (90% : 10%). Then, add a little water into the membrane mixture while stirring evenly until the mixture of the two is easy to form.
4. Membrane batter is made in the form of a pot-shaped filter with the membrane diameter of 21 cm, membrane height of 18 cm and membrane thickness of 1 cm to estimate shrinkage during the manufacturing process.
5. The batter is removed from the membrane mold, then dried at room temperature for 7 days.
6. The formed membrane is then dried in the sun to dry for several days.
7. The next stage, the membrane is burned in a furnace with a temperature of 850-900 °C for 8 hours.

Based on the ceramic filter guide book (2011), in the combustion process there are two stages of combustion temperature, namely:

1. The process of dehydration
2. The process of vitrification (changes in chemical elements) from the clay will produce mature ceramic pots.

The temperature of the first stage will produce the dehydration process at the temperature of 100 °C, the temperature of the second stage produces the vitrification process at the temperature of 850 °C.

4 RESULTS AND DISCUSSION

Sampling was carried out twice in this study. In the first sampling, Turbidity Value Analysis in Deli River was 13.76 NTU. Then, in the second sampling, 15.6 NTU were obtained. So that the average value of the two samples is taken with a value of 14.68 NTU in which the value has exceeded the quality standard in accordance with the Indonesian Ministry of Health Regulation Number 492/MenKes/Per/IV/2010.

4.1 Test Results of Water Infiltration Time on Clay and Rice Husk Ceramic Membrane

A good ceramic filter must have a permeating time that is not too fast and not too slow (Puspita, 2017).

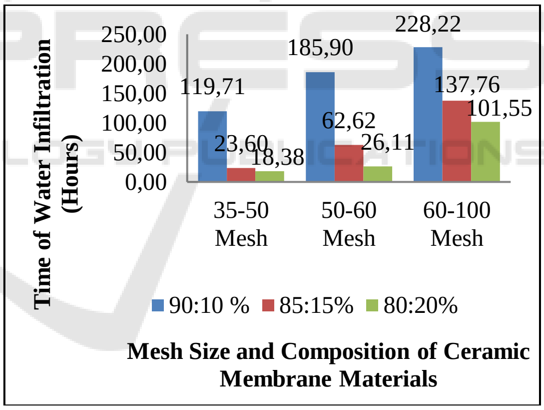

Figure 1: Average Water Infiltration Time (Hours) on Ceramic Membrane.

In this study, there were two variations carried out, namely mesh size and material composition, clay and rice husk. To see the effectiveness of mesh size and material composition on the time of water permeation, it is necessary to calculate the average time of water permeation based on mesh size and material composition. The fastest time to seize three liters of water on the membrane is on membrane number three with a time of 18.38 hours and the longest time to seize three liters of water on membrane number seven with a time of 228.22 hours.

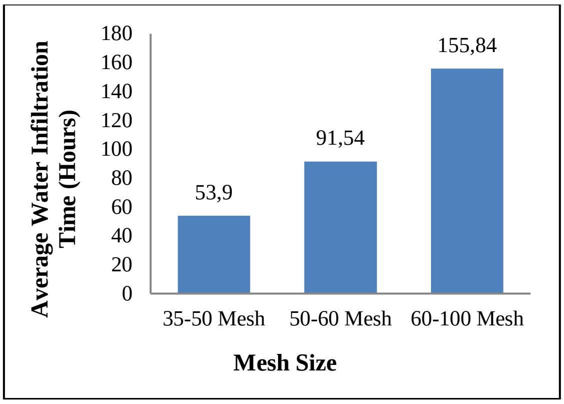

Figure 2: Average Time of Water Infiltration (Hours) Based on Material Size (Mesh).

Figure 3: Sediment on Ceramic Membrane.

Water seeps faster at a larger mesh size, which ranges from 35-50 mesh with 53.9 hours of water permeation time. The longest permeation of water occurs in smaller mesh sizes, namely the range 60-100 mesh with the time of permeation of water 155.84 hours. With a larger mesh size will produce large pores also on ceramic membranes so that the larger the size of the mesh, the faster the permeation of water.

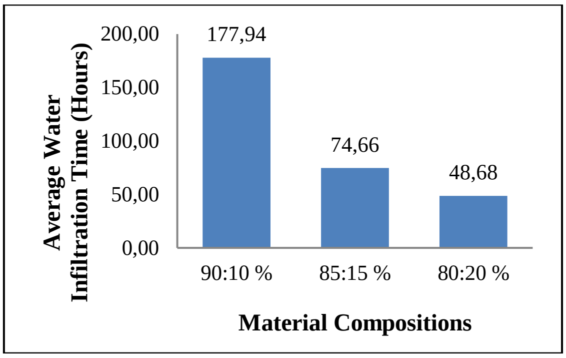

Figure 4: Average Time of Water Infiltration (Hours) Based on Material Composition.

Water seeps faster on the composition of clay compared to rice husk, the ratio is 80%:20% with the time of permeation of water is 48.68 hours. The water seeps longer with the composition of the clay compared to rice husk whose ratio is 90 %:10% with the time of permeation of water is 177.94 hours. The water flow rate increases with the increase in the composition of combustible materials (Zereffa and Bekalo, 2017).

At the beginning of the study, the water seemed to seep faster than the time after, due to pressure so that the water came out faster than the filter. Meanwhile, when the water has reached half of the membrane height, the permeation rate decreases and when the water has reached the bottom of the membrane, the rate of water permeation is very slow (Puspita, 2017). This is because solutes that cause turbidity are retained by ceramic filters so that they will eventually accumulate on the membrane surface to form a gel or fouling layer which results in compression or resistance to the surface of the membrane (Agmalini et al, 2013).

4.2 Test Results of Water Infiltration Time on Clay and Sawdust Ceramic Membrane

The flow rate of ceramic filters is seen from the time it takes for water to seep up through the ceramic filter pore, determined by the thickness of the clay, the composition of the clay used, the proportion and size of additional material in the clay mixture (Yayasan Tirta Mandiri, 2011).

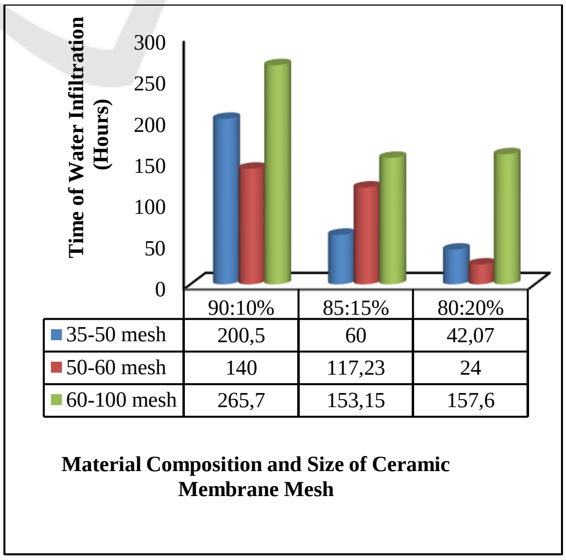

Figure 5: Average Time of Water Infiltration on Ceramic Membrane.

The fastest time to seize three liters of water on a membrane is membrane number 6 with a time of 24 hours and the longest time to seep three liters of water on a membrane is membrane number 7 with a time of 265.7 hours.

In this study, there were two variants carried out, namely mesh size and material composition which is clay and rice husk. To see the effectiveness of mesh size and material composition at the time of water permeation, it is necessary to calculate the average time of water permeation based on mesh size and material composition.

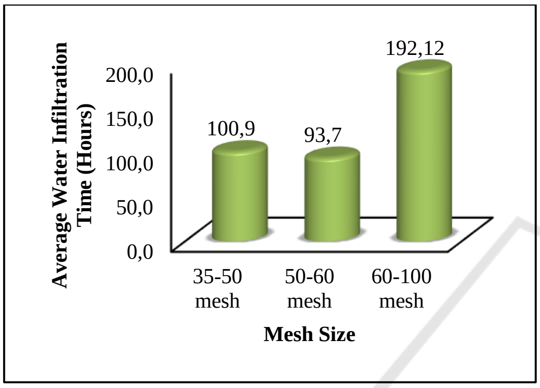

Figure 6: Average Water Infiltration Time on Ceramic Membrane Based on Mesh size.

The graph shows the fastest permeation time based on the size of the material used, namely the size range of 50-60 mesh with a time of 93.7 hours. Whereas, the longest average permeation time based on the size of the material used is in the size range 60-100 mesh with a time of 192.12 hours.

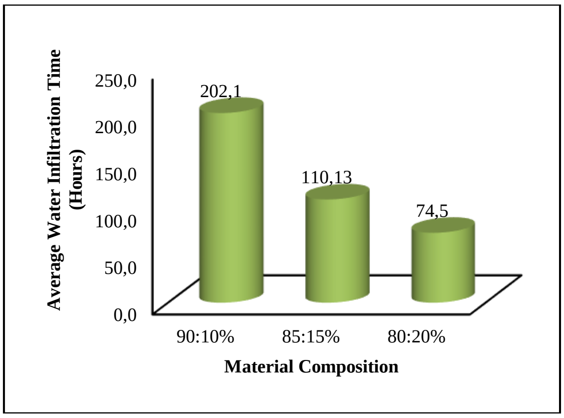

Figure 7: Average Time of Water Infiltration on Ceramic Membrane Based on Material Composition.

The graph above shows that the average time of permeation of water from ceramic membranes based on the composition of the material used, the composition of the mixture of clay and sawdust with a ratio (80%:20%) has the fastest permeation time, which is 74.5 hours. Whereas the composition of the mixture of clay and sawdust with a ratio (90%:10%) has the longest permeation time, which is 202.1 hours. The less composition of additional material, the more time needed for permeation. According to Clair (2006) and Dies (2003), when a ceramic filter is burned, sawdust contained in the mixing filter will burn out leaving pores or voids through filtered water. Therefore, ceramic filter with a higher percentage of sawdust and rice husk composition leave more pores after combustion, hence greater porosity can be proved by higher percolation or water flow rates.

There are other factors that have an impact on permeation times such as pore size distribution, the formation of cake layers under the ceramic membrane and the pore volume of ceramic filters (Musa, 2010). Ceramic filter flow rates made of 40% sawdust decrease from 1.5 L/hour to 0.5 L/hour because the cake layer is formed at the bottom and particles clog the pores. The slowing of the permeation time is caused by the filter being clogged by deposits carried by water. The longer the use of filters, the higher the thickness of the sediment that causes the ability of water to penetrate the filter pore is getting heavier (Matthies and Obst, 2010). Similarly, in this study, when water was poured into the ceramic membrane at the beginning, the water flowed faster when compared to when it had reached permeation half of the initial results were entered.

This is proven by the presence of deposits that are held on the ceramic membrane and the cake layer on the bottom of the ceramic membrane, so that there is a blockage when the water flows which results in long permeation time. However, to prevent a reduction in the performance of ceramic membranes, users need to scrub their filters with a brush when the filter has become slower. Half of the families in one study, they rubbed their filters no more than once every week (Nnaji et al., 2016).

4.3 Turbidity Reduction Efficiency on Clay and Rice Husk Made Membrane

Water samples originating from the Deli river before and after filtration turbidity testing were carried out to determine the effect of ceramic membranes in reducing turbidity in Deli River water.

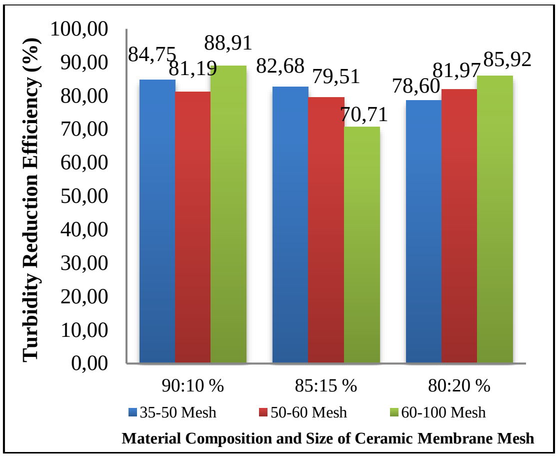

Figure 8: Average Efficiency of Turbidity Reduction in Ceramic Membrane.

The efficiency of turbidity values that have been averaged after passing through ceramic membranes on each membrane has decreased significantly to below the quality standard that is below 5 NTU. The highest efficiency is 88.91% on membrane number seven with the ratio of composition of clay and rice husk is 90% and 10% with the material size of 60-100 mesh. Meanwhile, the lowest efficiency is 70.71% on membrane number eight with the ratio of composition of clay and rice husk is 85% and 15% with the material size of 60-100 mesh.

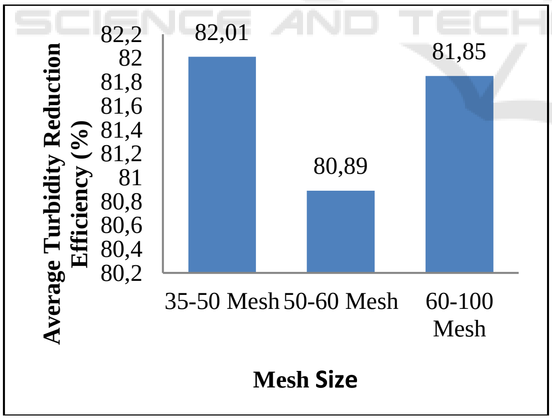

Figure 9: Average Efficiency of Turbidity Reduction on Ceramic Membrane Based on Mesh Size.

The average efficiency of turbidity value based on mesh size has the highest value on 35-50 mesh size with an efficiency value of 82.01% and the lowest efficiency with the size of 50-60 mesh with an efficiency value of 80.89%.

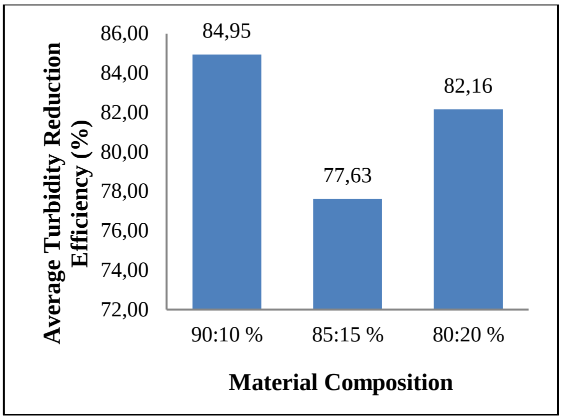

Figure 10: Average Efficiency of Turbidity Reduction on Ceramic Membrane Based on Material Composition.

The average efficiency of turbidity value based on the composition of clay material and rice husk has the highest value at the composition ratio of 90%:10% with an efficiency value of 84.95% and the lowest efficiency with a composition ratio of 85%:15% with an efficiency value of 77.63%.

In this study, the results obtained were not inversely proportional to the time of permeation of water, because the process of forming and mixing ceramic membranes was done by hand or manually, not using a mixing machine in the process of mixing ceramic membrane making materials and not using a friction machine or press machine on the process of forming ceramic membranes. The process of mixing the material is important so that the mixture of ceramic raw material with the arrangement of the composition and size of the grain becomes homogeneous. In addition, this process also reduces the porosity found in the membrane (Puspitasari, 2013). Mixing less homogeneous materials produces membranes that tend to have porosity, the limited number of pores and surface area. The inhomogeneity in ceramic membranes shows that some particles are released from the membrane body so that it covers the pore area on the membrane surface (Susanto dan Nurhayati, 2017).

In the process of forming a membrane, the density and the size of the filter pores are two factors that affect membrane performance (Hagan et al, 2009). The press machine is needed to condense the mixture of clay and rice husk (Jerefasio, 2015). Consistency between elements is easier to maintain with the use of a press machine compared to forming membranes with hands assisted with turning wheels (Dies, 2001). So that the density of clay and rice husk in the membrane formation process cannot be the same because of the limited emphasis during the process of forming ceramic membranes.

Based on the research of Widodo et al (2015) clay filters made by press molding are more effective than clay filters made without a press molding (manually).

4.4 Turbidity Reduction Efficiency on Clay and Sawdust Ceramic Membrane

Turbidity testing results from the nine ceramic membranes with variations in material composition and material size have different turbidity values, where the overall turbidity value on ceramic membranes has been below the quality standards set by Regulation of Ministry of Health Number 492/Menkes/Per/ IV/2010 that concerning the maximum level allowed in drinking water which is 5 NTU.

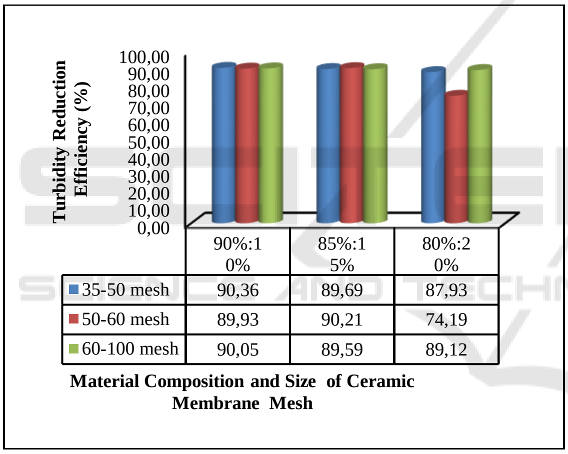

Figure 11: Average Efficiency of Turbidity Reduction on Ceramic Membrane.

The efficiency of turbidity values that have been averaged after passing through ceramic membranes on each membrane has decreased significantly to below the quality standard that is below 5 NTU. The graph of turbidity testing results above shows that the highest turbidity reduction efficiency is indicated by ceramic membrane number 1 with the composition ratio of the mixture of clay and sawdust is 90% and 10% with an efficiency value of 90.36%. While the lowest efficiency was indicated by ceramic membrane number 6 with the composition ratio of the mixture of clay and sawdust is 90% and 10% with an efficiency value of 74.19%.

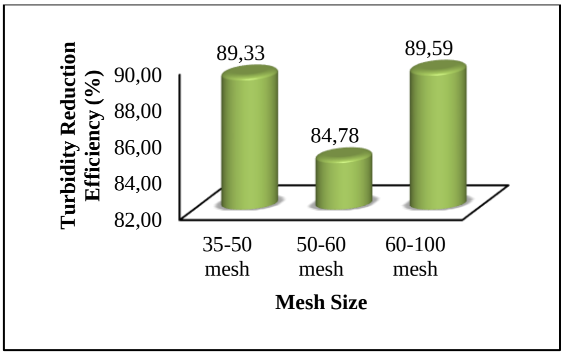

Figure 12: Average Efficiency of Turbidity Reduction on Ceramic Membrane Based on Mesh Size.

The average efficiency of turbidity values based on mesh size has the highest efficiency indicated in the range of 60-100 mesh with an efficiency value of 89.59%. This shows that filters that have smaller (finer) material sizes have advantages in terms of quality in reducing water turbidity, but the filtered volume becomes less and takes a long time (Widodo et al, 2015). Meanwhile the lowest efficiency is shown in the size range 50-60 mesh with an efficiency value of 84.78%.

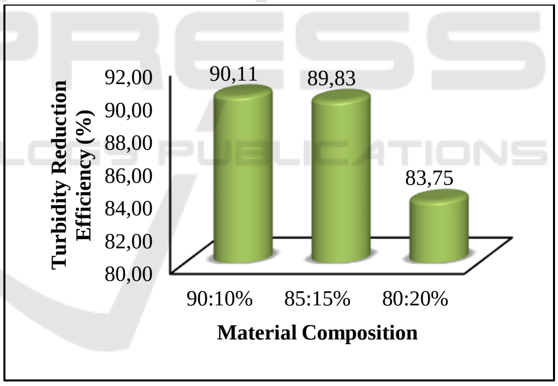

Figure 13: Average Efficiency of Turbidity Reduction on Ceramic Membrane Based on Material Composition.

The average efficiency of turbidity value based on the composition of the materials used for the highest efficiency is shown in the composition of the mixture of clay and sawdust (90%: 10%) with an efficiency value of 90.11%. This shows that the less additional material used in the process of making ceramic membranes, the less pore formed after the combustion process so that it can provide good quality turbidity values. Meanwhile, the lowest efficiency is shown in the composition of the mixture of clay and sawdust (80%: 20%) with an efficiency value of 83.75%. Conversely, the more additional material used, the greater the pore formed after the combustion process so that organic materials with smaller sizes than membrane pores can escape which cause high turbidity values and low turbidity reduction efficiency. This shows that larger pores because of the high content of sawdust cause less effectiveness of ceramic filters in reducing the turbidity of water and other pathogens.

The average turbidity value of all ceramic membranes obtained from the results of water samples that have been passed through ceramic membranes shows results that are below the quality standard. However, the chart also shows results that tend to fluctuate between the size of the material and the composition of the material forming the ceramic membrane. This happens because in the process of forming ceramic membranes using manual techniques by hand so that the pressing process is less effective than using a press machine. Certainly, this also results in more pore space due to uneven compression and non-homogeneous mixing when using hands. Manually pressing clay into the mold is very time-consuming. Pressing the shape by hand requires a mixture of clay that contains relatively more water so that the material retains its shape and blends together. Consistency between elements is more easily maintained by the use of a press machine compared to forming a membrane with a hand assisted with a turning wheel (Dies, 2003).

According to a study conducted by Ervin et al. (2000), the greater the printing pressure, the greater the force applied to suppress the material so that the distance between the clay particles becomes more tight and uniform. According to the research conducted, the technique of using a press machine on the manufacture of ceramic membranes can affect the results of the membrane. The use of press machines makes membranes have denser pores and have the same pressure so that the resulting pores are more uniform (Dies, 2003)Membranes made by the slip casting method show lower densities than those formed by pressing techniques. The sample produced by slip-casting has a higher turbidity level than the pressing process which shows that large diameter pores make it easy to cross particles through filter samples. But the pressing technique gives less turbidity value because of the compaction strength which causes the convergence item (Isikwue and Emmanuel, 2011). This condition shows that with a large printing pressure, the distance between clay particles is getting tight so that the formed pore is smaller so that it has the best quality in the turbidity level efficiency (Ervin et al, 2000).

5 CONCLUSIONS

The conclusions in this study are as follows:

1. The most effective ceramic membrane in reducing turbidity is ceramic membranes made from clay with additional sawdust with a turbidity reduction efficiency of 90.36% with the compositions ratio of clay and sawdust is 90% and 10%, and range 35-50 mesh material size.
2. Ceramic membranes made from clay and additional rice husks are able to reduce turbidity by reducing turbidity efficiency by 88.76% with the composition ratio of clay and rice husk is 90% and 10%, and the size of the material range from 60-100 mesh.
3. The membrane that most quickly seals 3 liters of water on the ceramic membrane is a ceramic membrane made from clay and sawdust with a permeation time of 24 hours, which is membrane number 6 with the composition ratio of clay and sawdust is 80% and 20%, and in the range 50- 60 mesh.
4. Ceramic membranes with clay material and additional rice husk seep 3 liters of water within 18.38 hours with the composition ratio of clay and rice husk is 80% and 20%, and range 35-50 mesh.

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