Potential of cocoa pod husk (*Theobroma cacao L.*) for seawater desalination

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ABSTRACT - The accessibility of clean water on the planet is extremely restricted. Therefore, the solution to obtain clean water is strongly required. Desalination using cacao pod husk activated carbon is one of method to obtain the clean water from seawater. This study aims to analyze the potential of activated carbon from cocoa pod husk for the seawater desalination. The utilization of activated carbon as a desalination medium can reduce the content of chloride, sodium, sulfate, hardness, and total dissolved solid in seawater. Hence, the activated carbon from the cocoa pod husk has the potential to be used for desalination or pretreatment medium in the desalination process.

1. INTRODUCTION

The earth's surface is made up of 70.0 % water with the total world water reserves up to 1.4 billion km^3. About 97.5 % of the water comes from the sea, the rest is freshwater found in the atmosphere, icebergs, and groundwater [1].

To fulfill their daily needs, urban society usually uses groundwater as a source of freshwater. Therefore, this activity decreases the ground level gradually. Jakarta faces this problem namely 11.5 cm every year [2]. In other side, the coastal community cannot utilize groundwater due to the high salt content.

Desalination is the process of separating salt in seawater and brackish to obtain a lower salt content. Using this technique can obtain freshwater from seawater. There are several desalination techniques, namely reverse osmosis (RO), distillation, electrodialysis, and ion exchange membrane desalination. However, this method requires high costs [3].

Desalination can be conducted by using activated carbon. This activated carbon generated from rich material carbon such as biomass. Cacao pod husk is one of byproduct of cacao. From total weight of cacao, cacao pod husk takes a 67.0 % [4]. The purpose of this paper is to review recent research on desalination and particularly potential of cocoa pod husk for desalination.

2. ACTIVATED CARBON FROM COCOA POD HUSK

Tejada et al. [5] synthesized activated carbon from cocoa pod husk at low temperatures with a variation in the ratio of activator $ZnCl_2$. As indicated in this research, it was found that after being activated with $ZnCl_2$, there was a very significant increase in carbon surface area. Activated cocoa pod husk carbon in a ratio of 1:3 has a surface area of 287.5 m^2/g while at a ratio of 1:4 resulting a surface area of 205.4 m^2/g [5]. In this research, activated carbon with a ratio of carbon to $ZnCl_2$ 1:3 was the most effective method to obtain activated carbon with a larger surface area. Table 1 shows the activated carbon that is synthesized from cocoa pod husk.

Table 1 Characteristic of activated carbon from cacao pod husk.

Temp. (°C)	Activator	Surface area (m^2/g)	Pore size (nm)	Ref.
800	KOH	490	2	[7]
800	K_2CO_3	614	2	[7]
650	$ZnCl_2$	780	2.9	[7]
350	$ZnCl_2$	287.5	2-4	[5]
850	CO_2	248.75	2.44	[6]

Cruz et al. [7] synthesized activated carbon from cocoa pod husk using three activators, namely KOH, K_2CO_3, and $ZnCl_2$ with a surface area of 490, 614, and 780 m^2/g respectively. The porosity varies depending on the activator. However, for cacao pod husk porous is mostly dominated by micropores. This is due to the higher cellulose content in cocoa pod husk than the lignin content [8].

The presence of $ZnCl_2$ results mesoporous structure in cocoa pod husk. In this case, it is possible to find the micropore structure inside mesoporous, where this is an important parameter as a material for water treatment. The mesoporous structure allows the penetration of water into activated carbon which will then come into contact with the micropore structure. Adsorption of metals occurs in this this micropore structure [7].

3. DESALINATION BY ACTIVATED CARBON

Activated carbon is the most used adsorbent for water treatment. This is due to its low cost, very high porosity, pore size, and high adsorption. Monnot et al. [8] conducted research about application of granular activated carbon for seawater desalination. According to this research, activated carbon has a surface area of about 950 m^2/g with a mesoporous structure. It was found that desalination using this activated carbon decreased the turbidity by 88%, dissolved organic carbon (DOC) by 72.0 %, and decrease in colloidal transparent exopolymer particle (cTEP) up to 92.0 % [8].

Another research about desalination utilized activated carbon was conducted by Jayaprakash et.al [9].

In this research, desalination of seawater using activated carbon derived from coconut shells decreased the content of chloride, sodium, iron, sulfate and hardness and total dissolved solids with a percentage of 9.6, 78.9, 100.0, 45.0, 53.0, 11.42, and 33.28% respectively [9].

The surface area of activated carbon from bituminous coal which was applied as a desalination medium is not too different from the surface area of activated carbon made from cocoa pod husk with $ZnCl_2$ activator. With a surface area of 950 m^2/g, activated carbon from a bituminous coal can be used in the seawater desalination pretreatment process. The optimum surface area of activated carbon from cocoa shell using the BET method was 780 m^2/g. The characteristics of cocoa shell activated carbon are strongly influenced by the synthesis process, including the activator used, the carbonization temperature, and the content inside of the cocoa pod husk itself. The presence of cellulose content in cocoa shells also affects the formation of mesoporous structures which are important point in adsorbents for water treatment.

4. CONCLUSION

Activated carbon from cocoa pod husk has potential to be applied in the desalination process or for pretreatment in desalination. Based on literature review, activated carbon from cocoa pod husk has almost the similar characteristics as activated carbon from other materials for desalination purpose. The abundance of cocoa waste particularly in Indonesia is an important source for desalination.

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