EFFECTS OF *IPOMOEA AQUATIC/IPOMOEA REPTANS* (KANGKUNG) ON WASTEWATER QUALITY FROM OIL PALM PRODUCTION

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ABSTRACT

In this era of complex and modern technology, water pollution has become a severe problem for the world to cope with. Enormous expenditure has been delivered to resolve this serious matter. Unfortunately, most of the efforts are to no avail without the people awareness and responsibility towards clean environment. To prevent this phenomenon from continuing spread, researchers have found a solution by using the power of nature. It is called Aquatic Plant System. This concept is an improvised technique from the wetland system. The system is an alternative in wastewater engineering especially for water treatment. The water treatment act as secondary filter to our wastewater after the treatment. Uniquely, the wetland system can operate by itself without so much works. This study was conducted to explore the feasibility of using plant species to remediate effluent from palm oil mill effluent. To achieve the objective, *Ipomoea Aquatic* was chosen for this project. This plant is tested with wastewater from LCSB Oil Palm Plantation in Lepar for two weeks. The water parameters that have been monitored were BOD5, COD, pH, TSS, and Oil and Grease. From the overall experiment results, we found that the removal percentage as follows, for BOD_5 is 80.1%, 75.2% for COD, 78.2% for TSS and 85.4% for Oil and Grease. Thus, *Ipomoea Aquatic* is potential to reduce toxic compounds in wastewater and it economic since it use the natural way.

ABSTRAK

Pada zaman moden yang canggih dan kompleks ini, pencemaran air telah menjadi isu dan masalah besar kepada seluruh masyarakat di dunia. Perbelanjaan besar telah diperuntukkan untuk menyelesaikan masalah ini. Namun, hampir semua usaha yang telah dijalankan menemui jalan buntu kerana ianya tidak akan berjaya tanpa kesedaran manusia itu sendiri mengenai kebersihan alam sekitar. Untuk mengelakkan fenomena ini daripada berlaku lebih buruk, para penyelidik menyarankan penggunaan teknik tumbuhan akuatik. Ia merupakan teknik yang diolah dan dipertingkatkan daripada teknik tanah bencah. Sistem tanah bencah ini merupakan satu alternatif dalam kejuruteraan air sisa dalam merawat pencemaran air. Sistem ini berfungsi sebagai penapis kepada air yang menjalani rawatan di loji rawatan air. Uniknya, sistem ini boleh beroperasi secara semulajadi tanpa memerlukan penyelenggaraan yang kerap. Projek ini dijalankan untuk mengkaji kebolehan tumbuhan akuatik menyingkirkan air sisa pemprosesan kelapa sawit.Dalam mencapai matlamat dan objektif ditetapkan, spesis tumbuhan akuatik telah dipilih untuk menjayakan projek ini.Tumbuhan tersebut ialah Kangkung(*Ipomoea Aquatic*). Tumbuhan ini diuji dengan air tercemar yang diperolehi daripada Kilang Kelapa Sawit LCSB di Lepar selama dua minggu. Bacaan parameter yang akan digunapakai dalam projek ini adalah BOD_5, COD, pH, pepejal terampai dan Minyak dan Gris. Daripada kajian ini, didapati bahawa penyingkiran adalah 80.1% untuk BOD5, 75.2% untuk COD, 78.2% untuk pepejal terampai and 85.4% untuk Minyak dan Gris.Maka dengan ini, Kangkung (*Ipomoea Aquatic*) berpotensi mengurangkan bahan cemar di dalam air sisa dan kosnya rendah kerana menggunakan kaedah semulajadi.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Palm oil comes from the fruit of the *Elaeis guineensuis* tree, also called the African oil palm tree. Native to Africa and now extensively cultivated in Malaysia, the tree bears a fleshy fruit which is the source of both palm oil and palm kernel oil. Palm oil is entirely different than palm kernel oil, which has a higher amount of saturated fat and has to be heavily processed to be extracted. Palm kernel oil is, in general, unhealthy.

Figure 1.1: Palm Fruit

Palm oil is the most versatile of all vegetable oils. It is consisting of 50% saturated fat and 50% unsaturated fat. It is semi-solid at room temperature. It is also odourless and tasteless. These two properties have made palm oil ideal for baked goods and packaged foods. Palm oil also works well with fried foods and stir-fry because its quality doesn't diminish under extremely high heat. Unlike most nutritional oils, palm oil is highly resistant to oxidation, giving it a longer shelf life.

Technological development has transformed the Malaysian palm oil industry into a strategic and well planned industry that responds to global challenges. In particular, genetic knowledge since as early as 1912 first led the phenomenal growth of the industry through the planting of tenera instead of dura palms. This was complemented by the government allocating land to the poor and landless to plant more oil palm, in great part causing the area to increase from 62 000 ha in 1975 to 1.02 million hectares in 1980 and 2.03 million hectares in 1990. By 2007, there were 4.3 million hectares of oil palm, constituting nearly two-thirds of the national agricultural area (Figure 1.2). Malaysia continues to be the world’s largest palm oil producer with a production of 16.20 million tonnes in 2006. The success of the crop is largely market driven with good long term price prospects for palm oil making oil palm more attractive than most other crops. Palm oil contributes more than one-third of the national agricultural GDP, generating RM 31.81 billion in export earnings in 2006, making it one of the pillars of Malaysia’s economy. At present, the industry employs more than 1.5 million people in the core and related sectors.

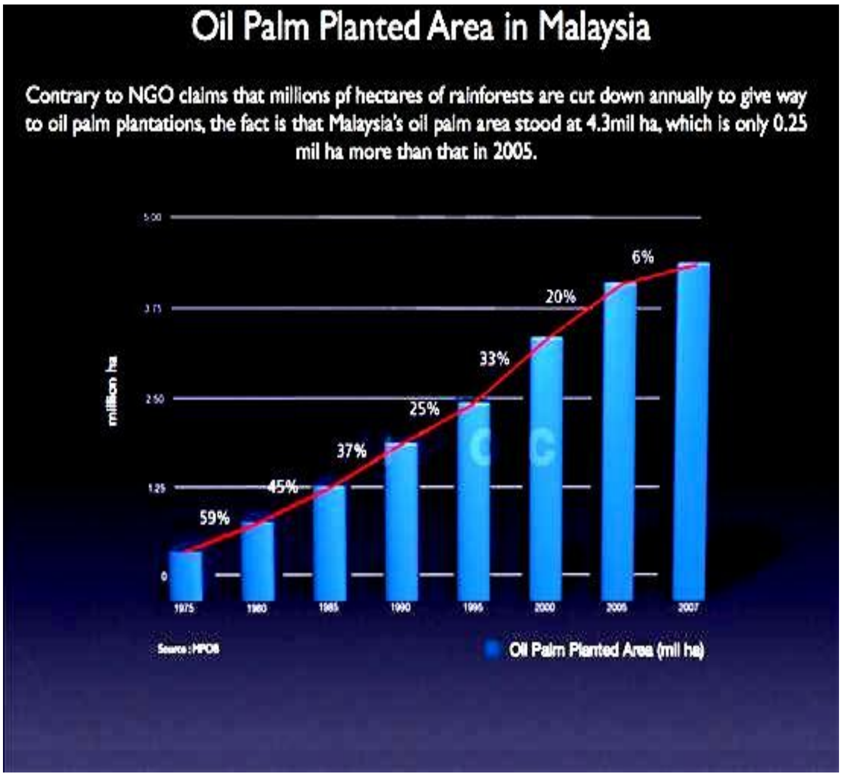

Figure 1.2: Oil Palm Planted Area in Malaysia 1975-2007

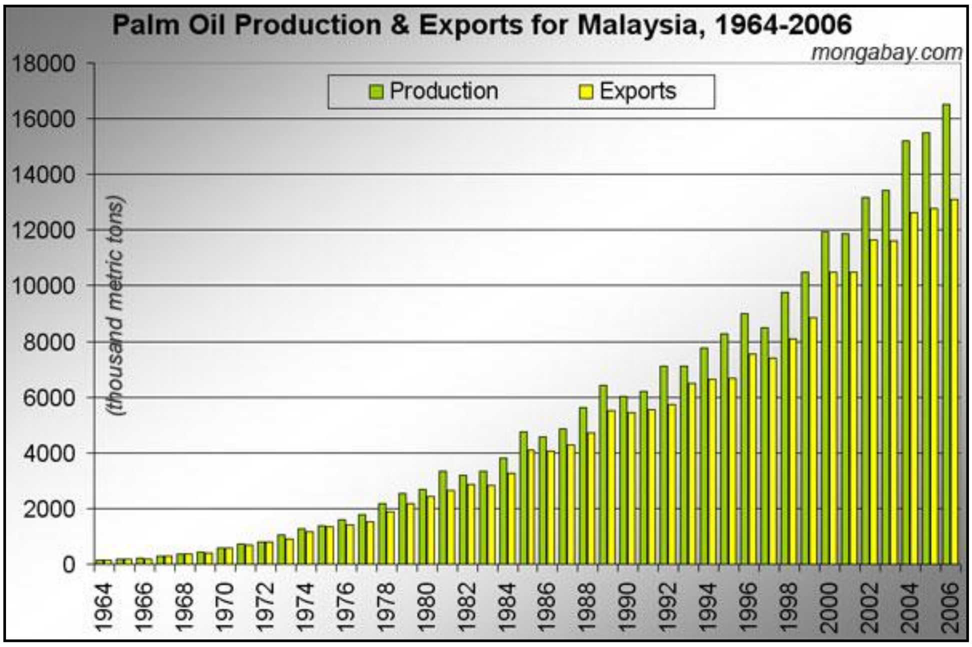

Figure 1.3: Palm Oil Production and Exports for Malaysia 1964-2006

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. In 1992, Malaysia produced about 6.7 million tonnes of crude palm oil contributing to 15.9 million cubic metres of palm oil mill effluent (POME). Raw POME has a high biochemical oxygen demand (BOD) which is about one hundred times more than that of sewage.

Realising the escalating situation, measures to counter pollution from POME have been deployed. In order to regulate the discharge of effluent from the crude palm oil (CPO) industry as well as to exercise other environmental control, The Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order, 1997 and The Environment Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1997 were promulgated under the Environmental Quality Act, 1974.

The government acted responsibility in enacting the Environment Quality Act 1974 and specific regulations for palm oil mill effluent. It is mandatory for all palm oil mills to treat their waste waters on site to an acceptable level before it is allowed to be discharged into water courses. The enactment of the environment regulations in 1975, a concerted and intensive research and development programmed has been initiated by both the public and private sector to find cost-effective solutions in minimize the environment impact of the palm oil industry. Another treatment process that can treat POME as well as recover the water is the evaporation process. About 85% of water in the POME can be recovered as distillate.

1.2 Research Background

Palm oil is one of the two most important vegetable oils in the world market following Soya beans [Hartley, C.N.S., 1988]. Oil palm (*Elaeis guineensis*) is the most productive oil producing plant in the world, with one hectare of oil palm producing between 10 and 35 tonnes of fresh fruit bunch (FFB) per year [Hartley, C.N.S., 1988;Ma, A.N., Y. Tajima, M. Asahi and J. Hannif, 1996]. The palm has a life of over 200 years, but the economic life is 20-25 years (nursery 11-15 months, first harvest is 32-38 months from planting and peak yield is 5-10 years from planting).

There are several stages of processing the extraction of palm oil from fresh fruit bunches (FFB). These include sterilization, bunch stripping, digestion, oil extraction and finally clarification and purifications; each process with its own various unit operations [Usoro, E.J., 1974].These extraction and purification processes generate different kinds of waste.

The oil palm mills generate many by-products and wastes beside the liquid wastes that may have a significant impact on the environment if they are not properly dealt with. 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.

1.3 Problem Statement

Palm oil is one of the two most important vegetable oils in the world's oil and fats market. The extraction and purification processes generate different kinds of waste generally known as palm oil mill effluent (POME). The environmental impact of POME cannot be over emphasized; hence the need for treatment measures to reduce these impacts before discharge.

Water pollution is a term that describes any adverse effect upon water bodies (lakes, rivers, the sea, groundwater etc.) caused by man and his activities. Organic wastes impose high oxygen demands on the receiving water leading to oxygen depletion with potentially severe impacts on the whole eco-system. Industries discharge a variety of pollutants in their wastewater including heavy metals, organic toxins, oils, nutrients, and solids. Water pollution affects organisms and plants that live in these water bodies and in almost all cases the effect is damaging either to individual species and populations but also to the natural biological communities. It occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful constituents. Additionally, many factories discharge undiluted poisons, corrosives and other completely noxious substances.

Malaysia currently accounts for 48% of world palm oil production and 58% of world export. However, the rapid growth of the palm oil industry in Malaysia has invited serious water pollution in the rivers. In year 2005, 14.96 million tonnes of crude palm oil (CPO) had been produced that resulted in 44.88 million tonnes of Palm Oil Mill Effluent (POME). With this statistics, the palm oil mill industry in Malaysia is identified as the industry that produces the ever largest pollution load into the rivers of Malaysia.

Palm oil production is growing fast in line with the swelling world population and global demand. From the earliest days, oil palm thrives in countries with tropical climate and evenly distributed rainfall. Malaysia has therefore emerged as major producers of palm oil. Palm oil processing, similar to other agricultural and industrial activities, raised environmental issues particularly water pollution which adversely affects aquatic life and domestic water supply.

Aquatic Plant System technology can be developing to replace previous treatment used to treat POME where the treatment is the best solution presently and has many advantages. Over time, the typical industrial factory has been fitted with various types of pollution control devices that are designed to minimize the amount of contaminants that are released into the water. While these and other means of decreasing pollution are somewhat effective, the pollution problem continues to be an increasing area of concern.

Over the years, the problems of POME pollution have been overcome with use of anaerobic and facultative digestion to treat the waste. Open digestion tank system have particular disadvantages such as a long hydraulic retention time of 45-60 days , bad odour, difficulty in maintaining the liquor distribution to ensure smooth performance over huge areas and difficulty in collecting biogas, a mixture of about 65% methane, 35% carbon dioxide and true amount of hydrogen sulphide which have detrimental effects on the environment.

In addition, biological treatment systems need proper maintenance and monitoring as the process relies solely on sensitive microorganisms to break down the pollutants. Biological treatment facilities tend to be very large and require substantial acreage. They also lack esthetic qualities and generates vast amount of harmful, odorous and corrosive biogases. Furthermore, the treated wastewater cannot be reused in the plant. Energy requirement is a major constraint in the evaporation processes. Under standard conditions specific energy consumption is very high where 1 kg of steam is required per 1 kg of water evaporated. Membrane processes, if applied directly with raw POME are susceptible to fouling and degradation during use.

Previous study has proved that the ponding system can works for treating POME. For the past years, ponding system is applied in palm oil mills to treat POME as waste for the production of crude palm oil. As in Malaysia, ponding system becomes more realistic because of the low energy requirement, cheap and intensive operating cost and maintenance. For the best solutions for this matter is aquatic plant system and is ready to replace the current treatment which is ponding system that is applied in many palm oil mills in Malaysia.

The trend over the past 70 years in the construction of water pollution control facilities for metropolitan areas has been toward “concrete and steel” alternatives. With the advent of higher energy prices and higher labour costs, these systems have become significant cost items for the communities that operate them. For small communities in particular, this cost represents a higher percentage of the budget than historically allocated to water pollution control. Processes that use relatively more land and are lower in energy use and labour costs are therefore becoming attractive alternatives for these communities. The high cost of some conventional treatment processes has produced economic pressures and has caused engineers to search for creative, cost-effective and environmentally sound ways to control water pollution.

1.4 Objectives

- to present an aquatic plants commonly known as *Ipomoea Aquatic* as a promising new commercial aquaculture crop and wastewater treatment for POME
- to test parameters and reduce the amount of the potentially toxic compounds to their acceptable discharge limit according to standards which are BOD_5, COD, TSS, pH and Oil and Grease

1.5 Scopes of study

- To evaluate and investigate the effectiveness of *Ipomoea Aquatic* to treat POME within 2 weeks of experiment regarding to shelf life of the plant
- The POME sample is taken from LCSB Oil Palm Plantation in Lepar only and pond stage number 7 is used
- The aquatic plant sample which is *Ipomoea Aquatic* is taken from R & R Gambang

1.6 Rationale and Significance

One technical approach is to construct artificial ecosystems as a functional part of wastewater treatment. Wastewater has been treated and reused successfully as a water and nutrient resource in agriculture, golf course and green belt irrigation. The conceptual change that has allowed these innovative processes is to approach wastewater treatment as "water pollution control" with the production of useful resources (water and plant nutrients) rather than as a liability. The interest in aquatic wastewater treatment systems can be attributed to three basic factors: (1) Recognition of the natural treatment functions of aquatic plant systems and wetlands, particularly as nutrient sinks and buffering zones, (2) In the case of wetlands, emerging or renewed application of aesthetic, wildlife, and other incidental environmental benefits associated with the preservation and enhancement of wetlands, (3) Rapidly escalating costs of construction and operation associated with conventional treatment.

Aquatic plant system has been accounted as one of the processes for wastewater recovery and recycling. The previous research shows that the aquatic plants were superior to treat wastewater. There are many justifications using the aquatic plant system technology for the next effective solution to treat POME;

- Low energy and low maintenance requirements
- Low cost
- No climatic constraint in Malaysia where *Ipomoea Aquatic* is easily to be found and exist in abundance
- Environmental friendly treatment system

CHAPTER 2

LITERATURE REVIEW

2.1 Palm Oil

The oil palms (*Elaeis*) comprise two species of the *Arecaceae*, or palm family. They are used in commercial agriculture in the production of palm oil. The African Oil Palm *Elaeis guineensis* is native to west Africa, occurring between Angola and Gambia, while the American Oil Palm *Elaeis oleifera* is native to tropical Central America and South America. The generic name is derived from the Greek for oil, elaion, while the species name refers to its country of origin.

Its commercial value lies mainly in the oil that can be obtained from the mesocarp of the fruit - palm oil - and the kernel of the nut - palm kernel oil. Palm oil is used mainly for cooking (cooking oil, margarine, shortening, etc.) and has non-food applications (soap, detergent, cosmetics, etc.)

To date, Malaysia is the largest producer and exporter of palm oil products. The Malaysian palm oil milling and refining industries developed rapidly in the 1980's such that palm oil has emerged as one of the major oil commodities in the world oil and fats market. Approximately 11.9 million tonnes of crude palm oil (CPO) were produced that amounted to RM14.79 billion in the year 2002 (MPOPC 2003). 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. A conventional palm oil mill, diagrammatically described in Figure 2.1, produces about 2.5m^3 of effluent for every tonne of palm oil produced. Raw POME has a high biochemical oxygen demand (BOD) which is about one hundred times more than that of sewage. In 2003, there were 370 palm oil mills generating about 36.0 million tonnes of POME per year. The total BOD load generated was about 1,750 tonnes per day, equivalent to the domestic sewage generated by a population of 37 million people!

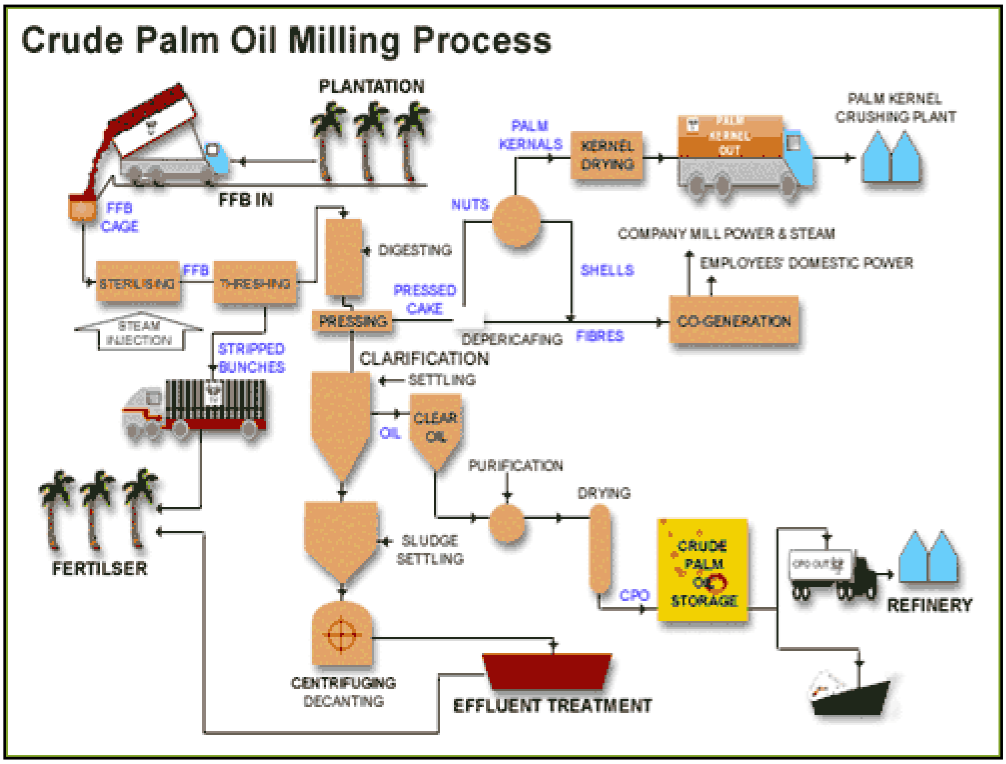

Figure 2.1: Crude Palm Oil Milling Process

2.2 Palm Oil Mill Effluent (POME)

Palm oil mill effluent is a waste produced from the palm oil processing plants. This oily waste is produced in large volumes and contributes major problem to the palm oil processing mill's waste stream. Thus it has to be treated efficiently to avoid environmental hazard.

Today, much attention is focused on industrial effluents which cause the environmental contamination. Effluent is the discharge of industrial facilities. Several technologies have been invented to treat the effluent of industries to meet the department of environmental (DOE) discharge standard. The rapid development of the palm oil industries in Malaysia over the years produced 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 by the mill [Ahmad, A. L., Ismail, S., Bhatia, 2003].

Palm Oil Mill Effluent (POME) is the largest palm oil industry by-product, it is a colloidal suspension containing 95–96% water, 0.6–0.7% of oil and grease and 4–5% of total solids. It is a thick,brownish in color liquid with a discharged temperature of between 80 and 90 ºC, being fairly acidic with a pH value in the range of 4.0–5.0[P.E. Poh, M. F. C.,April 2008].

2.3 Characteristics of Raw Palm Oil Mill Effluent

Table 2.1: 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						

Table 2.2: Environmental Quality (Sewage and Industrial Effluents) Regulations

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

Table 2.3: Interim National Water Quality Standards for Malaysia

Interim National Water Quality Standards For Malaysia Table2.3

INTERIM NATIONAL WATER QUALITY STANDARDS FOR MALAYSIA

CLASSES							
PARAMETERS	UNIT	I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5 - 7	5 - 7	3 - 5	<3	<1
pH		6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Elec. Conductivity *	umhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity (%)	%	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature (C)	^0C	-	Normal $+2^0C$		Normal $+2^0C$	-	-
Turbidity (NTU)	NTU	5	50	50	-	-	-
Faecal Coliform **	counts/100mL	10	100	400	5000 (20000) a	5000 (20000) a	-
Total Coliform	counts/100mL	100	5000	5000	50000	50000	>50000

Notes

N : No visible floatable materials or debris or No objectionable odour, or No objectionable taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : maximum not to be exceeded

<u>Class</u> <u>Uses</u>

CLASS I : Conservation of natural environment water supply 1 - practically no treatment necessary.
Fishery 1 - very sensitive aquatic species

CLASS IIA : Water Supply II - conventional treatment required
Fishery II - sensitive aquatic species
CLASS IIB : Recreational use with body contact
CLASS III : Water Supply III - extensive treatment required
Fishery III - common, of economic value, and tolerant species livestock drinking
CLASS IV : Irrigation

Table 2.4: Parameter limits for watercourse discharge

Parameters	Limits according to period of discharge 1.7.1978 - 30.6.1979	1.7.1981 - 30.6.1982	1.1.1984 and thereafter
BOD 3 day, 30°C (mg L^{-1})	5,000	500	100
COD (mg L^{-1})	10,000	1,000	-
Total solids (mg L^{-1})	4,000	1,500	-
Suspended solids (mg L^{-1})	1,200	400	400
Oil and grease (mg L^{-1})	150	50	50
Ammoniacal-nitrogen (mg L^{-1})	25	10	150*
Total nitrogen (mg L^{-1})	200	50	200*
pH	5.0-9.0	5.0-9.0	5.0-9.0
Temperature (°C)	45	45	45

2.4 Treatment of POME

The treatment of POME using different methods has recently increased the interest of many researchers. Some of the common effluent treatment schemes which are currently used are listed in descending order: (a) anaerobic/facultative ponds [Wong, F. M.,1980;Rahim, B.A.,Raj,R.,1982], (b) tank digestion and mechanical aeration, (c) tank digestion and facultative ponds, (d) decanter and facultative ponds, and (e) physico-chemical and biological treatment [Andreasen, T.,1982].

2.5 Research Parameters

2.5.1 Chemical oxygen demand (COD)

Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. COD measurements are commonly made on samples of waste waters or of natural waters contaminated by domestic or industrial wastes. Chemical oxygen demand is measured as a standardized laboratory