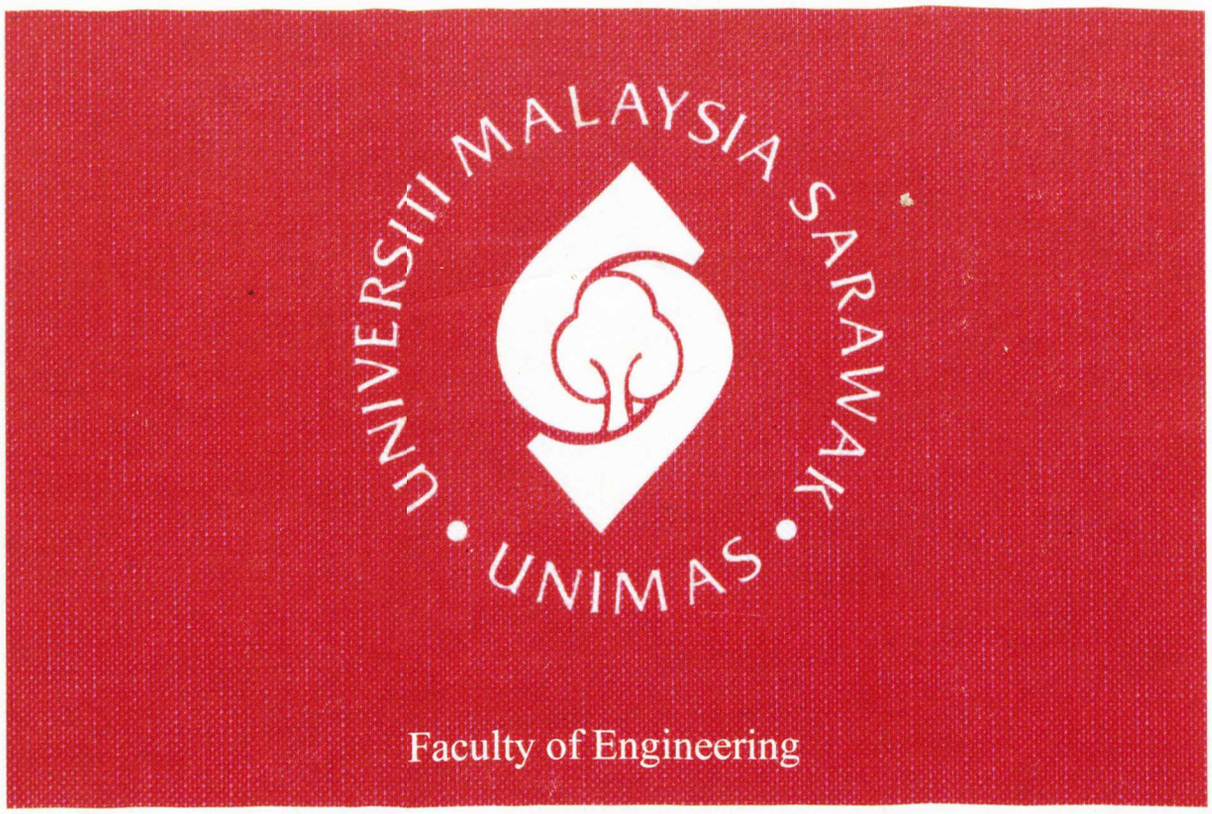

PHYTOREMEDIATION OF PALM OIL MILL EFFLUENT (POME) USING *P.STRATIOTES*

Ong Yong Ching

Bachelor of Engineering with Honours
(Chemical Engineering)
2013

UNIVERSITI MALAYSIA SARAWAK

Grade:_____

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Masters	
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Sekian, terima kasih.

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Yang benar,

Dr Shanti Faridah Salleh

Ketua Jabatan

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This project report which entitled "**Phytoremediation of Palm Oil Mill Effluent (POME) using *P.Stratiotes***" was prepared by Ong Yong Ching (24805) is hereby read and approved by:

DR. IVY TAN AI WEI
Project Supervisor

20/5/2013
Date

PHYTOREMEDIATION OF PALM OIL MILL EFFLUENT (POME) USING *P.STRATIOTES*

ONG YONG CHING

Thesis is submitted to

Faculty of Engineering, Universiti Malaysia Sarawak

In Partial Fulfillment of the Requirements

For the Degree of Bachelor of Engineering

With Honours (Chemical Engineering)

2013

Dedicated to my beloved parents, who always bestow me sustainable motivations and encouragements

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ABSTRACT

Palm oil industry is one of the largest industry in Malaysia. The waste produced from palm oil industry especially the palm oil mill effluent (POME) has become the major concern for public. Department of Environment (DOE), Malaysia has limited the BOD level of POME discharge to 20 mg/L. Therefore, POME treatment is a very important process in palm oil industry. Current technologies for the treatment of POME used in the industry are either not cost effective or unable to reduce BOD level to meet the requirement. This research aims to study the feasiblity of using phytoremediation treatment on POME using *P.Stratiotes* as the macrophytes. Experiments were conducted to study the effects of pH, retention time and plant to POME ratio on the characteristics of POME including BOD, COD and TSS. From the results, it was found that phytoremediation treatment by using *P.Stratiotes* was able to reduce BOD of POME to 85 % at the condition of pH 7 and plant to POME ratio of 0.0500 kg/L. The lowest BOD achieved in this research was 5.90 mg/L which had met the DOE requirement. The highest reduction of COD was 22.1 % at pH 4 whereas TSS was reduced to 80 % at pH 6 with plant to POME ratio of 0.0250 kg/L. The results showed that phytoremediation treatment was effective in the removal of contaminants from POME.

ABSTRAK

Industri minyak sawit telah menjadi salah satu industri terbesar di Malaysia. Sisa yang dihasilkan daripada industri minyak sawit terutamanya pelepasan efluen kilang minyak sawit telah menjadi kebimbangan utama bagi orang awam. Jabatan Alam Sekitar (JAS), Malaysia telah mengehadkan tahap BOD pelepasan POME kepada 20 mg/L. Oleh itu, rawatan effluen kilang minyak kelapa sawit (POME) menjadi satu proses yang sangat penting dalam industri minyak sawit. Teknologi terkini yang digunakan oleh kilang minyak sawit bagi rawatan POME adalah tidak kos efektif dan tidak dapat mengurangkan tahap BOD kepada tahap yang ditentukan oleh JAS. Kajian ini bertujuan untuk mengkaji potensi rawatan *phytoremediation* terhadap POME dengan menggunakan *P.Stratiotes*. Eksperimen telah dijalankan untuk mengkaji kesan beberapa parameter termasuk pH, masa tahanan dan nisbah tumbuhan ke POME pada ciri-ciri POME termasuk BOD, COD dan TSS. Hasil daripada kajian ini menunjukkan bahawa rawatan *phytoremediation* dengan menggunakan *P.Stratiotes* dapat mengurangkan BOD POME sebanyak 85 % pada POME dengan pH 7 dan 0.0500 kg/L nisbah tumbuhan ke POME. BOD terendah yang telah dicapai dalam kajian ini adalah 5.90 mg/L telah memenuhi keperluan JAS. Pengurangan COD adalah kira-kira 22.1 % pada POME dengan pH 4 manakala TSS telah dikurangkan sebanyak 80 % pada POME dengan pH 6 yang mempunyai 0.0250 kg/L nisbah tumbuhan ke POME. Hasil kajian ini menunjukkan bahawa rawatan *phytoremediation* berkesan dalam rawatan POME.

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°	-	Degree
° C	-	Degree Celcius
%	-	Percent
$CaCl_2$	-	Calcium Chloride
$CaCO_3$	-	Calcium Carbonate
Cd	-	Cadmium
cm	-	Centimeter
Cr	-	Chromium
Cu	-	Copper
Fe	-	Ferum
$FeCl_3$	-	Ferum Chloride
HNO_3	-	Nitric Acid
kg	-	Kilogram
kg/L	-	Kilograms per Liter
L	-	Liter
M	-	Molarity
mg/L	-	Milligrams per Liter
$MgSO_4$	-	Magnesium Sulphate
mL	-	Milliliter
Mn	-	Manganese
NaOH	-	Sodium Hydroxide
NH_3 -- N	-	Ammonia Nitrogen
Ni	-	Nickel
Pb	-	Lead
Si	-	Silicon
Zn	-	Zinc

LIST OF ABBREVIATIONS

BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
CVIF	-	Continuous Vertical-Inlet Upflow
DI	-	Deionised Water
DO	-	Dissolved Oxygen
DOE	-	Department of Environment
EAs	-	Ecological Areas
EFB	-	Empty Fruit Bunch
FELCRA	-	Federal Land Consolidation and Rehabilitation Authority
FELDA	-	Federal Land Development Authority
FFB	-	Fresh Fruit Bunch
HRT	-	Hydraulic Retention Time
MBR	-	Membrane Bioreactor
OPF	-	Oil Palm Fronds
OPT	-	Oil Palm Trunk
PKS	-	Palm Kernel Shell
POME	-	Palm Oil Mill Effluent
POMS	-	Palm Oil Mill Sludge
PPF	-	Palm Press Fiber
RBC	-	Rotating Biological Contactor
RISDA	-	Rubber Industry Smallholders Development Authority
SRT	-	Solids Retention Time
TN	-	Total Nitrogen
TP	-	Total Phosphorus
TSS	-	Total Suspended Solid
UF	-	Ultrafiltration
UNIMAS	-	Universiti Malaysia Sarawak

VF	-	Vermifiltration
VFA	-	Volatile Fatty Acids

CHAPTER 1

INTRODUCTION

1.1 Palm Oil Industry in Malaysia

Palm oil derived from fruit of oil palm tree is comestible plant oil and high in saturated fats. There are two major species of oil palm tree which are African Oil Palm (*Elaeis guineensis*) and Americal Oil Palm (*Elaeis oleifera*) (WWF, 2012). Palm oil industry has becoming one of the top agricultural industries in Malaysia since last decades. A lot of factories and palm oil mills have been operated to process the fruits from oil palms. Every year, large quantity of waste derived from palm oil industries are produced and hence environmental study remains a critical problem for researchers (Razali et al., 2009; Alkhatib, 2011). Currently, Malaysia has becoming one of the world's largest palm oil exporters around the globe. It constitutes for about 39 % of world palm oil production and 44 % of world exports. The total oil palm planted area in Malaysia during June 2012 was about 5,037,959 hectare (Malaysian Palm Oil Council, 2012). **Table 1.1** shows the oil palm planted area in Malaysia by category as in June 2012.

Table 1.1: Oil palm planted area in Malaysia by category as in June 2012 (Malaysian Palm Oil Council, 2012)

Category	**Hectares**	**%**
Private Estates	3,091,407	61.4
FELDA	711,108	14.1
FELCRA	166,984	3.3
RISDA	78,676	1.6
Govt./State Agencies	308,517	6.1
Independent Smallholders	681,267	13.5
Total	**5,037,959**	**100.0**

1.2 Palm Oil Wastes

There are several types of wastes produced from palm oil mills which include palm oil mill effluent (POME), empty fruit bunch (EFB), oil palm trunk (OPT), oil palm fronds (OPF), palm press fiber (PPF), palm kernel, palm kernel shell (PKS) and cake. However, only EFB, PPF, PKS and POME have been shown in big amount and considered as wastes while the others are sold as animal feed or fertilizer (Razali et al., 2009). These wastes bring huge consequence to environment if not treated properly (Zinatizadeh, 2006).

1.2.1 Liquid Effluent

Liquid effluent is mostly formed from the sterilization and clarification processes in palm oil mills where huge quantities of steam and hot water are being used. Hydro-cyclone operation is a process where the broken shells are separated from the kernels resulting in another source of waste. POME is formed from the mixing between both effluents (Zinatizadeh, 2006). It is a common liquid waste that is being produced in palm oil mill through the process of oil extraction, washing and cleaning processes in the mill. POME contains cellulosic materials, fat, oil and grease (Zinatizadeh, 2006; Rupani, 2010). It also contains significant amount of solid which are suspended solid and total dissolved solid for about 18,000 mg/L and 40,000 mg/L, respectively where these solids are usually known as palm oil mill sludge (POMS) (Rupani, 2010).

1.2.2 Solid Wastes

Leaves, trunk, decanter cake, EFB, seed shells and fiber are the solid wastes that are produced through extraction process (Rupani, 2010). The EFB is being burnt to produce potassium hydroxide which is used in the agricultural as fertilizer. Boiler fuel is produced by using fiber and shell materials whereas palm kernel is normally sold to palm kernel oil producers to extract the palm kernel oil (Zinatizadeh, 2006).

1.2.3 Gaseous Emission

The sources for gaseous emission from palm oil mill are mainly from boiler and incinerator caused by incomplete combustion of solid materials such as waste fiber, shell material and EFB (Zinatizadeh, 2006). Usually, POME is treated in open area such as pond and open digestion tank systems. This brings difficulty in collecting biogas that causes environmental pollution (Zinatizadeh et al., 2007).

1.3 Palm Oil Mill Effluent (POME)

Besides palm kernel, POME is another waste that is being generated from palm oil mill. It has a potential to damage environment if discharged untreated. POME is a greasy wastewater produced by the palm oil mill (Mustapa, 2008; Rupani, 2010). It is a thick brownish liquid that consists of high solids, oil and grease, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) values (Rupani, 2010). Generally, it consists of organic compounds created from biodegradable materials (Sulaiman and Ling, 2004). According to Sime Darby Plantation (2011), every ton of fresh fruit bunch process produces around 0.1 ton of raw POME. Rupani et al. (2010) also claimed that huge amount of water is needed in order to extract crude palm oil from fresh fruit bunch (FFB). For every ton of crude palm oil produced, about 5 – 7.5 ton of water is required where more than half of the water ends up as POME.