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Characterization of Activated Carbon from Industrial Solid Waste Agar with a Different Activator Concentrations

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ABSTRACT

Production of seaweed processing generates a huge amount of waste, either waste solid or liquid waste. Solid waste contains a lot of organic carbon derived from cellulose or hemicellulose. Therefore, the solid waste has the potential as a raw material of activated carbon. This study aimed to determine the characteristics of the activated carbon produced from solid waste agar and determine the optimal concentration of activator that produced the best characteristics of the activated carbon. The treatments were different activator concentration which was designed using completely randomized design (CRD) with five treatments and four replications. The results showed the five treatments had significant differences in the characteristics of the ash and pure active carbon content. This study showed that the manufacture of activated carbon industrial solid waste agar with a different activator concentration influenced characteristics of the active carbon with ash content parameter and pure active carbon content. The concentration of activator that could provide the highest value of pure activated carbon was in P5 with a concentration of 6 M. This study suggest further research on how to lower the ash content of the activated carbon from solid waste agar.

Keywords: *Solid waste agar, activated carbon, activators*

ABSTRAK

Produksi pengolahan rumput laut menghasilkan sejumlah besar limbah, baik limbah padat atau limbah cair. Limbah padat mengandung banyak karbon organik yang berasal berupa selulosa atau hemiselulosa. Limbah padat itu berpotensi sebagai bahan baku karbon aktif. Penelitian ini bertujuan untuk mengetahui karakteristik karbon aktif yang dihasilkan dari agar limbah padat dan menentukan konsentrasi aktivator optimal yang menghasilkan karakteristik terbaik karbon aktif. Perlakuan yang digunakan adalah konsentrasi aktivator berbeda yang dirancang menggunakan rancangan acak lengkap (RAL) dengan lima perlakuan dan empat ulangan. Hasil penelitian menunjukkan lima perlakuan perbedaan yang signifikan dalam karakteristik abu dan kadar karbon aktif murni. Studi ini menunjukkan bahwa pembuatan agar limbah padat industri karbon aktif dengan konsentrasi aktivator yang berbeda mempengaruhi karakteristik karbon aktif dengan parameter kadar abu dan kadar karbon aktif murni. Konsentrasi aktivator yang dapat memberikan nilai tertinggi karbon aktif murni ada di P5 dengan konsentrasi 6 M. Berdasarkan penelitian ini disarankan untuk melakukan penelitian lebih lanjut tentang cara menurunkan kadar abu karbon aktif dari agar limbah padat.

Kata kunci: *agar limbah padat, karbon aktif, aktivator.*

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1. Introduction

Production of seaweed processing generates a huge amount of waste, in the form of solid waste or liquid waste. One of the wastes produced by the seaweed processing industry is the processing of solid waste products agar (Sedayu et al, 2008). The need agar continue to grow as production increased and waste is not small, reaching 65-70% of the total raw material. Waste buildup can be a problem if waste disposal facilities can't accommodate the production of longer, so the necessary effort to take advantage of solid waste into a product with added value (Saputra, 2008).

Solid waste agar contains a lot of organic carbon. The carbon content in seaweed is derived from cellulose or hemicellulose (Suwilin, 2007). Based on research Faujiah (2012) that the crude fiber content in solid waste agar be quite high at 38.05% that indicates the carbon content in the solid waste that agar is also quite high. Therefore, the solid waste agar as a potential raw material of activated carbon.

Activated carbon or can be called activated charcoal is charcoal purified (Sudradjat and Pari, 2011) or charcoal that has undergone changes in nature because it has experienced the activation process so that absorption and increased surface area (Maryanto 2009 in Verlina, 2014). The world's consumption of activated carbon is increasing every year and 300,000 tons per year (Hadi, 2011). In the years 2005-2008 imports of activated carbon Indonesia increased by 58.3% and export of activated carbon in 2006-2008 increased by 25.9% (Sudradjat and Pari, 2011).

Manufacture of activated carbon consists of three stages: dehydration, carbonization, and activation (Nurdiansah and Susanti, 2013). Activation is a process to strengthen the absorption capacity, how to provide certain chemicals or by heating at high temperature (PPLH, 2007). The higher the concentration of a chemical solution, the greater the adsorption capacity of activated carbon, but if it is too high then the adsorption capacity tends to decrease (Adinata, 2013). According Siswati, et al (2015) that the use of excessive concentration of activators can damage the structure of the molecules of charcoal. Increasing the ratio of the activator will cause a higher surface area, but excessive use will also make higher operating costs (Kilic et al., 2012).

2. Materials and methods

2.1. Place and Time Research

This research was conducted from April until June 2017 at the Laboratory of the Faculty of Fisheries and Marine Airlangga University, Surabaya. Analysis of the characteristics of solid waste agar carried out in the Laboratory of Forage Faculty of Veterinary Medicine, Airlangga University, Surabaya.

2.2. Tools and Materials

Tools and materials used in this study is an electric furnace, oven, phosphoric acid (H_3PO_4)85%, distilled water, and solid waste in order from PT. Kappa Carrageenan archipelago, Brackets Village, District Kejayan, Pasuruan, East Java

2..3. Working Procedure

Solid waste agar has been obtained from the company and then dried. The drying process waste by means of drying under direct sunlight for three days. Next solid waste agar dried characterization of raw materials that include moisture content, ash content, crude fiber content and dry matter. Characterization is done in Faculty of Veterinary Medicine Laboratory, University of Airlangga.

Manufacture of activated carbon refers to the method used by Budiono (2009) and Faujiah (2012), 25 grams of solid waste agar dried carbonized at a temperature of 400°C for 10 minutes to obtain charcoal. The charcoal was added activator H_3PO_4 with a volume of activator used is 50 ml with different concentrations, i.e, 2 M, 3 M, 4 M, 5 M and 6 M. The sample was soaked in activator H_3PO_4 in a concentration different for 10 hours at room temperature. The samples were then filtered using filter paper and the residue was taken. The residue was washed repeatedly using distilled water until a neutral pH. Samples were dried for three hours in the oven at a temperature of 105°C and then cooled in a desiccator. Activated Carbon produced characterization rendemen, water content, ash content, volatile matter content, and the content of pure activated carbon.

2.4. Data Analysis

Data obtained from this study will be analyzed using ANOVA (Analysis of Variance) to determine whether or not differences in the results of each treatment. If from the analysis show that the treatment showed a significantly different effect or highly significant, it will be a further test that Duncan test. Duncan test aimed to compare which treatment produces the best results (Kusriningrum, 2012). As for the characteristics of the data analysis of activated carbon compared with the Indonesian National Standard (SNI) on activated charcoal.

3. Results and Discussion

The solid waste agar tested characteristics of the waste which has been dried beforehand by drying it under direct sunlight for ± 3 days. Waste from PT. Kappa Carrageenan archipelago that uses seaweed Gracilaria sp. harvested after 40 days as a raw material agar. Raw materials agar seaweed that contains high carbon and thus potentially as activated carbon (Rathinam, et al., 2011). Characterization of the chemical composition of solid waste agar includes water content, ash content, crude fiber content and dry matter. (see Table 1)

The characterization of activated carbon from solid waste agar includes rendemen, water content, ash content, volatile matter content, and the content of pure activated carbon. The results of the analysis of activated carbon characteristic of solid waste agar can be seen in Table 2.

Table 1. Components of Solid Waste Agar Chemical Composer.

No.	Chemical Components (%)	Value ± SD
1.	Water	5.24 ± 0.00
2.	Ash	59.49 ± 1.39
3.	Crude Fiber	8.18 ± 0.59
4.	Dried Materials	94.75 ± 0.00

ANOVA test results showed that the concentrations of different activators no effect on rendemen, water content, and the content of volatile substance activated carbon from solid waste in agar. F count<F table of 0.05 means that there are no significant differences among treatments activator concentration on the value of the rendemen, water content, and the content of volatile substance activated carbon. While the ANOVA test results showed that the use of different activator concentrations provides significant effect ($P < 0.05$) to the activated carbon ash content value and pure active carbon content.

Further test results using Duncan's Multiple Range Test 5% conducted to determine differences between treatments. The test results on the parameters of ash content showed that 5 (6 M) was significantly different from treatment 1 (2 M), 2 (3 M), 3 (4 M), and 4 (5 M). The results of a further test using test Duncan's Multiple Range 5% on the parameters carbon content of pure active showed that 5 (6 M) has the best value on the carbon content of pure active were not significantly different from treatment 4 (5 M) but was significantly different from other treatments.

Activated carbon water content of solid waste agar is less than the maximum limit of the Standar Nasional Indonesia (SNI) activated carbon by 15%, meaning that the parameters of activated carbon water content of the solid waste agar to meet the standard. Comparison of activated carbon ash content with SNI is the value of the activated carbon ash content of the solid waste agar to exceed the maximum limit of 10% of the SNI. This means that the active carbon with ash content not meet the parameters of activated carbon standards specified by SNI.

Table 2. Results of Activated Carbon Analysis.

Concentration (M)	Rendemen (%) ± SD	Water Content (%) ± SD	Ash Content (%) ± SD	Volatile Matter Content (%) ± SD	Pure Active Carbon Content (%) ± SD
2	70.11±11.49	3.42±2.30	64.70^{a}±5.69	23.54±3.76	11.76^{b}±3.79
3	68.99±14.19	3.26±2.42	64.40^{a}±2.59	23.66±4.63	11.94^{b}±3.84
4	70.87±11.64	3, 69±2.59	63.80^{a}±2.51	22.10±3.96	14.09^{b}±3.69
5	70.57±12.14	3.52±2.54	61.40^{a}±2.87	20.75±4.99	17.85^{ab}±4.19
6	78.58±8.57	4.47±1.69	55.15^{b}±3.88	20.61±4.00	24.23^{a}±7.86

*Different superscript letters indicated significant differences.

Values volatile substance content of activated carbon from solid waste agar less than the maximum limit of the Standar Nasional Indonesia (SNI) activated carbon by 25%, meaning that parameter volatile substance content of activated carbon from solid waste agar to meet the standard. While based on the Standar Nasional Indonesia (SNI) activated carbon pure active carbon content value of 65%, the resulting value does not meet those standards.

Value moisture and volatile matter content of a commercial activated carbon are higher than activated carbon waste agar. While the ash content and the carbon content of the pure active lower commercial activated carbon.

Based on research conducted ANOVA test results known that treatment of different activator concentrations does not affect the value of the rendemen of activated carbon. However, if viewed from the average of each treatment, the highest rendemen value in treatment 5 (activator concentration 6 M) of 78.58%. The lower the concentration of the activator, the lower the rendemen generated. But based on the results obtained by an increase and decrease at each concentration.

The low rendemen produced by the chemical reactions that happen between carbon formed by water vapor (H_2O) increases so that the carbon that acts to CO_2 and H_2O are also more numerous and otherwise carbon produced fewer and fewer (Lee et al., 2003 in Wibowo et al. 2010). Thus treatment 1, 2, 3, and 4 were experienced up and down the value of rendemen occurs because the drying process after activation is less than perfect so that the water content remaining cause severe rendemen rises.

Determination of water content aims to determine the hygroscopic properties of charcoal. The presence of water in charcoal related to the hygroscopic properties of charcoal itself, which has the properties of charcoal a great affinity to water (Subabdra 2002 in Khairani, et al 2015). Through testing the water content can be determined how much water can be evaporated so that water is bound to the activated carbon does not cover the pores of the activated carbon itself. The loss of water molecules that exist in the activated carbon causes the pores in activated carbon increases. The larger the pores of the surface area of activated carbon is increasing. (Herlandien, 2013).

Analysis of water content that has been done to get the highest water content in the delivery of the activator concentration of 6 M. The high water content such as during the process of heating the water molecules are not all evaporate, some water molecules are still trapped in the activated carbon (Syamberah, et al., 2015), High and low levels of activated carbon water also affects the levels of yield, because of the results of the analysis of activated carbon water levels higher than the rendemen is high and vice versa.

The ash content is lagging behind the rest of the minerals that when burned because the natural material as raw material not only the manufacture of activated carbon containing carbon compounds but also contains some minerals, where most of the minerals that have been lost during the carbonization and activation. Some are expected to remain behind in the activated carbon. The ash content is very influential on the quality of activated carbon. The existence of excessive ash can cause blockage of the pores so that the surface area of activated carbon to be reduced. (Herlandien, 2013).

During the activation process, tar and hydrocarbon compounds on activated charcoal dissolved in the activator and lost on heating temperature high enough to cause the pores bigger than the resulting ash content is also small (Widiyanti 2012 in Khairani et al, 2015). Activated charcoal is composed of stacked layers each other which form pores. Where in the pores of impurities in the form of charcoal usually contained inorganic mineral and metal oxides that cover the pores. During the activation process, the impurities dissolved in the activator causing the surface area of the larger pores because of the pores of the newly formed (Verlina, 2014). Ash produced by activated carbon from solid waste to be quite high and exceeding the maximum limit of standard activated carbon. According Wijayanti (2009) in Faujiah (2012) that high ash content is also influenced by the raw materials used and the process of composing.

Increasing the concentration of H_3PO_4 tends to reduce volatile matter content. This indicates that the hydrocarbon residues that stick to the surface of activated charcoal and many are extracted during the process of activation with vapor H_2O, hydrocarbons are reduced by H_3PO_4 come apart. (Wibowo et al., 2010). One function of the ingredients, phosphoric acid is not causing hydrocarbon residue forming organic compounds of oxygen which can react with carbon crystallites (Hassler, 1963 Sudradjat and Ani, 2002). High volatile matter content are caused because of incomplete decomposition of non-carbon compounds such as CO_2, CO, and H_2 (Ramdja, 2008). The amount of volatile matter concentration leads to the ability of activated carbon absorption. Volatile matter content substance may reduce the absorption of active charcoal. (Verlina, 2014).

Based on calculations of pure activated carbon content can be seen that increasing the concentration of activators affect the pure active carbon content, it is the same as that expressed by Wibowo, et al. (2010) that the increasing concentration of H_3PO_4, activated charcoal carbon content increases. High and low levels of pure activated carbon depending on the ash and volatile matter content. The higher levels of ash and volatile matter content, the lower the carbon content of pure action.

Utilization of activated carbon one of which is to reduce the levels of heavy metals in the waters. According to Jafar, et al (2014) that the presence of heavy metals in the water affect aquatic life, because biota ability to accumulate metals heavy in the water. Utilization of solid waste so as activated carbon need to be introduced to the public to be used, as is done by Andriyono, et al (2015) by applying the liquid smoke technology in processing and preserva-tion fishery products to the public so that people can apply themselves. Style et al. (2015) considers that the activated carbon has favorable surface properties, uniformity of adsorption and adsorption effects were outstanding. In addition, the activated carbon is relatively cost-effective compared with other inorganic adsorbents such as zeolites

4. Conclusion

The conclusions of this study are the manufacture of activated carbon industrial solid waste agar with a different activator concentra-tion influence on the characteristics of the active carbon with ash content parameter and pure active carbon content. While the parameters of rendemen, water content, ash content and volatile matter content have no effect. Characteristics of activated carbon from solid waste industry agar with a different activator concentration have met the Standar Nasional Indonesia (SNI) on the parameters of water content and volatile matter content. Activator optimal concentration is in treatment 5 is the provision of an activator concentration of 6 M. Treatment 5 had the lowest ash content and also the levels of activated carbon bonded highest of 24.23%.

Suggestions of this study are to further research on how to lower the ash content of the activated carbon in solid waste agar to meet the standards set.

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