COMPARATIVE STUDY OF AN OPEN LAGOON WITH HIGH EFFICIENT METHANE FREE TREATMENT PLANT AND CDM PROJECT IN PALM OIL MILL EFFLUENT

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A thesis submitted in partial fulfillment of the
requirement for the award of the degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
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NOVEMBER 2010

ABSTRACT

Treatment of POME has always be the famous research topic in Malaysia due to the rapidly grown of palm oil industry as a very important agriculture in Malaysia. Due to the rapidly grown of palm oil industry in Malaysia, a large volume of POME has been produced at the same time. Raw POME is extremely rich in organic content which means it has high biochemical oxygen demand (BOD). Thus it needs to be treated properly to minimized environmental hazard before discharge into water body. Ponding process or a conventional ponding process has been widely use in Malaysia to treat POME. Although it is simple in operation, it generated large amount of sludge and take up large space areas. Besides that, ponding process is also produce methane gas which bring adverse health to human being and significant contribute to the green house gases emission. Anaerobic treatment has been identified as source of methane gas. Thus many studies had been conducted to develop alternatives methods to treat POME which are more efficient in treating POME by reducing the high BOD content and capture the emitted methane gases while consuming less land area than ponding process. In this study, a comparison of the current technologies of POME treatment system is conducted. A study is carried out at palm oil mill Lepar Hilir to study the methane gas emission and organic content of POME From the study, it found out that high-efficient methane free POME treatment plants are unable to separate oil and particular from POME using micro-bubbles technology which showing a high biochemical oxygen demand at the result. On the other hands, through Clean Development Mechanism, high biochemical oxygen demand could be reduced significantly and successfully in capture methane gas for the use of electricity.

ABSTRAK

Kebolehrawatan efluen kilang kelapa sawit (POME) selalu menjadi satu bahan hangat untuk dibincang disebabkan oleh perkembangan industry kelapa sawit di Malaysia sebagai sector agikultur. Disebabkan perkembangan industri kelapa sawit yang amat pesat di Malaysia, isipadu air sisa dari kilang kelapa sawit juga banyak dihasilkan pada masa yang sama. Bahan kumbahan dari kilang kelapa sawit mengandungi banyak organic substrat dan menyebabkan keperluan oksigen biokimia tinggi. Disebabkan keaadaan itu, kumbahan dari kilang kelapa sawit perlu dirawat sebelum disalurkan ke air untuk mengurangkan pencemaran alam sekitar. Penggunaan kolam untuk merawat air sisa dari kilang kelapa sawit telah menjadi satu kebiasaan di Malaysia. Operasi untuk cara kolam adalah mudah tetapi ia menghasilkan banyak pepejal terampai dan memerlukan keluasan yang banyak. Selain daripada itu, ia juga menghasilkan gas methane yang membahayakan kesihatan manusia dan menyumbang kepada kesan rumah hijau. Kebolehrawatan POME secara anarobik telah membuktikan sabagai punca utama pembebasan gas methane. Oleh sebab itu, banyak kajian telah dijalankan untuk mencari alternative yang lebih effectif, menjimatkan tempat dan boleh mncegahkan pembebasan gas methane untuk merawat POME. Dalam kajian ini, prbandingan technology yang merawat POME telah dijalankan. Kajian ini dijalankan di kilang kelapa sawit Lepar Hilir untuk mengaji pembebasan gas methane dan juga kandungan di dalam POME. Dalam kajian itu, teknologi yang baru untuk merawat POME juga dijalankan. Tetapi melalui kajian itu, teknologi baru itu tidak berupaya untuk memisahkan kandungan minyak dari POME dan meyebabkan keperluan oksigen biokimia ia tinggi. Di sebaliknya, CDM projek berjaya menapplikasikan gas methane untuk menjana elektrik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
CDM	Clean Development Mechanism
COD	Chemical Oxygen Demand
CPO	Crude Palm Oil
DO	Dissolved Oxygen
DOE	Department of Environment
EFB	Empty Fruit Bunch
FFB	Fresh Fruit Bunch
GHG	Green House Gas
GWP	Global Warming Potential
KLK	Kuala Lumpur Kepong
MCF	Methane Conversion Factor
MPOB	Malaysia Palm Oil Board
O&G	Oil and Grease
POM	Palm Oil Mill
POME	Palm Oil Mill Effluent
SS	Suspended Solids
TN	Total Nitrogen
TNB	Tenaga Nasional Berhad
TS	Total Solids

Units	
d	days
mg/l	Milligrams per liter
%	Percentage
°C	Degree Celsius
h	Hours

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1. Research background

The palm oil industry in Malaysia has been expanding rapidly over the last four decades. Annual palm oil production has increased steadily and the production for 2002 stood at 11.9 million tonnes in crude palm oil and 1.47 million tonnes in palm Kernel oil (MPOB, 2003). The POME must be treated to an acceptable level before it is discharged to the environment or it will cause serious and adverse problems. Oil can kill quickly by coating marine and fresh life, interfering with gas exchanges for life such as oxygen gas. An accumulation of oil can cause conditions to become anaerobic. It has been found that 0.1ppm of oil in water can upset the biological cycle in rivers.

Palm oil mill effluent (POME) is a wastewater from which generate palm oil industry, it is a colloidal suspension which is 95-96% water, 0.6-0.7% oil and 4-5% total solids including 2-4% suspended solids originating in mixing of sterilizer condensate, separator sludge and hydrocyclone wastewater. 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} (Whiting, 1978).

About 0.1 tonne of raw Palm Oil Mill Effluent (POME) is generated for every tonne of fresh fruit bunch (FFB) processed (Wong, Y.S, 2006). POME consists of water soluble components of palm fruits as well as suspended materials like palm fiber and oil.

Despite its biodegradability, POME cannot be discharged without first being treated because POME is acidic and has a very high biochemical oxygen demand (BOD).

POME has generally been treated by anaerobic digestion, which resulting in methane as release into the air. Methane gas is another potent greenhouse gas, tapping heat 25 times as effectively as carbon dioxide (OECD, 1989). In high efficient treatment plant it is a closed system which does not involve anaerobic water treatment and thus the plant does not give off methane gas into the environment. Hence the new technology plant would be able to improve the environment condition.

In the palm oil mill effluent (POME), about five to seven tones of water are required to produce one tone of palm oil. About half of the water used ends up as palm oil mill effluent (POME). POME is a mixture of sterilizer condensate, separator sludge and hydrocyclone wastewater (Ahmad, A.L., and Ng, A.H., 2003). However in high efficient treatment plant water will be reuse or recycles to treated POME several times. Hence, the mill will consume lesser amount of water than the traditional treatment plant.

The major source of POME is the usage of steam and water extraction processes and washing activities in the mill (Agamuthu, 1995). POME is recognized not only because of the large quantity generated but more significant as a type of wastewater with the highest organic matters content where BOD and COD levels are at 25,000 mg/l and 50,000 mg/l respectively (MA et al, 1993). On the other hand, the new plant able to reduce the level of COD. The new plant will treat all POME generated at the mills in a more efficient manner than the current system by applied treated water to palm oil fields as fertilizer supplement.

1.2 Aims of study

The aim of the study is to survey an open lagoon POME (palm oil mill effluent) treatment system with current palm oil mill treatment plants.

1.3 Objectives of the study:

i. To determined the feasibility of high-efficient methane- free POME treatment plant.
ii. To compare the existing open lagoon POME treatment plant with Clean Development Mechanism project in capture methane.
iii. Replacement of open lagoon with other treatment plants

1.4 Scope of study

i. Identify the conventional method in treating palm oil mill effluent.
ii. Identify the current treatment system in treating palm oil mill effluent.
iii. Advantages and disadvantages of the system.
iv. Study the capture of methane gas emission for current palm oil mill effluent treatment plants.

1.5 Significant of the study

Discharge of palm oil mill effluent that did not follow the standard of discharged effluent will bring adverse effects to the environment, such as water pollution and air pollution.

Proper study for the current treatment plants is needed in order to improve the efficiency of the treatment plant and alleviate some adverse effect to the environment due to the treatment. Biochemical oxygen demand and methane gas emission is the most significant in this study because high BOD will result the palm oil mill pay up their summons and methane gas will endanger health of workers. Beside that methane gas is also one of the renewable energy that could be used for the generate electricity. This energy should be applied probably so it can bring benefits to people rather than harmful.

Studies of a palm oil mill effluent treatment plants can bring provide alternatives treatment methods for the treatment plants. It also enables Malaysian to study the new technology which would be installs in Malaysia in near future.

CHAPTER 2

LITERATURE REVIEW

2.1 Origin of palm oil mill effluent

Mill plays an important role in extracting crude palm oil (CPO) , apart from extracting the CPO, it also generates wastes such as palm oil mill effluent (POME), empty fruit bunch (EFB), palm kernel shell and fiber. Among all these wastes POME is being produced in large volume and highly polluted.

Palm oil mill effluent (POME) cause a serious environmental hazard due to its high biochemical (BOD) and chemical oxygen demand (COD) if it is disposed without treatment. The major source of POME is the usage of steam and water in extraction processes and washing activities in the mill (Agamuthu, 1995).

2.2 Palm oil mill processing

Process flow for a typical palm oil milling is depicted in Figure 2.1. It is a conventional process of extracting crude palm oil (CPO) from fresh fruit bunches (FFB). According to the Department of Environment (DOE) in 1999, approximately 225kg of crude palm oil could be extracts from 1000 kg of processed FFB. Harvested FFB needs to processes immediately to prevent poor quality of crude palm oil due to the increase in fatty acid content. FFB is processes at steam heat treatment in sterilizer process at the temperature of 140°C around 75 to 90 minutes (Maycock, 1990). After sterilizer process, FFB is subjected to thresher where the fruits are separated from the spikelet. At the temperature around 90 °C, fruits are then mashed in digester under high pressure. Screw press is used to press out the oil from the digested mashed fruit. Two outputs would generate at screw press process, there are crude oil and press cake. According to DOE in 1990, crude oil produce from the screw press process consist mixture of palm oil (35% - 45%), water (45%-55%) and fibrous material in varying proportions. Crude palm oil is then channel into clarification tank and temperature would be maintains around 90 °C for better oil separation. Pure crude palm oil would be storage at oil storage after the process of purifier and vacuum dried. On the other hand, press cake would channeled to fiber and nut separation stage where fiber are discharged and nut would be convey to hydrocyclone and store at kernel storage.

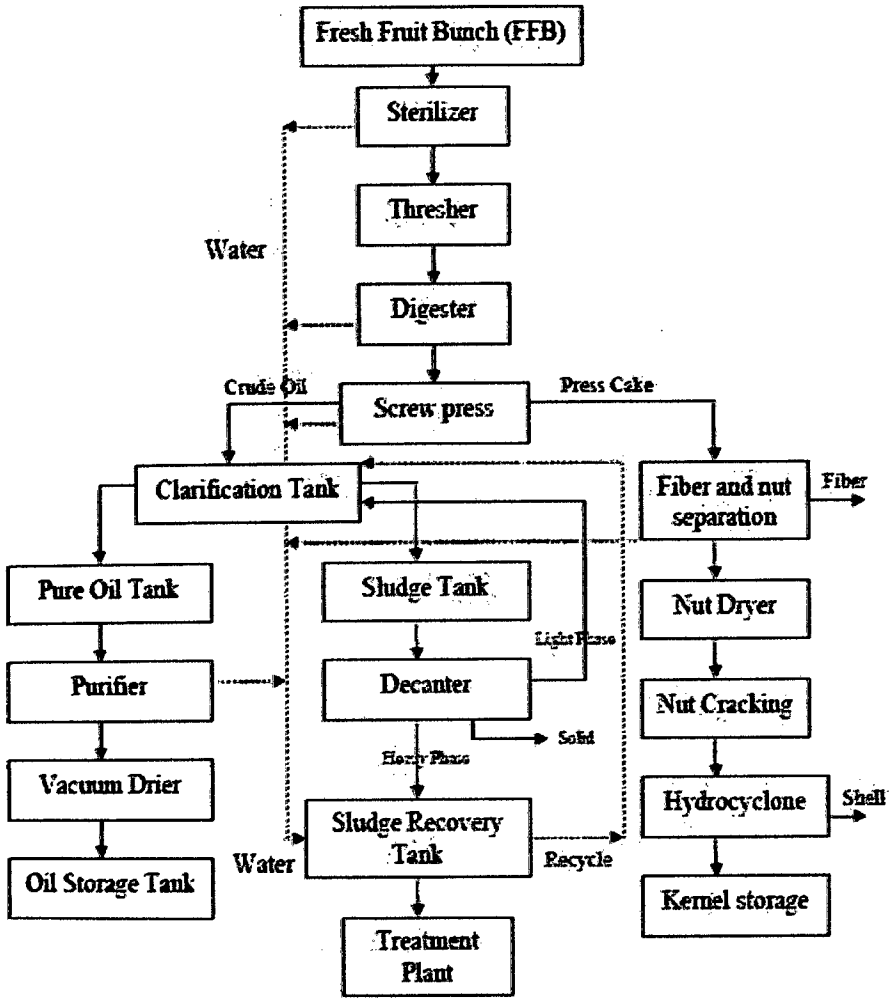

Figure 2.1 Palm oil mill process (Sources: MALPOM industries Sdn Bhd, 2006)

2.3 Treatment technologies of POME

Four types of treatment have been introduce to treat palm oil mill effluent, which are pre-treatment , biological treatment technologies, land application system, and zero waste evaporation technologies.

2.3.1 Pre- treatment

Generally pre-treatment include the stages of screening, sedimentation, and oil removal. Coagulation and flocculation process in the POME pre-treatment system help to reduce organic load before going into the secondary treatment in biological process. The most common coagulants used in treatment are Aluminium sulphate (alum), an inorganic salt. Coagulant and flocculants were used to reduce the total fatty acid and suspended solids. However the used of aluminium based coagulant has become under surveillance due to its side effect. Large amount of aluminium remained in the treatment and intake large amount of aluminium is believed to develop disease such as neurodegenerative and Alzheimer disease (Driscoll and Letterman, 1995).

2.3.2 Biological treatment technologies

The most common practice used to treat POME is biological process which based on anaerobic and aerobic ponding system. The organic substance of POME is generally biodegradable and hence micro-organism are used to degrade the substances. Micro organism which used here would gradually breakdown the organic substances into simple end-product such as methane gas, carbon dioxide, hydrogen sulphide, and water. However biological treatment systems need proper maintenance and control as the micro organism are very sensitive to the environment. Thus maintenance budget would increase.

2.3.3 Land application system

Land application system is suitable used in mills where they have plantation nearby. High concentrations of plant nutrient are contained in anaerobic digested POME. The application of the effluent would provide essential nutrient for plant growth. The surrounding plantation receiving it could efficiently absorb all treated nutrient. This has result in the substantial saving in fertilizer budget.

2.3.4 Zero waste evaporation technology

Evaporation is the process where a certain liquid reaches its boiling point and evaporated, leaving behind all the materials and substances it was combines with its liquid phrase. POME is made up of about 95% - 96% water thus by evaporation technology the water would be recovered and the residual solid can be concentrated for advance utilization (Ma, 2000). When POME boil only water is evaporating and all others materials will remain in its liquid state as they boiling point is higher than water. Almost 80% of water is reclaim but it disadvantage of using this technology is the high energy is required (MA, 1996).

2.3.5 Conventional system (Ponding system)

In traditional treatment system, palm oil mill effluent (POME) is treated in a system of anaerobic holding tanks and ponds, with final treatment provided by aerobic pond. The treated water is then release into the nearby river or to the palm oil fields as irrigation water. Ponding system comprises of de-oiling tank, acidification ponds, anaerobic ponds and facultative or aerobic ponds (Chan and Chooi, 1984). Number of ponds varies according to the capacity of the palm oil mill. Facultative or aerobic ponds are necessary to further reduce BOD concentration.

More than 85% of palm oil mills in Malaysia have adopted the ponding system for POME treatment (Ma et al., 1993). Ponding system comprises of de-oiling tank, acidification ponds, anaerobic ponds and facultative or aerobic ponds (Chan and Chooi, 1984). Anaerobic digestion means that the degradation of complex organic matters in the absence of oxygen. This process has longer retention time as the bacteria consortia responsible for the degradation process requires time to adapt to the new environment before they can start to consume on organic matters to grow.

Based from investigation of Chan and Chooi in 1984 the retention time in ponding system normally is around 20–200 days. In the process of degrading palm oil mill effluent (POME), several Greenhouse gases will be released and it includes methane, carbon dioxide and traces of hydrogen sulfide. Investigations by Yacob et al, 2006 showed that anaerobic pond had a higher emission of methane with an average methane composition of 54.4% compared to open digester tank. Microorganisms are very sensitive to changes in the environment and thus great care has to be taken to maintain the temperature so that microorganism can thrive. Conventional ponding process has been an effective method to reduce the biological and chemical constituents of POME. This method, even though simple and reliable, generates large amounts of sludge and takes up large land areas.

In a conventional palm oil mill, the mixed effluent (POME) contains a mixture of steriliser condensate, separator sludge and hydrocyclone waste. The mixed POME is treated by anaerobic, aerobic/facultative processes before it is discharged. In a palm oil mill using a decanter, steriliser condensate is the main liquid effluent generated (MA, A.N and Ong, S.H., 1987). The steriliser condensate was found to be easily treatable by a simple anaerobic process at ambient temperature.

A BOD removal efficiency of more than 90% could be achieved. The process seemed to attain optimum operating conditions at a BOD loading of 1·8 kg per cubic metre per day with a hydraulic retention time of 15 to 16 days. Despite the low pH of the steriliser condensate, no pH adjustment was required at steady state. The Volatile Fatty

Acid to alkalinity ratio was found to be a good control index. It was quick and simple to determine. The ratio was always below 0·3 for healthy digestion. About 21 cubic metres of biogas was generated for every cubic metre of steriliser condensate digested. The kinetic model developed by Lawrence & McCarty (1976) was used to determine various coefficients. The values of k, Ks, Y, kd and Θ_c^m were found to be 2·09 per day, 13 770 mg litre^{-1}, 0·358 mg VSS per mg BOD, 0·041 per day and 2·2 days, respectively.

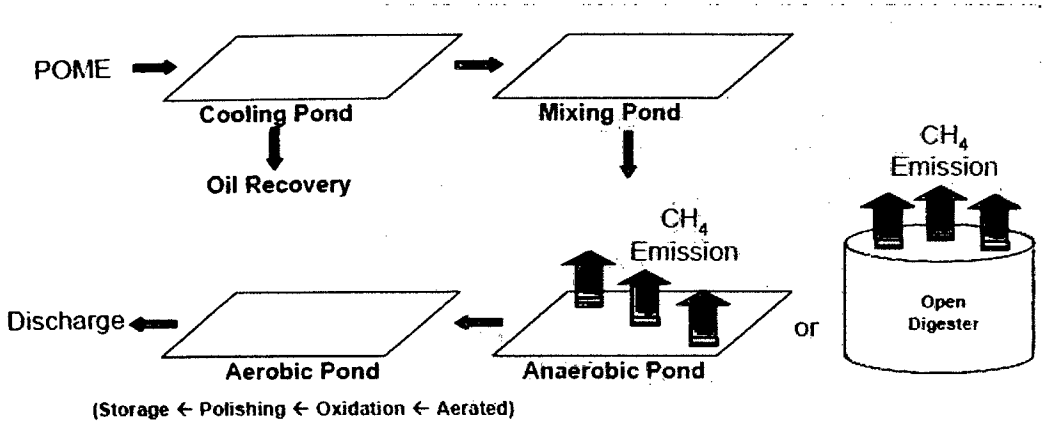

Figure 2.2 Conventional Lagoon System or Open Digester system (CDM, 2000)

Figure 2.3 Open lagoon at Lepar Hilir