Biogas Utilization Using Fish Waste with Constant Volume of Inoculum Cow-Dung

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***Abstract*— This research used fish waste as a raw material and inoculum cow-dung as a starter to produce biogas. It was calculated the weight of total solid and volatile total solid for the right amount of substrate to be incorporate into the digesters. The variation of 5g, 6g, 7g, 8g, 9g and 10g of volatile total solid was mixed with the inoculum cow-dung 100ml and water as the rest, which was filled up to 300ml of the total volume of slurry. Two digesters with amount of 100ml inoculum cow-dung and 200ml water were used as the comparison. This research was conducted for 30 days and it was measuring pressure in digesters, temperature and pH, which was conditioned once a week with NaOH or H2SO4. The best result can be seen in the variation of 5g fish waste as a substrate. The volume in the digester is 93.93ml/gVS with percentage levels of CH4 by 51% and CO2 by 47%.**

Keywords*— Biogas, Fish Waste, Inoculum Cow-Dung, Volatile Total Solid

I. BACKGROUND

The fish industry developed around fishing ports at a time when landings at Ngurah Rai airport Bali are plentiful and there is a little concern about environmental impacts. There is considerable potential for gaining more value from fish waste. Fish waste can be utilized in the production of organic fertilizer, composts and biogas stations.

The total amounts of fish wastes and trash fish available in Indonesia are not recorded in official fisheries statistics. However, the estimated minimum amount in 1976 was 450 000 tons and keeps increasing. In addition to trash fish, large gluts occur at times from the sardine industry in the Bali Strait. Mechanization of the boats and recent introduction of purse seining has resulted in greatly increased catches. During the heavy fishing season, which usually lasts for at least 30 days, the daily surplus is about 150 tons, giving a total excess of 5 000 tons. Fish waste is mainly produced at scattered processing plants. (Kompiang, 2013).

Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source, like solar and wind energy. Furthermore, biogas can be produced from regionally available raw materials such as recycled waste and is environmentally friendly.

This energy release allows biogas to be used as a fuel. It can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy from gas into electricity and heat by biogas combustion. Biogas can be compressed, the same way natural gas is compressed to CNG, and used to power motor vehicles. It qualifies for renewable energy subsidies in some parts of the world. Biogas can be cleaned and upgraded to natural gas standards when it becomes bio methane.

Bali has a lot of fishing companies, therefore it is not difficult to find and get sufficient fish waste. Some of those are Benoa port in Denpasar Bali, Kedonganan market, Kuta etc. Benoa port in Denpasar Bali, has larger companies than in the other fish markets, and data on fish waste is maintained by them. The company Gilantas Indonesia provided us the data for the period from January 2013 until mid October 2013. The biggest daily amount of fish waste was on July 2013 (25 771kg) and the smallest amount of fish waste was on February 2013 (only 152kg). The average monthly fish waste during the fishing season is 6 850kg. The company PT Bandar Nelayan also provided us their data for our case study. The average from January through mid October was 30 507kg fish waste per month. The biggest amount of fish waste was on April 2013 (63 981kg) and the smallest amount of fish waste was on February 2013 (only 1 711kg). These results show us that we may produce biogas from fish waste.

II. THEORY

A. Overview

Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source. Furthermore, biogas can be produced from regionally available raw materials such as animal waste, human waste, fish waste etc. Biogas is environmentally friendly.

Biogas, which consists mainly of methane, can be produced when food waste from households, manure, or crops from agriculture is broken down by micro-organisms in digesters and wastewater treatment plants. Biogas can be used for heating, power generation or upgrading to natural gas quality. To upgrade biogas to natural gas or vehicle fuel quality, carbon dioxide, hydrogen sulphide, and other contaminants need to be separated.

B. Biogas Composition Producer

There are a lot of fish markets in Bali and hence a lot of fish waste. Fishermen are not interested about the environment, so almost all of fish waste is thrown into the ocean. Fish waste as a biogas producer is a neat solution for both the environment

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and in biogas production. Using the fish waste to produce biogas keeps the fish markets and the ocean clean.

Fish waste. Fish waste can create water quality problems at marin area. Fishery processing industries generate large amounts of fish waste. The disposal of these wastes represents an increasing environmental and health problem. Interestingly, fish by-products provide an excellent nutrient source for microbial growth useful in enzyme production process, which is largely governed by the cost related to the growth media. Fish wastes (heads, viscera, chitinous material, wastewater, bones etc.) were prepared and tested as growth substrates for microbial enzymes production. (Faouzi Ben Rebah et al., 2012).

Cow dung. Cow dung is the waste product of bovine animal species. Cattle manure is basically made up of digested grass and grain. Cow dung is high in organic materials and rich in nutrients. It contains about 3% Nitrogen, 2% phosphorous and 1% potassium and 50 - 75% organic humus.

Cow dung gas is 55 - 65% methane, 30 - 35% carbon dioxide, with some hydrogen and other traces. Inoculum as cow-dung which is commonly used as a starter for produce biogas.

C. Biogas Digester

Fixed dome plants. A fixed-dome plant consists of a digester with a fixed, non-movable gas holder, which sits on top of the digester. When gas production starts, the slurry is displaced into the compensation tank. Gas pressure increases with the volume of gas stored and the height difference between the slurry level in the digester and the slurry level in the compensation tank.

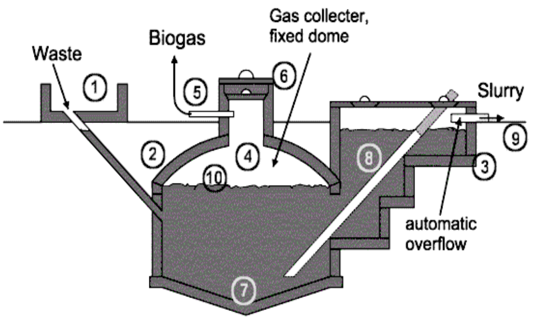


Figure 1 Digester Fixed Dome Plants

Temperature. Biogas-producing bacterial activity is strongly influenced by the temperature in the digester. Sudden temperature changes in the biogas digester can result in rapid decline of biogas production. Therefore, in order to be stable temperature, biogas installations should be placed in the ground. Typically, the optimum temperature for the production of biogas is 26-37°C. The digester is susceptible to corruption at higher temperatures resulting in the need for continual maintenance. An air-tight digester such as glass fiber type can help maintain desired temperature during the fermentation process by avoiding entry of outside air.

The degree of acidity (pH). Acidity has an effect on the biological activity and maintain a stable pH, therefore it is important for all life processes of bacteria. Methane bacteria cannot work if the environment is too acidic or too alkaline. Atmosphere neutral (pH 6.7 to 7.5) is the best atmosphere to produce biogas. Whereas a pH that is too acidic or alkalic is poisonous to methane bacteria. To adjust the pH to remain in neutral environment it is necessary to add other ingredients. If the pH is less than 6.7, NaOH can be added and for a pH greater than 7.5, H2SO4 can be added.

Total solid. Dry matter (total solid) is the material remaining after used traditional oven. The sample has been dried ata temperature of 105°C for approximately 24 hours. Dry matter is expressed as a percentage of theanalysis sampleusing the formula below.

$$TS\% = \frac{Final\ Weight}{Initial\ Weight}\ x\ 100$$

Volatile total solid (VS). Fish waste sp;id that has been drained of total solid testing and then weighed to determine the weight of the material. After it is heated at a temperature of 550°C in the oven for 2 hours, cooled and weighed again. The formula to determine volatile solid is as follows:

$$VS\% = \left(1 - \frac{Ash\ weight}{TS\ weight}\ x\ 100\right)$$

D. Number of percentage content of dry substrate

The amount of substrate has to be incorporated into the wet digester with certain percentage of content was calculated via the following formula:

$$Final\ substrat = \frac{mass\ substrate}{\%\ dry\ matter}$$

E. Calculation Analysis of Biogas Production

The biogas digester volume result can be calculated via the following formula:

$$VB = \frac{\Delta V\ x\ 273.15\ x\ Pb}{(273.15+Ts)\ x\ Ps}$$

Where:

VB = volume biogas [ml]
ΔV = head volume (volume digester – volume slurry) [ml]
Pb = pressure in a digester [bar]
Ts = surrounding temperature [ºC]
Ps = surrounding pressure [bar]

III. RESEARCH METHOD

A. Research Variable

There are two variables in this case:

1) Independent variable. The independent variable is the variable that is determined by the investigator and determined before the research is carried out. In this study the independent variable is the fish waste with variations:

- Variations in the composition substrate (volatile solid) used were 5g (A), 6g (B), 7g (C), 8g (D), 9g (E) and

10g (F) mixed with 100ml slurry for each digester. Each variation consists of two digesters. After that water was added to fill up each digester to 300ml.

- Variations two digesters only with inoculum cow-dung 100ml and 200ml water.

2) Dependent variable. The dependent variable is the variable that appears as a result of the magnitude of the free variable. In this study the dependent variables are: The digester pressure, pH, temperature, volume of biogas, methane content and gas composition in the biogas digester

B. Research Installation

The case study required 14 simple digesters or reactor plants. The reactor is a bottle with a volume of 1 liter. The reactor is equipped a system to add raw materials at the top of the reactor.

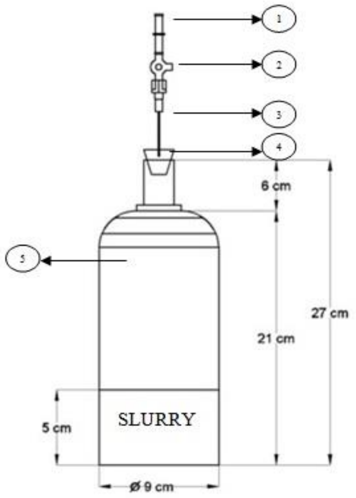


Figure 2 Installation Biogas Digester

information:

1. Connector
2. Tap
3. Needle
4. Rubber stopper
5. Glass bottle

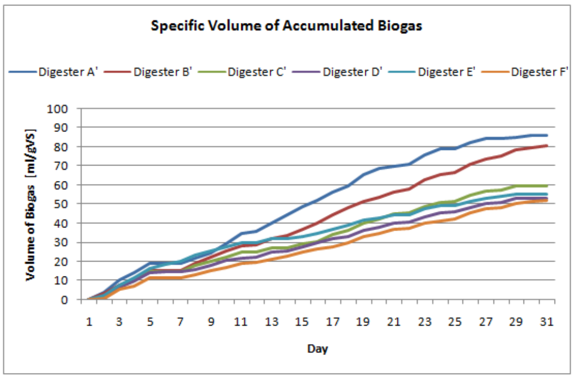
Figure 3 Biogas Digesters

IV. Results and Discussion

A. Research Installation

This study was conducted over 30 days. In the beginning of the study material was prepared and mixed in accordance with the methodology of the research that was presented in the previous section. Later we recorded pressure, pH, temperature, percentage of methane content and data was processed to find the volume of biogas.

B. Specific Volume of Accumulated Biogas



Gambar 4 Specific Volume of Accumulated Biogas, Condition Variation

The graph shows that the output increases until the 28th day in the biogas digesters which were controlled/conditioned for pH once a week. The increase lasts beyond 28 days but the increase is very small and is not significant from this study. The total production of control biogas digester A' is 86.168ml/gVS, control digester B' is 80.774ml/gVS, control digester C' is 59.318ml/gVS, control digester D' is 53.076ml/gVS, control digester E' is 55.163ml/gVS and control digester F' has a total production of 51.904ml/gVS. From this data, the control biogas digester A' is the most prolific with an average of 2.872ml/gVS and has the highest total volume of biogas 86.168 ml/gVS. The composition of control digester A' is the right composition when compared with the other control digesters.

C. Gas Composition

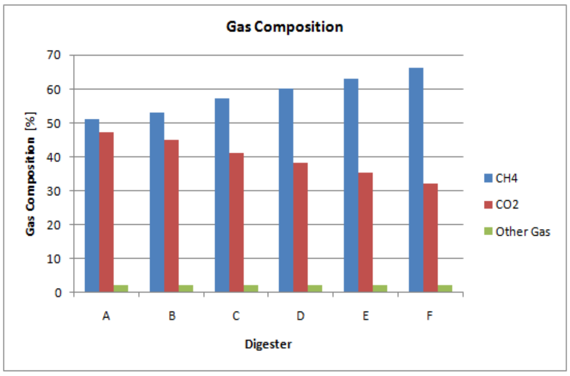


Figure 5 Gas Composition Production

From graph 4.17 it can be seen that digester F has the highest methane content of all digesters 63%. Gas composition in the digester A is 51%, in digester B 53%, in digester C 57%, in digester D 60% and in digester E 63%.

V. Conclusion

Pure inoculum produces very little of biogas, therefore inoculum cannot increase the biogas production by itself but provides necessary anaerobic bacteria which accelerate and increase the biogas production from fish waste. The optimal combination of substrate and inoculum is in the digester with a composition of: 5 grams of fish waste, 100ml of inoculum. This digester was not conditioned! Biogas production from fish waste is highest at 93.93ml/gVS for 30 days. Conditioning pH in biogas digesters extends lifetime of bacteria. Bacteria produce biogas for a longer time biogas than non-condition digesters and conditioning the pH supports the proliferation of bacteria. Hyperacidity or high alkalinity can kill bacteria, therefore it is necessary to keep the pH value between 6.8 - 7.5.

The gas composition is within accepted limits for CH_4 = (50-75)%, CO_2 = (25-50)% and other gas = (0-10)% for all digesters. The highest methane content is in the biogas digester F which has methane content 66%.CO_2 content is 32% and other gas content is 2%. Graph 4.19 shows the relationship between the amount of substrate and production of methane. Bacteria with bigger amount of substrate and the same amount of inoculant produce more methane and less carbon dioxide. Potential of biogas from fish waste in Bali island can be at the best conditions V = 784 990 dm^3/month. The best conditions are when a digester with optimal mass of fish waste is mixed with inoculum and water at defined parameters.

The best digester overall is the digester F' with composition 10g of fish waste and 100ml inoculum because has the highest volume of biogas and the highest methane content.

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