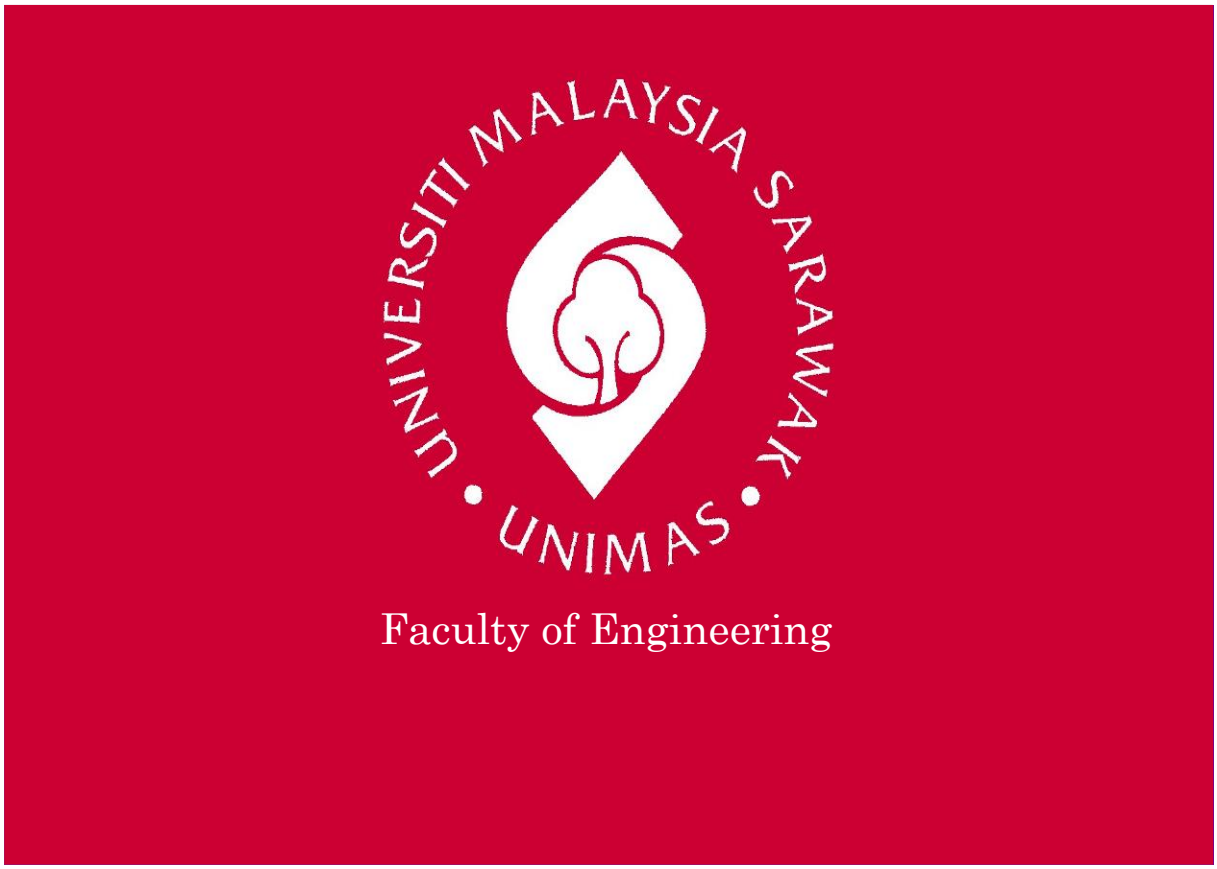

PRODUCTION OF BIOGAS USING DAIRY MANURE AS FEEDSTOCK AND RUMEN FLUID AS INOCULUM

Muhammad Hifzhan Amsyar Bin Zulkifli

Bachelor of Engineering with Honours

(Chemical Engineering)

2015

UNIVERSITI MALAYSIA SARAWAK

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This declaration is made on the 17 day of June 2015.

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_____

DR SHANTI FARIDAH SALEH

(Final Year Project Supervisor)

17 JUNE 2015

Date

PRODUCTION OF BIOGAS USING DAIRY MANURE AS FEEDSTOCK AND RUMEN FLUID AS INOCULUM

MUHAMMAD HIFZHAN AMSYAR BIN ZULKIFLI

A dissertation submitted in partial fulfillment of the requirement for the degree of
Bachelor of Engineering with Honors
(Chemical Engineering and Sustainability Energy)

Faculty of Engineering
Universiti Malaysia Sarawak

2015

Dedicated to my beloved parents, who always bestow me sustainable motivations and encouragements

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ABSTRACT

Anaerobic digestion is a break-down process of animal wastes or municipal wastes to produce biogas. The process involve microbial activities in the feedstock without the presence of oxygen. The resulted microbial activities is usually called as bioenergy, contain mostly methane gas with carbon dioxide and some other traces gases. Methane gas is a valuable gas that can be used a source of energy, either used for cooking fuel or small-scale electricity production. The most suitable application of the methane gas is in rural area which rarely have the source of energy. It can reduce the dependency of using diesel or gasoline in order to obtain electricity.This thesis focuses on the use of dairy manure as the feedstock and the rumen fluid as the innoculant which can improve the production of biogas. The amount of rumen fluid and water added were varied to create 0 %, 12.5 %, 25 %, 37.5 % and 50 % rumen fluid. Besides that, the pH level also been monitored and its effects towards biogas production is discussed. From the experiment that has been conducted, sample with 37.5 % rumen fluid gives the highest biogas production, followed by 50 %, 25 %, 12.5 % and 0 % rumen fluid.

Keywords: *Anaerobic digestion, biogas, rumen fluid, manure*

ABSTRAK

Proses anerobik merupakan proses penghadaman sisa haiwan atau pembuangan sampah untuk menghasilkan bio-gas. Proses ini melibatkan aktiviti bakteria yang terdapat di dalam sisa pembuangan tanpa kehadiran oksigen. Hasil daripada aktiviti bakteria ini di kenali sebagai bio-tenaga yang kebiasaannya mengandungi gas metana dan karbon dioksida serta gas-gas lain. Gas metana amat berguna sebagai satu sumber tenaga, samada digunakan dalam masakan atau penghasilan elektrik berkadar rendah. Aplikasi paling sesuai bagi penggunaan gas metana adalah di kawasan pedalaman yang tidak mempunyai sumber elektrik. Gas metana juga dapat mengurangkan kebergantungan kawasan pedalaman kepada diesel atau petrol untuk memperoleh tenaga. Kertas kerja ini memberi fokus kepada penggunaan tahi lembu sebagai bahan mentah dan air rumen sebagai inokulan yang dapat menambah baik penghasilan bio-gas. Kadar penambahan air rumen dan air berbeza-beza untuk menghasilkan 0 %, 12.5 %, 25 %, 37.5 %, 50 % air rumen. Selain itu, tahap pH juga diawasi dan kesannya terhadap penghasilan bio-gas akan dibincangkan. Hasil eksperimen yang telah dijalankan mendapati bahawa sampel mengandungi 37.5 % air rumen telah menghasilkan biogas tertinggi diikuti oleh 50 %, 25 %, 12.5 % dan 0 % air rumen.

Kata kunci: *Penghadaman anerobik, bio-gas, air rumen, sisa buangan*

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kWh	-	Kilo watt per hour
yr	-	Year
RM	-	Ringgit Malaysia
Kg.	-	Kampung
℃	-	Degree celcius
ml	-	Mililiter
g	-	gram
L	-	Liter

LIST OF ABBREVIATIONS

F	-	Feed
M	-	Manure
R	-	Rumen
I	-	Inoculum
W	-	Water
TS	-	Total Solid
VS	-	Volatile Solid
HRT	-	Hydraulic Retention Time
OLR	-	Organic Loading Rate
TVFA	-	Total Volatile Fatty Acid

CHAPTER 1

INTRODUCTION

1.1 Electricity Distribution in Rural Area

There are two different sources of energy production in Malaysia which are non-renewable and renewable. For several reasons, the energy production slowly change it focus to the renewable energy which is more green. Energy is most important in human daily life as the source of electricity and the challanges that have been critical in this modern age is to meet the rapid increment of energy needs for the citizen. The challange also comes in supplying the electricity to rural area where the extension grid need to be build in jungle and terrain. **Table 1.1** below show the electricity supply to the rural area by state in Malaysia.

Table 1.1 Electricity supply in rural area by state in Malaysia (Adapted from Borhanazard et al., 2013).

State	Electrity supply (%)
Johor	98.22
Kedah	98.58
Kelantan	97.50
Melaka	99.28
N. Sembilan	98.60
Pahang	93.96
Perak	96.11
Perlis	99.17
P.Pinang	99.16
Sabah	67.05
Sarawak	66.91

Selangor	97.92
Terengganu	98.24
W.P. Kuala Lumpur	-

This electricity supply in Malaysia mostly contributed from oil, natural gas and coal power generation which is non-renewable energy source. From **Table 1.1** above, the lowest electric supply to the rural area is Sarawak followed by Sabah with 66.91 % and 67.05 % respectively. Sabah and Sarawak are one of the highest land area states in Malaysia where most of the rural area is uncovered with modern technology. Rural areas are lived by various ethnics were not exposed to the real world due distance and transportation constrain. Especially in Sarawak where most of rural areas are located in deep forest and at high mountain. These problems has cause difficulties in construsting grid lines to supply electricity to the specific area.

1.2 Alternatives Energy

As alternative, biogas energy which categorized as renewable energy can be used as the power generation in the rural area. The term biogas is referring to a gas which is produced by the biological breakdown of organic matter in the absence of oxygen (Gerlach et al., 2013).

According to NRDC (n.d.), biogas that is produced contains majorly 60% - 70% of methane gas that can generate heat, hot water or electricity and the effluent can be used as fertilizer, while the other 30%-40% is carbon dioxide and some other traces gases. This process which consuming no oxygen is known as anaerobic digestion that done by the microbes presence in the animal wastes. **Table 1.2** shows the gases component and its ranges amount presence in biogas.

Table 1.2 Types of gases and its amount in biogas (Adapted from Gerlach et al., 2013).

Components	**Amount (%)**
Methane	50-75
Carbon dioxide	25-45
Water vapour	2-7

Sulphide	0.002-2
Nitrogen	<2
Ammonia	<1
Hydrogen	<1
Traces gases	<2

Table 1.2 above shows the gas components presence in the biogas produced from the animal wastes which is conquered by methane gas with 50% minimum and 75 % maximum. While the second highest gas presence is carbon dioxide with 25 % minimum and 45 % maximum.

The main gas that later will be used in electricity generation is methane gas. Generally, methane can be used as fuel in conventional steam-turbine system. The concept is where methane is used as fuel for boiler to generate high-velocity steam and rotate turbine to generate electricity. **Figure 1.1** will further shows how the methane involves in electricity generation.

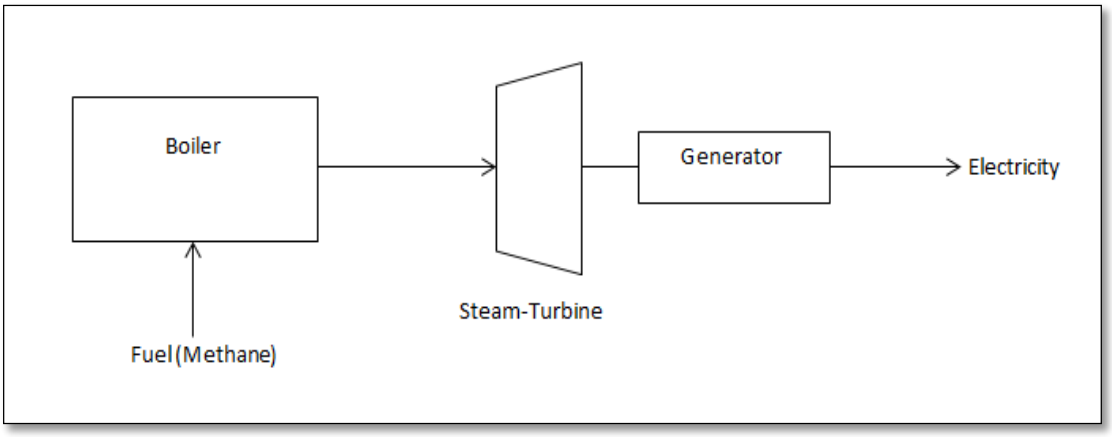

Figure 1.1: Schematic diagram of conventional steam-turbine system.

Basically, all animal wastes will produce methane gas, but the differences is in terms of amount biogas yield depending on the microbes presence in the animal wastes. There are four different stages that involve different types of microbes in producing biogas which will be studied and explained in later chapter. In order to generate the electricity, firstly, the methane gas need to be collected from the animal wastes. In general, the methane gas collector is called as anaerobic digester or biogas digester.

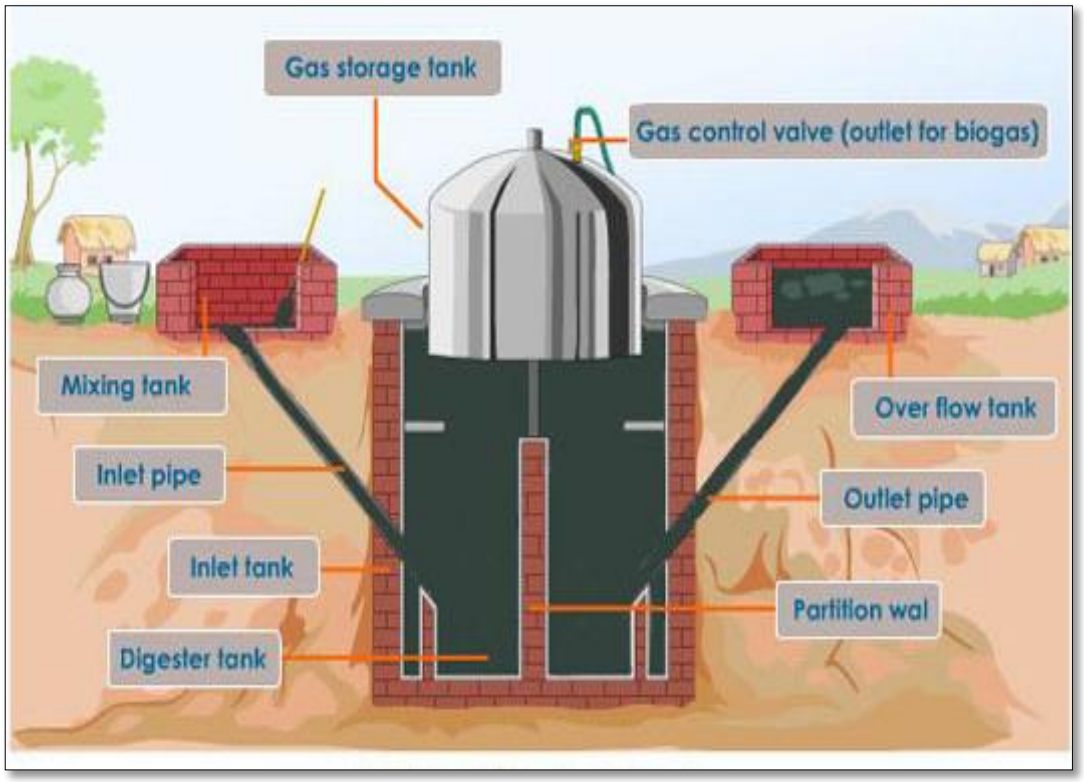

Figure 1.2: Common type of biogas digester.

Referring to **Figure 1.2** that shows the common biodigester unit used in collection of biogas. Mixing tank is a place for the animal wastes to be mixed with others materials such as water or inoculumn. Then, it will be passed through the inlet pipe to enter the digester tank. In the digester tank all anaerobic process will occur to produce biogas. After 20-50 days (Budiyono et al., 2009), the effluent can be collected by flowing through outlet pipe. The biogas which certainly will be at the top of the tank, is then collected and stored in gas storage tank.

There are several different types of raw materials specifically animal wastes in producing biogas energy. **Table 1.3** shows the different types of animal wastes and the electricity production per year.

Table 1.3 Electricity productions per year for different livestock manure (Adapted from Cherosky et al., 2011)

Per one head	**Electricity (kWh/yr)**
Dairy cow	385
Beef cattle	230

Swine	32
Poultry	2.5

From the **Table 1.3** above, the highest electricity production is from dairy cow followed by beef cattle, swine and poultry. Approximately, one cow can produced 385 kWh of electricity per year. It has proven that biogas energy has large potential as our future power generation.

Besides that, the biogas production also comes with other beneficial advantages. As proposed by Gerlach et al. (2013), the advantages of biodigester are as climate protection, close nutrient cycles, optimising of crop rotation and cropping system, increase crop yield and quality and alternative source of income.

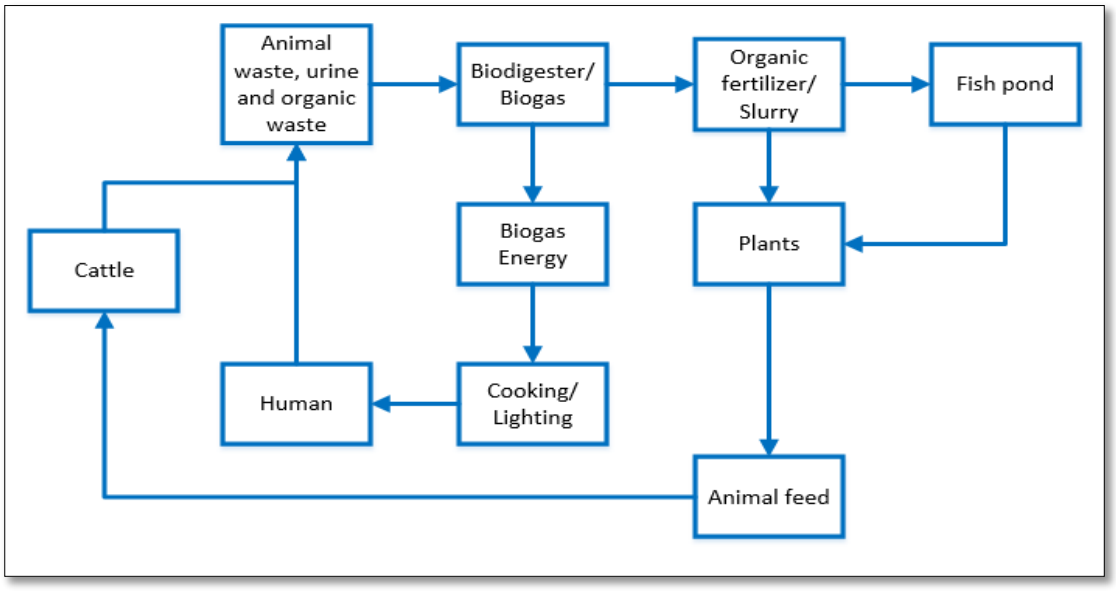

Figure 1.3: Life-cycle of biogas production.

Figure 1.3 shows the life-cycle analysis in the biogas production. In general, the biodigester can be considered as sustainable since the generation of electricity can be made while the raw materials is replenish. Besides that, animal wastes produce methane gas which is one of the green house gases that causing environmental problem. Therefore, the collection of animal waste in a closed tank will reduce the methane gas from escaping to the environment.

1.3 Problem Statement

Kg.Assum, Padawan located approximately 80 km from Kuching which characterize as rural area. Without eletricity supply from the power grid, their main source power of electricity comes from diesel generator. Located near Borneo Highland, this village is Bidayuh–village and electricity is not privilage. They spent almost RM 15 per day for diesel in order to generate their own electricity. With about 450 residents in the village, most of the income gain from selling crop products. Despite other necessity such as groceries that consumed money, they still have to purchase diesel in order to light-up their home at night for required activities. The implementation of biodigester can provide the electricity to the village and reduce the dependency of the residents to the diesel generator.

1.4 Aim and Objectives

The aim of this thesis is to study the effect of temperature in mesophilic condition in anaerobic digestion using remen fluid as inocolums to biogas production and its feasibility to be implemented in Kg. Assum. The objectives are as follows;

i) To study the volume production of biogas from biodigester reactor by varying amount of rumen fluid.
ii) To identify the factors that affecting biogas production in anaerobic digestion of dairy manure.

1.5 Scope of Study

The scope of this thesis is to study the characteristic of biodigester that will be implemented in Kg. Assum, Padawan, Sarawak. The biodigester will only used dairy manure as the feedstock with rumen fluid as the inoculum and the availability of the raw material is based on the location or nearest. The effect of biogas production to the introduction of rumen as the inocolum will be studied while other parameters such as operating temperature, pH, total solid content and volatile solid content will remain as constant. From the fermentation process through anaerobic digestion, the biogas produced

will focused on the methane content. The methane collected will be used as cooking oil or to generate elctricity. As short, the scope of study are as listed below;

i) Feedstock selection criteria- Dairy manure as feedstock for the biodigester.
ii) Parameters affecting biogas production- The effect of amount rumen fluid to biogas production.
iii) Methane application for rural area- Cooking fuel and lighting.

CHAPTER 2

LITERATURE REVIEW

2.1 An Overview of Dairy Waste Anaerobic Digestion

According to Wilkie (2005), anaerobic digestion is a break down process of organic matter by bacteria without the presence of oxygen to produce biogas. As quoted by Rabiu et al. (2014), the production of biogas basically consists of 60 % to70 % of methane (CH_4), 20 % to 30 % of carbon dioxide (CO_2) and remain traces gas such as hydrogen sulfide (H_2S). The most essential biogas in the anaerobic digestion is methane which can be used as a source of energy. This biogas can be used either as cooking oil or burned to rotate turbine and generating electricity. **Figure 2.1** below shows the microbial degradation processes of anaerobic digestion.

In the fermentation process of manure there are four different steps involved; hydrolysis, acidogenesis, acetogenesis and methanogenesis. At the hydrolysis stage all complex carbohydrates, proteins fats and glycerol are converted into simple sugar, amino acids, fatty acids and triglycerides respectively.

Then, acidogenesis take place where acidogenic bacteria change the products of hydrolysis process into short chain acid, ketone and alcohols. In the third stage, the importance of acetogenesis is the production of acetate, carbon dioxide and hydrogen gas from the carbohydrate conversion. The formation of hydrogen gas is essential for oxidation of lipid to acetate. Lastly, methanogen bacteria will complete the anaerobic process by converting acetate into methane gas and carbon dioxide (Ostrem, 2004).