ENHANCED SUSTAINABLE METHANE PRODUCTION FROM ANAEROBIC CO-DIGESTION OF POME USING UASBR (PH EFFECTS)

WONG JUNG WENG

BACHELOR OF ENGINEERING TECHNOLOGY
(INFRASTRUCTURE MANAGEMENT)
UNIVERSITY MALAYSIA PAHANG

ENHANCED SUSTAINABLE METHANE PRODUCTION FROM ANAEROBIC CO-DIGESTION OF POME USING UASBR (PH EFFECTS)

WONG JUNG WENG

Report submitted in partial fulfillment of the requirements

for the award of the degree of

Bachelor of Engineering Technology (Infrastructure Management) with Honors

FACULTY OF ENGINEERING TECHNOLOGY

UNIVERSITI MALAYSIA PAHANG

JANUARY 2018

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name : **WONG JUNG WENG**

Date of Birth : **941004-01-5045**

Title : **ENHANCE SUSTAINABLE METHANE PRODUCTION FROM ANAEROBIC CO-DIGESTION OF POME USING UASBR (PH EFFECT)**

Academic Session : **2017/2018**

I declare that this thesis is classified as:

☐	CONFIDENTIAL	(Contains confidential information under the Official Secret Act 1997)*
☐	RESTRICTED	(Contains restricted information as specified by the organization where research was done)*
☑	OPEN ACCESS	I agree that my thesis to be published as online open access (Full Text)

I acknowledge that Universiti Malaysia Pahang reserves the following rights:

1. The Thesis is the Property of Universiti Malaysia Pahang
2. The Library of Universiti Malaysia Pahang has the right to make copies of the thesis for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

_____	_____
(Student's Signature)	(Supervisor's Signature)
_____	_____
941004-01-5045	DR. NURUL ISLAM SIDDIQUE
Date: January 2018	Date: January 2018

NOTE: * If the thesis is CONFIDENTIAL or RESTRICTED, please attach a thesis declaration letter.

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of degree of Bachelor of Engineering Technology (Infrastructure Management) with Honours.

_____

(Supervisor's Signature)

Full Name : DR. NURUL ISLAM SIDDIQUE

Position : SUPERVISOR

Date : JANUARY 2018

_____

(Co-supervisor's Signature)

Full Name : IR. AHAMAD TARMIZI BIN ALI

Position : CO-SUPERVISOR

Date : JANUARY 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis/project* is my own except for quotations and summaries which have been duly acknowledged. The thesis/project* has not been accepted for any degree and is not concurrently submitted for award of other degree.

_____

(Student's Signature)

Full Name : WONG JUNG WENG

ID Number : TE14021

Date : JANUARY 2018

Dedicated to my parent, friends and supervisor.

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere gratitude to my supervisor Dr. Nurul Islam Siddique for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a Degree program is only a start of a life-long learning experience. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his progressive vision about my training in science, his tolerance of my naive mistakes, and his commitment to my future career. I also would like to express very special thanks to my co-supervisor IR Ahmad Tarmizi Bin Ali for his suggestions and co-operation throughout the study. I also sincerely thank for the time spent proofreading and correcting my many mistakes.

My sincere thanks go to all my lab mates and members of the staff of the Engineering Technology, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to member engine research group for their excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I acknowledge the sincerity of my parents, who consistently encouraged me to carry on my higher studies in Malaysia. I am also grateful to my family for their sacrifice, patience, and understanding that were inevitable to make this work possible. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

ABSTRACT

Malaysia is one of the biggest country that producer and exporter of the palm oil. Palm oil mills is used to process and generate palm oil from it fruit bunch. Large quantities of water are used during the extraction of crude palm oil from the fresh fruit bunch, and about 50% of the water results in palm oil mill effluent (POME). POME without proper treatment and left in the pond will decompose and generate methane gas which is a gas that can cause greenhouse effect. Methane gas is a harmful gas that 20 times stronger than Carbon dioxide in greenhouse effect if it attaches to the atmosphere. In order to prevent it happen to our environment, an enclose treatment method anaerobic co-digestion (ACD) by using upflow anaerobic sludge blanket reactor (UASBR) is used to treat POME as the microorganism in the sludge blanket digest the waste want organic passing through it. Anaerobic co-digestion can improve the methane production in mixing different type of material together. In this study, POME and cow manure is selected as our substrates in ratio of 50:50. During the digestion, the generated gas is collected and can be used for other purpose. In this paper, the different pH on affecting the methane production is study. The different pH (6.5, 7.0, 7.5) is used to observe the methane gas can be better generate in which pH. At the end of the study, the results showed that pH 7.0 give better methane production (76.7%) out of the total gas produced compared to the pH 6.5 (68.4%) and also pH 7.5 (60.6%), this is because the microorganism was pro-active and won't be affected by acidic or alkali base in degrading the organic, and hence, produce highest methane gas. This shows that the waste organic is more friendly to degrade in the pH 7.0 in order for it to digest and produce high amount of methane gas.

ABSTRAK

Malaysia merupakan salah satu negara terbesar pengeluar dan pengeksport minyak sawit itu. Kilang minyak sawit yang digunakan untuk memproses dan menghasilkan minyak sawit dari tandan buah-buahan. Kuantiti air yang digunakan semasa pengekstrakan minyak sawit mentah dari tandan buah-buahan segar, dan kira-kira 50% dari hasil air yang dalam efluen kilang kelapa sawit (POME). POME tanpa rawatan yang betul dan kiri di dalam kolam akan reput dan menghasilkan gas metana yang merupakan gas yang boleh menyebabkan kesan rumah hijau. Gas metana adalah yang berbahaya gas yang 20 kali lebih kuat daripada karbon dioksida di kesan rumah hijau jika ia melekat ke atmosfera. Untuk mengelakkan ia berlaku terhadap alam sekitar kita, kaedah rawatan enclose penghadaman bersama anaerobik (ACD) dengan menggunakan reaktor selimut enapcemar anaerobik upflow (UASBR) digunakan untuk merawat POME yang mahu mikrorganism di digest selimut enap cemar sisa organik lulus melaluinya. Penghadaman anaerobik bersama boleh meningkatkan penghasilan metana dalam mencampurkan bahan yang berlainan jenis bersama-sama. Dalam kajian ini, najis lembu dan EMISI dipilih sebagai substrat kami nisbah 50: 50. Semasa penghadaman, gas dihasilkan yang dikumpul dan digunakan untuk tujuan lain. Dalam kertas ini, pH yang berbeza pada mempengaruhi penghasilan metana adalah kajian. PH yang berbeza (6.5, 7.0, 7.5) digunakan untuk memerhati gas metana boleh menjana lebih baik di mana pH. Pada akhir kajian, hasil kajian menunjukkan bahawa pH 7.0 berikan lebih baik metana pengeluaran (76.7%) daripada jumlah gas yang dihasilkan berbanding pH 6.5 (68.4%) dan juga pH 7.5 (60.6%), ini adalah kerana mikroorganisma yang pro-aktif dan tidak akan terjejas oleh asid atau alkali ba Se masuk merendah-rendahkan organik, dan oleh yang demikian, menghasilkan gas metana yang tertinggi. Ini menunjukkan bahawa sisa organik yang lebih mesra untuk merendahkan dalam pH 7.0 supaya ia mencerna dan menghasilkan jumlah tinggi gas metana.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACD	-	Anaerobic Co-Digestion
AD	-	Anaerobic Digestion
BOD	-	Biochemical Oxygen Demand
C/N	-	Carbon and Nitrogen Ratio
COD	-	Carbon Dioxide Demand
F/M	-	Food and Microorganism Ratio
HRT	-	Hydraulic Retention Time
OLR	-	Organic Loading Rate
POME	-	Palm Oil Mill Effluent
UASBR	-	Up-flow Anaerobic Sludge Blanket Reactor
VFA	-	Volatile Fatty Acid
VS	-	Volatile Solid
VSS	-	Volatile Suspended Solid

CHAPTER 1

INTRODUCTION

1.1 Background

Methane gas is a gas that produced naturally by the bacterial decay of vegetation and animal wastes without atmospheric oxygen. It also emissions from livestock and agricultural practices, but the most important source came from production, transportation and use of fossil fuels. It can be used as a renewable energy which producing electricity by combining heat and power plants.

Anaerobic is the term that said living in the absence of air. It is the opposite of the aerobic. While anaerobic digestion a process or treatment for the organic wastes and turned it into biogas energy that contain Methane (CH_4) and Carbon Dioxide (CO_2).

Anaerobic Co-digestion is the mixture of two or more homogenous substrates. It is the enhancement of the anaerobic digestion which have a better stability to produce the Methane biogas.

POME- Palm Oil Mill Effluent. POME is a wastewater generated by palm oil mills factory. It will affect to the environment due to release of Methane gas to the atmosphere. However, the methane produced from POME can be also being reutilization to generated renewable energies. The treatment process of Anaerobic co-digestion is a way to treat the POME environment friendly with enclosed environment of methane production in the tank.

UASBR-Upflow Anaerobic Sludge Blanket Reactor. UASBR using a tank to treat the wastewater. The wastewater enters from the bottom and contact with the microorganisms when pass through the sludge bed hence occurs degradation of anaerobic. The treated effluent then removing from the top outlet of the reactor. Hydraulic turbulence is happening due to produce of biogas in this process as it flows up through the reactor. The design of the top of reactor is a solid, liquid, and gas separator which used to facilitate the biogas retention.

1.2 Problem Statement

In the new technology times, the pollution to the environment by the waste produce is getting serious nowadays. The waste can come from several field, for example, rubbish, trash, garbage or unwanted materials left from the manufacturing process. The organic waste sending to landfill and rots without oxygen which create a harmful biogas, which Methane. This gas is the family of greenhouse gases that increase heat in the atmosphere. Compare to the other family, it was 20 times stronger than Carbon dioxide in hurting our atmosphere. The purpose of this research is to enhance the sustainable of Methane gas from the organic waste Palm Oil Mill Effluent (POME). POME is type of waste will produce Methane gas when it is open to air and decompose but this is harmful without transform it into other usage. Hence the Upflow Anaerobic Sludge Blanket Reactor (UASBR) have been propose to use in order do the treatment for this organic waste. This UASBR is used to utilize the Methane gas from digesting the POME. The air pollution cause by the Methane gas must be prevent by stopping it contact directly to the atmosphere. The UASBR is good method to utilize Methane gas in the close area, hence no Methane gas is produce and expose to the air. To improve the function of UASBR, the latest improvement is release by changing anaerobic digestion in to anaerobic co-digestion. Anaerobic co-digestion which is adding another organic waste to mixed with POME to from two substrates and hence increase the stability of the method.

In the research paper, the changing in PH will effect to the yield of Methane gas from the anaerobic co-digestion is determined. Objective

1.3 Objective

The objective of the research:

i. To study the effect of pH value on the yield of methane in anaerobic co-digestion of POME using UASBR.

1.4 Scope of Research

In order to achieve the objectives, the important tasks below are carried out by investigated of these basic elements:

i. The source of POME obtained will be consistent throughout the research.
ii. The hydraulic retention time and temperature in the UASB reactor will be consistent throughout the research.
iii. Different pH value will be studied to obtain the best methane production.

1.5 Conclusion

Regarding the introduction above, the Anaerobic Co-digestion using POME in UASBR method will help to treatment of organic waste and transform them in the environmental friendly way to prevent Methane gas enter the atmosphere. Methane gas produce by UASBR method transform in to bio-energy gas to produce electricity when combined with heat. In next chapter, Chapter 2 will introduce the precious study and experiment with their methodologies, strength and weakness.

CHAPTER 2

LITERATURE REVIEW

2.1 Anaerobic Co-Digestion

Anaerobic Digestion (AD) in the recent years have been implement and used in stabilized the organic sludge and cleaning wastewaters from food process. Anaerobic digestion compare to aerobic digestion will more advantages. For example, low energy consumption and low production of sludge, require tiny space and low budget. (Demirel et al., 2002). Reliable to these benefits, digestion process stability and performance improved in high generated of biogas and energy. (Tchobanoglous et al., 1993). Anaerobic digestion process actually is used in decompose the organic wastes to produce Methane gas (CH_4) and Carbon Dioxide gas (CO_2) without present of oxygen molecule. Uncontrolled anaerobic condition of microbial activity of waste at open space will generate Methane (CH4) and carbon dioxide (CO2) to the atmosphere and causing green house effect. Methane produced from AD of agricultural and industrial waste bring benefits to the society by giving clean fuel renewable feedstock to reduce environment impact by using of fossil-fuel-derived. (Parawira, 2004). The different type of anaerobic bacterial make the degradation process happen which include hydrolysis, acidogenesis and also methanogenesis. The anaerobic methanogenesis process is curry out to degrade the methane gas from the organic waste. Production of methane may differ depending on the palm oil wastewater treatment practices. (Yee-Shian Wong et al., 2014).

A biological process of anaerobic co-digestion is strongly dependent to environment. The temperature, pH value, nutrients content, C/P & C/N ratio, presence of inhibitors, substrate typology, microelements availability and particles size, that in particularly unfavorable situations, can be responsible for undesirable drops in performance and even for detrimental failures. (Mata-Alvarez et al. 2000). To improve the efficiency of the AD, accurate setting of operation condition and continuous monitoring is a must and it could help in preventing inconveniences. Instead, adding another substrate simultaneously could also help in improving perform of the AD during processing methane gas. This process as known as Co-digestion.

Co-digestion with different substrates are resulting bio-methane production in the proper percentages of mixing two different substrates. (G. Esposito et al., 2012). The nutrient balance in containing the nitrogen rich substrates and carbon rich substrates gave better beneficial effect of co-digestion. Co-digestion brings along the other benefits like dilution of toxic compounds in the co-substrates, able to adjust pH and moisture content during AD process. In additional, Anaerobic Co-digestion have shown increase of the biodegradable material content compare with AD. Biogas yield can be increase by co-digestion of animal done with others organic and give advantages in organic waste and animal manure management. (Nielsen et al., 2002)

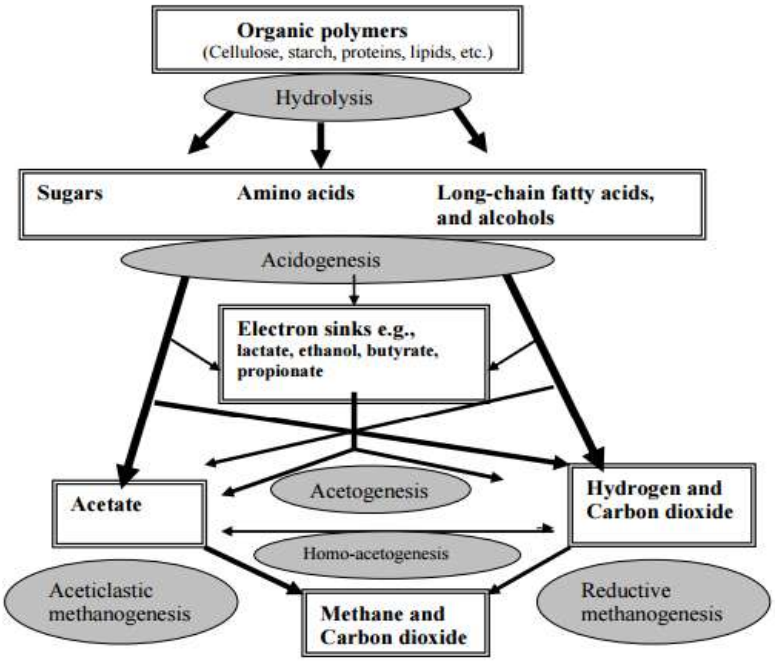


Figure 1: Anaerobic digestion pathways.

2.2 Renewable Biogas (Methane)

There are many things can produce the biogas. Manure, food waste (fruit, vegetable, uneaten food) and animal manure can produce the biogas. Formation of biogas from organic waste take place over many stages. Organic waste is first in breaking down and form simpler components of proteins, lipids, and carbohydrates in the digesters. And broken down again to form organic acids, CO_2, acetic acid, hydrogen gas and hence, form methane. (Karine Arrhenius, SP, Ulrika Johansson, SP, 2012). The components inside a biogas normally are methane (CH_4), carbon dioxide (CO_2), hydrogen (H_2), hydrogen sulphide ($H2_S$).

The present of methane and carbon dioxide from the biogas can cause the greenhouse effect to our atmosphere Earth if there are expose directly to the open area. Hence the temperature rises up and turn become global warming. In order to solve the problem, the biogas must be treated to overcome the greenhouse issues. The biogas that produced by the Palm Oil Mill Effluent (POME) using Upflow Anaerobic Sludge Blanket reactor (UASBR) to treat the harmful gas inside biogas.

Although methane gas is greenhouse gas which has 21 times greater heating effect than the carbon dioxide, but it exists in the biogas can be a good renewable energy source to replace those non-renewable natural gas that mined from underground. Methane can be act as a renewable gas energy.it can be used to replace the non-renewable fossil fuel by taking down the methane out of the atmosphere, hence saving environment become the victim of the biogas.

The formation of methane gas can be used as a renewable energy in convenient and efficient key technology. The methane gas generated is store and intermittent and fluctuating electricity and stable electricity is regenerated. (Koji Hashimoto et al., 2016). Methanation (hydrogenation) is a reaction to form methane where carbon oxides present in a gas react with H2(J. Gao et al., 2012). The reactions will take place when the temperature, flow rate, ratio of mixture, mass, gas composition and pressure. (E. Dace et al., 2015). Catalyst is used for initial the (E. Dace et al., 2014).

2.3 Palm Oil Mill Effluent (POME)

Malaysia is the world second largest country in produce and export the palm oil. Palm oil produce by palm oil mills where extract oil from it fruit bunch. Big amount of water is applied during extraction palm oil form it fruit bunch, half of the water turn became POME. The brownish of POME contains high total solid, COD, BOD and also oil & grease. (Abdul Latif Ahmah, 2003) POME is a highly polluting effluent if without any treatment and become a major problem to the environment. Palm oil mill effluent (POME) is a pollutants could pollute to the river s or lake without any treatment. (N Oswala, 2002)

POME's characteristics is depending on raw material quality and palm oil production in palm oil mills. POME have a low pH in range 4-5, it is because of the fermentation process produced organic acid, (Parveen Fatemeh Rupani, 2010) Most of the palm oil mills used AD to treat POME. (Tay, 1991).

The application of modem high rate anaerobic digester technologies, such as up-flow or down-flow filters, fluidized beds, up-flow anaerobic sludge blanket (UASB) systems or up-flow floe digesters, for the disposal of POME is rare. (Pandey et al, 1990)

2.4 Upflow Anaerobic Sludge Blanket Reactor (UASBR)

UASB is a system implement to treating in wide range of several waste of industrial effluents, POME is one of the waste that can be treated by UASB. UASB was introduce by Lettinga in year 1980. He said the UASB operation in corporate with an anaerobic sludge to achieve good settling properties. In history, UASB reactor had successfully in treatment waste product which are potato, ice-cream, pharmaceutical, instant coffee wastewater, sugar beet and also the POME.

The UASB was design in simple, creative and eco-friendly. It was a reactor where design to degrade the organic sludge and settles those biomasses inside it. The chemical reaction with take part when organic matter contact with sludge, hence the digestion by biomass granules occurred. UASB reactor which show its efficiency in treating high contaminate of solid wastewater and give greater methane production. (Kalyuzhnyi et al, 1996). The one of the worse thing of UASB is take a long time start-

up period. This is because it need to wait till the seeded sludge to be granulated. The seeded sludge with granulated shown shorter start-up period than the unseeded sludge which proven in study of Goodwin et al in year 1992.

UASB carry out the process which discover the physical and chemical conditions of sludge flocculation. Those conditions are used to separate the gas from sludge with contaminate solid. UASB reactor feature on both physical and also biological process. Its show the feature in physical process by separate the gases from the solid, while biological feature is using anaerobic digestion to carry out the degradation of the decomposition.

The operation of the UASB reactor is start from pump in the waste or substrate into the reactor and carry out formation sludge. The sludge blanket is make by microbial granules, when the microorganisms with stick and washed during up-flow. The organic compound undergoes degradation by the microorganisms in the sludge layer. Hence the biogas produced. The biogas produced moving upward and collected and stock in the gas tank. The main component if the gas normally consists high percentage of methane and carbon dioxide.

2.5 pH Effect

Anaerobic co-digestion is can be affected by the pH due to involve of different microbial groups has their specific pH range. The aspects influenced by pH include utilization of carbon and energy sources, efficiency of substrate dissimilation, synthesis of proteins and various types of storage material, and the release of metabolic products from the cell (Elefsiniotis and Oldham, 1994b). At the beginning phase of AD, the formation of VFAs by the soluble organic affected to the pH. VFAs reduce the pH value and lower biogas production if the pre-treatments are not efficient. Therefore, the pH is one of the factor that can affect to the methane production efficiency. Normal methane production generated by anaerobic digestion process has 6.5-7.5 pH value (Liu et al., 2008). Different substrate given different pH value. The initial pH must be setting up in order to enhance methane production rate and solid reduction rate, which suit for the digestion process. (Ningning Zhai et al., 2015).

In this study, the POME and cow manure act as the co-digestion substrates and determine the difference of pH value with affect to the methane production rate. Co-digestion is applied in order give stability in anaerobic process and increase production of methane. The acidogenic microbial populations (Zhang et al., 2012) and methanogenic bacteria (Ghosh et al., 2000), is affected by pH. The concentration of NH_4^+-N can impact to the pH, the activity of methane bacteria can be inhibiting by high concentration of NH_4^+-N. Hence, the NH_4^+-N must be control in suitable concentration to neutralize VFA.

While carry out the AD process, there are three main process which is acidogenic, acetogenesis and methanogenic. Both process show good perform in their suitable pH range, where acidogenic bacteria at pH above 5, methanogenic needed 6.2 pH above. Hence we can conclude it, the suitable pH for the AD process can be setting up within range 6.5 to 7.5 pH. Acetogenesis leading accumulate of big quantity of organic acids in pH less than 5. Methanogens are inhibiting by the excessive acid generated. Adding lime of residue wastes can help in reduce the pH. (K. M. Kangle et al., 2012)

CHAPTER 3

METHODOLOGY

3.1 Sample Collection and Characterization

The sample use in this research are POME and cow manure, contaminate of POME is shown in the table by the study of Krishnan in year 2016. Another substrate to be use ACD is cow manure, in the study of Khairuddin 2015, it shown cow manure characterization in the table.

Table 1: Raw POME's characteristics

Parameter	Concentration (mg/L)
pH	5.1 ± 0.2
Biochemical Oxygen Demand (BOD)	3500 ± 500
Chemical Oxygen Demand (COD)	56,500 ± 300
Total Carbohydrate	16,400 ± 200
Total Nitrogen	960 ± 100
NH_4^+-N	810 ± 100
Total Phosphorus	110 ± 1
Phosphorus	22 ± 1
Oil	109,000 ± 20
Total Solids (TS)	32,000 ± 300
Volatile Solids (VS)	26,000 ± 400
Suspended Solids (SS)	8300 ± 200
Ash	4500 ± 200

Fe	2 ± 0.1

Table 2: Characteristics of Cow Manure.

Parameter	Value
pH	7.5
Total solids (%)	15.2
Volatile solids (%)	13.8
Moisture content (%)	50.4
C:N	11.2
Ammonia (g/L)	26.88

3.2 Pre-treatment of activated sludge

Activation of sludge in thermal pre-treatment enhance CH4 produced by 20% and decrease stringy particle sizes (Angelidaki and Ahring., 2000). Therefore, activated sludge solids were heated up to 100-145 °C before AD to improve CH4 yield and volatile solids loss, as indicated by (Mladenovska et al., 2006). The cow manure and POME are mixing follow the suitable ratio as activated sludge.

3.3 Seeding

The combination of POME and cow manure is seeding in after activated of sludge. The waste is obtained from FELDA, Pahang, Malaysia. The blended of 2 L of activated sludge with total solids (TS) 75.5 g and (TS) 65.2g of activated granulated sludge is keep at 4°C in cold room. Filtration of the blended anaerobic microbial culture is carry out by passing through 0.05inch mesh size screen for 2.5 hours before inoculum. The UASBR have TS content 132.5g. Total suspended 128 g/L and volatile suspended solids 78g/L is feeding to the UASBR. (Siddique et al., 2015)

The formation of activated sludge biomass (ASB) was following the procedure of (Ahmad et al., 2010). An energy resource of mixed medium, K2HPO4, MgSO4, FeSO4. 7 H20, CaCl2. 2H2O is employed. Initially, the medium shown pH 4.5, the 150 mL POME is then added into 250 mL Erlenmeyer bottle with contain of 100 ml energy medium in aeration at 120 rpm and 30°C for 21 days. Subsequently, pH is maintained in 6 by control with HCl and NaOH throughout this process. The culture was lastly planted to agar medium and ameliorated. The microbial medium was established, after 20 successive cultures. Eventually, the medium was cultured in 500 mL Erlenmeyer bottle comprising 200 mL of medium and POME at 30 ˚C and 125 rpm in incubator for five days. The ultimate microbial medium was employed as combined activated sludge biomass for biological degradation of waste.

3.4 UASB Setup and Operation

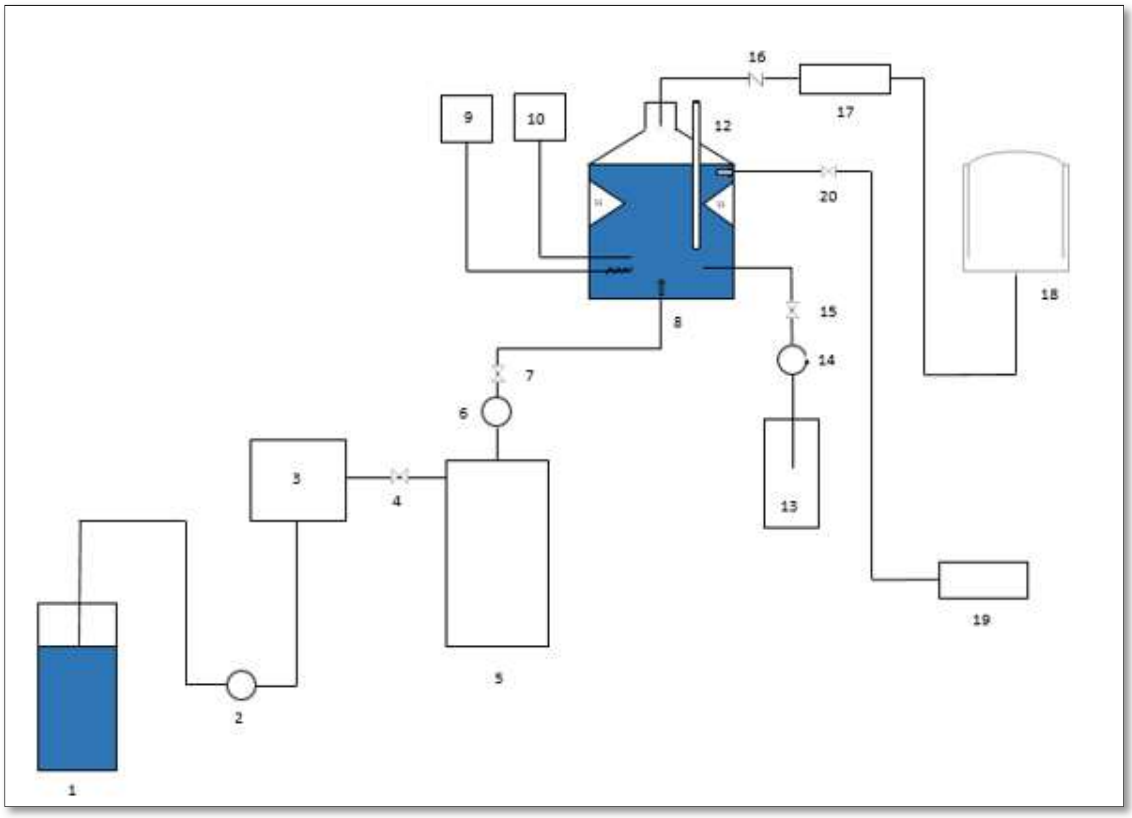


Figure 2: UASBR of experiment setup diagram.

Table 3: UASB reactor experiment setup diagram.

No	Item	No	Item	No	Item
1	Dosing zone	8	UASB reactor	15	Control Valve
2	Peristaltic pump	9	Heater	16	Check Valve
3	Power Generator	10	Temperature sensor	17	Biogas flow meter
4	Control Valve	11	Deflectors	18	Biogas Collection tank
5	Feeding tank	12	pH sensor	19	Drain
6	Peristaltic pump	13	Acid base control tank	20	Control Valve
7	Control Valve	14	Peristaltic pump		

A UASB reactor diagram is shown in figure 3.1. Conventional design of UASBR is found that cannot adjust the pH and temperature. After modified, the pH meter and thermometer is installer for observe and control the pH and temperature The UASB reactor used in this study have the dimension of 4.5 L and 2.7 L working value. Glass and stainless steel is used to build the main digester. The reactor is sealed with steel plate and locking by 6 nuts. The deflectors are than installed inside the reactor for the propose of holding sludge blanket. Heater is also installed for adjust the temperature. A feeding tank is also added to serve the feeding. Biogas generated is collected by a biogas collection tank. A partial fraction of the biogas generated in the digester was re-circulated by a triangular shaped biogas distributor having approximately 1mm openings connected to a pump. Gas flow meter is also installed and used for observe the gas collected. Before starting the biogas recirculation process, the media degradation and blockage of UASBR was tested. The operated temperature for the reactor is set as 37°C. COD, biogas generation and removal efficiency is used to examined the UASBR effectiveness.

3.5 pH effect

The pH of POME and Cow manure with different value operate in the UASB reactor are investigated to show the effect of pH to the productive of methane. The experiment is carry out by using different pH value 6.5, 7.0, 7.5. The initial pH was adjusted by using concentrated NaOH.

3.6 Analysis

Liquid displacement is used to measure the biogas production. Biogas constitution was analyzed with Shimadzu Class-GC 14B gas chromatography apparatus armed with a Porapak N column and thermal conductivity detector. Helium gas was carry at a 30 mL/min flow rate. The temperatures of oven, detector and injector were set as 70, 120, 120°C. APHA s used to analyzed the VFA, pH, total solid, volatile solids, COD, BOD, total nitrogen.

3.7 Functional and performance parameters

The functional and performance parameters use is HRT, food to microorganism ratio (F/M), organic loading rate (OLD), and also reactor VFA/alkalinity ratio. Concentration of pollutant and bacteriological mass is accommodated by F/M. Furthermore, the mass of contamination from F/M is applied to a unit mass of microbial mass per unit time. (e.g. g COD/g VSS day). The parameters were calculated by the relationship given below:

i. Flow Rate

   The flow rate is defined as the ratio of working volume of reactor and HRT. The smaller the diameter of tube hose; the lower the flow rate of the influent and vice versa.

$$\text{Flow Rate} = \frac{\text{Volume of Influent}}{\text{Days}} \quad (1)$$

ii. Hydraulic Retention Time

The mean time of a fluid resides in a reactor as known as Hydraulic Retention time (HRT). HRT can be defined as the time required by a liquid entering until all soluble matter degraded from inlet to the outlet.

$$HRT = \frac{V}{Q} \tag{2}$$

3.8 Flow Chart

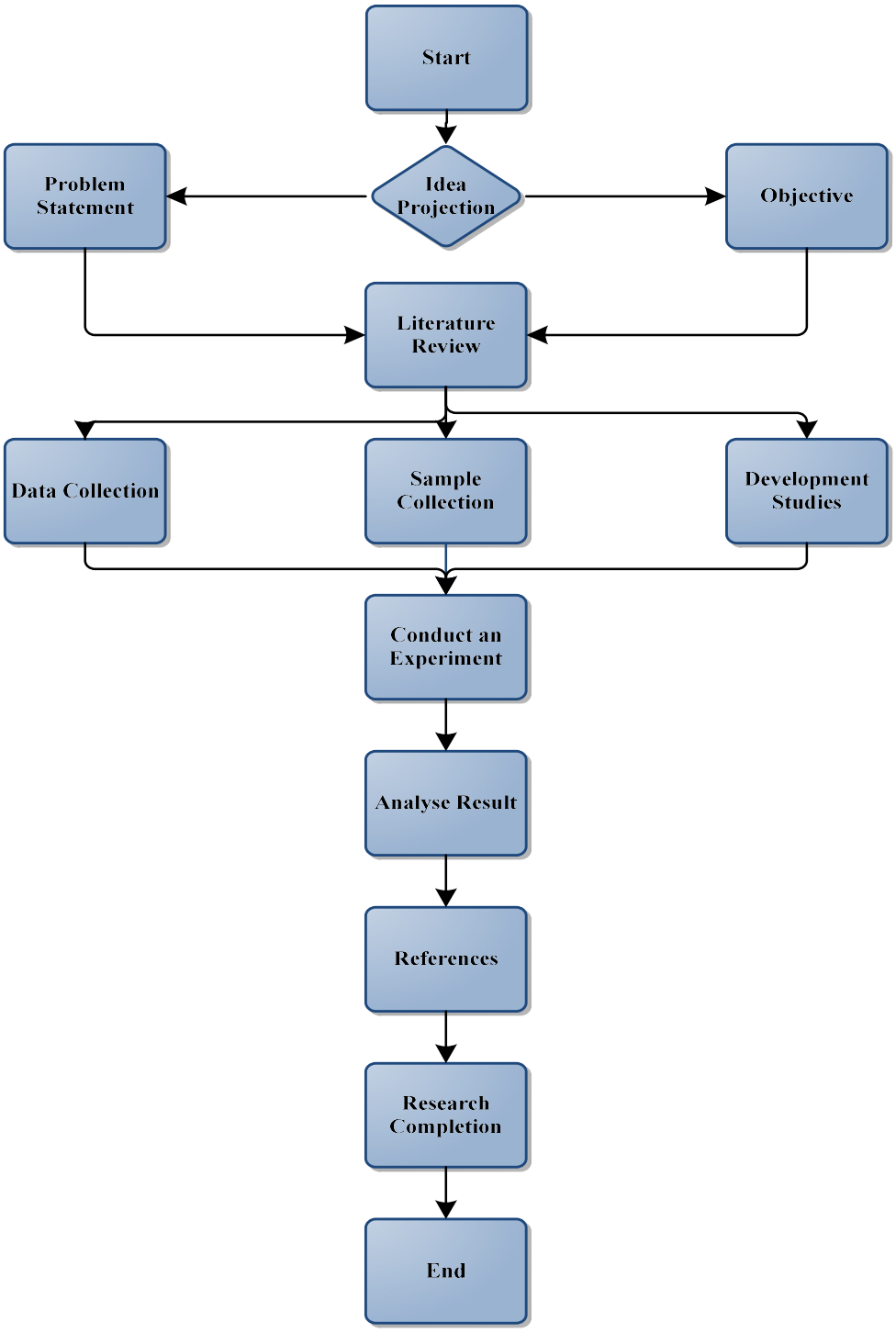


Figure 3: Flow Chart

3.9 Gantt Chart

Table 4: Project Schedule of Final Year Project 1.

No	Months	February			March				April				May				Jun			
	Activities	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	SDP 1 Briefing								MID SEMESTER BREAK							REVISION WEEK	EXAMINATION WEEK			
2	Proposal Preparation																			
3	Progress Report Preparation																			
4	Proposal Presentation																			
5	Proposal Submission																			
6	Log Book Submission																			

Table 5: Project Schedule of Final Year Project 2.

No	Month	September				October				November				December				January			
	Activities	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	SDP 2 Briefing							MID SEMESTER BREAK								REVISION WEEK	EXAMINATION WEEK				
2	Collecting Sample																				
3	Experiment																				
4	Progress Report Preparation																				
5	Proposal Presentation																				
6	Report Submission																				
7	Log Book Submission																				

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter describes implementation, experimental outcomes and discussion of Palm Oil Mill Effluent (POME) treatment by using UASB reactor. The result described in this chapter is effect of pH. This implementation have the purpose to illustrate chemical biological coupled technology usefulness and feasibility. Hence, compared the results with other process.

4.2 Characterization of Palm Oil Mill Effluent

The parameters pH, TSS, BOD, COD, Oil & Grease, Ammoniacal nitrogen, Nitrate and Phosphorus used to characterize the raw POME. The summarized POME characterization shown in Table 4.1. While the filtered values will be shown in the Table 4.2.

Table 6: Composition and Characteristics of POME.

Parameters	Unit	POME
pH	-	7.3
TSS	mg/L	8662
BOD	mg/L	378
COD	mg/L	1828
OIL & GREASE	mg/L	4
AMMONIACAL NITROGEN	mg/L	260
NITRATE (as NO_3)	mg/L	203
PHOSPHORUS	ppm	79.88

Table 7: Composition and filtered characteristics of POME.

Parameters	Unit	RAW POME	Filtered POME
pH	-	7.3	8.4
TSS	mg/L	8662	2332
BOD	mg/L	378	374
COD	mg/L	1828	1278
OIL & GREASE	mg/L	4	Not detected (less than 1)
AMMONIACAL NITROGEN	mg/L	260	250
NITRATE (as NO_3)	mg/L	203	304
PHOSPHORUS	ppm	79.88	75.27

4.3 Effect of pH on UASB Reactor Performance

The anaerobic digesters bacteriological species is sensible to pH variations, and methanogenesis is disturbed greatly (Leslie et al., 1990). The different pH feed on reactors shown efficiency at HRT of 15 days and temperature of 37ºC. NaOH as an alkalinity effluent at pH 7 ± 0.5. The NaOH effluent running under mesophilic condition with never exceed 1 g/L. That was no drastic pH drop for this conditions. Thus, co-digestion of POME and Cow manure can successfully sustain sufficient buffering capacity without extraneous inclusion of nutrients and buffering sources restricted by need of nitrogen. Therefore, the co-digestion of POME and Cow manure might reduce both chemical application and operating charges for POME to generated methane. Likewise, effluent of co-digestion incorporated little quantity of ammoniacal nitrogen than POME alone. It could inhibitory influence of ammonia on anaerobic digestion and lead a subsequent-treatment process for eliminate the nitrogen inexpensive and easy. Hence, co-digestion can be more profitable on producing biogas.

In the research, Methane produced from POME and cow manure by using UASB reactor and can be affect by pH value. In order to study the methane production, the HRT and temperature was set constanly go thought the experiment, where HRT set 15 days in 37 ºC at mesophilic condiction and the difference pH value 6.5, 7.0, 7.5 are used to determine whether acidic or alkalic produce more methane production. NaOH and HCl are used to adjust and control the pH value along the process. The pH value is observed by pH meter. The temperature is controlled by using heater and observe by thermometer.

Table 8: Methane production at difference pH with constant temperature 37 ˚c and 15 days of HRT.

Parameters	**pH**		
	6.5	7.0	7.5
Total biogas production (m^3/kg)	0.643	0.808	0.594
Total methane (m^3/kg)	0.44	0.62	0.36
Methane production (%)	68.43	76.7	60.61
HRT (day)	15	15	15

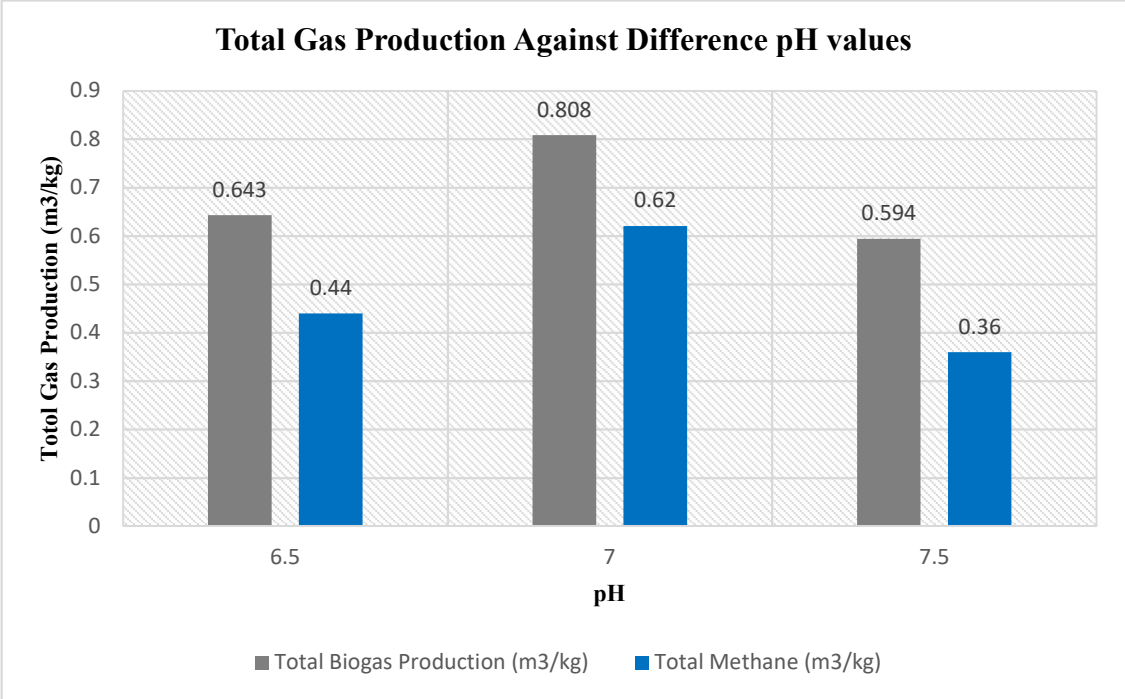


Figure 4: Total biogas and methane production against different pH values.

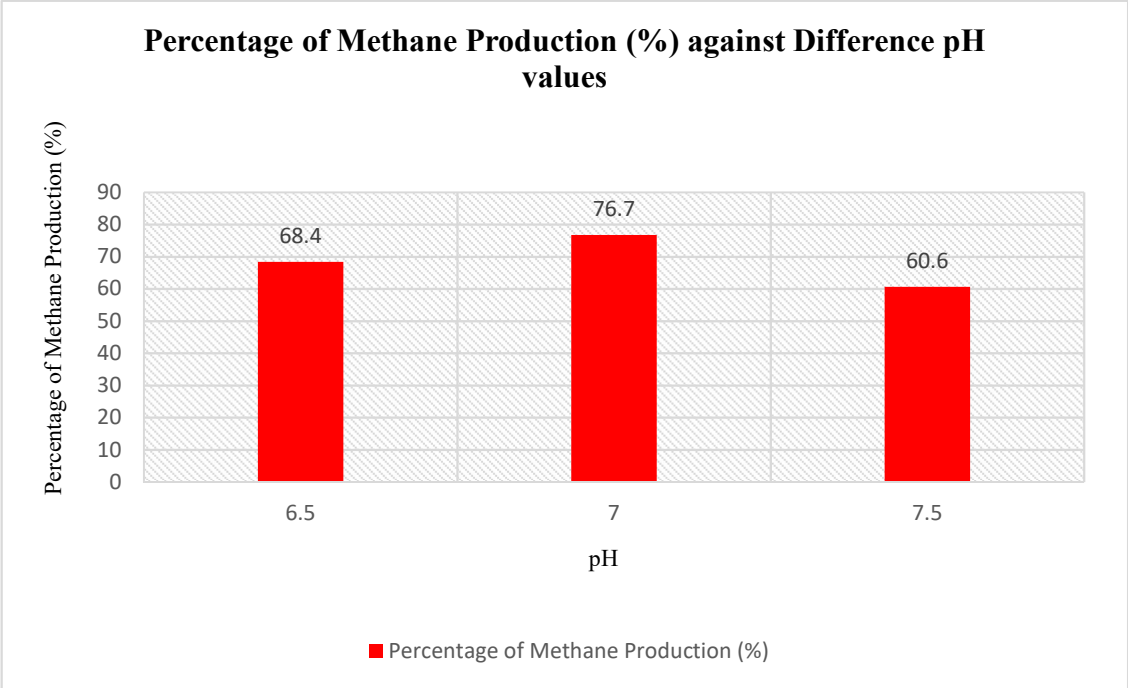


Figure 5: Percentage of Methane Production against difference pH values.

As shown in the table above, the pH value at 7 give the highest methane production compared to the pH at 6.5 and 7.5. pH value at 7 produced 76.7%, where pH 6.5 are slightly lower (68.43%) than 7.0 but higher than pH at 7.5 (60.61%). That means that the most suitable environment of bacteria in order to destroy organic into biogas is under condition of pH at 7.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter conclude the important of the results obtained from the discussed of POME using UASB reactor in the previous chapter. This chapter also including recommendation and future works on the analyzed methane production rate and the effectiveness of co-digestion of POME and Cow Manure.

5.2 Conclusions

In conclusion, UASB reactor is still not so common practiced anaerobic reactor strategy treating of wastewaters. There are still many palm oil mill using ponding system to treat the POME. UASB is a unique technology on waste treatment application and also easy installation. This research investigates the effect of anaerobic co-digestion strategy by POME and Cow manure on and significant enhancement in bioenergy production.

Co-digestion of POME and Cow manure with the ratio 50:50 successfully raised up methane production up to 50-60% compared to conventional treatment systems. From the operational trials conducted, it is suggested that the optimum pH might be 7.0, it provides the maximum digestion of the feed substrates. Besides that, the product after treatment can be harnessed and stored as combustion fuel to generate electric energy for internal combustion engine installed to an electric generator.

Furthermore, the amount of energy produced may be utilized in a boiler to heat variety of liquids. In addition, control of operating pH is an accretion of UASB reactor.

This research giving some novel contributions: The treatment technology of chemical and biological framework. The following contribution is successful implement of POME treatment along the compliance to the environmental regulations as well.

The key findings of anaerobic co-digestion of POME with Cow Manure are:

An UASB reactor resulted the POME with Cow manure treatment successfully in equal proportion at 37ºC. The addition of digital control of operating pH and co-digestion of POME with cow manure improved methane production compared to control and COD reduction. In this respect, this technology shows a promising option to enhance the effluent quality.

5.3 Future Works

The chemical pretreatment and subsequent anaerobic co-digestion affect in UASB reactor performance treating POME was investigated. The application of this new technology is successfully and can be expanded by recommending further research below:

1. UASB reactor shown it effectiveness in converting wastewater into methane by anaerobic co-digestion process. The accumulated methane gas collected can be further used as combustion material to generate energy by various type of energy generators.
2. Models are beneficial tools in the UASB reactors design and development. The reseachers should investigate and study the significant model consequences for the reactor performance of different cpmcemtration of inlet substrate , different type substrate, flow rates and of biomass.
3. POME and Cow manure are the good sources to generate methane gas. Palm oil mill industry can utilize this method as another income by collecting the methane gas produced by POME and sell to other parties where this methane gas can generate electricity. Furthermore, it is also an action to protect the environment as preventing release of methane gas to the atmosphere.
4. Non-inhibitory substrate with high concentration, (brewery waste, industry waste, distillery waste) is successfully applied into UASB reactor. The modification of suitable treatment for inhibitory compound of complex industrial wastewater is a challenge. The successful application of UASB will lead to development in food processing waste, slaughterhouse waste and manufacturing waste treatment.

References

Abdul Latif Ahmah, S. I. (2003). Desalination. Water recycling from palm oil mill effluent (POME) using membrane technology, 1.

Angelidaki, L. Ellegaard, B. K. Ahring, 1993. A mathematical model for dynamic simulation of anaerobic digestion of complex substrates: focusing on ammonia inhibition. Biotechnol. Bioeng, 42, 159–166.

Born, J., 2005. From Sugar Factories to Biorefineries. Baltic Biorefinery Symposium, pp. 23–32. ISBN: 87-7606-009-8.

C. F. Liu, X. Z. Yuan, G. M. Zeng, W. W. Li, J. Li, 2008. Prediction of methane yield at optimum pH for anaerobic digestion of organic fraction of municipal solid waste. Bioresour. Technol. 99 (4), 882–888.

Chynoweth, D.P., 2004. Biomethane from energy crops and organic wastes. In: International Water Association (Eds.), Anaerobic Digestion 2004. Anaerobic Bioconversion … Answer for Sustainability, Proceedings 10th World Congress, vol. 1, Montreal, Canada. www.ad2004montreal.org, pp. 525–530.

Demirel, B. and Yenigun, O. 2002 Two-phase anaerobic digestion processes: A Review. Journal of Chemical Technology and Biotechnology, 77.

E. Dace, D. Blumberga, I. Veidenbergs, 2015. Modeling syngas composition in an integrated system of biomass gasification. Electrolysis and methanation.Energ Proc, 75, pp. 801–806.

E. Dace, J. Rusanova, J. Gusca, D. Blumberga, 2014. Selecting a catalyst for methanation process: Technical and economic performance based TOPSIS Analysis. Proc 27th int conf effic cost, optim simul environ impact energy syst, ECOS 2014, Aabo Akademi University.

Elefsiniotis, P. and Oldham, W.K. 1994b Influence of pH on the acid-phase anaerobic digestion of primary sludge. Journal of Chemical Technology and Biotechnology, 60, 89-96

G. Esposito, L. Frunzo, A. Giordano, F. Liotta, A. Panico, F. Pirozzi, 2012. Anaerobic co-digestion of organic wastes. Rev Environ Sci Biotechnol.

Holm-Nielsen, J. (2009, November). Bioresource Technology. The future of anaerobic digestion and biogas utilization.

J. Gao, Y. Wang, Y. Ping, D. Hu, G. Xu, F. Gu, F. Su, 2012. A thermodynamic analysis of methanation reactions of carbon oxides for the production of synthetic natural gas. RSC Adv, 2 (6), pp. 2358–2368

J.H. Tay (1991) Complete reclamation of oil palm wastes Resources Conservation and Recycling, 5 (1991), pp. 383–392

Karine Arrhenius, SP, Ulrika Johansson, SP. (2012, Sep). Characterisation of contaminants in biogas before and after upgrading to vehicle gas. Characterisation of contaminants in biogas before and after upgrading to vehicle gas, 1.

K. M. Kangle, S.V. Kore, G.S. Kulkarni, 2012. Recent Trends in Anaerobic Codigestion: A Review. Review Article, Volume 2, Issue 4: 210-219.

Koji Hashimotoa, Naokazu Kumagaib, Koichi Izumiyab, Hiroyuki Takanob, Hiroyuki Shinomiyab, Yusuke Sasakib, Tetsuya Yoshidab, Zenta Katoa, 2016. The use of renewable energy in the form of methane via electrolytic hydrogen generation using carbon dioxide as the feedstock. Applied Surface Science, Volume 388, Part B, 608–615.

Kristensson, I. et al., 2007. Biogas på gasnätet utan propantillsats. Rapport SGC 176, 1102-7371, ISRN SGC-R-176-SE, pp. 6–18.

Mata-Alvarez J, Mace S, Llabres P (2000) Anaerobic digestion of organic solid wastes. An overview of research achievements and perspectives. Bioresour Technol 74: 3–16

Nielsen, L.H., Hjort-Gregersen, K., Thygesen, P., Christensen, J., 2002. Samfundsøkonomiske analyser af biogasfællesanlæg. Rapport 136. Fødevareøkonomisk Institut, København (Summary in English).

Ningning Zhai, Tong Zhang, Dongxue Yin, Gaihe Yang, Xiaojiao Wang, Guangxin Ren, Yongzhong Feng, 2015. Effect of initial pH on anaerobic co-digestion of kitchen waste and cow manure. Waste Management.

N Oswala, P. S. (2002). Bioresource Technology. Palm oil mill effluent treatment by a tropical marine yeast.

Pandey, A. and Ramakrishna, S.V. (1990) Management of effluent from edible oil (palm oil) industry. In: Pollution Management in Food Industries Symposium, pp. 159-17 1.

Parawira, W. (2004). Anaerobic Treatment of Agricultural Residues and Wastewater-Application of High-Rate Reactors. Anaerobic Treatment of Agricultural Residues and Wastewater- Application of High-Rate Reactors.

Parveen Fatemeh Rupani, R. P. (2010). Review of Current Palm Oil Mill Effluent (POME) Treat Methods: Vermicomposting as a Sustainable Practice, 1193.

Persson, M., Jönsson, O., Wellinger, A., 2006. Biogas upgrading to vehicle fuel standards and grid injection. IEA Bioenergy, Task 37 – Energy from Biogas and Landfill Gas, 2006.

S. Ghosh, M. Henry, A. Sajjad, M. Mensinger, J. Arora, 2000. Pilot-scale gasification of municipal solid wastes by high-rate and two-phase anaerobic digestion (TPAD). Water Sci. Technol., 41 (3), pp. 101–110.

S. Kalyuzhnyi, L.E. de los Santos, J.R. Martinez Anaerobic treatment of raw and preclarified potato-maize wastewater in a UASB reactor, Bioresource Technology, 66 (1998), pp. 198–199

Tchobanoglous, H. Theisen, S. Vigil, 1993. Integrated solid waste management. McGraw-Hill Inc, New York. The organic fraction of municipal solid waste for the production of liquid fuels".

Van der Berg, L., Kennedy, K.J., 1983. Comparison of advanced anaerobic reactors. In: Proceedings of III International Conference on Anaerobic digestion, August 1983, Boston, NRCC no. 22613

X. Zhang, W. Qiu, H. Chen, 2012. Enhancing the hydrolysis and acidification of steam-exploded cornstalks by intermittent pH adjustment with an enriched microbial community. Bioresour. Technol., 123, pp. 30–35.

Yee-Shian Wong, Tjoon-Tow Teng, Soon-An Ong, M. Norhashimah, M. Rafatullah, Jing-Yong Leong, 2014. Methane gas production from palm oil wastewater an anaerobic methanogenic degradation process in continuous stirrer suspended closed anaerobic reactor. Journal of the Taiwan Institute of Chemical Engineers, 45, Issue 3, 896–900.

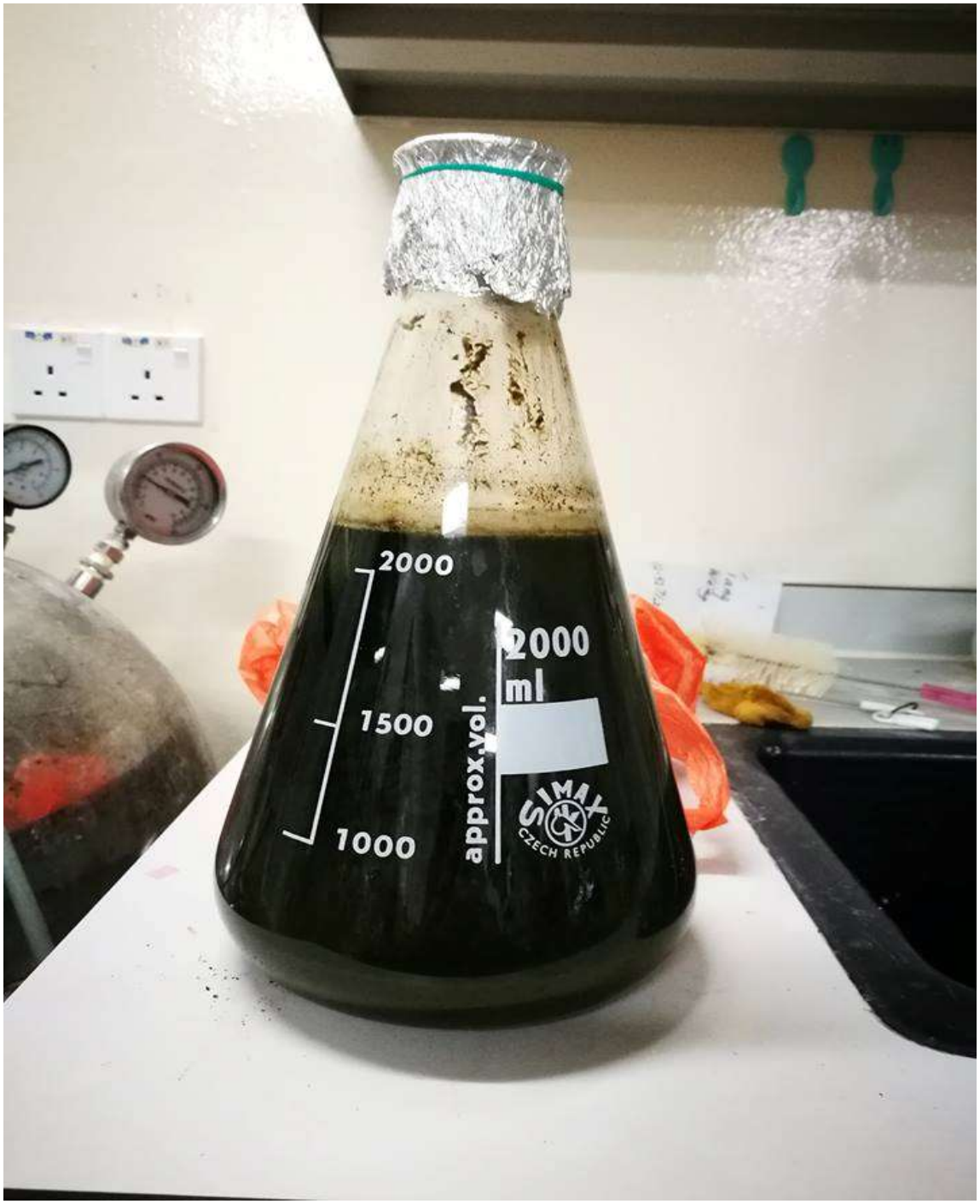
APPENDIX A1

Measuring pH of raw POME by pH meter.

APPENDIX A2

Mixing POME with Cow Manure in ratio 50:50.

APPENDIX A3



Activation Sludge of Biomass.

APPENDIX A4

Raw POME and Filtered POME.