The Biogas From Biomass Waste

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Abstract— The Raw materials from plants such as rice stalks and straw may produce methane gas of about 55%.. The Biogas is the gas which able to produce from agricultural waste or animal husbandry as the raw materials. . The Biogas is renewable energy with circumstance friendly and easy to produce. . The biogas is cheap enough compare with others gas or natural gas. The Biogas weighs 20% lighter than air, it has a combustion temperature of 650^o-750 ^{o}C, odorless and colorless. The Biogas when burned will produce blue color. The Methane gas calorific value is 20 MJ / m^3 with a combustion efficiency of 60% on a conventional biogas stove.

Key words : Agricultural waste, Biogas, Cheap,combustion Odorless, Rice stalks, Rice stalks, natural gas.
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1.. INTRODUCTION

Biogas is a gas produced from the process of decomposition of organic materials by the activity of microorganisms in the absence of oxygen or anaerobic condition[12]. Biogas is a mixture of some gases with main components are methane gas (CH_4) and carbon dioxide (CO_2); With a small amount of water vapor, hydrogen sulfide (H2S), carbon monoxide (CO) and nitrogen (N2). The composition of the biogas depends on the raw material used. When using raw materials of human waste, animal waste or liquid waste of slaughterhouses, methane gas produced can reach 70%[11].

The Raw materials from plants such as rice stalks and straw may produce methane gas of about 55%. The biogas composition in generally presented in Table 1.

Table 1. The Biogas composition

Gas	Concentration (%)
Methane (CH_4)	50 – 75
Carbon dioxide (CO_2)	25 – 50
Nitrogen (N_2)	0 – 10
Hidrogen (H_2)	0 – 1
Oksigen (O_2)	0 – 2

Source : [7]

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Biogas was first invent by Robert Boyle and Stephen Hale in the 16th century, when they acquired combustible gases from river and lake sediments that were disturbed by stirring. In 1859 the tank in the absence of oxygen (anaerobic digester) was first designed by a colony in Bombay, India. In the UK the technology was developed using a septic tank to produce gas used for street lighting. The anaerobic process itself only gained recognition around 1930. Since 1975, the use of domestic-scale biogas in China and India has been made a government program [7]

The use of biogas as energy is a step that needs to be supported, given the energy used today is mostly derived from fossil energy (petroleum). The availability of fossil energy raw materials will be thinned and non-renewable. On the other hand increased energy demand for human survival increased sharply. It is therefore necessary to develop new energy produced from materials that will not be exhausted or from renewable materials, such as solar energy (sun) wind energy, water energy and biomass energy. The Biogas is a new form of environmentally friendly energy and is produced from renewable biomass materials[10].

The Biogas production from biomass waste raw materials, in addition to reducing the quantity of biomass waste, also adds value to the biomass waste material[3]. The use of biogas as an alternative energy is relatively more reducing the occurrence of pollution. Besides preventing the accumulation of biomass waste which can be a place for the development of disease, bacteria and air pollution, the superiority of biogas production is the production of byproducts of compost and liquid mud[11].

2. THE RAW MATERIALS OF BIOGAS

Biogas production raw materials are materials containing organic substances, mostly found in biomass materials. The use of biomass as a raw material of biogas production is cultivated not to clash with food and feed provision programs. The use of bioamass such as cassava, corn, sorghum and others will conflict with the interests of food and food security, because these materials can be used as food and feed providers. Therefore, biomass materials used are biomass waste materials[8}.

Some materials that can decompose organically can be used as raw material of biogas production, either in the form of solid or liquid. Technical and economical reasons determine some materials more desirable as raw materials of biogas production[1]. Preferred raw materials to be used in the form of waste, easy to obtain and widely available and biodegradable easily biodegradable. Biomass waste is the abundant raw material of biogas in Indonesia. The advantages of using biomass waste are the biogas economic value, environmental pollution from the accumulation of biomass waste can be minimized and the use of biogas production byproducts as agricultural fertilizer. Some variables that need to be considered in the production of biogas is the ratio of C / N raw materials, pH, temperature, type of unstable solid it contains.

Materials that are widely used as raw materials of biogas production are farm and agricultural waste, both in solid or liquid form. Examples of solid wastes that can be buried for biogas production are livestock manure, human waste, domestic waste; While liquid waste that can be used among other industrial waste, industrial waste of tapioca and others.

3. FACTORS THAT INFLUENCE THE BIOGAS PRODUCTION PROCESS

The production process of biogas from raw materials of organic materials is influenced by 2 factors namely, bioteik factor and abiotic factor. Biotic factors such as types of microorganisms and jassd renik are active in the reshuffling of organic materials into biogas. Abiotic factors include raw material composition, water content of raw materials, C / N and P ratio in raw materials, temperature, pH, and the presence of toxic materials.

Microorganisms as living organisms require certain environmental conditions for their growth and development, so that for each type of microorganism there are requirements of different environmental conditions[9]. Factors affecting environmental conditions of microorganisms include; Time, food, moisture, and temperature. Temperature is a factor affecting the process of reshuffling anaerobic organic matter into biogas, because temperature is an important factor affecting the activity of microorganisms. The optimal temperature of the anaerobic fermentation process is divided into three, namely mesophilic (30^o - 40^oC),, psychrophilic (45^0-55^oC) and thermophilic (50^o - 60^oC) [9]. The optimal temperature of most mesophilic microorganisms is around at 35 ° C. The optimal temperature is most thermophilic microorganisms at 55 ° C. The optimal temperature for various biodigester designs is 30^o-35^oC [12]. At that temperature range is the best condition for growth of microorganisms and methane production.

According to Haryati [4] methane gas production will stop at 10^oC temperature. Optimal gas production occurs at mesophilic temperature. At temperatures outside the temperature, the resulting biogas has a high carbon dioxide gas content.

Microorganisms that work to produce biogas are very sensitive to changes in pH. Since the anaerobic process in the biogas production therein is an acid formation stage and a methane gas formation stage, the initial pH adjustment of the process is very important.

At the beginning of anaerobic biogas production process, the pH will decrease because a number of microorganisms convert organic matter into organic acids. The next process is the reshuffling of organic acids into biogas that will raise the pH again. The ideal pH of the biogas production process is 6 -8 with the acceptable level being pH 5 (minimum) and pH 12 (maximum) [6]. Initial treatment is generally carried out on wastewater with a pH <5 with the addition of Ca $(OH)_2$ to make the pH neutral.

The anaerobic biogas production process will be inhibited by high concentrations of certain materials such as ammonia, heavy metals, light metal cations, oxygen and sulfide. This is demonstrated by the low biogas productivity. Therefore, special handling is required so that the contaminants are not present in anaerobic decomposition system.

Organic materials change into biogas is also influenced by ratio of C / N in raw material. The concentration of the necessary microorganisms is also related to the C / N ratio. Anaerobic bacteria consume carbon about 30 times faster than consuming nitrogen. According to Suryati [13], for anaerobic needs C / N ratio of 20 - 30. If the C / N ratio is too high, nitrogen will be consumed rapidly by methanogen bacteria to meet its growth needs and few react with carbon. This condition causes the resulting gas to be slightly. Under conditions of low C / N ratios, nitrogen will be liberated and accumulate in the form of ammonia (NH_4) which will increase the pH. This condition also resulted in little methane gas produced.

4. THE PHASE OF PROCESS IN BIOGAS FORMATION

Anaerobic digestion is a biological oxidation of organic materials contained in raw materials by microorganisms in the absence of O_2 (anaerobes)[7]. The microorganisms used in the anaerobic breakdown process are facultative microorganisms. For the production of methane is used obligate anaerob microorganism.

5 BASIC OF ANAEROBIC PROCESS

In the anaerobic solution process, organic materials present in the feedstock are food sources of microorganisms and converted into oxidized materials, new microorganisms cells, energies, gases (CH_4 and CO_2) and other products[8]. In general anaerobic splitting process can be written as follows:

$$\text{Organic matter} \xrightarrow{\text{Micro organism}} CH_4 + CO_2 + \text{new cells} + \text{energy} + \text{others yield}$$

without O_2

(H_2S , SO_4^{2-},NO_3^-)

The stage of biogas formation process can be divided into 4 main stages, namely [11],

A. Hydrolysis

At this stage complex organic polymer compounds such as polysaccharides, proteins and fats, are degraded by hydrolytic microorganisms into sugar monomers, amino acids and peptides. A large number of anaerobic and facultative microorganisms involved in the hydrolysis process include Clostridium.

B. Acidogenesis

At this stage the hydrolysis-processed monomers are converted into simple organic compounds, such as volatile fatty acids (acetic acid, butyric acid and propionic acid), lactic acid, alcohols, CO_2, H_2, NH_4-, HS-. At this stage the conversion is carried out by a group of microorganisms that are mostly anaerobic obligate bacteria and some are facultative anaerobic bacteria.

C. Acetogenesis

The result of the acidogenesis process, at this stage is described by acetogenic bacteria (bacteria that produce acetic acid and H_2) to acetic acid, H_2 and CO_2. Alcohol, propionic acid and butyric acid are converted to acetic acid by acetogenic bacteria such as Syntrobacter wolinii wand Syntrophonas walfei [13].

The decomposition reaction by the acetogenic bacteria is:

$$CH_3CH_2OH + CO_2 \longrightarrow CH_3COOH + 2H_2$$

Alcohol Acetic Acid

$$CH_3CH_2COOH + 2H_2O \longrightarrow CH_3COOH + CO_2 + 3H_2$$

Propionate Acid Acetic Acid

$$CH_3CH_2CH_2COOH + 2H_2O \longrightarrow CH_3COOH + 2H_2$$

Butiric Acid Acetic Acid

D. Methanogenesis

The last stage of the biogas formation process is the stage of methane gas formation. At this stage involves 2 different groups of methanogen bacteria. Acetyrophic methanogen bacteria decompose acetic acid to methane and CO2

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$$CH_3COOH \longrightarrow CH_4 + CO_2$$

Acetic Acid Methane

The hydrogenotropic methanogen bacterium reduction the CO_2 to methane

$$2H_2 + CO_2 \longrightarrow CH_4 + 2\,H_2O$$

Methane

The first three steps in the process of forming biogas are called acid forming stages, while the fourth stage is called the methane formation stage

The flow of methane gas production from organic materials is illustrated in Figure 1 below:

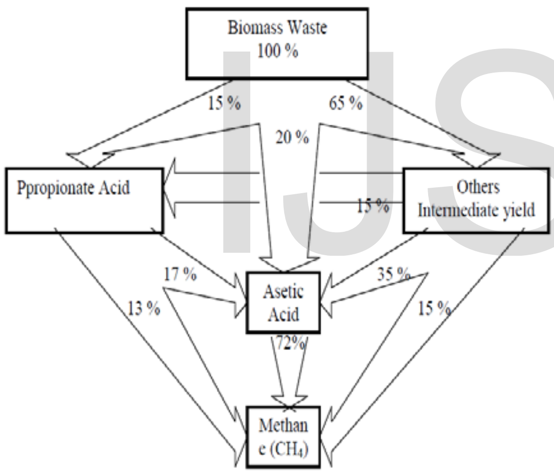

Figure 1. The flow of methane gas production from organic materials

The process of anaerobic decomposition of organic materials in the process of biogas formation is influenced by two factors, namely biotic factors and abiotic factors[3]. Biotic factors include the type of microorganisms that are active in the decomposition process. Abiotic factors include substance content, C / N ratio, P content in material / substrate, temperature, toxic substances, pH and stirring. Microorganisms as living organisms require appropriate environmental and food conditions to obtain the conditions under which the activity of the microorganism is optimum. For each microorganism has certain requirements to obtain growth and optimal development[5]. There are 5 variables that need to be considered for growth and development, among others: time, food, humidity, temperature and oxygen for the aerob.

6. TYPE OF BIOGAS REACTOR

At the moment there are 2 types of biodigester, the fixed dome type in Figure 2 and the CIGAR type (Covered in the Ground Anaerobic Reactor) in Figure 3[2].

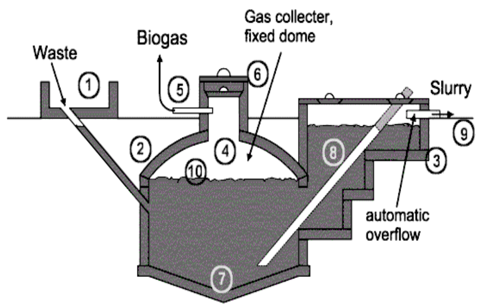

Figure 2. Biodigester fixed dome type

In CIGAR technology, existing pools will be covered with HDPE type plastic to prevent the release of methane gas into the air. The gas is then flowed into the kitchen for use as a boiler heater that produces steam to cook rice and vegetables. As a support, it takes a pole buffer on each end of the plastic so as not to be released when exposed to wind or rain. As for the basic part, should be given a waterproof layer so that waste water does not penetrate into the soil, so it is expected that all organic materials can be converted into biogas.

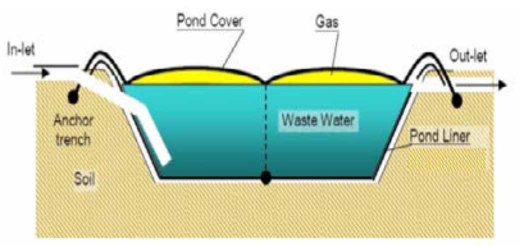

Fig. 3. The Biodigester of CIGAR type

7.CONCLUSSION

1. The Biogas is the gas which able to produce from agricultural waste or animal husbandry as the raw materials.
2. The Biogas is renewable energy with circumstance friendly and easy to produce.

3. The biogas is cheap enough compare with others gas or natural gas.

8..REFERENCE

1.Ari Serkkola[b]. 2018. Data analytics approach to create waste generation profiles for waste management and collection. Waste Management, Elsevier. https://doi.org/10.1016/j.wasman.2018.04.033

2.Asheal Mutungwazi, Patrick Mukumba, Golden Makaka 2017. Biogas digester types installed in South Africa: A review. Journal Renewable and sustainable energy Reviews Vol 81 part 1, Januari 2018 p172=180

3. Carlos Rodríguez-Monroy[a]Gloria Mármol-Acitores[b]
Gabriel Nilsson-Cifuentes[cd] 2017.Electricity generation in Chile using non-conventional renewable energy sources – A focus on biomass. Journal Renewable and sustainable energy Reviews Vol 81 part 1, Januari 2018 p 937= 945

4.Haryati, Tuti; 2006 : Biogas : Limbah Peternakan Yang Menjadi Sumber Energi Alternatif, Journal Wartazoa, volume 16 no 4

5.Hammad S.M.D., 1999, Integrated Environmental and Sanitary Engineering Project at Mirzapur, Journal of Indian Water Work Association 28 : 231-236

6.João Paulo SotoVeiga[A1]Teresa LosadaValle[B]José CarlosFeltran[B]Waldir AntonioBizzo[A]. 2016

Characterization and productivity of cassava waste and its use as an energy source. Journal of Renewable energy vol. 93, August 2016, p: 691-699. Elsevier.

7..Kadarwati, Sri, 2003, Studi Pembuatan Biogas Dari Kotoran Kuda dan Sampah Organik Skala Laboratorium, Journal P3TEK II

8..Karim, K., Hoffmann, R., Klasson, T., Al-Dahhan, MH., (2005), Anaerobic digestion of animal waste: Waste strength versus impact of mixing, Journal Bioresource Technology, 96, 1771-1791

9.Metcaff dan Eddy, 2003, *Wastewater Engineering Treatment, Disposal, and Reuse,* 4th ed, McGraw-Hill, Singapore

10. MingZhang[a]LiXie[a]ZhixuanYin[a]Samir KumarKhanal[b]QiZhou[a]. 2016.

Biorefinery approach for cassava-based industrial wastes: Current status and opportunities. Journal of Bioresource Technology vol 215, September 2016 P:50-62

11.Moog, FA., Avilla, HF., Agpaoa, EV., Valenzuela, FG., Concepcion, FC., (1997), Promotion and utilization of polyethylene biodigester in smallhold farming systems in the Philippines, Livestock Research for Rural Development, Volume 9, Number 2.

12.Nurhasanah, Ana.,Teguh W.W., Ahmad A., dan Elita R., 2006, Perkembangan Digester Biogas di Indonesia (Studi Kasus di Jawa Barat dan Jawa Tengah), Balai Besar Pengembangan Mekanisasi Pertanian, Serpong

13..Sa"id, E. G., 2006, Bioindustri, Penerapan Teknologi Fermentasi, Jakarta : PT Mediyatama Sarana Perkasa.

14.WuLi[a1]QingLi[c1]LongyuZheng[b]

YuanyuanWang[a]JibinZhang[b]ZiniuYu[b]YanlinZhang[a] 2015. Potential biodiesel and biogas production from corncob by anaerobic fermentation and black soldier fly. Journal Bioresource technology vol 194 october 2015 p 276=282

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