Improving Effluent Water Quality of Rubber Liquid Waste Treatment using Ceramic Membranes based on Bentonite, Zeolite and Iron Additives

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Abstract—The effluent water quality from rubber liquid waste treatment has the potential to be recycled as raw water for clean water. The purpose of this study was to examine the most effective composition of ceramic membranes from the composition of bentonite, zeolite, and iron additives and to determine the efficiency of reducing the concentration of TDS, T- Coliform, and LAS parameters according to the quality standard in the Ministry of Health Regulation Republic of Indonesia Number 32 of 2017. The stages of this research are the manufacture of ceramic filters, the filtration process using bentonite and zeolite-based ceramic membranes with iron additives. Variation of filtration operating time for 5 hours with sampling once every hour using an up-flow system. The results showed that the four variations in the composition of ceramic membranes had been effective in improving effluent water quality. The highest efficiency for decreasing TDS parameters was found in the CF4 membrane-type at the third hour of operation as much 23.64%, the T-Coliform parameter was found in the CF4 membrane-type at the fifth hour of operation as much 64%, and LAS parameter in all variations of tines in various operating time with optimal reduction efficiency above 99%.

Keywords—bentonite, ceramic membranes, effluent water quality, iron additives, zeolite

I. INTRODUCTION

Various methods to reduce rubber waste have been carried out by chlorination, adsorption, chemical coagulation, and membranes filtration. Rubber industry wastewater treatment by adsorption process using a combination of bentonite and zeolite adsorbents [6], that were carried out can reduce contaminants contained in the rubber industrial waste water and the permeate has met the quality standards of rubber industry wastewater which have been regulated in the Minister of Environment and Forestry Regulation Republic of Indonesia Number 68 of 2016. However, the processed water from the rubber liquid waste cannot be used as clean water. Further processing is needed to improve its quality by lowering parameters that exceed the quality standard of clean water, so that it is more appropriate to use raw water for clean water according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs. Therefore, in this study, a process development from previous research will be carried out with the achievement of improving effluent water quality from rubber liquid waste treatment through the application of ceramic filters so that it meets the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs. The ceramic filter designed in this study is a type of Microfiltration or Ultrafiltration from bentonite and zeolite with the consideration that these two materials are widely available in Indonesia so that the possibility of commercial applications will be wider. Ceramic membranes or porous ceramics as waste water filters have good performance, one of which is permeability. It is also known that membrane technology is the most widely used technology to overcome the waste problem because it does not require too much energy and does not use energy in the form of heat so that the components in it can be maintained. Several inorganic filters have been widely used, such as clay-based ceramic membranes, zeolite and sawdust [1], ceramic filters from clay and rice husks [3], cult-intermediate filters and polyethylene glycol (PEG) [11], silica nanofiltration membrane with PEG [10], clay-based ceramic filter and natural zeolite [8], clay filter and PEG as a pore maker [7]. Inorganic materials that have the potential to be used in ceramic membranes in this study are bentonite, and zeolite because they have a cavity or pore structure that is selective in the filtration process, is resistant to heat and has good absorption mechanism strength, and is resistant to extreme chemical environments. Meanwhile, ceramic media is made with the purpose of fast filtration with a simple operation, does not require a large space, and obtains good quality permeability. However, one of the weaknesses encountered is the nature of the membrane which is fragile and easily broken (brittle). For this reason, in this study, the iron powder will be added to the process of making ceramic membranes to strengthen the ceramic structure.

This research is expected to provide benefits for all research circles and the wider community. This bentonite and zeolite based porous ceramic filter and iron powder additive can filter waste water and is a solution for building the porous ceramic industry which is material efficient, easy to manufacture, easy to use, easy to carry, cheap, very environmentally friendly. When it is no longer used, it can be easily disposed of into the environment without being processed. In line with the recommendation to develop a product neighborhood to order release depended on imports as well as anticipate the need for clean water in the future.
In addition, it also contributes positively to the advancement of science in the field of Chemical Engineering, especially Membrane Technology.

Based on the above description, the researcher researched improving effluent water quality from rubber liquid waste treatment by ceramic membranes based on bentonite and zeolite with iron powder additives according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs, where this research is advanced processing of previous research and becomes an innovation in the rubber liquid waste treatment using the ceramic filter.

II. CERAMIC FILTER

Ceramic water filtration as explained by Agbo et al. [12] is an activity of making water to pass via a permeable ceramic material which is affordable in term of cost and also greatly reduces water-borne disease. Ceramic pot water filters over the years have been the most effective and efficient among several household water treatment. The concept of ceramic filtration method for the treatment of drinking water has existed for a while and has been utilized in different forms since olden times. Processing effluent WWTP Industrial Zone using dual filtration media with three variations of membrane composition tile (clay, sawdust and zeolite) [5] can reduce levels of parameters TDS and Detergents that have met quality standards but the value of the Total Coliform parameter can decrease significantly but has not been able to meet the quality standards according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017. Compared to the research of Sutrisno and Sari [13] regarding the reduction of total coliform in groundwater using ceramic membranes with a variable composition of 50% clay, 20% rice husks, and 30% zeolite, the efficiency of total coliform reduction was the highest of 95.83% which has met the water quality standards. Other research on the application of ceramic membranes to reduce levels of TDS in water effluent from industry with ceramic membrane composition consisting of 87.5% clay, rice husk 10% and 2.5% iron powder can reduce TDS levels with efficiency decreased by 16.75%. [8] The application of a ceramic filter made from a mixture of 77.5% clay, 20% rice husks, and 2.5% zeolite and 2.5% iron powder carried out by Nasir et.al., on treated wastewater from the laundry process can reduce levels of TDS, COD, BOD and LAS contained in the wastewater from the laundry process had the highest permeate flux, but the increased use of zeolite in the filter composition accelerated the occurrence of fouling.

Not all ceramics derived from clay but includes all non-metallic, and inorganic solid form. In general, ceramic compounds are more stable to heat (up to 1200°C, even up to 2000°C for engineering ceramics/oxide ceramics) and chemicals than the elements. Commonly used ceramic raw materials are feldspar, clay, quartz, kaolin, and water. The brittle, hard and rigid properties of ceramics are largely determined by their very complex crystal structure, chemical composition, and inherent minerals. [4]

Porous ceramics used as filters use high alumina material because alumina has advantages in strength, hardness, and resistance to pressure, heat, and chemicals [3]. Therefore, this research focuses to produce low-cost ceramic filter pots based on bentonite and zeolite clay with iron powder additives. More importantly, to show the efficiency of reducing concentration on the parameters of TDS, Total Coliform and Detergent of effluent water from rubber liquid waste treatment which refers to the clean water quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs.

A. Bentonite

Bentonite is a clay consisting mostly of montmorillonite with minerals such as quartz, calcite, dolomite, feldspars, and other minerals. Montmorillonite is part of the smectite group with a general chemical composition (Mg,Ca)O.Al$_2$O$_3$.5SiO$_2$.nH$_2$O. The mineral montmorillonite consists of very small particles that can only be known through studies using XRD (X-Ray Diffraction). Based on the content of hydrated aluminosilicate contained in bentonite, the bentonite can be divided into two groups, activated clay, is a clay that has a low bleaching power and Fuller's earth, is a clay that naturally has the ability to absorb dyes in oils, fats, and lubricants.

B. Zeolite

Zeolite is a porous tetrahydrate alumina silicate crystalline mineral that has a three-dimensional skeletal structure, formed by tetrahedral [SiO4]4- and [AlO4]5- which are connected to each other by oxygen atoms in such a way that they form an open three-dimensional framework containing channels. The channels and cavities in them are filled with metal ions, usually alkali or alkaline earth metals and freely moving water molecules. Zeolites have a hollow structure and usually these cavities are filled with water and exchangeable cations and have a certain pore size. Most of Indonesia's territory consists of volcanoes that have volcanic larvae that contain a lot of zeolite so that zeolite minerals in Indonesia are abundant. In principle, the use of natural zeolite is the same as synthetic mineral zeolite because the two types of zeolite have physical and chemical similarities, although they have some differences in physical and chemical properties. Many zeolites are found in nature, but these materials can also be synthesized under controlled conditions to produce cavities of very uniform size and shape. Most zeolites contain water molecules in their cavities, which serve as the mobile phase for the migration of charge balancing cations. This allows the zeolite to function as an ion exchange material (where one type of positive ion can easily be exchanged with another positive ion) and is the key to its ability to soften water. The second use of zeolite is obtained from the ease with which it is also able to adsorb small molecules.

III. MATERIAL AND METHODS

This research is a laboratory experimental scale where the design of the ceramic filter includes variations in the composition of the mixture and the amount of additives in the manufacture of the filter. This aims to determine the improvement effluent water quality from rubber liquid waste using a ceramic membranes, so that it can produce water quality that can be used as raw water for clean water.
A. Sample Collection and Preparation

The sample used in this study is effluent water that comes from rubber liquid waste treatment with an adsorption process using a filtration column that were carried out in previous studies. The materials used in this research are zeolite, bentonite and iron powder was collected from local manufacturers. The equipment used in this research include ceramic membrane unit, PVC pipe, ceramic membrane housing, filter housing, pump, flowmeter, pressure gauge, plastic tank, hose, water faucet and elbow.

B. Experimental Design

- Preliminary analysis of effluent water quality from rubber liquid waste treatment that exceeds for clean water according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs.

- The ceramic filter is designed in the form of a tube and is made from a mixture of bentonite, zeolite, and an additive in the form of iron powder with the composition (72.5%:25%:2.5%) (67.5%:30%:2.5%), (70%:25%:5%) and (65%:30%:5%). The particle sizes of zeolite and iron powder used were 250 µm and 500 µm, respectively. The mixture of bentonite, zeolite and iron powder was stirred and homogenized with the addition of clean water and then molded into a mold made of gypsum, dried at room temperature for approximately 7 days. The mixture was sintered or heated at about 900°C for 12 hours. The dimensions of the filter are as follows: inner diameter of 4 cm, an outer diameter of 5 cm, thickness of 1 cm, and length of 25 cm. The filter housing is made of polyethylene with the following dimensions: an outer diameter of 9 cm, inner diameter of 8.5 cm, and height of 30 cm.

- Procedure of research are pumped into a pipe that is connected to three filtration pipes in which there are ceramic filter with different composition of ceramic membranes. The filtration process was carried out for 5 hours continuously with sampling every 1 hour for laboratory testing of the test parameters and measuring the volume of water from the ceramic membranes.

- The data obtained were analyzed descriptively in the form of tabulations, presented in the form of graphs and percentages and described in the form of narration. Determination of test parameters is carried out by analyzing wastewater treated water exceeds for clean water according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs. From the preliminary analysis, it was found that the parameters of TDS, Detergent and Total Coliform still exceed the quality standard so that the improvement of the quality of wastewater treated with ceramic filters is carried out to reduce the levels of these parameters.

IV. RESULT AND DISCUSSION

Data obtained from observations entire series of experiments conducted by using ceramic membranes and analysis of parameters. The discussion includes the results of the activities carried out in research that improving effluent water quality from rubber liquid waste treatment by ceramic membranes based on bentonite and zeolite with iron powder additives. The data provided are analyzed and presented in tables and Figure. Based on the results of the calculation of the water pressure that can be accepted by the ceramic membrane and compared with the results of the compressive strength test of the ceramic membrane, the compressive test value of the ceramic membrane is still above the resulting water pressure value of 0.00952 N/mm². Ceramic membrane is able to accept water pressure without any leakage in the membrane because it has a compressive strength value that is greater than the value of water pressure. If the compressive strength test value of the ceramic membrane is below the calculated water pressure, it will cause the ceramic membrane to break.

A. Ceramic Membrane Analysis

Ceramic membrane analysis for effluent water quality from rubber liquid waste treatment carried out by varying the composition of the ceramic membrane. Comparison of ceramic membrane material composition is determined based on the percentage of the volume of material. The data on the results of ceramic membrane analysis are in the table below.

<table>
<thead>
<tr>
<th>Ceramic Filter code</th>
<th>bentonite by (wt)%</th>
<th>zeolite by (wt)%</th>
<th>iron powder by (wt)%</th>
<th>Screen size (mm)</th>
<th>Thickness (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF1</td>
<td>72.5</td>
<td>25</td>
<td>2.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>CF2</td>
<td>67.5</td>
<td>30</td>
<td>2.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>CF3</td>
<td>70</td>
<td>25</td>
<td>2.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>CF4</td>
<td>65</td>
<td>30</td>
<td>5</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

B. Filtrate Volume

Measurement of the volume of filtered water is used to determine the ability of ceramic membranes to filter processed water samples. The ceramic membrane types of CF 1 produces the largest volume of filtered water, which is 63 L while the ceramic membrane types of CF4 produces the lowest volume of filtration, which is 46 L. Seen in Figure 1, based on the filtration time interval, the volume of water produced is decreasing. This shows that the ability of the ceramic membrane to filter water is decreasing and producing less filtration water. The decrease that occurs is due to the presence of metal deposits and microorganisms that inhibit the rate of water filtration so that at a certain time there is a saturation process. When the filtration discharge does not meet the needs, the ceramic membrane can be activated again. Based on the ratio of the composition of the materials used, ceramic membranes with composition of bentonite as much as 72.5% have a better compressive strength than the others so that it affects the volume of filtered water produced.
C. Flux Permeate Analysis

Figure 2 shows that the mixture of bentonite, zeolite and iron powder each resulted in a change in flux. The smaller the particle size of the material, the smaller the flux in the ceramic. Small pores can only drain a little water because of the density of the pore space, thus the flux value is also small in the same area and time interval. That way the value of the flux is also small at the same area and time interval. In Figure 2 it can be seen that the value of the effluent flux with time, where in the initial 60 minutes the flux value changed, but after that the flux value showed an almost constant value. This decrease in water flux is caused by the blockage of the membrane pores by micro particulates and the denser the structure of the membrane. CF4 ceramic membrane type with a higher number of zeolite and iron powder particles gave a relatively better permeate flux. From the data in Figure 2, where the more zeolite used, the greater the flux produced. This is consistent with the theory of filtration, the liquid that is inserted into a porous membrane, the smaller the pores of the membrane, the filtrate down also getting slower, whereas the larger pores of the membrane, the water coming down faster.

D. Parameter Analysis

The following is the decrease in levels of TDS, Total Coliform and Detergent parameters after processing using ceramic membrane filtration media, which is presented in the graph below.

The effect of bentonite and zeolite with the addition of iron powder to the Total Dissolved Solid (TDS) showed a decrease in the effluent water quality from rubber liquid waste treatment, where the total dissolved solids for the initial sample was 1025 mg/L. Then after being filtered with variations of this membrane, there is a decrease so that according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs.

The highest efficiency of reducing TDS levels was found in the 3rd hour sampling CF4 membrane, which was 845 mg/L or 23.46%. In the early minutes, which is the first filtered water out until the first hour of processing, the TDS level in the membrane filtered water increased. A significant increase in efficiency occurred at the 2nd hour for each type of membrane.

The highest total coliform reduction efficiency was found in the CF4 membrane type and sampling at 5 hours was 64%. Meanwhile, the lowest total coliform reduction efficiency was found in the CF1 membrane type, which was 57%. In the first minute to the second hour of processing, the Total Coliform content in the treated water of the four membrane variations experienced a significant increase in efficiency. The decrease in Coliform concentration using ceramic membranes also occurs due to a filtering and absorption process where the organic materials contained in the wastewater are filtered and absorbed by the ceramic membrane with strong pressure causing organic materials to stick to the membrane wall, this happens because Coliform bacteria which has a size of 0.5–1 micron can be filtered by a ceramic membrane which has smaller pores than Coliform bacteria.

The results of the analysis of the permeate produced by each filter with various compositions of bentonite, zeolite and iron powder can be seen in the figure 5.
It can be seen that improving effluent water quality from rubber liquid waste treatment by ceramic membranes based on bentonite and zeolite with iron powder additives is quite effective in reducing TDS, T-Coliform and LAS according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs. However, ceramic filters with a fairly good composition used are 65% bentonite, 30% zeolite and 5% iron powder. This can be seen from the filter’s ability to produce permeate rate, and the ability to reduce TDS, T-Coliform and LAS which is quite high. CF4 ceramic membrane type with a higher number of zeolite and iron powder particles gave a relatively better permeate flux. The composition of zeolite particles contained in ceramic membranes can cause the adsorption process of metal ions or detergent residues containing surfactants both anions and cations so that the permeate flux will decrease over time. Linear Alkylbenzene Sulphonate is an anionic surfactant which contains Na⁺ ion group in its molecular structure. Residue of the surfactant will interact hydrophobically and electrostatically with the zeolite contained in the ceramic filter used.

V. CONCLUSION

Based on the results of the study, it can be concluded that the effect of composition on the manufacture of ceramic membranes as a filter media for effluent water quality from rubber liquid waste treatment is very effective in removing particles in the water. Variations in the composition of ceramic membranes CF1, CF2, CF3 and CF4 have been effective in improving effluent water quality from rubber liquid waste treatment according to the quality standard in the Minister of Health Regulation Republic of Indonesia Number 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Needs for TDS and Detergent parameters. Meanwhile, the Total Coliform parameter is still not able to meet the quality standards. The greater the composition of bentonite, zeolite and iron powder used, the greater the flux produced and the better the percentage reduction in TDS, T-

ACKNOWLEDGMENT

The author would like to thank the DIPA BLU, University of Lampung, which has funded this research.

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Dear Ms Rizka Mayasari, et al

Thank you for submitting your manuscript for presentation at The 2nd Universitas Lampung International Conference on Science, Technology and Environment (ULICoSTE) 2021, “Promoting Synergy Trought Collaborative Research in Science and Technology for Digital Transformatio” to be held online on August 27 - 28, 2021 at Bandar Lampung, Indonesia.

Your manuscript entitled: "Improving Effluent Water Quality Of Rubber Liquid Waste Treatment Using Ceramic Membranes Based On Bentonite, Zeolite And Iron Additives" has been peer-reviewed and accepted. Congratulations! Please be advised that your manuscript is recommended for publication in (International Conference Proceedings (AIP) - Indexed Scopus). For further information, please visit our official website at https://ulicoste.unila.ac.id/.

We look forward to seeing you at the Conference.

Kind regards,

ULICoSTE 2021 Committee

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