OPTIMIZATION OF BIOGAS AS RENEWABLE ENERGY FROM CLOSED ANAEROBIC DIGESTION BIOMASS FOR PALM OIL MILL EFFLUENT AT MESOPHILIC TEMPERATURE

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by

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APPROVAL AND DECLARATION SHEET

This project report titled Optimization Of Biogas As Renewable Energy From Closed Anaerobic Digestion Biomass For Palm Oil Mill Effluent At Mesophilic Temperature was prepared and submitted by Lee Hong Chen (Matrix Number: 061130244) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Engineering (Environmental Engineering) in University Malaysia Perlis (UniMAP).

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PENGOPTIMUMAN BIOGAS SEBAGAI TENAGA BOLEH DIPERBAHARUI DARIPADA PROSES ANAEROBIK TERTUTUP UNTUK AIR SISA KILANG MINYAK SAWIT PADA SUHU MESOFILI

ABSTRAK

Air sisa kilang kelapa sawit ialah satu air buangan yang mencemarkan persekitaran jika dilepaskan secara langsung kerana mengandungi keperluan oksigen kimia (COD) dan keperluan oksigen biologi (BOD) yang tinggi. Selain itu, pembebasan gas rumah hijau secara antropologi, terutama karbon dioksida (CO_2) dan metana (CH_4) dari proses anaerobic untuk air sisa kilang minyak sawit telah dianggap sebagai salah satu faktor yang penting kepada pemanasan global. Oleh itu, kajian ini bertujuan bagi membincangkan tahap kecekapan penyingkiran COD, prestasi asid lemak meruap (VFA) dan kecekapan pengeluaran biogas dalam reaktor anaerobik tertutup untuk rawatan air sisa kilang kelapa sawit. Operasi kajian ini telah dilakukan dalam satu siri eksperimen dengan menggunakan pelbagai jenis aliran air sisa kilang kelapa sawit yang terdiri daripada 375 ml/d [ujikaji 1], 450 ml/d [ujikaji 2], 560 ml/d [ujikaji 3], 750 ml/d [ujikaji 4], 1125 ml/d [ujikaji 5] dan 2250 ml/d [ujikaji 6] bersesuaian dengan masa tahanan hidraul (HRT) dengan 12, 10, 8, 6, 4 dan 2 hari. Tempoh percubaan menjalankan ujikaji 1, 2, 3, 4, 5 dan 6 adalah 27, 15, 11, 18, 14 dan 14 hari. Keputusan dari eksperimen ini menunjukkan bahawa kecekapan penyingkiran COD and kadar pengeluaran biogas berkurangan dari 87.08 % ke 38.20 % and dari 3000 ml biogas/hari ke 604 ml biogas/hari apabila HRT berkurangan. Dalam pada masa itu, kepekatan VFA bertambah dari 11569.71 mg CH_3COOH/L ke 16956.00 mg CH_3COOH/L apabila HRT berkurangan. Selain itu, kandungan CH_4 dan pecahan CH_4:CO_2 telah berkurangan dari 24.05 % ke 10.64 % dan dari 0.76 ke 0.27 apabila HRT berkurangan manakala kandungan CO_2 dan H_2 telah bertambah dari 31.45 % ke 39.63 % dan dari 4.35%

ke 8.15 %, apabila HRT berkurangan. Situasi ini berpunca daripada variasi HRT yang menjejaskan kestabilan sistem.

OPTIMIZATION OF BIOGAS AS RENEWABLE ENERGY FROM CLOSED ANAEROBIC DIGESTION BIOMASS FOR PALM OIL MILL EFFLUENT AT MESOPHILIC TEMPERATURE

ABSTRACT

Palm oil mill effluent (POME) is a highly polluting wastewater that pollutes the environment if discharged directly due to its high chemical oxygen demand (COD) and biochemical oxygen demand (BOD) concentration. In addition, anthropogenic release of greenhouse gases, especially carbon dioxide (CO_2) and methane (CH_4) from POME anaerobic degradation process has been recognized as one of the main causes of global warming. Thus, this study aims to discuss the COD removal efficiency, behavior of volatile fatty acid (VFA) and efficiency of biogas production in the suspended closed anaerobic reactor (SCAR) for the treatment of POME wastewater. The operation of this research study was performed by a series of continuous experiments using feed flow-rates of 375 ml/d [run 1], 450 ml/d [run 2], 560 ml/d [run 3], 750 ml/d [run 4], 1125 ml/d [run 5] and 2250 ml/d [run 6] of the wastewater, which correspond to hydraulic retention time (HRTs) of 12, 10, 8, 6, 4 and 2 days, respectively. The duration of the experimental runs 1, 2, 3, 4, 5 and 6 was 27, 15, 11, 18, 14 and 14 days, respectively. The results indicated that the COD removal efficiency and the biogas production rates decreased from 87.08 % to 38.20 % and from 3000 ml biogas/day to 604 ml biogas/day, respectively as HRT decreased. Meantime, the VFA concentration increased from 11569.71 mg CH_3COOH/L to 16956.00 mg CH_3COOH/L with a decrease in HRT. Moreover, the methane content and the CH_4: CO_2 fraction decreased from 24.05 % to 10.64 % and from 0.76 to 0.27, respectively with a decrease in HRT whereas the carbon dioxide and hydrogen contents were increased from 31.45 % to 39.63 % and from 4.35 % to 8.15 %, respectively, with a decrease in HRT. These were attributed to variation of HRT that affects the system stability.

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F/M	Food to Microorganism Ratio
$\Delta G^{\circ\prime}$	Gibbs Free Energy Values
q	Feed Flowrate
S	Substrate Concentration at the Digester Effluent
S_0	Substrate Concentration at the Digester Inlet
$V_{methane}$	Volume of Methane Produced Per Day
Y_{CH4}	Methane Yield
C	Carbon
CH_4	Methane
CO_2	Carbon Dioxide
H_2	Hydrogen
H_2S	Hydrogen Sulphide
H_2O	Water
N	Nitrogen
NH_4-N	Ammonia Nitrogen
NaOH	Sodium Oxide
N_2	Nitrogen Gas
NH_3	Ammonia
O_2	Oxygen
P	Phosphate
SO_2	Sulfur dioxide

LIST OF ABBREVIATIONS

Alk	Alkalinity
APHA	American Public Health and Association
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CPO	Crude Palm Oil
CSTR	Continuous Stirred Tank Reactor
EQA	Environmental Quality Act
FFB	Fresh Fruit Bunches
GHG	Green House Gases
HDPE	High Density Propylene
HRT	Hydraulic Retention Time
LCFA	Long Chain Fatty Acid
MLSS	Mixed Liquid Suspended Solid
MLVSS	Mixed Liquid Volatile Suspended Solid
O & G	Oil and Grease
OLR	Organic Loading Rate
POME	Palm Oil Mill Effluent
SCAR	Suspended Closed Anaerobic Reactor
SCOD	Soluble Chemical Oxygen Demand
SRT	Solid Retention Time
SS	Suspended Solid
TS	Total Solid
TVS	Total Volatile Solid
UASB	Up-flow Anaerobic Sludge Blanket

UASFF	Up-flow Anaerobic Sludge Fixed-film
VFA	Volatile Fatty acid
VSS	Volatile Suspended Solid