Preliminary Study of the Characteristics of Nipah Fruit Bioadsorbent as Greenhouse Gas Adsorption

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Abstract: This research is a preliminary study that aims to determine the bioadsorbent characteristics of nipah fruit based on SNI 06-3730-1995. Nipah fruit bioadsorbent that is made will later be applied as a medium for absorbing pollutants from greenhouse gas emissions. Nipah fruit obtained from Kampung Laut, Cilacap Regency, Central Java, was carbonized at a temperature of 500 ^{o}C for 4 hours. The charcoal obtained is then pulverized to a size of 50, 100, and 150 mesh. The activation process is carried out using 0% KOH; 2.5%; 5%; and 7.5%. The results obtained in the form of water content and iodine absorption that have met the quality requirements of SNI 06-3730-1995. However, the ash content and volatile matter content did not meet the quality requirements of SNI 06-3730-1995. This is because the nipah fruit bioadsorbent has high metal oxides and organic compounds.

1 INTRODUCTION

Vehicles powered by fossil fuels have altered the side of the earth over the last few century. The arrival of these vehicles covered the way for industrialization though we have been grappling with their ill effects for a decade. Hydrogen is the neatest fuel known to people and advances in hydrogen technology are expected to impact transportation and energy markets. In addition, greenhouse gases (GHGs) produced from exhaust fumes from automobiles and industrial factories are a major cause of global warming and further harmful environmental impacts (Mukherjee et al., 2019). The rejection of the global warming phenomenon by world leaders underscores the task of scientists in addressing this man-made catastrophe.

Adsorption of greenhouse gases for instance carbon dioxide and methane is one of the useful methods to reduce these effects. In contrast, burning fossil fuels produces greenhouse gases (GHG) and dangerous gases such as CO_2, H_2S, CH_4, NO_2 for the environment, which are improving in line with recent energy needs for rapid economic improvement (Mukherjee et al., 2019). Consequently, it is highly desired to find a cheap and environmentally responsive adsorbent to remove pollutants from air.

Many techniques can be used to reduce greenhouse gas emissions such as filtration, oxidation, reverse osmosis, flocculation, aerobic, anaerobic, magnetic separation and adsorption. Of all the techniques, adsorption is one of common methods for removing contaminants from wastewater and air pollution because it is inexpensive, easy to use, environmentally responsive, harmless to health and non-harmful (Wickramaratne & Jaroniec, 2013). The adding of bioadsorbent in the adsorption practice helps remove various contaminants and carcinogenic composites such as metallic, drugs and non-metal pollutants, colorants, and even taste then odor from aqueous solutions (Idrees et al., 2018).

Compared to other adsorbents such as zeolites, polymers and clays, activated carbon takes improve performance and firmness in conditions of adsorption (Narkiewicz & Morawski, 2016). Recently, the adsorption of pollutant gases by bioadsorbent has been established as a capable technology for the mechanism of attraction among pollutants and superficial functional groups (Xu et al., 2014). Bioadsorbent making from biomass can be realized

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as an advantage in two aspects, firstly it can avoid CO_2 production by sequestering carbon and secondly bioadsorbent can enter the soil naturally (Alabadi et al., 2015).

Bioadsorbent has more benefits other adsorbents due to its high thermal constancy and low feedstock costs. Bioadsorbent can be produced from some of materials, such as coal, manufacturing by-products, and wood or more biomass sources (Jia et al., 2020). Bioadsorbent is generally produced by chemical and physical activation. Physical activation is commonly undertake with carbon dioxide, air steam, or mixtures thereof. Chemical activation requires several agents such as HCl, $Ca(CO)_2$, $ZnCl_2$, H_2SO_4, KOH, HNO_3, and K_2CO_3 (Erawati & Fernando, 2018; Hendrawan et al., 2017; Hui & Zaini, 2015; Pallarés et al., 2016; Satriawan et al., 2021). Bioadsorbent adsorption performance hinge on the structure of pore and properties of surface. Bioadsorbent achieved by activation of chemical often have large surface of areas and well-developed of micropores, making them desirable materials for carbon dioxide (CO_2) adsorption (Heidari et al., 2014).

This study aims to examine the characteristics of bioadsorbents made from nipah fruit biomass with variations in size and chemical activation. The characteristics of the bioadsorbent in the form of adsorption of iodine content, volatile matter content, moisture content, and ash content were carried out to see whether the bioadsorbent of nipah fruit activated with KOH had complied with SNI 06-3730-95, 1995 regarding technically activated charcoal. This bioadsorbent will be used for the adsorption of air and water pollutants in future research.

2 METHODOLOGY

This research was conducted in the Environmental Pollution Control Engineering study program, Cilacap State Polytechnic. The raw material for bioadsorbent comes from the biomass of nipah fruit obtained in Kampung Laut, Cilacap Regency. Nipah fruit is split into four parts which are then dried in the sun. The pyrolysis process was carried out at 500 °C for 4 hours to get nipah fruit charcoal. Nipah fruit charcoal was then mashed with variations of 50 mesh, 100 mesh, and 150 mesh.

The refined charcoal was then activated using KOH with various concentrations of 0%: 2.5%; 5%; and 7.5%. Activation of nipah fruit charcoal was carried out by heating at 70 °C for 2 hours with 300 rpm stirring. Activation of nipah fruit charcoal is then left for 24 hours after the heating process.

The filtering process was carried out using filter paper and the obtained bioadsorbent was then neutralized with hot distilled water to a neutral pH (6.5 - 7.5). The neutralized bioadsorbent is then placed in the oven to remove the water content. The process of bioadsorbent analysis in the form of iodine analysis, volatile matter content, ash content, water content refers to the method of SNI 06-3730-95, 1995.

3 RESULTS AND DISCUSSION

3.1 Moisture Content

Analysis of the water content of the bioadsorbent refers to SNI 06-3730-95, 1995 regarding technically activated charcoal. 1 gram of bioadsorbent was put into the oven at 115 °C for 3 hours. The bioadsorbent that has been baked is then put into a desiccator and weighed with an analytical balance. The difference between the initial and final weight reduction is the water content that evaporates in the bioadsorbent. The results of the analysis of the water content of the bioadsorbent made from nipah fruit are presented in figure 1.

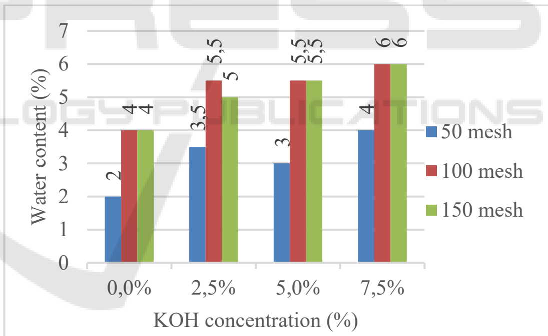

Figure 1: The effect of KOH concentration on the water content of nipah fruit bioadsorbent.

The purpose of analyzing the water content of this nipah fruit bioadsorbent is to determine and analyze the hygrascopic properties of rice husk charcoal. Satriawan et al., (2021) stated that the hydroscopic nature of the bioadsorbent or activated carbon shows the ability of the bioadsorbent to absorb water vapor in the air when it is in the cooling process. In addition, this hydroscopic nature shows the percentage of water vapor that is still absorbed in the carbonization process of the bioadsorbent (Husin & Hasibuan, 2020). Based on SNI 06-3730-95, 1995, the water content that meets the quality requirements of activated charcoal is a maximum of 15%. This maximum level indicates the ability of dry activated charcoal to absorb moisture in the air. Figure 3.1 shows that all nipah fruit bioadsorbents have met the standard of SNI 06-3730-95, 1995 with a maximum moisture content of 15%.

3.2 Ash Content

Analysis of ash content of bioadsorbent made from nipah fruit refers to SNI 06-3730-95, 1995 regarding technically activated charcoal. 2.5 grams of bioadsorbent was weighed and put into porcelain. The bioadsorbent was then put into the furnace for 1 hour at a temperature of 600 ºC. This temperature was used to ash the test sample for the nipah bioadsorbent. After one hour, the temperature of the furnace was raised to 900 ºC for 2 hours. The bioadsorbent that has been in the furnace is then put into a sedikator and weighed. The results of the analysis of the ash content of the bioadsorbent made from nipah fruit are presented in figure 2.

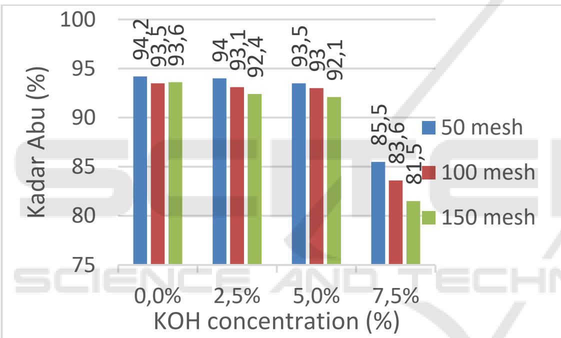

Figure 2: The effect of KOH concentration on ash content of nipah fruit bioadsorbent.

The ash content indicates the weight of metal oxides contained in the nipah fruit bioadsorbent. This metal oxide is a mineral that has an influence on the quality of the bioadsorbent adsorption made (Satriawan et al., 2021). High ash content indicates the amount of metal oxides contained in the bioadsorbent. This metal oxide will cause blockage of the pores of the nipah bioadsorbent so that the adsorption process that occurs cannot be optimal (Suherman et al., 2021). Based on SNI 06-3730-95, 1995, the requirement for ash content that meets the standard of activated carbon or bioadsorbent is a maximum of 10%. Figure 3.2 shows that the nipah fruit bioadsorbent does not meet the ash content standard based on SNI 06-3730-95, 1995. The ash content of unactivated nipah bioadsorbent was 81.5 - 85.5%; while the ash content of activated nipah fruit reaches >90%. From these data it can be shown that the addition of KOH activation can increase the ash content of the nipah fruit bioadsorbent.

3.3 Volatile Matter Content

Analysis of volatile substances or missing parts in bioadsorbents made from nipah fruit refers to SNI 06-3730-95, 1995 regarding technically activated charcoal. Nipah fruit bioadsorbent was weighed as much as 1.5 g and put into porcelain. The bioadsorbent is then put into the furnace at a temperature of 950 ºC. After the temperature reaches 950 ºC, the furnace is then cooled. The bioadsorbent is then put into a desiccator and weighed. The results of the analysis of volatile substances are presented in figure 3.

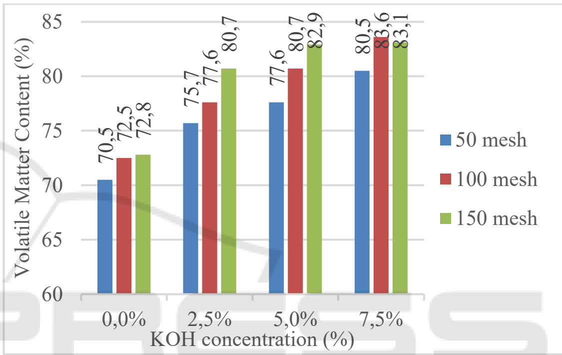

Figure 3: The effect of KOH concentration on the level of volatile substances of nipah fruit bioadsorbent.

The analysis of volatile substances or the missing part of the bioadsorbent aims to find out how many organic compounds are bound to the nipah fruit bioadsorbent made (Erawati & Fernando, 2018). Based on SNI 06-3730-95, 1995, the content of the volatile substance or part lost in the bioadsorbent is a maximum of 25%. Figure 3.3 shows the value of the volatile content of the nipah fruit bioadsorbent has exceeded the SNI limit for the volatile substance content that has been set up to >70%. This indicates that the nipah fruit bioadsorbent has high organic compounds in the form of methanol, acetic acid vapor, tar, and hydrocarbons (Rezvani et al., 2019).

3.4 Iodine Absorption Analysis

Analysis of iodine absorption in bioadsorbent made from nipah fruit also refers to SNI 06-3730-95, 1995 regarding technically activated charcoal. The nipah fruit bioadsorbent sample was first oven-dried at 115 ºC for 1 hour. The bioadsorbent that has been baked in the oven is then cooled in a desiccator. Weigh 0.5 g of nipah bioadsorbent and add 50 ml of 0.1 N iodine solution. Stirring was carried out for 15 minutes and then filtered. Take 10 ml of the obtained filtrate and titrate with 0.1 N sodium thio-sulphate. Titrate until a faint yellow color. Added 1% starch solution and titrate again with 0.1 N sodium thio-sulfate until the blue color disappears. The results of the analysis of iodine absorption are presented in figure 4.

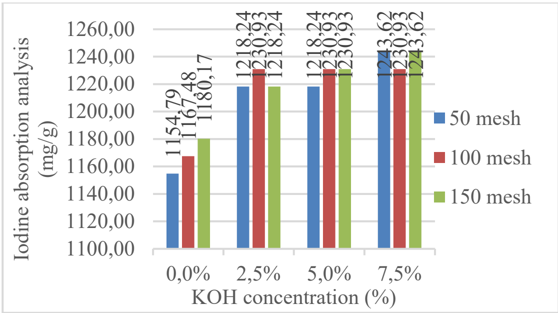

Figure 4: Effect of KOH concentration on iodine absorption in nipah fruit bioadsorbent.

Iodine absorption analysis aims to determine the ability of nipah fruit bioadsorbent in absorbing pollutants. Based on SNI 06-3730-95, 1995, the bioadsorbent quality requirement based on iodine absorption is at least 750 mg/g. The higher the value of iodine absorption, the better the ability of the bioadsorbent to absorb pollutants. Figure 3.4 shows the results of the analysis of iodine absorption in the nipah fruit bioadsorbent. Iodine absorption in nipah fruit bioadsorbent has met the quality requirements of SNI 06-3730-95, 1995, namely >750 mg/g. Iodine absorption in nipah fruit bioadsorbent without activation also has a good value for iodine absorption, namely 1154.79 - 1180.17 mg/g. This is because the nipa fruit bioadsorbent has been physically activated by using heating during the pyrolysis process (carbonization) so that the nipa fruit bioadsorbent is physically activated (Ogungbenro et al., 2018).

4 CONCLUSIONS

Nipah fruit bioadsorbent has met the quality requirements of activated charcoal based on SNI 06-3730-1995 for water content and iodine absorption. However, nipah fruit bioadsorbent did not meet the quality requirements for activated charcoal based on SNI 06-3730-95, 1995 based on analysis of ash and volatile matter content. This is because the nipah fruit bioadsorbent has high metal oxides and organic compounds. These high metal oxides and organic compounds can reduce the effectiveness of nipah bioadsorbent adsorption.

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