Applications of micro size anorganic membrane of clay, zeolite and active carbon as filters for peat water purification

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Abstract. Ceramic membrane is one of technology membrane which used as a filtration. Filtration process is the easy way to solve the problem for water purification. Ceramic membrane was used as filtration for peat water. Peat water is the surface water of peat soils that contain high organic matter as well as high enough iron, acidic taste with a pH of 3-5 and a low level of hardness. Therefore, one of the managements of peat water is by using ceramic membrane. The goal of this study is making ceramic membrane from clay, zeolite and activated carbon as a filter for peat water. The research was conducted by using ceramic membrane with composition ratio of 80:10:10; 70:20:10; 60:30:10; 50:40:10, respectively, with the temperature of combustion varied from 600, 700 and 800 Degree Celsius, respectively. The ceramic membrane applied as a filtration for peat water. The permeats from filtration process using ceramic membrane had been analyzed parameter which indicate the good quality of peat water. This study obtained the highest Fe2+ removal efficiency in peat water by 100 percent, the highest Mn2+ removal efficiency of 99.94 percent, followed by a TDS removal efficiency of 82.58 percent and turbidity 95.65 percent.

1. Introduction

Basically, the problem of fresh and drinkable water resources in Indonesia is not caused by the scarcity of water availability, but rather than the inability of the community to manage and conduct the treatment of water resources. Although the provision of clean water has a very important role in improving environmental conditions and public health, but the problem of clean water is a never-ending problem, since not everyone realizes that clean water is very important for their lives. In order to overcome the clean water problem, currently many water technologies have been developed due to carry out clean water treatment, one of the technologies is water filter ceramic membrane technology.

Membranes can be defined as the process of separating two or more components of the fluid flow through a membrane. Membrane serves as a barrier (Barrier) which selectively between two phases. In other words, the membrane serves to separate material based on the size of the solute article, hold the components of the feed which has a larger size than the pores of the membrane and skip components that have a smaller size [1].

Nowdays membrane processes are used for water treatment and contaminants from drinking water. Membrane separations are applied for the removal or partial removal of microbiological contaminants, organic substances, and particles [2, 3]. The performance membrane as a filtration is limited by material properties. One of membrane for waste treatment is ceramic membrane. The most widely used materials in ceramic membrane as filtration is zeolite and activated carbon. The mineral content of sedimentation in nature which is a compound of alumina silicates that form a three-dimensional structural framework between AlO4 and SiO4 tetrahedral. So that natural zeolite is used as a suitable material in the fabrication of ceramic membranes because it is not easy to expand in water and easily form a suspension for coat the membrane as support [4].

Zeolite based membranes can also be used for waste minimization and solvent recovery at high temperatures, especially for components with adjacent boiling points, azeotropic compounds and isomers, gas separation from hydrocarbons, dehydration of solvents, catalysts for conversion of adjacent boils, azeotropic compounds and isomers. chemical, remediation of pollutants and for the production of clean water [5]. Moreover, ceramic membrane has been manufactured with catalytic nanoparticles for synergistic effects on the membrane performance [6] and with clay has been chosen because of its natural abundance, non-toxicity and a low cost. This membrane for filtration application produces the clean water from high turbidity water [7].

Furthermore, the previously study has successfully made ceramic membranes from natural clay and fly-ash coal to improve the quality of swamp water. The results of this research show that the performance of ceramic filters made from a mixture of clay, fly-ash coal and iron powder is relatively effective in producing good quality permeate. This is reflected in the reduction in the content of heavy metal iron (Fe) ions in the swamp water to reach 91.54% and the content of organic matter (number of KmnO4) reached 84.83%, and it also followed by a reduction in TDS of around 60.2% [8]. Simple ceramic membrane made from clay soil and rice bran can be applied to remove more than 95% of Fe through oxidation, co-precipitation and filtration [9]. In another study, ceramic membrane made from clay can reduce concentration cations (Mg2+, Ca2+, and Fe2+) and nitrite ions with more than 50 % efficiency from water. The removal of cations and anions might be due to the ion exchange on the ceramic surface, formation of precipitate as oxides and hydroxides of the ions, and adsorption on activated carbon media formed in the ceramic body from combustible material [10]

In this study, a ceramic membrane was made with clay, zeolite and activated carbon nanoparticles as drinking water filter media. Nanoparticles are currently of concern to researchers for developments in science and technology. Ceramic membrane is in nano-scale material that can enhance the physical, mechanical and chemical properties of a material without having to damage the atomic structure. One of the materials used in ceramic membrane is zeolite. Zeolites are a group of natural minerals which are non-metallic and also have a chemical structure of aluminous silicate. The framework properties of zeolites that found in nature have high cation exchange capacity, high adsorption and hydration-dehydration. The color of the zeolite itself is white-greyish, white-greenish, and white-yellowish. The size of the zeolite ranges from no more than 10-50 microns.

Moreover, porous carbon or well known as activated carbon, is used as an adsorbent for color removal, waste treatment and water purification processes. Activated carbon is charcoal that has undergone changes in its physical and chemical properties due to the activation treatment carried out with the activator of chemicals or by heating at high temperatures. Activated carbon then forms the amorphous which consists mainly of free carbon and has a hollow inner surface, black, odourless, tasteless, and has a much greater absorption compared to carbon that has not undergone the activation process.

Ceramic membrane with micro particle size was made as a filter media for drinking water. The water raw for sample used is peat water. So, this study aims to find alternative water treatment with using ceramic membrane. Ceramic material has sufficient porosity to separate impurities, is relatively durable and has sufficient mechanical strength and is not reactive to water.

2. Methodology

2.1. Tools and chemical substances
The used tools are Digital Scales, Turbidimeters, TDS meters, pH meters, Sieve size 140, planetary ball milling of Fritsch pulverisette, PSA and AAS. Chemical substances that being used are Clay, Zeolite, Activated Carbon, HCL 2M and Aquadest.

2.2. The making of zeolite and activated carbon nanoparticles
Zeolites are sieved with 140mesh sieves. The making of zeolite and activated carbon nanoparticles was carried out by the top down method using the planetary ball milling Fritsch pulverisette by grinding the starting material (zeolite and activated carbon) into the milling device. During the milling process, 80 grams of zeolite is milling using a ball mill with a speed of 350 rpm that lasts for 6 hours. The grinded zeolite as much as 2 kg is soaked with 2.2 liters of 2 M HCl solution for 1 hour, filtered, washed with distilled water to neutral zeolite pH and roasted at 130^{o}C for 4 hours.

2.3. The making of membrane
It started by mixing clay, zeolite and activated carbon particles with a ratio of clay: zeolite: activated carbon (i.e., 80%:10%:10%, 70%:20%:10%, 60%:30%:10%, and 50%: 40%:10%, respectively), then add water and mix thoroughly. After that the material is printed manually of shaped tube. The printed material is dried at room temperature for 4 days. Then it is burned with a combustion temperature of 600^{o}C, 700^{o}C and 800^{o}C, respectively, so that a complete dehydration (drying) and verification (change of chemical elements from clay to ceramic) formed into the ceramic filter.

2.4. Ceramic membrane as a filtration
Ceramic membrane has been applied as a tool filtration for peat water. Peat water flowed in ceramic membrane. The premeats from peat water has been obtained after filtration. The premeats from peat water analyzed its characteristic such as Fe2, Mn2t, turbidity and TDS.

3. Results and discussion
Peat water is one of the abundant and important water resources for the communities around the area. It's just that peat water cannot be used by the community for their daily needs due to the content of TDS, Turbidity, pH, Fe2+ and Mn2+ contained in peat water does not meet clean water requirements. This research utilizes Clay, zeolite and activated carbon as membrane membrane media to reduce TDS, Turbidity, pH, Fe2+ and Mn2+ content contained in peat water. The use of zeolite nanoparticles and activated carbon nanoparticles as adsorbents can reduce the content of solutes in water. So that the substance can be reduced by a membrane with a mixture of clay, zeolite and activated carbon. This is because the zeolite pore structure that is different makes zeolites widely used for separation various small molecules [11]. Zeolites have a good ability to absorb, and also able to separate molecules based on their sizes and configurations [12].

Table 1. Parameter characteristics.

Parameter	Unit	Measured value
TDS	mg/L	580
Turbidity	NTU	2.99
pH	-	5.5
Fe	mg/L	1.2143
Mn	mg/L	7.1294

Based on the peat water test results obtained from the analysis of the initial characteristics of several parameters listed in Table 1. Refers to the drinking water quality standard of the Indonesian Ministry of Health is stated in the Health Regulation Number. 492/MENKES/PER/IV/2010, peat water has exceeded the threshold to be used as drinking water [13]. Therefore, peat water must be treated before it is used as drinking water.

3.1. Effect of temperature and material composition from ceramic membrane on TDS
In this study, the TDS value of peat water before passing through the membrane was 580 mg / L and after passing through the membrane it decreased very much with the content before passing through the membrane. In Figure 1 obtained the highest TDS removal efficiency was 82.58% of peat water in the ratio of 50%:40%:10%, at a 600oC. Meanwhile, the lowest removal efficiency was 78.44%, in the ratio of 80%:10%:10% at 800°C. The amount of TDS removal efficiency in peat water was influenced by the amount of zeolite composition and the addition of the used activated carbon so that the more pores formed and the surface area enlarges and is also influenced by the membrane combustion temperature, the lower the combustion temperature the smaller the size of the pores formed so that particles dissolved in water will be more retained.

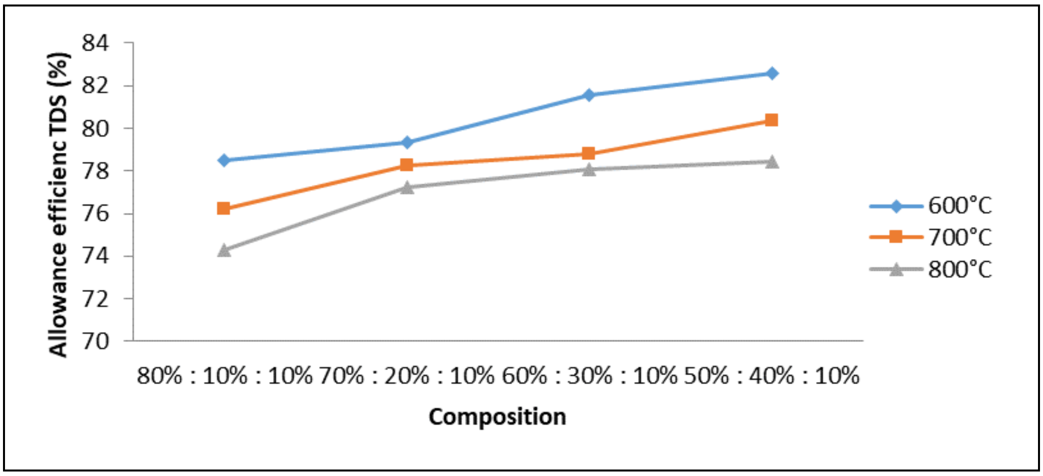

Figure 1. Effect of temperature and composition of materials of ceramic membrane towards Removal efficiency of TDS content.

The results of the water obtained after the screening are included the requirements of Republic of Indonesia Minister of Health Regulation No. 492 / MENKES / PER / IV / 2010 concerning drinking water quality requirements, namely with a membrane composition of 50%: 40%: 10% at a combustion temperature of 600°C.

3.2. Effect of temperature combustion and membrane composition towards efficient of turbidity
The results of the research have shown that the membrane's ability to purify water in general is near perfect. Peat water samples before passing through the membrane amounted to 2.99 NTU, this states that the peat water before filtration is included in the standard drinking water group which is equal to 5 NTU. The removal efficiency value of turbidity content in peat water can be seen in Figure 2.

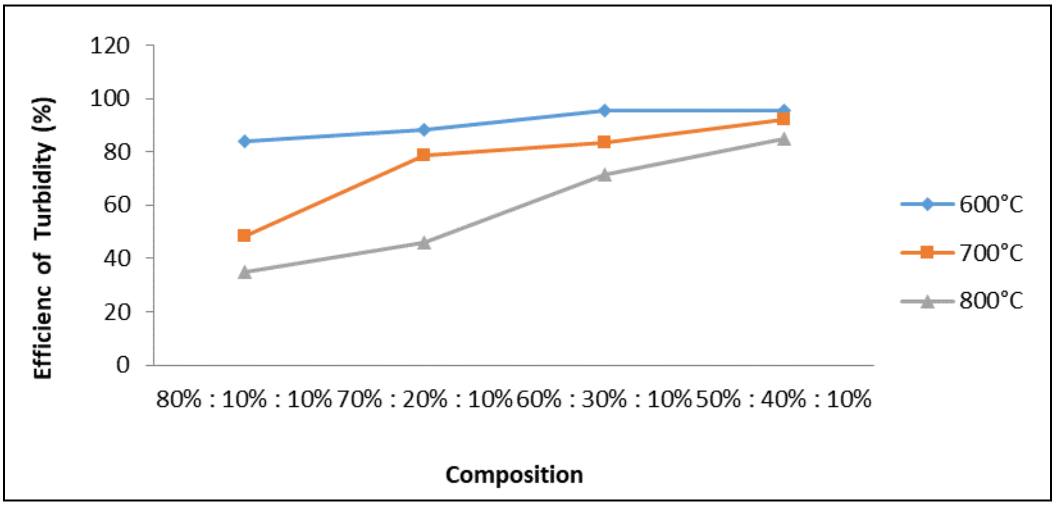

Figure 2. Effect of temperature and composition of materials of ceramic membrane towards Removal efficiency of Turbidity content.

The result shown that turbidity of sample has decreased where the highest efficiency of turbidity reduction of membrane was 95.65%, with a composition of 60%:30%:10%, at 600°C. Meanwhile, the lowest turbidity reduction efficiency of membrane was 35.11%, with a composition of 80%:10%:10%, at 800°C. The magnitude of the reduction in turbidity efficiency in peat water is influenced by the amount of zeolite in the composition of the membrane-making chemical substances and the combustion temperature which is not too high, while the small efficiency of turbidity reduction is influenced by the lack of zeolite material in the membrane-forming chemical substances and high temperature so that it causes fracture in the membrane which makes turbidity peat water improperly filtered.

3.3. Effect of temperature combustion and membrane composition towards pH

Figure 3 determined the pH of peat water after filtration with using ceramic membrane. The results obtained neutral pH or 7 at a composition of 50: 40: 10 (clay: zeolite: activated carbon) at a temperature of 600 oC, this is because the material used zeolite and activated carbon as an adsorbent capable forming pores and zeolite surface area and enlarged activated carbon. This causes the absorption of H+ ions contained in peat water so that the pH becomes neutral and the pH is still in the standard range of Permenkes / No. 492 / Menkes / Per / IV / 2010 for drinking water which is 6.5-8.5.

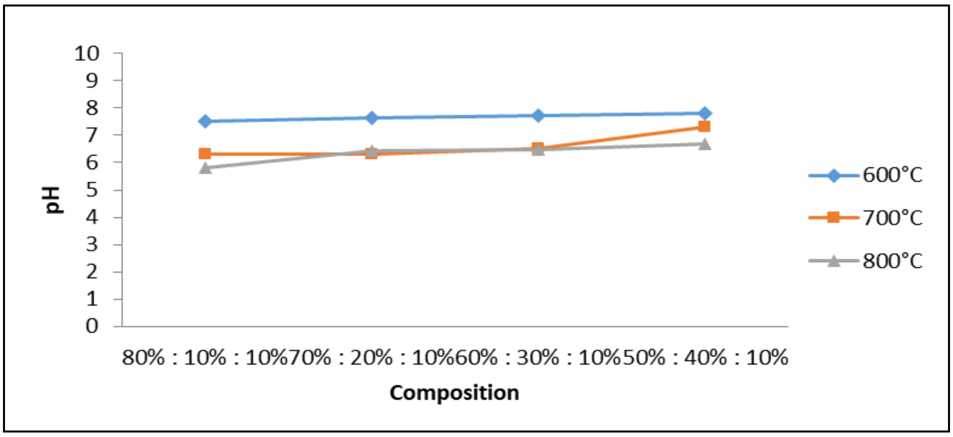

Figure 3. Effect of temperature and composition of materials of ceramic membrane towards pH.

3.4. Effect of temperature combustion and membrane composition towards Fe2+ content

The efficiency value of persen removal of Fe2+ ion content in peat water can be seen in Figure 4. The greatest removal efficiency of Fe2+ ions was obtained at a mixture of 50%: 40%: 10% at a temperature of 600°C that is equal to 100 % and the lowest removal of Fe2+ ions obtained at a mixture of 80%: 10%: 10% at a temperature of 800°C that is 96.31 %. The removal efficiency of Fe2+ ions is significant. This is because the comparison of zeolite mixtures in the manufacture of membranes greatly influences the formation of membrane pores. The more surface area, the more the exchange of ions with zeolites will affect the amount of Fe2+ decrease in peat water samples. The results of the water analysis obtained after the screening are included the requirements of Republic of Indonesia Minister of Health Regulation No. 492 / MENKES / PER / IV / 2010 concerning drinking water quality requirements, namely with a membrane composition of 50%: 40%: 10% at a combustion temperature of 600°C.

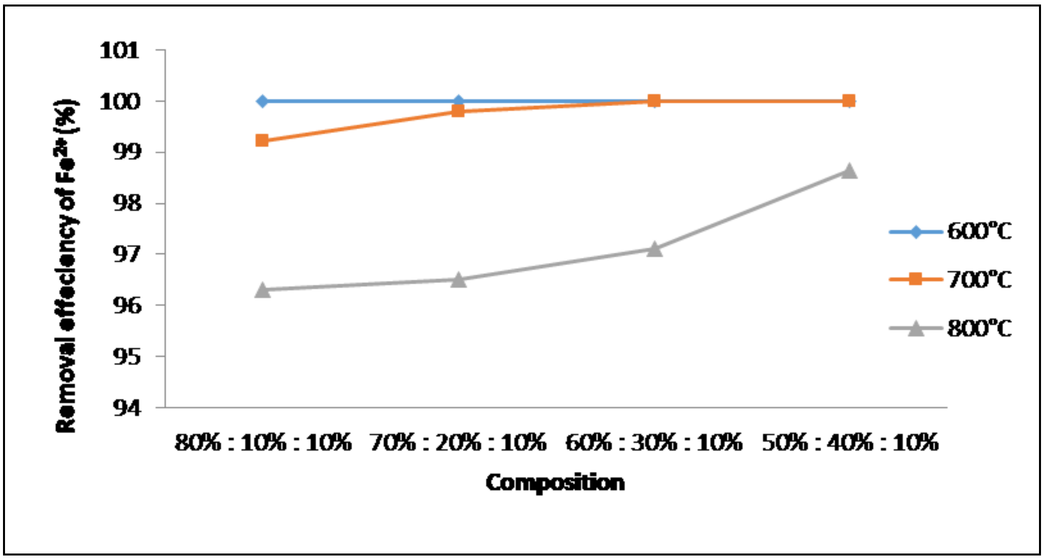

Figure 4. Effect of temperature and composition of materials of ceramic membrane towards removal efficiency of Fe2+.

3.5. Effect of temperature combustion and membrane composition towards Mn2+ content

The efficiency value of % removal of Mn2+ ion content in peat water can be seen in Figure 5. The greatest removal efficiency of Mn2+ ions was obtained in a mixture of 50%: 40%: 10% at a temperature of 600°C that is equal to 99.94 % and the lowest allowance for Mn2+ ions was obtained at a mixture of 80%: 10%: 10% at a temperature of 800°C that is 0.171 %. The lowest removal efficiency of Mn2+ ions is also influenced by the small amount of zeolite mixture used and the high combustion temperature resulting in the formation of cracks in the membrane causing ion exchange in the zeolite is not effective when water filtering is done. The results of the water analysis obtained after the screening are included the requirements of Republic of Indonesia Minister of Health Regulation No. 492 / MENKES / PER / IV / 2010 concerning drinking water quality requirements, namely with a membrane composition of 50%: 40%: 10% at a combustion temperature of 600°C.

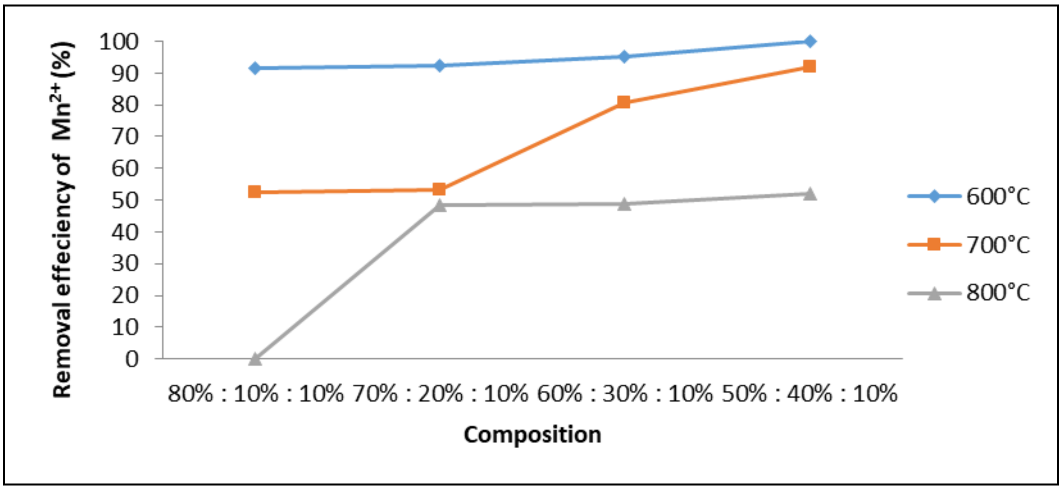

Figure 5. Effect of temperature and composition of materials of ceramic membrane towards removal efficiency of Mn2+.

4. Conclusions

Ceramic membrane has been produced as a filtration for peat water. Peat water was used as a sample which flowed in ceramic membrane. The filtrate from peat water after filtration analyzed TDS, turbidity, pH, Fe2+ and Mn2+. This study obtained the highest Fe2+ removal efficiency in peat water by 100%, the highest Mn2+ removal efficiency of 99.94%, followed by a TDS removal efficiency of 82.58% and turbidity 95.65%.

5. References

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