CO-DIGESTION OF PALM OIL MILL EFFLUENT (POME) WITH COW MANURE FOR BIOGAS PRODUCTION

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To my beloved family and friends

Thanks for the support, caring and sharing

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ABSTRACT

In this study, experiments were conducted to investigate the production of biogas through anaerobic digestion from the co-digestion of palm oil mill effluent (POME) with cow manure. Besides, the effect of co-digestion towards the change of methane composition in biogas was also evaluated. The batch type of digester was used for the digestion and was operated at room temperature, 28 ± 2˚C for 10 days. The digester was operated at different V_{CM} / V_{POME} (volume of cow manure/ volume of POME) ratio of 0.05, 0.10, 0.15, 0.22, 0.29 and 0.36. From the results, biogas production was enhanced by the addition of cow manure to POME. The volume of biogas production was increase from 36% up to 126% with addition of cow manure. In addition, through co-digestion, the percentage composition of methane in biogas was also increases with the increment from 28% to 42 %. This study can provided useful information for the researchers and agricultural practitioners that interested on improving and applying for this type of anaerobic digestion in the future.

Keywords: Biogas, Methane, Anaerobic digestion, Co-digestion, POME and Cow manure.

ABSTRAK

Dalam kajian ini, ekperimen telah dijalankan bagi menyiasat penghasilan biogas menerusi penghadaman anarobik daripada ko-penghadaman sisa pemprosesan kelapa sawit bersama najis lembu. Selain itu, kesan ko-penghadaman terhadap perubahan komposisi metana di dalam biogas turut dikaji. Penghadam jenis '*batch*' telah digunakan untuk penghadaman dan beroperasi pada suhu bilik, 28 ± 2˚C dalam tempoh 10 hari. Penghadam beroperasi pada nisbah V_{CM} / V_{POME} (isipadu najis lembu / isipadu sisa pemprosesan kelapa sawit) yang berbeza, iaitu pada 0.05, 0.10, 0.15, 0.22, 0.29 dan 0.36. Menerusi keputusan, penghasilan biogas berjaya ditingkatkan dengan penambahan najis lembu kepada sisa pemprosesan kelapa sawit. Penghasilan isipadu biogas meningkat dari 36% sehingga 126% dengan penambahan najis lembu. Tambahan pula, dengan ko-penghadaman, peratusan komposisi metana dalam biogas juga meningkat dengan tokokan tambahan daripada 28% sehingga 42%. Kajian ini dapat memberi informasi yang berguna kepada pengkaji dan pengamal agrikultur yang berminat untuk menambah baik dan mengaplikasikan metodologi penghadaman anarobik ini pada masa hadapan.

Kata kunci: Biogas, Metana, Penghadaman anarobik, Ko-penghadaman, Sisa pemprosesan kelapa sawit dan Najis lembu.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	-	Percent
°C	-	Degree Celsius
±	-	More or Less
µm	-	Micrometer
€	-	Euro Pound
Al	-	Aluminum
As	-	Arsenic
B	-	Boron
C	-	Carbon
Ca	-	Calcium
Cd	-	Cadmium
CDM	-	Clean Development Mechanism
CH_4	-	Methane
cm	-	Centimeter
Co	-	Cobalt
CO_2	-	Carbon Dioxide
COD	-	Chemical Oxygen Demand
Cr	-	Chromium
Cu	-	Copper
Fe	-	Iron
g	-	Gram

GC-TCD		Gas Chromatography- Thermal Conductivity Detector
H_2	-	Hydrogen
K	-	Potassium
kcal	-	Kilo calorie
kg	-	Kilogram
kmol	-	Kilo mol
L	-	Liter
m^3	-	Cubic Meter
mg	-	Milligram
Mg	-	Magnesium
MJ	-	Mega joule
ml	-	Milliliter
mm	-	Millimeter
Mn	-	Manganese
Mo	-	Molybdenum
N	-	Nitrogen
Na	-	Sodium
Ni	-	Nickel
nm	-	Nanometer
P	-	Phosphorus
Pb	-	Lead
PE	-	Polyethylene
POME	-	Palm Oil Mill Effluent
ppm	-	Part Per Million
RM	-	Ringgit Malaysia
S	-	Sulfur
Se	-	Selenium
Si	-	Silicon
Sn	-	Tin
sp	-	Species

TS	-	Total Solid
V	-	Vanadium
V_{CM}	-	Volume of Cow Manure
V_{POME}	-	Volume of Palm Oil Mill Effluent
Zn	-	Zinc
µV	-	Micro voltage
min	-	minute

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Recent increases in the prices of fossil fuels have renewed global interest in exploring alternative renewable energy sources which given an attention to bio-energy sources such as wood fuels, agricultural wastes, animal wastes, municipal solid wastes wastewater and effluents. In addition to being renewable and sustainable, these types of energy sources are considered as environmentally friendly. These sources also have great potentials for mitigating climate change (Shahrakbah *et al*., 2006).

Renewable energy such as biogas has many advantages, even if compared to other renewable energy alternatives. It can be produced when needed and can easily be stored. It can be distributed through the existing natural gas infrastructure and used in the same applications similar like the natural gas. Biogas can be utilized for renewable electricity and heat production and also replacing fossil fuels in the transport sector (Holm *et al*., 2009).

The application of anaerobic digestion technology to biomass has received many attentions because it can be applied to produce valuable by-products such as biogas. In particular, biomass fuels hold great promise as a component of Clean Development Mechanisms (CDM) strategies to reduce greenhouse gases (GHG) emissions to acceptable levels (Brown *et al*., 1998). Malaysia as a tropical country has an enormous supply of biomass resources generated from photosynthetic activities throughout the year. The biomass is mainly consisted from palm oil, wood and agro industries.

According to Chen (2004), palm oil cultivation and animal farming contributed to major biomass sectors in Malaysia. Therefore, it is a huge potential of utilizing these wastes from the industry such as palm oil mill effluent (POME) and animal manure as a bio energy source.

For palm oil cultivation, it is estimated that more than 50 million tonnes of biomass will be generated from the palm oil industry in the year 2005. This will continuously increase in proportion to the world demand of edible oils. From the byproducts of this milling, only POME has not been commercially re-used by the industry. However, by using POME there is a great potential for renewable energy projects. Like municipal waste, POME also can produces methane gas, which can be used to generate electricity (Hassan *et al*., 2004).

POME has to treated before been released to the environment due to its highly polluting properties, with average values of 25000 mg/ L biochemical oxygen demand (BOD) and 50000 mg/ L chemical oxygen demand (COD), the most cost effective technology is anaerobic treatment. Previously, the concept of anaerobic treatment is only being applied either in the pond or open digesting tank systems (Hassan *et al*., 2004). Earlier studies by Ma *et al*. (1999) and Quah and Gillies (1984) have shown that the end

product of the anaerobic digestion of POME is biogas which is mainly consisted of methane and carbon dioxide.

In case for animal waste, when it is untreated or poorly managed, it becomes a major contribution towards air and water pollution. Nutrient leaching, mainly nitrogen and phosphorous, ammonia evaporation and pathogen contamination are some of the major threats. The animal production sector is responsible for 18% of the overall green house gas emissions, which measured in CO_2 equivalent. As for 37% of methane, it has 23 times the global warming potential of CO_2. In addition, 65% of nitrous oxide and 64% of ammonia emission are originates from the worldwide animal production sector (Steinfeld *et al*., 2006). If handled properly, manure can be a valuable resource for renewable energy production and a source of nutrients for agriculture.

In Malaysia for example, no known anaerobic digestion of cattle manure is found. Actually, there are a few guidelines for cattle and poultry farming which was suggesting for the integration of an anaerobic digester for waste management (Jabatan Perkhidmatan Haiwan, 2003). However, this system is not attracting an attention towards the small farmers due to high capital cost to set up the digester and lack of environmental consciousness. There is a population of more than 300,000 pigs and cattle recorded in Penang alone, which indicating an urgent need to set up for this technology (Jabatan Perkhidmatan Veterinar Pulau Pinang, 2001). This technology of treatment is developed due to the advantage of producing energy as well as generating odor free residues rich nutrients which has a huge potential to be used as fertilizers (Karim *et al*., 2005). This would encourage sustainable agricultural practices in mitigating possible manure pollution problems, thereby sustaining development while maintaining environmental quality.

Recently, there is a great interest on mixing different types of waste towards enhancing biogas yield. This technique is known as co-digestion. From the previous research, co-digestion helps to increase the production amount of biogas. Besides, co-digestion of different types of organic by-products has been increasingly applied in order to improve plant profitability through easier handling of mixed wastes.

In this study, POME and animal manure are expected to have a great potential to be integrated together as substrates source for the biogas production. In case for digestion of POME, the supplementation of nitrogen-like nutrients could be quite costly. Besides of addition to nitrogen, other macronutrients and trace elements are also needed for the sake of a successful operation of any anaerobic digestion. Therefore, in this study, the feasibility of co-digesting of POME with some other locally problematic residue streams such as cow manure is evaluated. Cow manure which is rich in nutrient is capable of transferring their nutrient content, especially nitrogen into POME. In addition, co-digestion is expected to result in higher recovery of the bio energy content of POME.

1.2 Objective

The objective of this study was to investigate the effect of biogas production through the co-digestion of POME with cow manure.

1.3 Scopes

Scopes of this study are to

i) evaluate the effect of V_{CM} / V_{POME} towards the biogas production (volume of biogas).
ii) investigate the effect of V_{CM} / V_{POME} towards the change of methane composition in biogas.

1.4 Significance of Study

From the study, co-digestion with the best V_{CM} / V_{POME} was established to maximize the biogas production rate with the high quality biogas that consists with high percentage of methane composition. Besides, it can be a valuable guideline to the researchers and agricultural practitioners that interested on improving and applying this technology in the future.

1.5 Limitation of Study

This study did not evaluate the change in substrate mixture (POME and cow manure) content during the anaerobic digestion.

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