STUDY OF THE EFFECTS OF *Limnocharis Flava* (YELLOW VELVETLEAF) ON WASTEWATER QUALITY FROM OIL PALM PRODUCTION

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ABSTRACT

Malaysia is world biggest exporter of quality palm oil. Oil palm in Malaysia was contributing 50% of world production. From palm oil processing, a large amount of solid wastes such as palm trunks, palm fronds, empty bunches and palm shell are generated. These wastes offer problems to environment if not treated and properly dealt with. There are many ways to treat the POME. One of the alternative treatment methods was biological treatment, by using of emergent aquatic plants which was *Limnocharis Flava*. The research had two objectives: 1) to investigate an optimal design condition whereby emphasis was placed on waste water circulation and 2) to study the feasibility of *Limnocharis Flava* in Palm Oil Mill Effluents (POME) treatment system. The aquatic plant treatment method consisted of 4 plastic containers which 7 gal of each capacity and aquarium pump. This experiment consisted of three condition in which: the wastewater only (control 1), POME and aquatic plants without circulation (control 2), and the last one is POME, aquatic plant and the existence of circulation (sample) from a container to another one. The experiments were conducted in 9days to reduce the contaminants such as TSS, COD, BOD and Oil and Grease. The effectiveness of treatment using aquatic plants only were the second highest, while wastewater treatment plants without the plants and circulation give the most lowest percentage during the process of removal of organic material. The greatest percentage removal of contaminated materials when the existence of aquatic plants and circulation where 97.48% of Oil and grease was removed followed by the percent removal of BOD, TSS and COD were 86.6%, 82.65% and 76% respectively.

ABSTRAK

Malaysia adalah pengeksport terbesar di dunia minyak kelapa sawit berkualiti. kelapa sawit di Malaysia memberikan sumbangan 50% daripada pengeluaran dunia. Dari pemprosesan minyak kelapa, sejumlah besar hasil buangan seperti batang kelapa, daun kelapa sawit, tandan kosong dan tempurung kelapa yang dihasilkan. Sisa ini menawarkan masalah persekitaran jika tidak dirawat dan ditangani dengan betul. Ada banyak cara untuk mengubati POME. Salah satu kaedah rawatan alternatif rawatan biologi, dengan menggunakan tanaman akuatik yang muncul iaitu *limnocharis flava*. Penelitian ini mempunyai dua sasaran: 1) untuk menyiasat suatu keadaan desain yang optimum di mana penekanan diletakkan pada sirkulasi sisa air dan 2) untuk kajian kelayakan *limnocharis flava* di Limbah Pabrik Minyak Sawit (POME) sistem rawatan. Kaedah kilang pemprosesan air terdiri dari 4 bekas plastik yang masing-masing 7 gal keupayaan dan pam akuarium. Kajian ini terdiri daripada tiga keadaan di mana: hanya air sisa (kawalan 1), POME dan tanaman air tanpa sirkulasi (kawalan 2), dan yang terakhir adalah POME, tanaman air dan adanya sirkulasi (contoh) dari bekas ke bekas lain. Percubaan dilakukan selama 9 hari untuk mengurangkan kontaminan seperti TSS, COD, BOD, dan Minyak dan Gris. Keberkesanan rawatan menggunakan tanaman air merupakan yang kedua tertinggi kedua, sedangkan tanaman tanpa pemprosesan sisa tanaman dan sirkulasi memberikan peratusan paling terendah ketika proses penghapusan bahan organik. Peratusan penghapusan terbesar bahan tercemar ketika kewujudan tumbuhan akuatik dan sirkulasi di mana 97,48% dari Minyak dan lemak telah dihapuskan diikuti dengan penghapusan peratus BOD, TSS dan COD adalah 86,6%, 82,65% dan 76% masing-masing.

TABLES OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

%	-	Percentage
°C	-	Degree Celsius
BOD	-	Biological Oxygen Demand
BOD_5		Biological Oxygen Demand for 5 days
COD	-	Chemical Oxygen Demand
D_1	-	Dissolved Oxygen value in initial sample
D_2	-	Dissolved Oxygen in final sample
DO	-	Dissolved Oxygen
EQA		Environmental Quality Act
FKASA		Faculty of Civil Engineering and Earth Resources
gal	-	Gallon
H_2SO_4,	-	Sulphuric Acid
HR	-	Higher Range
L	-	Liter
LR	-	Lower Range
m	-	Meter
m^3		Cubic Meter
mg	-	miligram
mL	-	miliLiter
O & G	-	Oil and Grease

P	-	Decimal volumetric fraction of sample used

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

Palm oil and its liquid fraction, palm olein are consumed worldwide as cooking oils and constituents of margarine and shortening. During oil palm planting and processing, a large amount of solid wastes such as palm trunks, palm fronds, empty bunches and palm shell waste are generated (Hussain et al., 2006) beside the liquid wastes that may have a major impact on the environment if they are not properly dealt with.

Empty fruit bunch is the most common among these by-products. The empty bunch is a solid waste product of the oil palm milling process and has a high moisture content of approximately 55-65% and high silica content, from 25% of the total palm fruit bunch. Effluent water is defined as water discharged from industry, which contains soluble materials that are injurious to the environment (Igwe and Onyegbado, 2007).

Palm Oil Mill Effluent or POME contains 4,000 mg/L of oil and grease, which is relatively high compared to the limit of only 50 mg/L set by the Malaysian Department of Environment. Currently effluent discharged from palm oil mill, which have high concentration of organic contents, is dumped into open lagoons for anaerobic treatment. Under the current treatment system, POME is a large source of methane emission through open lagoons. Without treatments, clean water cannot be produced and the pollution will rise day by day.

Today, many attentions are focused on industrial effluents which may cause severe impact to environmental is the discharge of industrial facilities and several technologies have been invented to treat industrial effluent to meet the department of environmental (DOE) discharge standard. The rapid development of the palm oil industries in Malaysia over the years produce high amount of palm oil mill effluent (POME). During palm oil extraction, about 1.5 tones of palm oil mill effluent (POME) is produced per tone of fresh fruit bunch (FFB) processed (Hojjat et al., 2009).

In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, use up dissolved oxygen as they decompose, and after that were block the light to deeper waters where less oxygen can be supplied into the water. This, in turn, proves very harmful to aquatic organisms as it affects the respiration ability of fish and other invertebrates that reside in water.

Water treatment describes those processes used to make water more acceptable for a desired end use, including as drinking water, industrial processes, medical and many other uses. The goal of all wastewater treatment process is to remove existing contaminants in the water, or reduce the concentration of such contaminants so it becomes fit for its desired end use. One such use is returning water that has been used back into the natural environment without adverse ecological impact.

The study aims to investigate the efficiency of using emergent aquatic plant which is *Limnocharis Flava* including efficient removal of *nutrients* from the POME *wastewater* based on the circulation treatment system.

1.2 Problem Statement

Malaysia is fast becoming an industrial country. In support of Vision 2020 (Yusoff, 2006) towards achieving developed nation status, many of rivers have become polluted due to the many wastes that have been poured out into rivers, require chemicals, often poisonous in its production. The rivers are used as an outlet for the chemicals to drain away, in turn harming the waters and the lives that revolve around them. Department of Environment identified the palm oil processing industries as the biggest polluters in 1995. According to Ahmad et al (2003), POME has been identified as 100 times as polluting as domestic sewage. Furthermore, it is reported that all highly polluted rivers located in a highly urbanized area has altered the quality of water as disturbances to biodiversity.

Figure 1.1: Fresh POME from LCSB factory

There are many ethnic aboriginal groups that still exist in Malaysia and the people depend on the rivers and streams to survive. They depend on the river for food, water supply for drinking, bathing and for their crops. Besides that, the river as a major center of their livelihoods and without the rivers the whole tribes cannot survive as their ancestors had done generations before them, because all of them are depending on the rivers.

On the other hand, species richness of herbaceous plants can increase with moderate enrichment. However, severe enrichment drastically shifts community structure, and can decrease species richness. This might be particularly true of macrophyte communities in flowing water wetlands, where nutrients otherwise tend to be less limiting than in most standing water (basin) wetlands. But, some species have been found to develop tolerant eco-types that either able to survive at higher concentration (Mishra et al., 2008) of POME and some species are not able to survive at higher concentration of POME. Because of that, it is very important in determining the appropriate macrophytes species that can survive in the industrial wastewater environment. Thus, the industries have become a threat to the aquatic living and the ecosystem.

Palm oil industries are facing tremendous challenges to meet the increasingly stringent environmental regulations. Over the past decades, several cost-effective treatment technologies comprising anaerobic, aerobic and facultative processes have been developed for the treatment of POME. Anaerobic treatment has been widely practiced to treat strong organic wastewater. In Malaysia, a system of anaerobic open ponds is the most popular treatment, since it can offer the lowest treatment cost as well as simplicity in design and operation. However, it has several drawbacks such as extremely low treatment efficiency, and there can be a problem of odors (Chaiprasert et al., 2003).

A long retention time is required for treatment using anaerobic ponds; hence a series of several ponds is commonly needed and required a reasonably large land area. Moreover, the generation of methane from these open ponds will be emitted to atmosphere. Nowadays, the crisis of oil price including low environmentally sound and very high land price makes the anaerobic open pond system unattractive.

In this research, an alternative treatment was suggested by using an aquatic plant (*Limnocharis Flava*) to treating the dangerous POME. This kind of treatment is cost effective compared to chemical treatment system, low maintenance requirements and operational costs also environmental friendly. Besides that, it may reduce the aquatic toxicity (Wyszynska, 2006) in order to improve the water quality and finally industrial effluents discharge standards requirement can be achieved.

Because of its capability to reduce the organics and inorganic compounds in wastewater, this treatment also can take into consideration that is able to reduce the pollutant in the Palm Oil Mill Effluent. The purpose of circulation system is to supply the oxygen to the wastewater and assist the algae and microorganism growth. The more escalation of microorganism and algae growth will be the shorter retention time desirable to decrease the pollutants in POME. Furthermore, this technique has opportunity to be developed and commercialized into POME wastewater treatment technologies.

1.3 Objective of the Study

There are two main objectives of this research study. The objectives are:

1) To investigate an optimal design condition whereby emphasis is placed on waste water circulation.

2) To study the feasibility of *Limnocharis Flava* in Palm Oil Mill Effluents (POME) treatment system.

1.4 Scope of Research Work

The treatment system is consists of yellow velvetleaf (*Limnocharis Flava*) that vegetate in POME stage 7 with different experimental conditions. Parameters that considered to be analyzed in the experiment are Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD), pH, Total Suspended Solid (TSS), and Oil and Grease (O&G).

The scopes of this study are;

i. Investigate the removal efficiency in treatment system by using *Flava*.

ii. The treatment system will be conducted in 9 days; the sample of wastewater will be examined once in 2 days.

iii. The sample of palm oil mill effluent is obtained from LCSB Oil Palm Plantation in Lepar Hilir.

iv. The POME is taken from stage 7.

v. The *Limnocharis Flava* is collected from Maran, Kuantan.

vi. The experiment will be conducted in University Malaysia Pahang.

vii. Investigate the effectiveness of circulation process (to enhance aquatic plant treatment).

Figure 1.2: LCSB Oil Palm Factory

Figure 1.3: POME at stage 7

Figure 1.4: Lab Scale Experiment

1.5 Significance and Rationale

The objective of this study is to investigate the novelty of the research and the ability of the yellow velvetleaf (*Limnocharis Flava*) in removing an inorganic compounds and organic compounds in treatment system. Since POME containing compounds that are toxics and harmful to the environment, it becomes necessary that effluents water should be treated or purified before discharged into the environment (Igwe & Onyegbado, 2007).

Biological treatment methods is the most effective and eco-friendly option of the available treatment processes (Wyszynska, 2006). The abundance supply of yellow velvetleaf (*Limnocharis Flava)* will reduce the operational costs to handle a wide range of flows (Wyszynska, 2006) of the research project. In addition, this treatment need less energy required, environmental friendly and gives the attraction to the varied wildlife. Lastly, it has potential to be developed into an environmentally and economically industrial wastewater technology.

CHAPTER 2

LITERATURE REVIEW

2.1 Palm Oil Industry in Malaysia

The oil palm is indigenous to West Africa (Hai, 2002). Oil palm or it scientific name is *Elaeis guineensis* is one of the most versatile crops in tropical countries. The first commercial oil palm estate in Malaysia was set up in 1917. Although commercial planting of oil palm in Malaysia began in 1917, large-scale cultivation did not take off until the 1960s following the Government's crop diversification thrust strategy to reduce the country's dependence on rubber, which hitherto had been one of the two pillars of the Malaysian economy (Hai, 2002).

Since then the industry in Malaysia has been growing by leaps and bounds, Palm Oil Industry become one of the most important contributors to Malaysia economy. The Malaysian palm oil industry is growing rapidly and becomes a very important agriculture-based industry. The increase in production in Sabah was particularly impressive, reflecting the aggressive planting policy in the state and it became the largest CPO producer in 1999. In 2001, Sabah accounted for 31.5% of the national production. Other major CPO producing states are Johor, Pahang and Perak in Peninsular Malaysia (Hai, 2002).

Table 2.1: Production of Crude Palm Oil in Malaysia (Tonnes).

Region	1980	1990	1995	1999	2000	2001
P. Malaysia	2,394,324	6,094,622	6,094,560	7,427,838	7,221,539	7,477,338
Sabah	156,471	678,995	1,493,623	2,664,516	3,110,320	3,716,168
Sarawak	22,378	107,651	222,363	461,564	520,236	610,282
Total	2,573,173	6,881,268	7,810,546	10,553,918	10,852,095	11,803,788

Source: MPOB (www.mpob.gov.my)

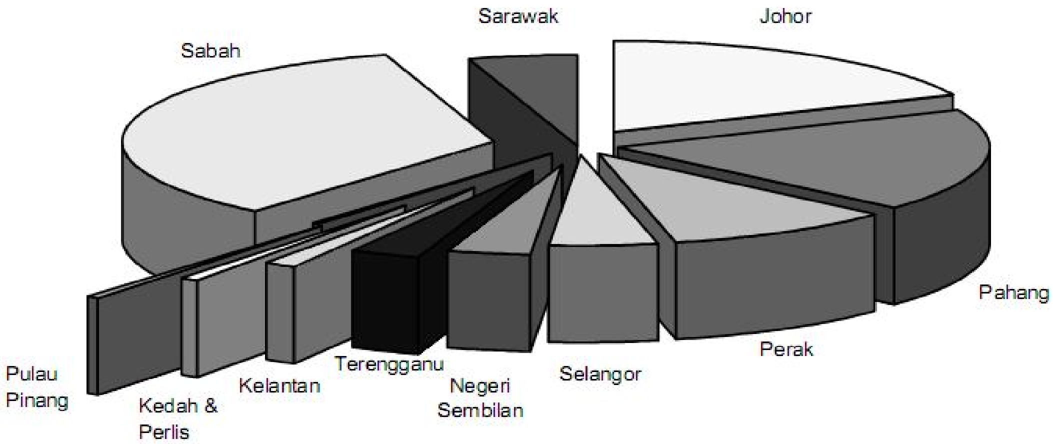

Figure 2.1: Production of Crude Palm Oil by States in 2001 by (Hai, 2002)

Now, Malaysia is the world’s leading producer and exporter of palm oil, replacing Nigeria as the chief producer since 1971 (Yusoff, 2004).

Today, even though Indonesia is the world's largest producer of palm oil, but Malaysia is still the world's biggest exporter of quality palm oil with revenue of RM65 billion last years and emerged as the only country have the highest quality palm oil (Bernama News). *Recently, the Director General of Malaysia Palm Oil Board (MPOB), Dato' Dr. Mohd Basri Wahid said in Bernama News that* Malaysia was contributing 50.0% of world production. It was estimated that 75 percent of the total production of the country's palm oil in 2008 where 21.76 million metric tonnes was exported.

Table 2.2: World Production of Palm Oil

Country of Origin	1990	1995	1999	2000	2001
Malaysia	6,095	7,811	10,554	10,800	11,804
Indonesia	2,413	4,480	6,250	6,900	7,480
Nigeria	580	660	720	740	750
Colombia	226	387	500	516	547
Cote d'Ivoire	270	285	282	290	275
Thailand	232	354	475	510	535
Ecuador	120	180	230	215	240
Papua New Guinea	145	223	260	281	325
Others	786	1,097	1,339	1,699	1,226
Total	10,867	15,477	20,610	21,951	23,182

Source: Oil World and MPOB (cited in www.mpob.gov.my)

Table 2.3: World Major Exporters of Palm Oil

Country	1990	1995	1999	2000	2001
Malaysia	5,727	5,613	8,914	9,056	10,618
Indonesia	1,163	1,856	3,319	4,140	4,800
Papua New Guinea	143	220	254	282	320
Cote d'Ivoire	156	120	105	110	124
Singapore	679	399	292	293	259
Hong Kong	51	275	94	132	187
Others	276	790	837	909	1,063
Total	8,195	10,173	13,815	14,922	17,371

Source: Oil World (cited in www.mpob.gov.my)

2.2 Liquid Effluents

The production of palm oil results in the generation of large quantities of polluted wastewater which commonly referred to palm oil mill effluent (POME). Typically, 1 tonne of crude palm oil production requires 5 to 7.5 tonnes of water; over 50 % of which ends up as POME (Ahmad et al., 2003). Based on palm oil production in 2005 (14.8 million tonnes), an average of about 53 million m^3 POME is being produced per year in Malaysia.

POME is complex in nature and content highly organic matter (Tan et al., 2006). From environmental perspective, fresh POME is hot and acidic brownish colloidal slurry of 95-96% water, 0.6-0.7% oil, and 4-5% total solids including 2-4% fine suspended solids. The temperature is about 80 to 90^{o}C and it's slightly acidic with a pH in between 4.0 to 5.0 (Sethupathi, 2004). This polluting effluent has total solids content of 5–7% of which a little over half is dissolved solids. This property, coupled with its high BOD loading, makes it not only highly polluting but also extremely difficult to treat (Bhatia et al, 2006). High metal such as Calcium (Ca), Zinc (Zn), Carbon (C), Potassium (K) also included in POME.

POME contains 4,000 mg dm^{-3} of oil and grease, which is relatively high compared to the limit of only 50 mg dm^{-3} set by the Malaysian Department of Environment POME. POME contains very high organic matter as indicated by its high BOD. POME has been identified as 100 times as polluting as domestic sewage (Okwute et al., 2006). If the untreated effluents are discharged into watercourses, it is certain to cause considerable environmental problem (Davis and Reilly, 1980). Aside from being one of Malaysia's highest money earning industry, palm oil production is also one of the major potential, if unabated, organic polluters of the environment producing very high strength waste effluents (Shah and Singh, 2004). Now, POME becomes one of the major sources of aquatic pollution in Malaysia.

Below is the characteristic of fresh POME and its discharge standard for Malaysia.

Table 2.4: Characteristic of POME

CHARACTERISTICS OF POME		
Parameter*	Mean	Range
pH	4.2	3.4 - 5.2
Biological Oxygen Demand	25000	10250 - 43750
Chemical Oxygen Demand	51000	15000 - 100000
Total Solids	40000	11500 - 79000
Suspended Solids	18000	5000 - 54000
Volatile Solids	34000	9000 - 72000
Oil and Grease	6000	130 - 18000
Ammoniacal Nitrogen	35	4 - 80
Total Nitrogen	750	180 - 1400
*Units in mg/l except pH		

This tables cited in www.mpob.gove.my

Table 2.5: Palm Oil Mill Effluent Discharge Standards

PALM OIL MILL EFFLUENT DISCHARGE STANDARDS

Parameter*	Std A	Std B	Std C	Std D	Std E	Std F
	1/7/78	1/7/79	1/7/80	1/7/81	1/7/82	1/7/84
pH	5 - 9	5 - 9	5 - 9	5 - 9	5 - 9	5 - 9
Biological Oxygen Demand	5000	2000	1000	500	250	100
Chemical Oxygen Demand	10000	4000	2000	1000	-	-
Total Solids	4000	2500	2000	1500	-	-
Suspended Solids	1200	800	600	400	400	400
Oil and Grease	150	100	75	50	50	50
Ammoniacal Nitrogen	25	15	15	10	150	100
Total Nitrogen	200	100	75	50	-	-
Temperature (°C)	45	45	45	45	45	45

*Units in mg/l except pH and temperature

This tables cited in www.mpob.gove.my

Table 2.6: Environment Quality Act
1974

THIRD SCHEDULE

ENVIRONMENTAL QUALITY ACT 1974

ENVIRONMENTAL QUALITY (SEWAGE AND INDUSTRIAL EFFLUENTS) REGULATIONS 1979

(REGULATIONS 8(1), 8(2), 8(3)

PARAMETER LIMITS OF EFFLUENTS OF STANDARDS A AND B

Parameter		Unit	Standard	
			A	B
(i)	Temperature	°C	40	40
(ii)	pH value	-	6.0 - 9.0	5.5 - 9.0
(iii)	BOD at 20°C	mg/ l	20	50
(iv)	COD	mg/ l	50	100
(v)	Suspended Solids	mg/ l	50	100
(vi)	Mercury	mg/ l	0.005	0.05
(vii)	Cadmium	mg/ l	0.01	0.02
(viii)	Chromium, Hexavalent	mg/ l	0.05	0.05
(ix)	Arsenic	mg/ l	0.05	0.10
(x)	Cyanide	mg/ l	0.05	0.10
(xi)	Lead	mg/ l	0.10	0.5
(xii)	Chromium Trivalent	mg/ l	0.20	1.0
(xiii)	Copper	mg/ l	0.20	1.0
(xiv)	Manganese	mg/ l	0.20	1.0
(xv)	Nickel	mg/ l	0.20	1.0
(xvi)	Tin	mg/ l	0.20	1.0
(xvii)	Zinc	mg/ l	2.0	2.0
(xviii)	Boron	mg/ l	1.0	4.0
(xix)	Iron (Fe)	mg/ l	1.0	5.0
(xx)	Phenol	mg/ l	0.001	1.0
(xxi)	Free Chlorine	mg/ l	1.0	2.0
(xxii)	Sulphide	mg/ l	0.50	0.50
(xxiii)	Oil and Grease	mg/ l	Not Detectable	10.0