UNIVERSITI PUTRA MALAYSIA

ANAEROBIC TREATMENT OF FRESH LEACHATE FROM TRANSFER STATION

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By

SEYED MOHAMMAD DARA GHASIMI

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia,
In fulfilment of the Requirement for the Degree of Master of Science

July 2008

SPECIALLY DEDICATED TO:

MY BELOVED PARENTS, BROTHER, SISTERS FOR THEIR SACRIFICES AND INVALUABLE LOVE,

TO MY GRAND MOTHERS, UNCLES, AUNTS & RELATIVES WHO ALWAYS SUPPORT ME,

AND TO ALL

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

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July 2008

Chairman: **Professor Azni Idris, PhD**

Faculty: **Engineering**

One stage anaerobic digestion was carried out in this study where fresh leachate from Taman Beringin Transfer Station was used as a substrate to be treated in terms of chemical oxygen demand (COD) removal by using 10 L stirred tank reactor (STR) within period of two and three months for semi-continuous and batch anaerobic treatment processes, respectively, in which the maximum loading rate of the system was tested at 6kg COD/m^3.day. Palm oil mill effluent (POME) sludge was used as an inoculum in phase 2 in order to obtain high amount of COD removal. Three experiments were conducted in anaerobic treatment of fresh leachate until steady state was achieved, i.e. (1) no seed was added and pH and temperature were not controlled (phase1); (2) POME sludge was used as an inoculum and no pH adjustment and temperature control was done, fresh leachate was fed in semi-continuous mode and hydraulic retention time (HRT) 10 days was selected (phase2, run1); (3) POME sludge was used as an inoculum, pH was adjusted by using Sodium Hydroxide (NaOH) and temperature was not controlled and HRT 10 days was chosen (phase 2, run 2).

In general, anaerobic digestion using POME seed sludge shows better efficiency in COD reduction and biochemical oxygen demand (BOD_5) in comparison to batch process and unadjusted pH in run 1 which has been obtained in this study. The initial values for both COD and BOD_5 of fresh leachate were extremely high compared with the stabilized landfill leachate. COD reduction rate for the batch (phase 1) and semi-continuous process (phase 2, run1 & 2) experiments were found 43, 37 and 52.7 % for period of 91, 27 and 30 days, respectively. These results clearly show that using seed sludge as an inoculum as well as pH adjustment indicated better efficiency in terms of COD removal in comparison to phase 1 and run1 (unadjusted pH). Maximum reduction in BOD_5 occurred in run 2 (pH adjusted) with more than 90 % and 80-85 % for batch process at two ending points; day 53 and 91, respectively.

The volatile fatty acid (VFA) concentration was a rapid indicator of the reactor's stability. High concentration of VFA indicated that the reactor was unstable. It was apparent that as the total VFA concentration rose, the microbial population's ability to utilize these compounds effectively was inhibited. The major acids produced were acid acetic (HAc), propionic (HPr) and butyric acids (HBu). The levels of HAc acid and HPr appeared to be the VFA species that accumulated and started to cause an imbalance in the reactor. Acetic and propionic acid have been accumulated in run 2 and their concentration increased to 39 and 5 % respectively, while n-butyric decreased about 46% in comparison to day 27 in run 1. All these cases show that anaerobic treatment in run 2 has been subjected to failure.

In this study it was also found that with decrease in pH, decrease in amount of COD removal and increase in total volatile fatty acids (TVFA) was detected for run 1. TVFA was indicated at a range of 6000-9000 mg/L and 9000-10000 mg/L for run 1 and 2,

respectively, which showed despite of adjusting pH above 7 still considerable accumulations of VFA was observed in the bioreactor. Therefore, it was concluded that the methanogenic population has not reached sufficient level to convert the organic acids produced from the acidogenic bacteria.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

RAWATAN ANAROBIK AIR LARUTAN SAMPAH SEGAR DARI STESEN PINDAH

Oleh

SEYED MOHAMMAD DARA GHASIMI

Julai 2008

Pengerusi: **Profesor Azni Idris, PhD**

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Satu peringkat fermentasi telah dijalankan di dalam kajian ini yang mana air larutan sampah (*leachate*) dari Stesen Pindah Taman Beringin telah digunakan sebagai substrat untuk dirawat dari segi penyingkiran COD dengan menggunakan 10 L tangki reaktor berpengaduk dalam tempoh dua dan tiga bulan bagi masing-masing proses rawatan anarobik separa-selanjar dan berkelompok dengan kadar maksima muatan sistem diuji pada 6kg COD/m^3.day. Enapcemar POME telah digunakan sebagai inokulum di dalam fasa 2 bagi mencapai kadar penyingkiran COD yang tinggi. Tiga eksperimen telah dijalankan bagi rawatan anarobik untuk air larutan sampah segar sehingga keadaan mantap diperolehi, iaitu (1) tiada benih ditambah dan pH dan suhu tidak dikawal (fasa 1); (2) enapcemar POME telah digunakan sebagai inokulum dan tiada pengubahan pH dan kawalan suhu telah selesai, air larutan sampah segar telah disuap dalam bentuk separa-selanjar dan HRT 10 hari dipilih (fasa 2, ujikaji 1); (3) enapcemar POME telah digunakan sebagai inokulum, pH telah diubah dengan menggunakan natrium hidroksida (NaOH) dan suhu tidak dikawal dan HRT 10 hari dipilih (fasa 2, ujikaji 2).

Secara umumnya, pencernaan anarobik menggunakan benih enapcemar POME menunjukkan kecekapan yang lebih baik bagi penurunan COD dan BOD_5 berbanding dengan proses berkelompok dan tanpa kawalan pH bagi eksperimen 1 seperti yang telah diperolehi di dalam kajian ini. Nilai awalan bagi kedua-dua COD and BOD_5 air larutan sampah segar adalah sangat tinggi berbanding dengan air larutan di tapak pelupusan sampah yang telah stabil. Penurunan kadar COD bagi proses kelompok (fasa 1) dan separa-selanjar (fasa 2, ujikaji 1 & 2) diperolehi pada 43, 37 dan 52.7% untuk jangka masa masing-masing pada 91, 27 dan 30 hari. Keputusan-keputusan ini jelas menunjukkan bahawa penggunaan benih enapcemar sebagai inokulum dan juga pengubahan pH memberikan kecekapan yang lebih baik dari segi penyingkiran COD dan masa yang digunakan sebagai perbandingan fasa 1 dengan ujikaji 1 (tiada pengubahan pH). Penurunan maksima BOD_5 yang berlaku pada eksperimen 2 (pengubahan pH) dengan lebih 90% dan 80-85% telah diperolehi bagi proses berkelompok pada dua titik akhir; masing-masing pada hari 53 dan 91.

Kepekatan asid lemak meruap (VFA) merupakan penunjuk segera kepada kestabilan reaktor. Kepekatan VFA yang tinggi menunjukkan bahawa reaktor adalah tidak stabil. Jelasnya apabila jumlah kepekatan VFA meningkat, keupayaan populasi mikroorganisma untuk menggunakan campuran-campuran ini secara berkesan telah direncat. Pengeluaran asid yang terbanyak adalah asid asetik (HAc), propionik (HPr) dan asid butirik (HBu). Kadar asid HAc dan HPr didapati merupakan spesis VFA yang berkumpul dan menyebabkan permulaan ketidakstabilan di dalam reactor. Asid asetik dan propionik telah terkumpul di dalam ujikaji 2 dan kepekatannya telah meningkat masing-masing kepada 39 dan 5%, manakala kadar penurunan n-butirik sebanyak 46%

sebagai perbandingan pada hari 27 di dalam ujikaji 1. Kesemua kes ini menunjukkan rawatan anarobik di dalam ujikaji 2 telah gagal.

Di dalam kajian ini juga didapati bahawa penurunan pH, penyingkiran COD dan peningkatan asid-asid lemak meruap terkumpul (TVFA) telah dikesan pada ujikaji 1. TVFA telah didapati pada kadar masing-masing 6000-9000 mg/L dan 9000-10000 mg/L untuk ujikaji 1 dan 2, yang mana menunjukkan walaupun pengubahan pH di atas 7, masih menunjukkan pengumpulan VFA di dalam bioreaktor. Oleh yang demikian, tiada benih/biojisim yang mengandungi populasi metanogenik untuk menukarkan asid organik yang dihasilkan daripada bakteria asidogenik.

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Seyed Mohammad Dara Ghasimi, 2008

I certify that an examination committee has met on the 30th July 2008 to conduct the final examination of Seyed Mohammad Dara Ghasimi on his Master of Science thesis entitled "Anaerobic Treatment of Fresh Leachate from Transfer Station" in accordance with Universiti Pertanian Malaysia (High Degree) Act 1980 and Universiti Pertanian Malaysia (High Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of Examination Committee are 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 Science. The members of Supervisory Committee were as follows:

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Date: 11 September 2008

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citation, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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SEYED MOHAMMAD DARA GHASIMI

Date: 11 August 2008

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μ	Specific growth rate
Alk	Alkalinity
APB	Acid producing bacteria
BOD	Biochemical oxygen demand
C	Carbon
Cm	Centimeter
COD	Chemical oxygen demand
CODrem	COD removal
CSTR	Continuous stirred tank reactor
DO	Dissolved oxygen
FID	Flame ionization detector
FSS	Fixed suspended solids
g/L	Gram per liter
GC	Gas chromatography
HAc	Acetic acid
HBr	Butyric acid
HPr	Propionic acid
HPr	Propionic acid
HRT	Hydraulic retention time
HVc	Valeric acid
ID	Ionized detector
I-HBu	Isobutyrate acid
I-HVa	Isovalerate acid
L	Liter
LLR	Leachate loading rate
M	Molar
Mm	Millimeter
mM	Mili mol
MSW	Municipal solid waste

N	Nitrogen
NADH	Nicotinamide adenine dinucleotide, reduced
N-HBu	N-butyrate acid
N-HVa	N-valerate acid
Nm	Nanometer
°C	Celsius
OLR	Organic loading rate
ORP	Oxidation-reduction potential
P	Phosphorous
PID	Proportional integral derivative
POME	Palm oil mill effluent
Q	Flow rate
RBC	Rotating biological contactors
Rpm	Rotation per second
S_0	Influent substrate concentration
SBR	Sequencing batch reactors
SMP	Soluble microbial product
SRT	Solids retention time
TCD	Thermal conductivity detector
TDS	Total dissolved solids
TF	Trickling filters
TKN	Total kjeldhal nitrogen
TS	Total solids
TSS	Total suspended solids
TVFA	Total volatile fatty acids
UVFA	Un-ionized acids
VFA	Volatile fatty acids
VS	Volatile solid
VSS	Volatile suspended solids

CHAPTER 1

INTRODUCTION

1.1 Background

It has been observed that the solid waste generation in Malaysia has increased concurrently with the development of the country. For the past 20 years, Malaysia has undergone an economic growth with the rate of 5.2% (Agamuthu, 2001). The solid waste generated per capital has increased from 0.5kg/capital/day in the 1980´s to current volume of 1kg/capital/day.This represents a 100% increased in 20 years (Agamuthu, 2001).

Municipal solid waste (MSW) is one of the major environmental problems faced by the Malaysian municipalities. Each year, there are about 8 million tonnes of solid waste being generated which accounts to each person generates about 1kg of solid waste per day (LUMES, 2000). Majority of the landfills in Malaysia are crude dumping ground and thus cause various environmental problems such as health hazards, surface water and ground water contamination, odour, etc. Sanitary landfills offer a viable option for the Malaysian municipalities to deal with the environmental hazards caused by open dumps practice within its financial constraints.

Because of low cost and short term solution to solid waste problems, landfills are usually used in solid waste disposal. However, in modern cities such as Kuala Lumpur, there is a growing interest to use transfer station as an economic mode of transportation of MSW before it goes to the landfill. Leachate from wet constituents of solid wastes and water production from biological degradation of solid wastes becomes a source of

water resource pollution. As leachate migrates away from landfill or transfer station it may cause a serious pollution to ground water aquifer as well as adjacent surface waters.

1.2 Problem Statement

There is growing concern about surface and ground water pollution from leachate. Different methods have been introduced for leachate treatment. Treatment of leachate is very complicated, expensive and requires various process applications due to high concentration of COD, BOD, nitrogen, heavy metals as well as colour. Biological, chemical and physical processes have been used to treat leachate. High COD, BOD, ammonia, sulfate and presence of heavy metal in leachate cause different removal efficiency in each method. BOD/COD ratio is one of the factors in selecting treatment methods to remove organic matters. Biological treatment is usually used when BOD/COD ratio is equal or greater than 0.4 (Badkoubi *et al.*, 2002).

In biological processes aerobic and anaerobic organisms are used to treat high concentration of COD. Activated sludge, sequencing batch reactors, aerated lagoon, trickling filters, rotating biological contactors (RBCs) and anaerobic system are used to treat leachate from municipal solid waste landfills.

Anaerobic treatment systems to treat leachate have suffered many difficulties and it leads to instability of bioreactor systems as reported in many studies. Such instability is usually witnessed as a drop in the methane production rate, a drop in the pH, a rise in the volatile fatty acid (VFA) concentration, causing reactor failure.