Seaweed Sargassum sp. as material for biogas production

by Iis Hamsir Ayub Wahab

Seaweed *Sargassum* sp. as material for biogas production

[1]Muhammad Irfan, [2]Iis H. Wahab, [3]Sarni, [4]Riyadi Subur, [5]Nebuchadnezzar Akbar

[1] Aquaculture Department, Faculty of Fisheries and Marine Science, Khairun University, Ternate, Indonesia; [2] Civil Department, Faculty of Engineering Khairun University, Ternate, Indonesia; [3] Agronomy Department, Faculty of Agriculture, Khairun University Ternate, Indonesia; [4] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Khairun University, Ternate, Indonesia; [5] Marine Science Department, Faculty of Fisheries and Marine Science, Khairun University, Ternate, Indonesia. Corresponding author: N. Akbar, nezzarnebuchad@yahoo.co.id

Abstract. Biogas refers to the final product of the organic material conversion through the anaerobic digestion process. Its main components include methane (55-65%), carbon dioxide (33-40%), hydrogen sulfide (>1%), other gases and water vapour. This research aims to determine and observe the potential of *Sargassum casifolium* as material for biogas production and determine the gas pressure that seaweed *S. casifolium* can produce as a new energy alternative. This research was conducted in the waters of Ternate Island, in which the samples of seaweed were collected from the waters of Kastela Beach. The analysis of seaweed material for biogas was conducted at the Laboratory Alkalis, Faculty of Fisheries and Marine Science, Khairun University, Ternate, Indonesia, within 6 months. The results of the research show that the following gasses can be obtained from *S. casifolium*: methane 24.56%, nitrogen 5.85%, hydrogen sulfide 0.006% and CO_2 3.29%. This showed that methane is the biogas compound with the highest level in *S. casifolium*. Meanwhile, the observations on biogas pressure showed good values. Hence, based on the biogas composition of *S. casifolium*, the seaweed has the potential to be used as biogas material.
Key words: carbon, hydrogen sulfide, methane, *Sargassum casifolium*, seaweed.

Introduction. Biogas refers to the final product of organic matter conversion through anaerobic digestion processes. It is mainly composed by methane (55-65%), carbon dioxide (33-40%), hydrogen sulfide (>1%), lesser gases and water. The utilization of biogas obtained from of raw materials like agro-industrial solids or liquid wastes, agricultural wastes, livestock manure is performed widely (Oktiana et al 2015). However, the biogas made from the aforementioned wastes might be hard to develop in the coastal areas and small islands in Indonesia in relation to the minimum access and distance to the materials - particularly for the coastal areas that are far from agroindustry, farmlands and livestock (Wahyudi et al 2015). Hence, using the seaweed as the raw material for producing biogas is seen as a solution to make the small islands in Indonesia energy independent. The potential of algal biomass as a source of liquid and gaseous biofuels has been the subject of considerable research over the past few decades, with researchers strongly agreeing that algae have the potential of becoming a viable aquatic energy crop, with a higher energy potential compared with that of either terrestrial biomass or municipal solid waste (Milledge et al 2019).

Seaweed has the potential to be the raw material for biogas (Indriani & Sumiarsih 1991; Dawes 1995; Sitompul et al 2012). In general, waters are able to yield about 50% of the total world biomass (Wahyudi et al 2015). Seaweed has high levels of carbohydrates and water and low levels of lignin, in comparison with terrestrial plants (Anggadiredja 2006; Zatnika 2009). This means that seaweed can be simply degraded (Putra et al 2019). Also, the use of seaweed as raw biogas producing material can be beneficial, as it does not require land areas or fresh water for cultivation and it will not compete with food agriculture or settlement areas (Oktiana et al 2015). One of the critical challenges in achieving energy return from microalgae is harvesting and concentrating the algae (Okubo et al 2005; Collet et al 2015; Wang et al 2015). To our knowledge, a study on the potential of seaweeds in North Maluku Province in general and in Ternate city in particular has not been conducted. This encourages further studies. This research aims to determine and learn the potential of *Sargassum* sp. as material for biogas production and to determine the gas pressure produced by *Sargassum* sp. as a new alternative of energy source.

Material and Method

Sample collection. This research was conducted in September 2018. *Sargassum casifolium* was collected from Ternate Island, Kastela Beach. The analyses of the samples for biogas production were conducted at the Laboratory Alkalis, Faculty of Fisheries and Marine Science, Khairun University, Ternate, within 6 months.

The collected samples were placed into a container, at 20°C. The seaweeds that will be used as biogas material need to be still fresh before being placed in the digester. The seaweeds were left at room temperature for 2 days to dry.

Using a shovel, the substrates were taken and adjusted with the size of digester used. The seaweed mix was made by soaking the dried seaweeds in saline water for 2 hours to get back to its initial condition, in a ratio of 1:2 seaweed to water. Then, the mixture was refined using a blender (Oktiana et al 2015).

Sample processing. This research used the continuous load displacement digester model, as it was seen as more practical and continual in producing the gas. Using the displacement digester, the materials could be inserted often/continually to enable the continuity of gas production (Saputra et al 2011).

The substrate was made based on the information presented by Saputra et al (2011). 500 g of lime were added every time the seaweed was introduced in the 100 L digester. It was also important to add the fertilizer, as a nutrient for the growth of methanogenic bacteria. Nutrients needed by the bacteria include C, N and P. C is obtained from the carbohydrates of the seaweed. To fulfill the N and P requirements, NPK fertilizer was added. In this research, 500 g of NPK fertilizer were used. Once the sample was placed in the digester, observations of the generated biogas pressure were conducted using a manometer. These observations were carried out for approximately for one month.

Biogas composition was determined anaerobic biodegradation of the batch method the ratio of substrate to the seaweed mix was 2:1. It took 2 to 4 weeks to produce methane. Furthermore, 5 kg of refined seaweed were introduced into the digester (AOAC 2005).

Sample analyses. Observations of the biogas pressure were determined by manometer, using the following formula (Saputra et al 2011):

$$h=(p1-p2)/pg \longrightarrow p1-p2=hpg \longrightarrow p1 = hpg+p2$$

Where: p1 - pressure in tube 1 (psi); p2 - pressure in tube 2 (psi); h - distance between h1 and h2 (cm); g – gravitational acceleration (10 m/s^2); p (water) - water density (1000 kg/m^3).

The gas composition analysis was carried out using GC-MS, with a gas temperature of 200°C, and a column temperature of 150°C. The flow rate in the column was 43 mL/min.

Results and Discussion

Biogas composition. The composition of the biogas obtained from *Sargassum casifolium* can be seen in Table 1.

Table 1

Biogas composition of seaweed *Sargassum casifolium*

Type of Gas	*Amount (mg/L)*	*Amount (%)*
Methane	2456	24.56
Nitrogen	585	5.85
Hydrogen Sulfide	0.66	0.006
CO_2	329	3.29

The composition of the biogas consisted of methane 24.56%, nitrogen 5.85%, hydrogen sulfide 0.006%, and CO_2 3.29% (Table 1). This shows that methane is the predominant component of the biogas in the seaweed *Sargassum casifolium*. The result of the research showed that the level of methane produced was not yet optimal. Susanto & Yudhistira (2012) stated that, in general, the level of methane produced can reach 50-60%. Furthermore, it is stated that there are some factors that are assumed to cause issues in the methanogenic process, including the incompletely hydrolyzed carbohydrates, nutrient content that is not optimal and the decline of the pH value in the aerobic digestion process.

Biogas pressure. The observations regarding the biogas pressure within one month (30 days) present the pressure values from the 2 gallon tubes from the digester (gallon tube 1 and gallon tube 2). The pressures could be observed after placing the seaweed starter twice without any additional substrate, in the digester. The biogas pressure in gallon tube 1 showed a mean p1 value of 2.806 psi, reaching in day 30 4.3 psi, while gallon tube 2 showed a mean p2 value of 2.348 psi, reaching in day 30 4.96 psi. The distance between heights h1 and h2 was 8 cm. The results of biogas pressure observations for 1 month (30 days) in gallon 1 and gallon 2 can be seen in Figure 1.

The result show that the biogas pressures in the gallon tube 1 and gallon tube 2 are similar. Thus, based upon the biogas composition produced by the seaweed *Sargassum casifolium*, it can be stated that the seaweed genus has the potential to be used as material for biogas production.

The biogas material from seaweed has a high level of carbohydrates. The higher the carbohydrate in the seaweed is, the greater the biogas pressure will be. Because carbohydrates are one of the major elements, it will later form biogas by bacterial fermentation (Saputra et al 2011: Lutfiawan et al 2015). The levels of sugar and alcohol in each gram of seaweed are determined by the level of carbohydrates. This shows that a higher level of carbohydrates can determine the level of alcohol produced in the carbohydrate fermentation process (Saputra et al 2011).

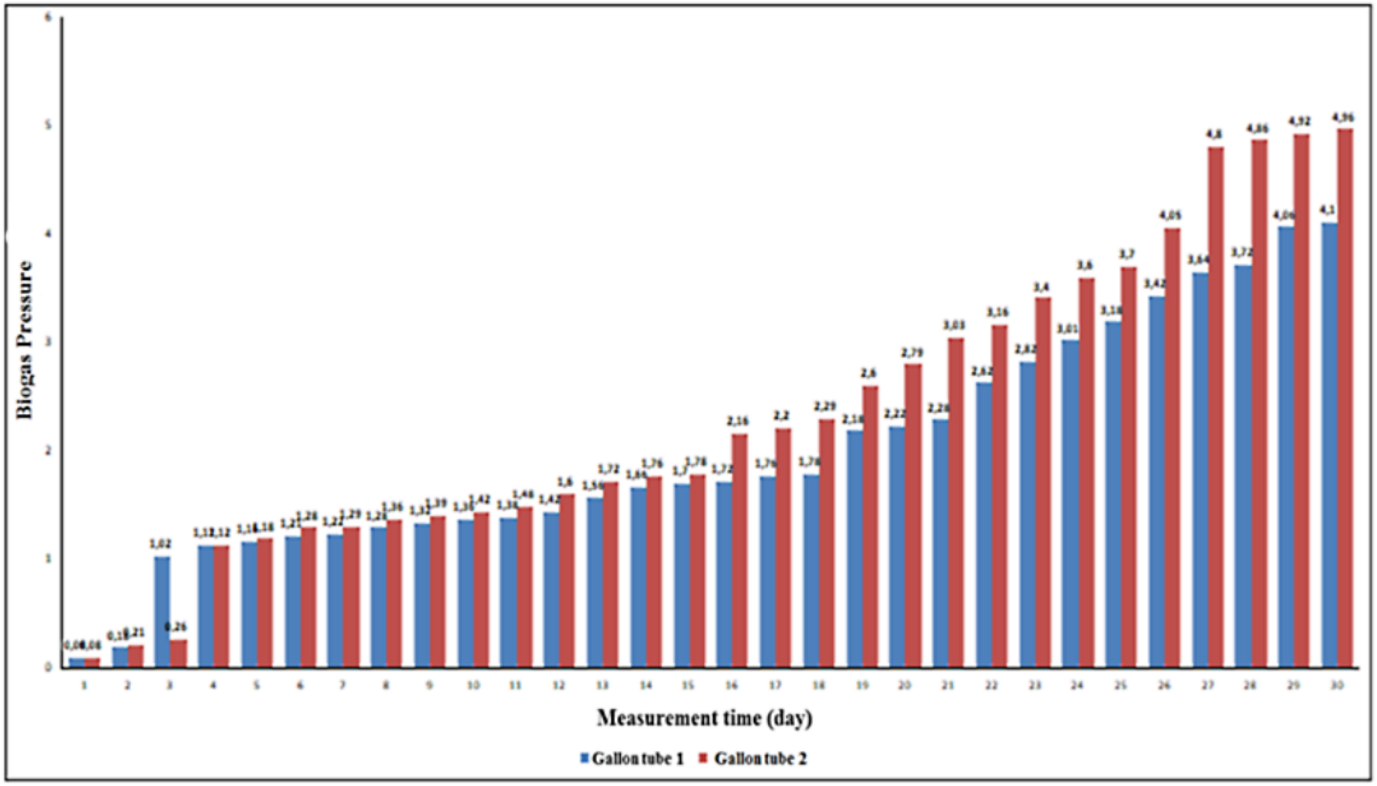

Figure 1. Biogas pressure by days.

Conclusions. Based on the obtained research results, it can be concluded that *Sargassum casifolium* has the potential to be used as biogas material. The biogas pressure mean values in gallon tube 1 was 3.553 psi and in gallon tube 2 3.654 psi.

References

Anggadiredja, 2006 [Seaweed, cultivation, processing and marketing of potential aquaculture commodities]. Penebar, Swadaya, Jakarta, 144 p. [in Indonesian].

Collet P., Helias A., Lardon L., Steyer J. P., Bernard O., 2015 Recommendations for life cycle assessment of algal fuels. Applied Energy 154:1089-1102.

Dawes C. J., 1995 Marine Botany. John Willey & Sons, New York, Chicester, Brisbane, Toronto, Singapore, 628 p.

Indriani H., Sumiarsih E., 1991 [Culture, Processing and Marketing of Seaweed]. Penebar Swadaya, Jakarta, 99 p. [in Indonesian].

Lutfiawan M., Karnan, Japa L., 2015 Analysis of *Sargassum* sp. growth with different cultivation systems in east Lombok Ekas Bay as enrichment material for plant ecology course. Journal of Tropical Biology 15(2):135-144.

Milledge J. J., Nielsen B. V., Maneein S., Harvey P. J., 2019 A brief review of anaerobic digestion of Algae for bioenergy. Energies 12:1-22.

Oktiana D. T, Santoso J., Kawaroe M., 2015 Green Algae (*Ulva* sp.) as biogas production materials. Journal of Tropical Marine Science and Technology 7(1):91-203.

Okubo N., Taniguchi H., Motokawa T., 2005 Successful methods for transplanting fragments of *Acropora formosa* and *Acropora hyacinthus*. Coral Reefs 24:333-342.

Putra H., Putri R. M. S., Ilhamdy A. F., 2019 Biogas Production From Seaweed *Padina* sp. Marinade 2(1):1-9.

Saputra A., Putri E. A. W, Aryawaty R., 2011 [Making biogas from seagrass *Caulerpa racemosa* and *Sargassum duplicatum* as alternative energy materials]. Maspari Journal 3:30-35. [in Indonesian].

Sitompul J. P., Bayu A., Soerawidjaja T. H., Lee H. W., 2012 Studies of bio-gas production from green seaweeds. Journal of Environment and Bioenergy 3(3):132-144.

Susanto A. B., Yudhistira R. A., 2012 [Seaweed and biogas as alternative fuels]. Navila Idea, Yogyakarta, 82 p.

Wahyudi J., Kurnani T. B. A., Clancy J., 2015 Biogas production in dairy farming in Indonesia: a challenge for sustainability. Journal of Renewable Energy Development 4(3):219-226.

Wang S. K., Stiles A. R., Guo C., Liu C. Z., 2015 Harvesting microalgae by magnetic separation: A review. Algal Research 9:178-185.

Zatnika A., 2009 [Technical guidelines for seaweed cultivation]. Agency for Assessment and Application of Technology, BPPT, Jakarta, 62 p. [in Indonesian].

***AOAC (Association of Official Analytical Chemists), 2005 Official methods of analysis. 18th ed, Washington, 1899 p.

Received: 29 January 2019. Accepted: 25 September 2019. Published online: 30 October 2019.

Authors:
Muhammad Irfan, Aquaculture Department, Faculty of Fisheries and Marine Science, Khairun University, 97719 North Maluku, Ternate, Indonesia, e-mail: ifan_fanox@yahooo.co.id
Iis Hamsir Wahab, Civil Department, Faculty of Engineering, Khairun University, 97719 North Maluku, Ternate, Indonesia, e-mail: iishamsiraws309@mail.ugm.ac.id
Sarni, Agronomy Department, Faculty of Agriculture, Khairun University, 97719 North Maluku, Ternate, Indonesia, e-mail: sarniriyadi@yahoo.com
Riyadi Subur, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Khairun University, 97719 North Maluku, Ternate, Indonesia, e-mail: riyadisubur58@gmail.com
Nebuchadnezzar Akbar, Marine Science Department, Faculty of Fisheries and Marine Science, Khairun University, 97719 North Maluku, Ternate, Indonesia, e-mail: nezzarnebuchad@yahoo.co.id

How to cite this article:
Irfan M., Wahab I. H., Sarni, Subur R., Akbar N., 2019 Seaweed *Sargassum* sp. as material for biogas production. AACL Bioflux 12(5):2015-2019.

Seaweed Sargassum sp. as material for biogas production

ORIGINALITY REPORT

6%	6%	5%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.mdpi.com Internet Source	4%
2	newjournal.ssmu.kz Internet Source	1%
3	biodiversitas.mipa.uns.ac.id Internet Source	<1%
4	researchspace.ukzn.ac.za Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		