

CARBON DIOXIDE CAPTURE EFFICIENCY USING ALGAE BIOLOGICAL ABSORBENT AND SOLID ADSORBENT FOR BIOGAS PURIFICATION

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Article history

Received

9 November 2015

Received in revised form

27 December 2015

Accepted

7 Februari 2016

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Graphical abstract



Abstract

CO₂ is the main gas impurity on biogas production which must be reduced to produce optimum CH₄ content of biomethane. This biogas purification research was conducted at experiment field of PT Bumimas Ekapersada, Cikarang, Bekasi, Jawa Barat, Indonesia from April until June 2013. The research purpose was compare the purification results of four sorption materials: (i) imported products of solid adsorbent; (ii) domestic products of solid adsorbent; (iii) biological absorbent of *Scenedesmus* sp., and (iv) wild algae which grow on cat fish (*Clarias gariepinus*) pond as biological liquid absorbent. This research was repeated six times to produce average (in percentage) of CO₂ capture efficiency and used t test as statistical inference. Solid adsorbent test utilized a cylinder measured (diameter × length) 10 cm × 50 cm, filled with 2.3 kg to 2.5 kg adsorbent materials. Liquid absorbent test utilized a cylinder measured (diameter × length) 10 cm × 100 cm. The test results showed that there were no significant statistical different among the sorption materials. Therefore, imported products of solid adsorbent can be replaced by domestic products and solid adsorbent can be replaced also by biological absorbent of *Scenedesmus* sp. and/ or wild algae absorbent.

Keywords: Biogas, biological purification, biomethane, solid adsorbent purification

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1.0 INTRODUCTION

Adam [1] on World Bank Publication stated that biogas may be perceived as a modern cooking fuel, particularly in rural and remote areas. This publication reported that biogas utilization increases households' health level due to reduction of acute respiratory illnesses, heart diseases, cataract, and cancers normally associated with traditional biomass burning in countryside. Biogas utilized for torch light, electricity generators, water pumps, ovens and henhouse warmers in the remote areas are also resulted in positive impacts [2].

However, biogas has also been known to have a weakness, namely the low heating value, as a result of CO₂ and H₂S presence in biogas as impurities. Deublin and Steinhauser [3] stated that biogas should be contain 45 % of methane for fuel utilization. Wirdth *et al.* [4] presupposed that methane content must be more than 50 %. Furthermore, 60 % to 70 % of methane is the minimum requirement of biogas which was utilized as electricity generator fuel [5, 6].

One of the purposes of purification by minimizing CO₂ content is efficiency improvement. Wahono *et al.* [7] experiment found that increasing methane by 5.27 % can accelerated cooking time on stove. Furthermore, biogas purification using "biogas filter" also improved generator efficiency up to 39.07 % [8]. On the household scale biogas, "methane purifier MP 24150" was reported that it increased methane composition from 4 % to 20 % [6]. Wahyuni [2] suggested to utilize "desulfurizer" tools/materials to increase the methane content in biogas. Wahono *et al.* [8] suggested to utilize "biogas filter" in the form of modified-activated natural zeolite. Zeolite was utilized due to its ability to adsorb and absorb H₂O, CO₂, SO₂, H₂S [9], which reduce biogas impurities up to 25 % [10]; without absorbing CH₄ [11]. Sutarti and Rachmawati statement [10] on zeolite's CO₂ dan H₂S

absorption performance was supported by Hamidi *et al.* [12] and Sugiarto [13].

Nowadays, some household biogas projects in Indonesia utilize imported grain (solid adsorbent) as purification. This was also reported by Bach Khoa [14] in Vietnam. The grain material was chosen because it is easy to buy in the market. Actually, Indonesia has the ability to produce grain for biogas purification, one of the required material (solid adsorbent) has been granted since 2015.

In addition, biological purification technology needs to be reviewed because it has double impacts. Kao *et al.* [15] cited that four studies conducted between 2003 and 2010 concluded that biological purification is a potential technology. Rostika [16] said that microalgae purification is an innovative and economical technology because microalgae is available in nature on various species. It has a high ability to consume carbon, therefore it has a good potential as biogas CO₂ capture. Cebula [17] wrote that algae also has the ability to capture H₂S from biogas. Sialve *et al.* [18] supported the previous known fact on biogas purification using algae culture.

This research was conducted to study the performance of grain solid adsorbent as biogas purification materials, by comparing between imported materials and local (Indonesia) materials. It also studied the performance of biological purification technology which compare between pure algae culture and wild-natural algae which is grow on the catfish (*Clarias gariepinus*) pond.

2.0 MATERIALS AND METHOD

This research was conducted at experiment field of PT Bumimas Ekapersada, Cikarang, Bekasi, Jawa Barat, Indonesia from April to June 2013. Four

purification materials were used as research objects: (i) imported products of solid adsorbent; (ii) domestic products of solid adsorbent; (iii) biological liquid absorbent made from *Scenedesmus* sp., and (iv) biological liquid absorbent made from wild algae which grow on cat fish (*Clarias gariepinus*) pond as biological liquid absorbent. Adsorbent materials (ii) were modified-activated zeolites which was appropriate with Wahono, et al. procedure [19]. Solid adsorbent was made in cylinder measured (diameter × length) 10 cm × 50 cm filled with 2.3 kg to 2.5 kg materials. Liquid absorbent utilized in cylinder, measured (diameter × length) 10 cm × 100 cm. Materials and tools research were elucidated in Figure 1.

This research was conducted in six repetition to produce average of CO₂ (in percentage) capture efficiency and used t test as statistical inference. The average of CO₂ content in the influent and effluent was measured by orsat apparatus with three repetition for every variables. Percent average of CO₂ capture efficiency formula referred to Kao et al. [15] as follows:

$$\frac{\text{Influent of CO}_2 - \text{Effluent of CO}_2}{\text{Influent of CO}_2} \times 100 \% \quad (1)$$



Figure 1 Materials and tools

3.0 RESULTS AND DISCUSSION

Table 1 elucidated that solid adsorbent was able to capture 16 % to 19 % CO₂. The result was lower from previous research [10] which stated that capture efficiency was 25 %. However, CO₂ capture efficiency which range was accordance to reference [6, 8] was equal to 4 % to 20 %.

Table 1 elucidated biological adsorbent capture efficiency was 14 % to 31 %. These data support previous research on wild algae performance absorption of CO₂ [20]. However, the previous result was higher than Hendroko et al. [21] research which

stated *Scenedesmus* sp capture efficiency was 2.5 % to 11.5 %. Also lower than research [22-24] which stated that capture of biological absorbent was more than 90 %.

The result of t test for 16 pair wise-combinations of treatment indicated no significant difference in four different materials and two-scale purification of tap openings as treatment. Based on the research result, the utilize of imported solid adsorbent may be replaced by domestic product. Statistically, it has been shown that biological purification from wild algae or *Scenedesmus* sp. can replace the solid adsorbent

Table 1 The average of CO₂ removal efficiency (%) based on sorption type and valve opening percentage

Variable	The percentage of valve opening	
	25 %	50 %
Imported solid adsorbent	19 (ns)	19 (ns)
Domestic solid adsorbent	16 (ns)	18 (ns)
Algae biological absorbent *)	22 (ns)	14 (ns)
Algae biological absorbent ("wild algae" **)	31 (ns)	15 (ns)

Note:

ns = not significantly different

*) *Scenedesmus* sp

**) *Scenedesmus* sp., *Nitzschia* sp., *Tetraspora* sp., and *Selenastrum* sp. (178 to 315) cell · mL⁻¹.

4.0 CONCLUSION

Domestic-made solid adsorbent have similar capability with imported adsorbent which is in the range 16 % to 19 % of CO₂ adsorption. Biological adsorbent of *Scenedesmus* sp. has similar capability with solid adsorbent which is in the range 14 % to 31 % of CO₂ adsorption. Biological adsorbent of "wild algae" can capture CO₂ of 50 % on two purification cycles.

Acknowledgement

The authors would like to thank to PT Sinar Mas Agro Resources and Technology (PT SMART Tbk.) Jakarta, Indonesia for supporting this study. Special thanks to Dwi Yono, Plant Production and Biotechnology PT SMART for statistics analysis and to the research technicians, Ata Atmaja WKD, Acam Are Hikman, and Dewi Tiara Sagita for their contribution.

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