
**UNIVERSITI PUTRA MALAYSIA**

# *ANAEROBIC DIGESTION OF CATTLE MANURE WITH PALM OIL MILL EFFLUENT AS INOCULUM FOR BIOGAS PRODUCTION*

**ISMAIL MUHAMMAD NASIR**

# ANAEROBIC DIGESTION OF CATTLE MANURE WITH PALM OIL MILL EFFLUENT AS INOCULUM FOR BIOGAS PRODUCTION

**By**

**ISMAIL MUHAMMAD NASIR**



**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,**

**in Fulfillment of the Requirement for the Degree of Master of Science**

**December 2011**

## DEDICATION

***This thesis is specially dedicated to my parents.***

## ABSTRACT

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

**ANAEROBIC DIGESTION OF CATTLE MANURE WITH PALM OIL MILL EFFLUENT AS INOCULUM FOR BIOGAS PRODUCTION**

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**Chairman: Tinia Idaty Mohd. Ghazi, PhD**

**Faculty: Engineering**

Recently, environmental concerns associated with manure waste management generated from the feedlot farming with abattoir integration in Malaysia needs to be carefully addressed. Biogas production from anaerobic digestion of cattle manure is regarded as an alternative, due to the simultaneous benefits of environmental pollution control and meeting the national energy demands. Although anaerobic digestion is a common process for treatment of cattle manure, the digestion rate remains very low. This is due to the low growth rate of the micro-organisms and the presence of hard biodegradable components. Hence, supporting the growth rate of the micro-organisms by the utilization of inoculum can be used as an alternative. One such inoculum is palm oil mill effluent (POME), characterized by having a high nutrient content, mainly oil and fatty acids, and it is also a source of bacteria.

In this study, the anaerobic treatment using a 10 L laboratory-scale bioreactor was used to improve the biogas production at different POME mixing ratio, which was performed at 53$^{o}$C and agitated at 150 rpm. Parameters used for monitoring were the

volatile and total solids (VS and TS), temperature, pH, chemical oxygen demand (COD), ammonia nitrogen ($NH_3$-N), biogas production and its respective methane content (%$CH_4$) during the treatment. The research was conducted in batch and semi-continuous modes. The effect of cattle manure with POME inoculum digestion on the biogas potential was investigated at mixing ratio of 5:0, 5:0.5, 5:1 and 5:1.5 and the performance of anaerobic digestion with controlled and uncontrolled pH at various mixing ratios was also studied.

Results indicated that stable digestion and high biogas production were achieved at mixing ratio of 5:1.5. The result represents nearly a threefold increase in the biogas production as compared to the digestion of cattle manure alone. The biogas yield and methane content varied from 0.093 to 0.346 $m^3$ $kg^{-1}$ VS added and 19 to 55% respectively, with a reduction of VS between 22 and 51%. In addition, the final $NH_3$-N concentration ranged from 970 to 1140 mg/L with an average COD removal of 25%. The improvement of cattle manure digestion was attributed to the enhancement of the process by the POME inoculum. Significantly, higher average biogas production and removal rates of VS, TS, COD and $NH_3$-N concentration at controlled pH to that at uncontrolled pH were observed. The average removal at uncontrolled pH could be improved by 1 to 2 times by controlled pH. The results from this study indicated that the improvement of anaerobic digestion of cattle manure with POME as inoculum by controlled pH is feasible.

## ABSTRAK

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuh ikeperluan untuk ijazah Master

**PENCERNAAN ANAEROBIK NAJIS LEMBU DENGAN EFLUEN KILANG MINYAK SAWIT SEBAGAI INOKULUM UNTUK PENGHASILAN BIOGAS**

Oleh

**ISMAIL MUHAMMAD NASIR**

**Disember 2011**

**Pengerusi: Tinia Idaty Mohd. Ghazi, PhD**

**Fakulti: Kejuruteraan**

Baru-baru ini, perhatian terhadap alam sekitar berkaitan dengan pengurusan sisa najis dari tempat perladangan yang digabung kan dengan tempat sembelihan di Malaysia perlu diberikan penelitian. Penghasilan biogas daripada pencernaan anerob daripada najis lembu merupakan alternatif sesuai dengan manfaat-manfaat seperti pengawalan pencemaran alam sekitar dan juga keperluan tenaga negara. Walaupun pencernaan anaerob merupakan proses yang biasa digunakan untuk rawatan najis lembu, kadar pencernaan masih terlalu lambat. Ini adalah disebabkan oleh kadar pertumbrhan mikroorganisma yang rendah dan kewujudan komponen yang sukar diurai secara bio. Oleh itu, bantuan untuk kadar pertumbuhan yang baik oleh inokulum dapat digunakan sebagai alternatif. Antaranya ialah efluen kilang minyak sawit (POME), dicirikan sebagai mempunyai kandungan nutrien yang tinggi, terutamanya minyak dan asid berlemak, dan juga sumber bakteria.

Dalam kajian ini, rawatan anaerob menggunakan 10 L bioreaktor berskala-makmal digunakan untuk mempertingkatkan penghasilan biogas pada nisbah campuran POME

yang berbeza pada 53°C dan diaduk pada 150 rpm. Parameter yang telah digunakan untuk pemantauan adalah pepejal meruap dan pepejal jumlah (VS dan TS), suhu, pH, tuntutan oksigen kimia (COD), nitrogen ammonia ($NH_3$-N), penghasilan biogas dan kandungan mentana (%$CH_4$) sepanjang rawatan tersebut. Penyelidikan ini dilakukan dalam kaedah kelompok dan semi-selanjar. Kesan pencernaan baja lembu dengan inokulum POME pada potensi biogas telah dikaji pada nisbah campuran 5:0, 5:0.5, 5:1 and 5:1.5. Prestasi pencernaan anaerob juga dikaji dengan pH terkawal dan tidak terkawal dengan pelbagai nisbah campuran.Keputusan menunjukkan bahawa pencernaan yang stabil dan penghasilan biogas yang banyak telah dicapai pada nisbah campuran 5:1.5. Keputusan tersebut adalah hampir tiga kali ganda peningkatan penghasilan biogas berbanding dengan pencernaan najis lembu tanpa campuran POME.

Hasil biogas dan kandungan metana berbeza dari 0.093 kepada 0.346 $m^3$ $kg^{-1}$ VS dan 19 hingga 55% masing-masing, dengan pengurangan VS antara 22 dan 51%. Di samping itu, kepekatan akhir bagi $NH_3$-N adalah di antara 970-1140 mg/L dengen penyingkiran COD purata sebanyak 25%. Peningkatan pencernaan najis lembu adalah kerana peningkatan proses oleh inokulum POME. Purata penghasilan biogas dan kadar penyingkiran VS, TS, COD dan kepekatan $NH_3$-N yang lebih tinggi pada pH terkawal telah diperhatikan. Purata penyingkiran pada pH tidak terkawal pula dapat dipertingkatkan sebanyak 1 kepada 2 kali ganda daripada pH terkawal. Hasil daripada kajian ini menunjukkan bahawa peningkatan pencernaan anaerobik najis lembu dengen POME sebegai inokulum oleh pH terkawal adalah berhasil.

## ACKNOWLEDGEMENTS

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Finally, I would like to thank all and sundry who in one way or the other helped to make my master degree programme a sounding success, but whose name I failed to mention due to my own limitations as a human being.

## APPROVAL

I certify that a Thesis Examination Committee has met on 27th December, 2011 to conduct the final examination of Ismail Muhammad Nasir on his thesis entitled "Anaerobic digestion of cattle manure with Palm Oil Mill Effluent as inoculum for biogas production" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

**ISMAIL M. NASIR**

Date: 27th Dec., 2011

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