UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS

JUDUL: ACCELERATE THE REDUCTION OF PALM OIL MILL EFFLUENT CRITICAL PARAMETERS WITH BIOLOGICAL TREATMENT

SESI PENGAJIAN: **2009/2010**

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ACCELERATE THE REDUCTION OF PALM OIL MILL EFFLUENT CRITICAL PARAMETERS WITH BIOLOGICAL TREATMENT

MOHAMMAD ZULHILMI BIN JAMAL

A thesis submitted in fulfillment
of the requirements for the award of the degree of
Bachelor of Chemical Engineering

Faculty of Chemical & Natural Resources Engineering
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APRIL 2010

I declare that this thesis entitled *"Accelerate The Reduction of Palm Oil Mill Effluent Critical Parameters With Biological Treatment"* is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	: 27 April 2010

We all have dreams but in order to make dreams come into reality, it takes an awful lot of determination, dedication, self-discipline and effort. With love, to my beloved mother, father, families, and friends, who gave me everlasting inspiration, never ending encouragements and priceless support towards the success of this study

ACKNOWLEDGEMENT

Thank to Allah S.W.T, the Almighty for giving me this great chance to enhance my knowledge and to complete this research. May the peace and blessings be upon prophet Muhammad (SAW).

The preparation of this research would not have been possible without the support, hard work and endless efforts of a large number of individuals. First and foremost, I would like express my sincere gratitude to my supervisor, Tn. Hj. Mohd Noor Nawi for his helpful advice, effective encouragement and constructive guidance throughout this research.

Moreover, I would like to thanks to all FKKSA lab assistants that help me so much to deal with the laboratory machines and handling all of the chemicals required together with this study.

Furthermore, not forgotten are staffs of Dominion Square Sdn. Bhd. especially plant manager, En. Wan Zulizad and lab person, En. Awang which provides me with all the facilities and help I needed for my project.

I also want to take this opportunity to give appreciate to my dearest parents, my family, my friends and all personnel that involved and help me directly or not. Thanks for your love, encourages and support.

Last but not least, I would like to apologize for any inconvenience and mistakes during this project. Thank to all of you.

ABSTRACT

Palm oil mill effluent (POME) is the highest single polluter of Malaysian rivers. The Biological Oxygen Demand (BOD, 3-day,30^{o}c) content of the effluent ranges from 20000-30000 p.p.m., which is about 50-60 times stronger than the domestic sewage. The Malaysian Government, the industry and the people of Malaysia in general are very concerned about the pollution problems caused by the palm oil industry. Dominion Square Sdn. Bhd (DSSB) is one of the player involve in the production of crude palm oil from fresh fruit bunch. This research will enhance the reduction process of DSSB wastewater treatment plant so the discharge will meet the regulation standard by Department of Environmental (DOE) of Malaysia. The objective of this research are to accelerate current treatment method of POME by decreasing the time consume and cost of treatment. The best loading of chemical to the pond and optimum condition of the microbiological activity studied in order to provide best place for the reduction process. The research carried out onsite and inside the laboratory to obtain the reading of temperature, pH and biological oxygen demand (BOD) for each sample. From the result, the best loading of the chemical NK-8 is at 25kg with reduction of BOD was 340.5 mg/l. The optimum pH for the biological activity was 6.5 to 7.5 while the best temperature was 45^{o}c-55^{o}c. Clear water and recycle path should be preserve for best performance of biological activity. As the conclusion, the best condition of the POME reduction has been successfully obtained for DSSB plant so that the cost of the wastewater treatment plant can be reduce at the same time the still comply with the discharge standard by DOE.

ABSTRAK

Sisa kilang minyak kelapa sawit adalah pencemar efluen tunggal tertinggi sungai di Malaysia. Permintaan oksigen biologi (BOD, 3-hari, 30^{o}C) efluen berkisar di antara 20 000-30 000 ppm adalah sekitar 50-60 kali lebih kuat daripada sisa domestik biasa. Kerajaan Malaysia, industri dan masyarakat Malaysia pada umumnya sangat peduli tentang masalah pencemaran yang disebabkan oleh industri minyak sawit. Dominion Square Sdn. Bhd (DSSB) adalah salah satu pengeluar yang terlibat dalam pemprosesan minyak sawit mentah dari buah segar. Kajian ini akan meningkatkan proses penurunan air sisa DSSB sehingga memenuhi standard peraturan oleh Jabatan Alam Sekitar (DOE), Malaysia. Tujuan kajian ini adalah untuk mempercepat kaedah rawatan sisa kumbahan (POME) dengan mengurangkan pengambilan masa dan kos. Kuantiti terbaik bagi penggunaan bahan kimia, keadaan kolam dan persekitaran terbaik bagi aktiviti mikrobiologi dipelajari agar dapat memberikan medium terbaik untuk proses penurunan. Penelitian yang dilakukan di lokasi dan di dalam makmal bagi mendapatkan bacaan suhu, pH dan keperluan oksigen biologi (BOD) bagi setiap sampel. Dari hasil kajian, pemuatan terbaik penggunaan bahan kimia NK-8 adalah pada 25 kg dengan penurunan BOD sebanyak 340.5 mg / l. PH optimum untuk aktiviti biologi adalah 6,5-7,5 dan suhu terbaik adalah 45^{o}C-55^{o}c. SIstem laluan kitar semula air harus berfungsi untuk prestasi terbaik bagi aktiviti biologi. Sebagai kesimpulan, keadaan terbaik pengurangan POME telah berjaya diperolehi untuk kilang DSSB sehingga kos pemprosesan sisa boleh dikurangkan pada masa yang sama masih memenuhi standard pelupusan oleh DOE.

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LIST OF ABBREVIATIONS & SYMBOLS

%	-	Percentage
BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
DOE	-	Department of Environmental
g	-	Gram
kg	-	Kilo Gram
cm	-	Centimeter
m	-	Meter
Felda	-	Federal Land Development Authority
mm	-	Millimeter
EQA	-	Environmental Quality Act
NaOH	-	Sodium Hydroxide
OH	-	Hydroxide
ºC	-	Degree Celsius
Pa	-	Pascal
DSSB	-	Dominion Square Sdn. Bhd.
V	-	Volume
POME	-	Palm Oil Mill Effluent

CHAPTER 1

INTRODUCTION

1.1 Research Background

Malaysia is the largest producer and exporter of crude palm oil (CPO). Exports of palm oil gained 2.9% to 15.87 million tonnes in 2009 as against 15.41 million tonnes in 2008. The Malaysian palm oil industry is growing rapidly and becomes a very important agriculture-based industry, where the country today is the world's leading producer and exporter of palm oil, replacing Nigeria as the chief producer since 1971. This amount will continuously increase in proportion to the world demand of edible oils seeing as palm oil already is bio-diesel product. Although the palm oil industry is the major revenue earner for our country but it has also been identified as the single largest source of water pollution source due to the palm oil mill effluent (POME) characteristic with high organic content and acidic nature. At an average, about 0.1 tonne of raw Palm Oil Mill Effluent (POME) is generated for every tonne of fresh fruit bunch processed. POME consists of water soluble components of palm fruits as well as suspended materials like palm fibre 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) and Chemical Oxygen Demand (COD).The proposed treatment was design in order to dealing with POME before it can be release to the sewage system or into the river.

1.2 Research Collaborator

Dominion Square Sdn Bhd (DSSB) is one of the subsidiary company of LKPP Corporation. Their main business is on supplying and obtaining crude palm oil from fresh fruit bunch. Operation starts on January 2002 with the capacity of processing 40 MT/hour fresh palm oil fruit. Annual production process is around 230,000 MT. Their fresh fruit bunch been supply 99% from their own farm and another 1% from others farm. Major waste of DSSB plant is palm oil mill effluent where they are treating with ponding wastewater treatment system. DSSB has been decided by Department of Environmental that they need to comply with standard B before their wastewater can be release to the water system. Table 1.1 show the discharge permits which were outlined by the Department of Environment Malaysia (DOE). The regulation based on the Malaysian Malaysia Environmental Quality Act & Regulation, 1974 by Department of Environmental (DOE) Malaysia.

Oil palm cultivation and processing, like other agricultural and industrial activities, are regulated by a number of environmental legislations aimed at conserving and protecting the natural environment. These rules and regulations, together with the growing awareness for a clean and pollution-free environment, plays a significant role in minimizing the degradation of the soil, water and atmospheric environment while, others, attempt to mitigate the health hazards encountered at the work place. Table 1.1 showed the summary of wastewater discharge standard set by the Environmental Quality Act 1974 (EQA). This legal mechanism spurred research and development works regarding innovative measures to treat and dispose discharges from the plants. (Singh et al, 1999)

Table 1.1: Parameters limit for watercourse discharge for POME

	Parameters	Units	Standards	
			A	B
1	Temperature	^{0}C	< 40.0	< 40.0
2	pH	pH	6.0 – 9.0	5.5 – 9.0
3	BOD_5 at 20 ^{o}C	mg/L	< 20.0	< 50.0
4	COD	mg/L	< 50	< 100
5	Suspended Solids	mg/L	< 50	< 100
6	Mercury	mg/L	< 0.005	< 0.05
7	Cadmium	mg/L	< 0.01	< 0.02
8	Chromium, hexavalent	mg/L	< 0.05	< 0.05
9	Arsenic	mg/L	< 0.05	< 0.10
10	Cyanide	mg/L	< 0.05	< 0.10
11	Lead	mg/L	< 0.10	< 0.50
12	Chromium, trivalent	mg/L	< 0.20	< 1.00
13	Copper	mg/L	< 0.20	< 1.00
14	Manganese	mg/L	< 0.20	< 1.00
15	Nickel	mg/L	< 0.20	< 1.00
16	Tin	mg/L	< 0.20	< 1.00
17	Zinc	mg/L	< 2.00	< 2.00
18	Boron	mg/L	< 1.00	< 4.00
19	Iron	mg/L	< 1.00	< 5.00
20	Phenol	mg/L	< 0.001	< 1.000
21	Chlorine, Free	mg/L	< 1.00	< 2.00
22	Sulphide	mg/L	< 0.50	< 0.50
23	Oil & Grease	mg/L	Not Detectable	10.0

Source: Malaysia Environmental Quality Act & Regulation, 1974, DOE

DSSB wastewater treatment main objective is to meet the standard for wastewater discharge set by Department of Environment, Malaysia. This study carried out in order to accelerate the reduction of POME critical parameters at optimum condition.

1.3 Problem Statements

Ponding was the most common method used in Malaysia when handling with POME treatment. The waste will be release to a series of pond in order to decrease the concentration of organic content and acidic nature below the regulation act available. POME contains large source of biological pollutant. The reduction process involved with high retention time at about 100 days for complete process before discharge. Raw POME BOD initial reading is about 27 000 mg/l already large source of pollutant compare to the release standard set by Department of Environmental (DOE) which is less than 100 mg/l.

In Malaysia, DOE stress on a strict rule on the release of Palm Oil Mill Effluent to the drive water system. Each palm oil industry needs to follow the standard of this regulation so they will not be suing by the government. DSSB has been decided by the DOE that their wastewater need to meet the regulation of standard B wastewater release. BOD must be less than 100 mg/l (3 days, 30^{o}c).

The desludging process of POME pond itself is very costly. Current cost is about RM100,000 per pond. This cost not included the cost of maintenance and utilities for each pond. When the process can be accelerate, the cost of treatment can also be reduce by reducing the number of pond. When the POME waste treatment can be improved, the cost will also reduce. The ponds are placed at an open area. The climate will also affect the treatment process. It is dangerous to the environment if the pond overflow and the waste will be flooded. The character of the waste will to a large extent determine its impact on the surroundings, and in this context physical, chemical, mineralogical and microbiological aspects of the waste have to be considered (Leden and Pedersen, 1996). That bring the important of manage the POME wastewater treatment system properly.

1.4 Research Objectives

Based on the aforementioned research background and problem statement, the objectives of this study are:

(i) Accelerate current treatment method of Palm Oil Mill Effluent by decreasing the time consume.

(ii) Find the effect of chemical on the reduction of POME and effect of temperature and pH to the microbe. Study the best loading for optimum BOD reduction.

(iii) Study the best condition for the microbiological activity during the reduction of POME inside the pond.

1.5 Scopes of Study

In order to achieve the objectives stated above, the following scopes of study have been drawn.

(i) Effect of the microbiological activity to the reduction of POME to be release according to the environmental quality standard.

(ii) Effect of temperature and pH on the Palm Oil Mill Effluent to the time consume of the reduction of POME.

(iii) Effect of supporting chemical added to the performance of biological activity inside the treatment pond.

(iv) Study the reduction of biochemical oxygen demand on different loading of NK-8 chemical into the anaerobic pond 2. Best loading to be analyze.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The year 2009 was a challenging one for the Malaysian palm oil industry amid the lingering effects of a weak global economy and issues on sustainability and environment associated with oil palm cultivation. Nevertheless, the industry still remains resilient, recording a satisfactory performance with exports of oil palm products rising by 2.9%, although export earnings declined by 24.0% to reach RM 49.6 billion because of the relatively lower oil palm product prices traded in 2009. The total oil palm planted area in the country increased by 4.5% to 4.69 million hectares in 2009. Among the regions, Sarawak registered the largest increase in planted area with a growth of 12.8%, followed by Peninsular Malaysia 3.3% and Sabah 2.1%. Sabah is still the largest oil palm planted State, accounting for 1.36 million hectares or 29% of the total planted area in the country (MPOB, 2010). With this large amount of production will also contribute to large production of palm oil mill effluent (POME).

2.1.1 Palm Oil History

Palm oil (from the African oil palm, Elaeis guineensis) is long recognized in West African countries, and is widely used as cooking oil. European merchants trading with West Africa occasionally purchased palm oil for use in Europe, but as the oil was bulky and cheap, palm oil remained rare outside West Africa. In the

Asante Confederacy, state-owned slaves built large plantations of oil palm trees, while in the neighbouring Kingdom of Dahomey, King Ghezo passed a law in 1856 forbidding his subjects from cutting down oil palms.

Palm oil became a highly sought-after commodity by British traders, for use as an industrial lubricant for the machines of Britain's Industrial Revolution. By century 1870, palm oil constituted the primary export of some West African countries such as Ghana and Nigeria, although this was overtaken by cocoa in the 1880s. Oil palms were introduced to Java by the Dutch in 1848 and Malaysia (then the British colony of Malaya) in 1910 by Scotsman William Sime and English banker Henry Darby. The first few plantations were established and operated by British plantation owners, such as Sime Darby and Boustead. The large plantation companies remained listed in London until the Malaysian government engineered the “Malaysianisation" policy throughout the 1960s and 1970s.

Federal Land Development Authority (Felda) was formed on 1 July 1956 when the Land Development Act came into force with the main aim of eradicating poverty. Settlers were each allocated 10 acres of land (about 4 hectares) planted either with oil palm or rubber, and given 20 years to pay off the debt for the land. After Malaysia achieved independence in 1957, the government focused on value adding of rubber planting, boosting exports, and alleviating poverty through land schemes. In the 1960s and 1970s, the government encouraged planting of other crops, to cushion the economy when world prices of tin and rubber plunged. Rubber estates gave way to oil palm plantations. In 1961, Felda's first oil palm settlement opened, measuring only 375 hectares of land. As of 2000, 685,520 hectares of the land under Felda's programmes were devoted to oil palms. By 2008, Felda's resettlement broadened to 112,635 families and they work on 853,313 hectares of agriculture land throughout Malaysia. Oil palm planting took up 84% of Felda's plantation landbank.

In December 2006, the Malaysian government initiated merger of Sime Darby Berhad, Golden Hope Plantations Berhad and Kumpulan Guthrie Berhad to create the world’s largest listed oil palm plantation player. In a landmark deal valued at RM31 billion, the merger involved the businesses of eight listed companies controlled by Permodalan Nasional Berhad (PNB) and the Employees Provident

Fund (EPF). A special purpose vehicle, Synergy Drive Sdn Bhd, offered to acquire all the businesses including assets and liabilities of the eight listed companies. With 543,000 hectares of plantation landbank, the merger resulted in the new oil palm plantation entity that could produce 2.5 million tonnes of palm oil or 5% of global production in 2006. A year later, the merger completed and the entity was renamed Sime Darby Berhad.

2.1.2 Palm Oil and the Environment

Malaysian palm oil industry is a highly regulated industry. Currently, the industry is adhered to more than 15 laws and regulations including the Land Acquisition Act 1960, Environmental Quality Act 1974, Environmental Quality (Clean Air Regulations) 1978, Pesticides Act 1974 (Pesticides Registration Rules), Occupational Safety and Health Act (1977), and Protection of Wildlife Act 1972. The industry is also complying with Hazard & Critical Control Points (HACCP) and the Environmental Impact Assessment (EIA) requirements. Being sensitive and proactive on current environmental concerns, the industry is actively pursuing ISO 14000 standard series discussions and formulations notably on climate change, life cycle analysis (LCA), ecolabeling & Design for the Environment (DfE), environmental communications, and environmental management system (EMS).

The industry and its R&D arm are continuously working to improve the industry's environmental performance. Various approaches and technologies aimed to reduce the impact of the industry on the environment have been converted to successful practices in oil palm plantation, palm oil mill, and refineries. The industry envisions achieving the highest standards of sustainability of palm oil.

It is important to note that the industry is also participating in the Roundtable on Sustainable Palm Oil (RSPO) discussions. This roundtable is a platform to reach mutual understanding at the international level among various palm oil stakeholders namely; oil palm growers, palm oil processors/traders, consumer goods manufacturers, retailers, investment organizations, social or development NGOs and environmental or nature conservation NGOs. This understanding would be translated into common actions towards achieving sustainability of palm oil production and use in its entire supply chain. (www.mpoc.org.my, 25 April 2010)

2.2 Palm Oil Mill Effluent

Palm oil mill effluent is the highest single polluter of Malaysian rivers. The Biological Demand (BOD, 3-day,30^{o}c) content of the effluent ranges from 20000-30000 p.p.m., which is about 50-60 times stronger than the domestic sewage. The Malaysian Government, the industry and the people of Malaysia in general are very concerned about the pollution problems caused by the palm oil industry. The government enacts laws and regulation to curb the pollution loading. Effluent discharge standard for palm oil mill waste water is currently set at100 mg/l BOD. (Maheswaran)

POME, when fresh, is thick brownish colloidal slurry of water, oil and fine cellulosic fruit residues. It is hot (80-90^{o}c) and acidic (pH 4-5). The characteristics of a typical POME are shown in table 2.1. It is characterized by a very high BOD, which 100 times that of domestic sewage. The suspended solid in the POME are mainly cellulosic material from the fruit. POME is non-toxic as no chemical is added during the oil extraction process. However, it contain appreciable amounts of N, P, K, Mg and Ca which are essential nutrient elements for plant growth.

Table 2.1: Characteristics of palm oil mill effluent (POME)

pH	4.7	Phosphorous	18
Oil and Grease	4,000	Potassium	2,270
Biochemical Oxygen Demand	25,000	Magnesium	615
Chemical Oxygen Demand	50,000	Calcium	439
Total Solid	40,500	Boron	7.6
Suspended Solid	18,000	Iron	46.5
Total Volatile Solid	34,000	Manganese	2.0
Ammoniacal Nitrogen	35	Copper	0.89
Total Nitrogen	750	Zinc	2.3

All parameters in mg/l except pH

Source: Ma & Ong (1985)

In response to the government regulations, the industry has employed several types of waste water treatment system to reduce the BOD to the specified standard. Most of these systems are biological in nature. The most commonly used are ponding systems where the effluent is directed into a series of ponds before being discharged into the rivers. Aerobic and anaerobic microbial activity occurs in these ponds to reduce the BOD. An anaerobic tank digestion system has also been attempted where methane gas is produced.

Raw POME is a colloidal suspension containing 95–96% water, 0.6–0.7% oil and 4–5% total solids including 2–4% suspended solids that are mainly consisted of debris from palm fruit mesocarp generated from three main sources, namely sterilizer condensate, separator sludge and hydrocyclone wastewater. For a well-controlled conventional mill, about 0.9, 1.5 and 0.1m^3 wastewater are generated from sterilizer condensate, separator sludge and hydrocyclone wastewater, respectively, for each tonne of crude palm oil produced. In the year 2004, more than 40 million tonnes of POME was generated from 372 mills in Malaysia. If the effluent is discharged untreated, it can certainly cause considerable environmental problems due to its high biochemical oxygen demand (25,000 mg/l), chemical oxygen demand (53,630 mg/l), oil and grease (8370 mg/l), total solids (43,635 mg/l) as well as suspended solids (19,020 mg/l). That what make the palm oil mill industry in Malaysia is identified as the one that produces the largest pollution load into the rivers throughout the country.

The discharge of untreated POME though creates adverse impact to the environment, the notion of nurturing POME and its derivatives as valuable resources should not be dismissed. Below are types of POME treatment

2.2.1 Anaerobic Digestion System

Generally, palm oil mill effluent treatment plants (ETPs) are operated on two–phase anaerobic digestion process followed by extended aeration process. This two-phase anaerobic process gives excellent pollutant destruction efficiency of above 95% while extended aeration ensures that the final pollutant levels in the effluent are within the stipulated limits set by the Department of Environment (DOE). In the anaerobic digestion process, the raw POME is first converted into volatile fatty acids by acid forming bacteria. The volatile acids are then converted into methane and carbon dioxide. The advantages of anaerobic digestion system are:

- The two phase system allows greater control of digester environmental conditions.
- Long solid retention times allow better biodegradation efficiencies.
- Additional settling of liquor ensures minimum loading to the aerobic process.
- There is capability to cope with full effluent load, regardless of fluctuation.

Anaerobic digestion also consists of breaking down of organic materials in the absence of oxygen. These materials are broken down biologically by a complex group of acid-forming and methanogenic bacteria which obtain their energy from the oxidation of organic compounds converting them into end products consisting of water, gases (mainly methane and carbon dioxide) and stabilized solids. (Singh et al, 1999)

2.2.2 Extended Aerobic Process

In the extended aerobic system, the anaerobic liquor is aerated to further reduce the BOD content. In addition to providing oxygen, the floating aerators also ensure complete mixing is achieved and the pod contents are always in suspension. In this process, levels of beneficial micro-organisms are increased which in turn hasten the conversion of pollutants into carbon dioxide, water and energy. The aerobic suspension is allowed to settle in a settling tank to ensure production of a fairly clean supernatant. The main advantages of extended aerobics systems are its high BOD removal efficiency and low solid yield.

2.2.3 Ponding System

This is by far the most popular treatment system adopted by more than 85 per cent of the palm oil mills in the country. Various design and configurations of ponding system are used. The ponds are mostly earthen structures with no lining. The raw effluent is treated using a ponding system comprising of three phases involved anaerobic, facultative, and aerobic processes. Although the system takes a longer retention time of 90 days, it is less sensitive to environment changes, stable, efficient and could guarantee excellent pollutant biodegradation efficiency of above 95%. Dominion square Sdn Bhd is one of is also one of the crude palm oil supplier that use this kind of treatment for their palm oil mill effluent treatment before it can be release to the water system and comply the standard B by the department of environmental.

Microorganism or microbe, is any organism too small to be seen by the naked eye and can only be seen under a microscope. Categories of microorganisms include Algae, Bacteria, Fungi, Protozoa, Viruses, or Subviral Agents. Effective microorganisms (EM) technology has now become a major science, assisting in the creation of sustainable practices for agriculture, animal husbandry, nature farming, environmental stewardship, construction, human health and hygiene, industrial, community activities and more. Specially-cultured microbes are used in the biological treatment of sewage and industrial waste effluent, a process known as bioaugmentation. Treatment of POME involve the biodegrading by thermophilic and mesophilic anaerobic microb. Lifecycle of microb involve in the reduction of POME directly related to the temperature of the effluent. That is one of the parameters that going to be investigate in this experiment. Some studies of the structure of mesophilic and thermophilic granules and biofilms have already been made. The structure of mesophilic granular sludge has been described as consisting of three distinct layers. The outer layer consists mainly of a heterogeneous population of acidogenic bacteria, the middle layer of syntrophic cocci- and rod-shaped bacteria, and the center of densely packed *Methanothrix* with many gas cavities. Such a structure would enable substrate to pass through the biomass, being degraded by the various types of bacteria to reach the methanogens that produce biogas. This could then diffuse outward via gas channels. Morganet et al used sequential staining to examine the internal architecture of mesophilic granules treating papermill and sugar refinery effluents. Both types of granule had a heterogeneous surface population of bacteria, with an abundance of *Methanothrix* being found internally. (Quarmby and Forster)

Chan (1982) and Chooi (1984) have reported that ponding system is reliable, stable and is capable of producing good quality discharge with BOD less than the DOE standard and meet the regulatory watercourse discharge standard. Ponding system is cheap to construct but requires a large land area. The anaerobic ponds are usually 5-7 meter deep while the facultative ponds are 1-1.5 meter in depth. The hydraulic retention time (HRT) for this system are 1, 4, 45 and 16 days for de-oiling tank, acidification, anaerobic and facultative ponds respectively.

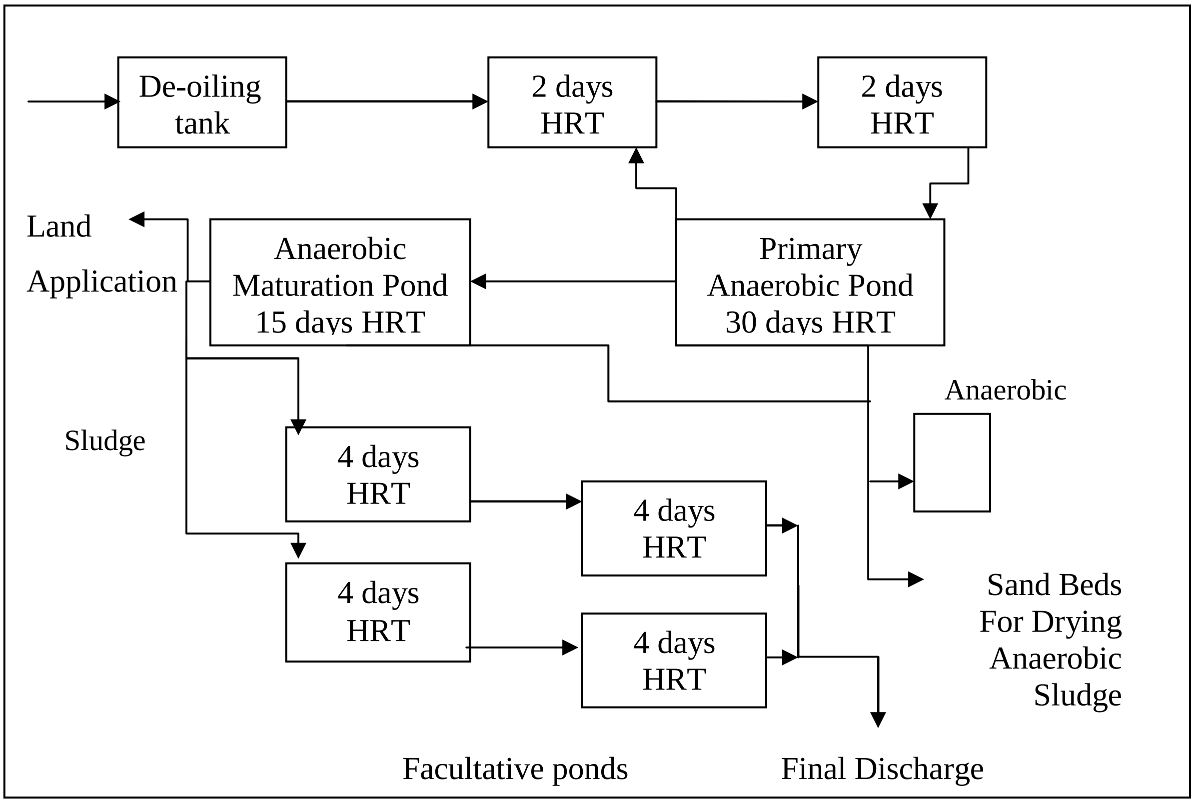

Figure 2.1 : Schematic flow diagram for ponding system

Source: Chooi (1984)

Ponding system is normally operated at very low rate. The organic loading varies from 0.2 to 0.35 kg BOD/m^3/day. Because of the size and configuration of the ponds, the processes are relatively difficult to control and monitor. Furthermore, there is no mechanical mixing in the ponds. Limited mixing is achieved through the bubbling of biogas generated during the anaerobic digestion process. Also, the rising biogas will bring along with it the fine suspended solid to the surface of the pond. If it is allowed to accumulate, it will develop into scum. The presence of residual oil in the pond will make the situation worse. The oil agglomerates with the fine solids and forms a sticky scum. Consequently, it is not uncommon to find discrete islands floating on the surface of the pond resulting in the dead spots and short circulating in the ponds. Another feature of the ponding system is the build up of solids at the bottom of the pond. If these solids are allowed to accumulate to excessive levels, they together with the scum at the top will effectively reduce digester capacity and shorten the HRT. This will adversely affect the treatment efficiency of the process. Regular desludging (solid removal) is therefore recommended.

Energy required to operate the ponding system is minimum. It is only required to run the pumps. Gravity flow is exploited wherever possible. For a 30-tonne FFB/hour mill, the energy demand to operate the ponding system is about 20 kwh. Figure 2.2 showed the schematic flow diagram for DSSB wastewater ponding treatment process use in DSSB.

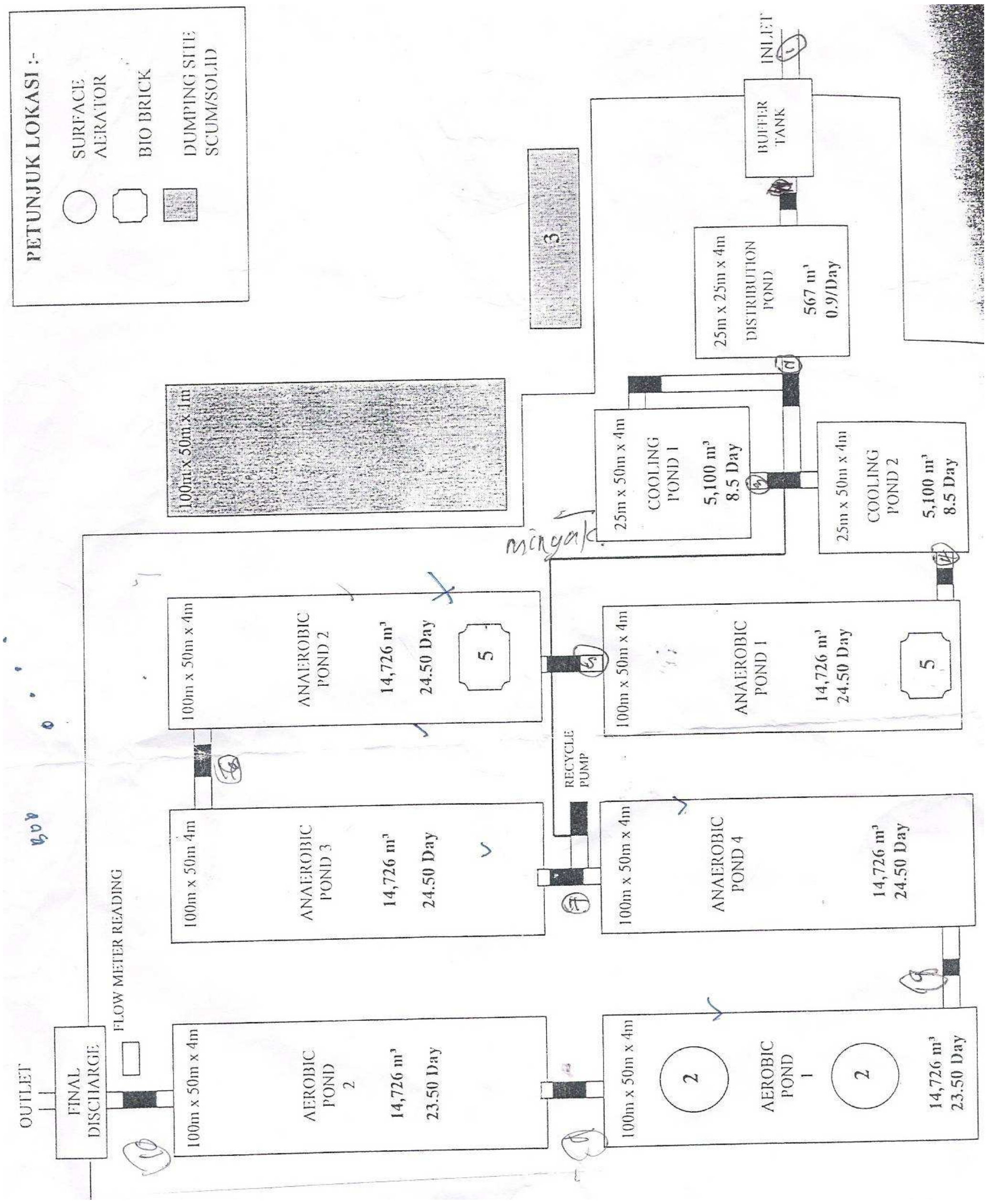

Figure 2.2 : DSSB Schematic flow diagram for ponding system

CHAPTER 3

METHODOLOGY

3.1 Material

1. Sample of palm oil mill effluent (POME) obtain from the palm oil processing plant
2. The effluent pre-filtered by means of simple depth filtration to remove the coarse solid found in the suspension
3. The POME was preserved at a temperature less than 4^{o}C, but above the freezing point in order to prevent the wastewater from undergoing biodegradation due to microbial action (APHA, 1985).
4. The initial value of all those below parameters will be measured on the POME.
5. Experimental procedure for effect of microb growth on the POME reduction.
6. Experimental procedure on the effect of temperature of the POME on the grow of the microb.
7. All the result been summarize.

Biochemical oxygen demand (BOD) test measures the ability of naturally occurring microorganisms to digest organic matter, in 3 days incubation at 30°C by analyzing the depletion of oxygen inside the POME. BOD is the most commonly used parameter for determining the oxygen demand on the receiving water of a municipal or industrial discharge. BOD can also be used to evaluate the efficiency of treatment processes, and is an indirect measure of biodegradable organic compounds in water. The BOD test is normally required by a regulatory program. For this experiment, BOD3 will be examined by dilution method (Standard Method 5210B).

3.2 Equipment and Apparatus

(i) Incubation bottles: 300 mL bottles having a ground-class stopper and a flared mouth. Clean bottles with a detergent, rinse thoroughly, and drain before use. Adding water to the flared mouth of special BOD bottles. Place a paper or plastic cup or foil cap over flared mouth of bottle.

(ii) Air incubator: Thermostatically controlled at 20±1°C. Exclude all light from incubator.

(iii) Volumetric flask, 1L.

(iv) Beaker, 500mL.

(v) Dissolved oxygen meter.

3.3 Reagents

Reagents prepared in advanced but discard if there is any sign of precipitation or biological growth in the stock bottles. Use reagents grade or better for all chemicals and use distilled or equivalent water.

(i) Phosphate buffer solution. 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4 \cdot 7H_2O$, and 1.7 g NH_4CI dissolved in about 500 mL distilled water and diluted to 1L. The pH should be 7.2 without further adjustment.

(ii) Magnesium sulfate solution. 22.5 MgSO4.7H2O dissolved in distilled water and diluted to 1L.

(iii) Calcium chloride solution. 27.5 g $CaCI_2$ dissolved in distilled water and diluted to 1L.

(iv) Ferric chloride solution. 0.25 g $FeCI_3 \cdot 6H_2O$ dissolved in distilled water and diluted to 1L.

(v) Acid and alkali solutions, 1N for neutralization of caustic or acidic waste samples.

- Acid-Slowly and while stirring, add 28 mL concentrated sulfuric acid to distilled water. Diluted to 1L.
- Alkali-Dissolve 40 g sodium hydroxide in distilled water. Diluted to 1L.

3.4 BOD Measurement

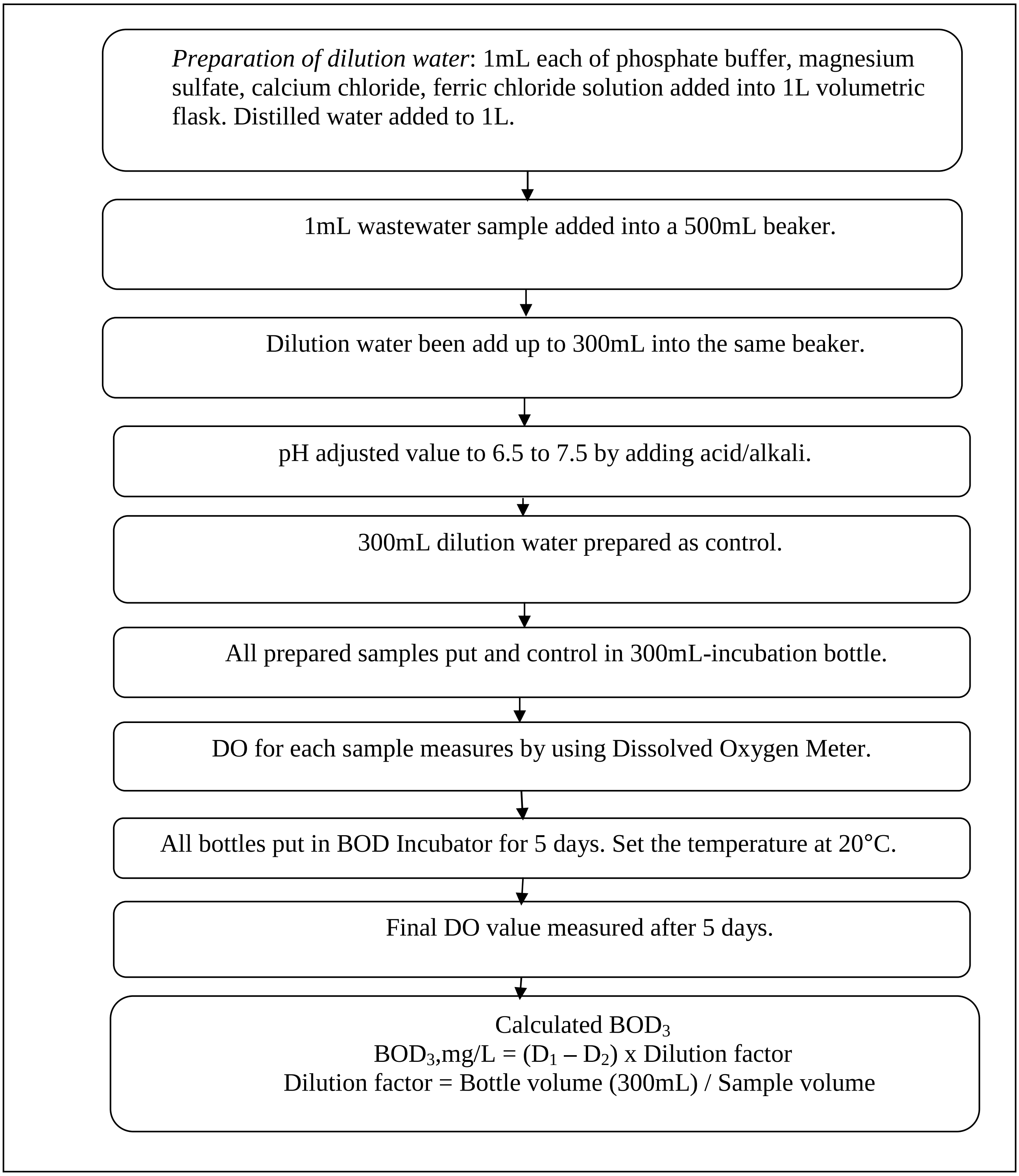

Figure 3.1: Sequence of BOD calculation

3.5 Onsite Study Method

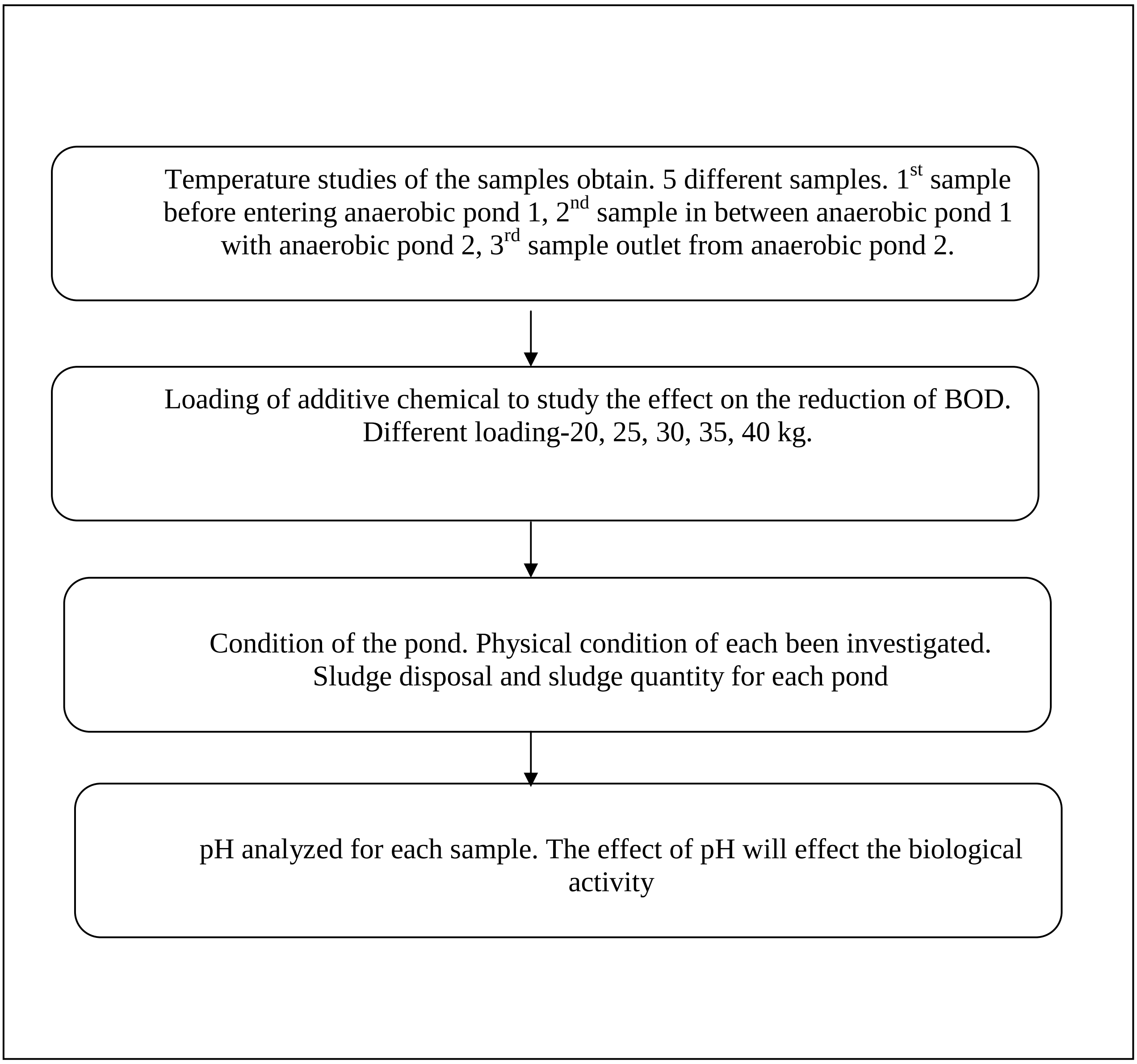

Figure 3.2: Sequence of on-site study method (to obtain the data)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Effect of Chemical Loading

To study the effect of chemical loading to the BOD reduction of the POME, five different data set have been taken by manipulated the loading capacity. The loading capacity has been set at 20 kg, 25 kg, 30 kg, 35 kg and 40 kg. The total reduction of biochemical oxygen demand (BOD) for each loading capacity has been summarized in table below.

Table 4.1: BOD reading for 20 kg loading capacity

Sample	BOD(mg/L)
1	3093.0
2	601.5
3	486.0

Table 4.2: BOD reading for 25 kg loading capacity

Sample	BOD(mg/L)
1	2802.0
2	970.5
3	630.0

Table 4.3: BOD reading for 30 kg loading capacity

Sample	BOD(mg/L)
1	2010.0
2	682.5
3	414.0

Table 4.4: BOD reading for 35 kg loading capacity

Sample	BOD(mg/L)
1	1797.0
2	462.5
3	212.0

Table 4.5: BOD reading for 40 kg loading capacity

Sample	BOD(mg/L)
1	2226.0
2	397.5
3	168.0

Table 4.6: Summarize total reduction for each loading

Loading (kg)	ΔBOD (mg/L)
20	115.5
25	340.5
30	268.5
35	250.5
40	229.5

From the overall BOD reduction, graph has been plotted.

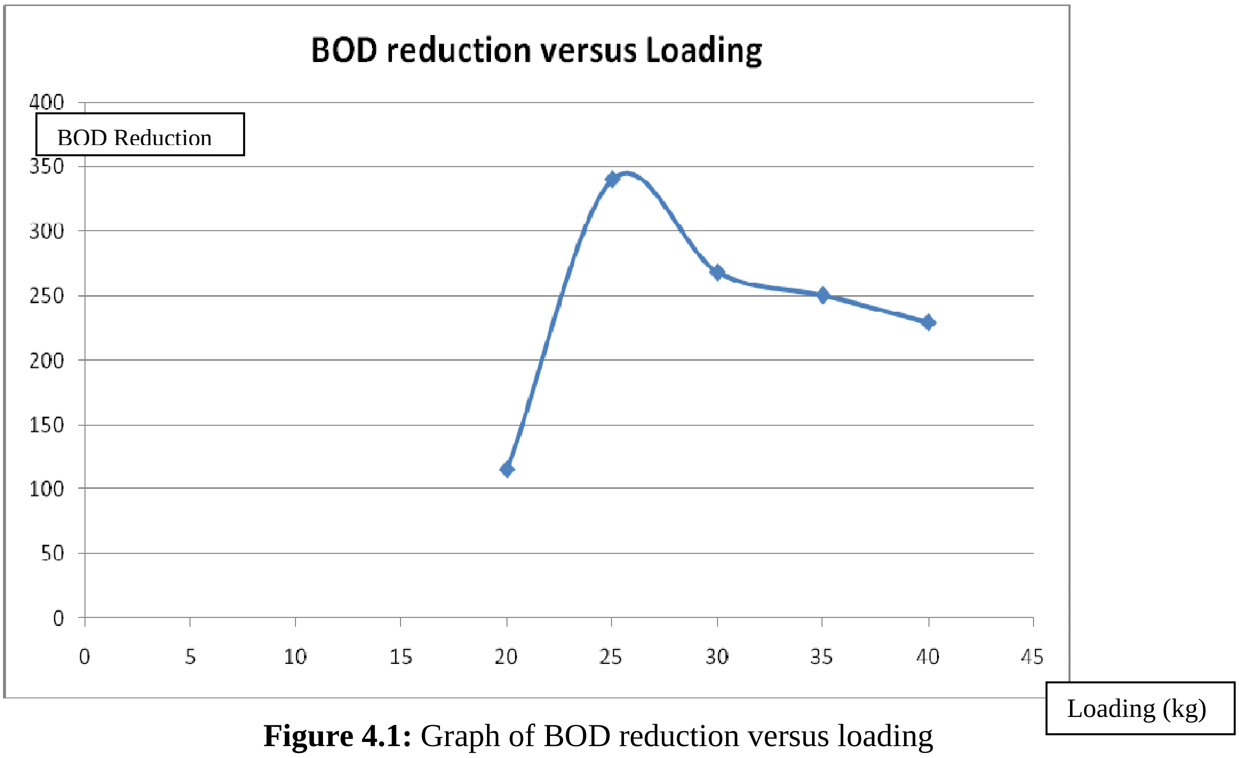

Figure 4.1: Graph of BOD reduction versus loading

4.2 Optimum Condition for Biological Activity

For optimum result in the reduction of BOD, the conditions of the microbiological activity inside the pond need to be in the best condition for its presence. To do so, the temperature and pH of anaerobic pond 1 and anaerobic pond 2 has been obtained because most of the reduction happens in both of this pond. Table below summarized the reading of temperature and pH of each sample taken at anaerobic pond one and anaerobic pond two. Sample one taken at the inlet of anaerobic pond one, sample two taken in between anaerobic pond one and anaerobic pond two while sample three taken at the outlet of anaerobic pond 2.

4.2.1 Effect of pH and Temperature

Table 4.7: Temperature reading of each sample

Sample	Temperature (^oc)
1	43-45
2	29-30
3	28-30

Table 4.8: Average pH reading for each sample

Sample	pH
1	4.27-4.76
2	7.04-7.96
3	7.14-7.7

4.3 Discussion

Table and graph above showed the result of the analyzing at LKPP Corporation Wastewater treatment process. Below is details discuss on each parameters that has been investigate.

(i) NK-8 was the chemical that been investigate towards the reduction of BOD inside POME. The loading decide to be at Anaerobic pond 2 where the condition for microbiological activity most suitable to happen at optimum rate.

Figure 4.2: NK-8 chemical

Figure 4.3: Loading process

4.3.1 Anaerobic Pond Two

Anaerobic pond 2 has clear water compare to anaerobic pond 1. Biological activity should be in its optimum efficiency in suitable temperature range, pH, physical condition and concentration of dissolve oxygen.

Figure 4.2: Anaerobic pond 2

Graph of Loading versus POME BOD reduction showed that the most optimum reduction happen when the loading at 25 kg. NK-8 is acidic chemical with average pH in between 2-3. High loading will affect the pH inside the pond and directly affect the biological activity of the microbe inside the pond. Optimum pH for biological treatment is in between 6.5-7.5. (Liu et al, 2007)

4.3.2 Anaerobic pond One

Table 4.9: Average pH and Temperature for anaerobic pond one

Temperature (^{o}c)	36-40
pH	6-7

From the data, anaerobic pond 1 should be in their best condition in term of suitable temperature and pH parameters for effective biological activity. Best temperature range was in between 40-45^{o}c and pH in between 6.5-7.5. Unfortunately, the physical condition inside be the major constraint to the microorganism development.

Figure 4.3: Left-Anaerobic pond 1, right-Anaerobic pond 2

Anaerobic pond 1 contains a large amount of sludge. Sludge will affect the microbiological activity by covering the microorganism and reduce its efficiency. It also disturbs the rate of oxygen entering the system.

Figure 4.4: Oil carryover to anaerobic pond 1

Oil has lower density compare to water. Its will cover the surface of the pond. Oil carryover will affect the rate of dissolve oxygen inside anaerobic pond 1. Large amount of sludge also is the result of oil carryover to anaerobic pond 1. The oxygen transfer rate in an activated sludge process also depends on the solid content. The oil and fat recovery system adopted obviously depends on the local circumstances. Typically, the first stage of pretreatment is the use of physical process to recover the free oil and fat. Commonly used treatment was by oil trap at previous cooling pond.

Figure 4.5: Recycle path to balance microbe concentration

Figure 4.6: pond inlet

The main disadvantage of the aerated lagoon as reported by McDermott, is that it requires large land area and long hydraulic retention time. Hence, to provide the best condition for biological treatment, recycle path should be install to balance the concentration of microbe back to the previous pond. Recycle path should operate at its best condition. The long retention time require because of the low mixed liquor suspended solid (MLSS) concentration in the aerated lagoon.

Oil carryover will result in increasing amount of scum at the surface of the pond. Scum will cover the pond and affect the rate of oxygen entering the system.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The conclusions withdrawn from the study are:

1. DSSB wastewater treatment plant use fully biological activity for the purpose of its wastewater reduction process. The reduction of POME critical parameters is very vital before it can be release to the water system. Thus, we need to provide the best condition for the microbiological activity inside the pond.

2. The biological activity inside the POME directly depend with the presence of microorganism such as thermophilic and mesophilic microbe. Both play their function for the reduction process in aerobic and anaerobic condition. Parameters that affect the efficiency of this microorganism should be control in order to get their best performance. From the study, it can be conclude the best temperature range for both anaerobic and aerobic decay was in between 45-50^{o}c.

3. PH was also a factor that affects the decay activity of POME. The methane production efficiency is the most important evaluation yardstick in anaerobic digestion, pH is also one of the factor that affecting production efficiency (Molnar and Bartha, 1989). Methane production is directly depending with the biological activity of anaerobic microorganisms that contribute to the POME reduction. May be conclude that, the optimum pH reading was in the range 6.5 until 7.5.

4. Oil carryover will affect the physical, chemical and biological condition of the pond and affect microorganism activity inside the pond. From the study, its can be conclude that the temperature and pH inside anaerobic pond one already can be the major contribution to the reduction of POME. Unfortunately the biological activity not in its optimum condition inside anaerobic pond one because of oil carryover from previous cooling pond contributes to the scum covering the surface of the pond.

5. Quantity of pond, time consuming and cost of the treatment can be reduce. So, the total production capacity of the crude palm oil can be increase.

5.2 Recommendations

Based on the results and conclusions obtained through this study, the followings are recommended to fully comprehend the findings of the present study:

- Operate the Wastewater treatment system in it best condition for biological activity (pH = 6.5-7.5, Temperature = 45^{o}c-55^{o}c)
- Separation of oil from anaerobic pond one. Separation of oil will also result in decreasing the amount of scum at the surface of anaerobic pond two thus provide better quality for biological activity. System can be install on the surface to skim the oil for separation with the wastewater. Stream for inlet to the next pond should install underneath so only water transfer to the next pond.
- To operate effectively, recycle stream piping system should be install in order to balance the concentration of microorganism inside the anaerobic pond.
- Decrease the temperature of effluent by installing heat exchanger. By doing so, the reaction can start earlier at suitable temperature.

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APPENDICES

EXPERIMENTAL READING

Loading data (20 kg)

Sample	pH	Temp (^oC)	Do_i (initial)	Do_f (final)
1	4.76	45	10.47	0.16
2	7.27	29	10.44	7.92
3	7.96	29	10.53	9.04
4	7.70	30	10.54	8.92

BOD= Do_i-Do_f x Dilution factor

Where,

Dilution factor = Volume of Sample / Volume of Dilution

Volume of sample = 1 mL
Volume of Dilution =300 mL

Sample	BOD (mg/L)
1	3093
2	756
3	447
4	486

Loading data (25 kg)

Sample	pH	Temp. (^oc)	DO_i (mg/l)	Do_f (mg/l)	BOD (mg/l)
1	4.64	45	9.52	0.18	2802
2	7.04	29	10.03	6.15	1164
3	7.54	32	9.99	7.40	777
4	7.54	29	9.87	7.77	630

Loading Data (30 kg)

Sample	pH	Temp. (^oc)	DO_i (mg/l)	Do_f (mg/l)	BOD (mg/l)
1	4.27	45	6.92	0.22	2010
2	7.04	31	7.14	5.15	597
3	7.08	29	6.89	4.33	768
4	7.14	29	7.26	5.88	414

Loading Data (35 kg)

Sample	pH	Temp. ($^o c$)	DO_i (mg/l)	Do_f (mg/l)	BOD (mg/l)
1	4.64	43	6.10	0.11	1797
2	5.86	30	6.32	5.81	153
3	7.5	29	6.10	6.48	-
4	7.5	29	6.14	6.97	-

Loading Data (40 kg)

Sample	pH	Temp. ($^o c$)	DO_i (mg/l)	Do_f (mg/l)	BOD (mg/l)
1	4.65	45	7.52	0.1	2226
2	7.31	30	7.76	7.32	132
3	7.67	29	7.63	5.42	663
4	7.66	28	7.70	7.14	168

DSSB license by DOE

AS: C31/152/000/069

AKTA KUALITI ALAM SEKELILING, 1974.

Peraturan-Peraturan Kualiti Alam Sekeliling
(Premis Yang Ditetapkan)(Minyak Kelapa Sawit Mentah), 1977 – P.U. (A) 342.
Dan
Peraturan-Peraturan Kualiti Alam Sekeliling (Udara Bersih), 1978 – P.U. (A) 280.

JADUAL PEMATUHAN

NO. LESEN : **000813** TEMPOH SAH LESEN : **1 JANUARI 2010 Sehingga 31 MAC 2010**

NAMA/ALAMAT PREMIS : **Dominion Square Sdn Bhd,**
Kilang Sawit Dominion Square,
KM 37, Lebuhraya Tun Razak,
26300 Gambang, Pahang.

HASIL PENGELUARAN : **Minyak Kelapa Sawit Mentah**

CARA PELUPUSAN EFFLUEN : **Alurair**

HAD-HAD DAN SYARAT-SYARAT

1. Kapasiti maksimum pemprosesan Buah Tandan Segar (BTS) sebanyak **40 tan metrik sejam sahaja.**

2. Semua effluen hasil daripada pemprosesan dan pembasuhan hendaklah diolah dengan sempurna dan dilepaskan ke alurair melalui takat pelepasan akhir yang ditetapkan seperti mana ditunjukkan dalam pelan bertajuk **"The Flow of Effluent and Hydrocyclone wastewater"** No. Lukisan **"LKPP/C/1"** bertarikh **Mac 1995.** Pelupusan sebarang effluen melalui apa-apa kaedah lain adalah dilarang sama sekali.

3. Sebarang effluen yang dilepaskan melalui takat pelepasan akhir ke mana-mana alurair mestilah mematuhi standard kualiti yang ditetapkan di Jadual Kedua P.U.(A) 342 iaitu Oksigen Biokimia yang diperlukan (BOD) 3 hari, 30°C ≤ 100 mg/l, Pepejal Terampai ≤ 400 mg/l, Minyak & Geris ≤ 50 mg/l, Ammoniakal Nitrogen ≤ 150 mg/l, Jumlah Nitrogen ≤ 200 mg/l, 5.0 ≤ pH ≤ 9.0 dan suhu ≤ 45°C.

4. Sebarang tumpahan, air cucian atau air kotor daripada bahagian pemprosesan buah sawit, pembersihan lantai kilang atau tapak pelupusan tandan kosong hendaklah disalurkan ke dalam sistem pengolahan effluen.

5. Operasi kilang hendaklah dihentikan apabila berlaku apa-apa kerosakan pada mana-mana bahagian sistem pengolahan effluen atau mana-mana alat kawalan pencemaran udara. Kerosakan ini hendaklah dimaklumkan dengan serta merta kepada Jabatan Alam Sekitar Pahang.

6. Semua komponen sistem pengolahan effluen dan **tapak pelupusan enapcemar** hendaklah diselenggara dengan sempurna dan dapat berfungsi dengan baik dan mematuhi standard pelepasan pada setiap masa.

7. Kolam-kolam pengolahan effluen mestilah dibentengkan dengan sempurna untuk mengelakkan pendawasan effluen oleh air hujan dari kawasan sekelilingnya. Pencairan atau pendawasan effluen adalah dilarang sama sekali.

8. Meter jangka alir (flow meter) ditakat keluar effluen mestilah diselenggara dengan sempurna dan dapat berfungsi dengan baik pada setiap masa. **Bacaan harian kuantiti aliran effluen** mestilah direkodkan dan dikemukakan kepada Jabatan ini pada setiap bulan, tidak lewat **14 hari** bulan berikutnya.

9. Laporan sukutahun, mengikut borang yang ditetapkan di **Jadual Pertama** P.U.(A) 342, mestilah dikemukakan kepada Jabatan ini, tidak lewat **14 hari** selepas sukutahun berkenaan. Laporan ini hendaklah disertakan dengan laporan analisis kimia effluen yang disahkan oleh Ahli Kimia berdaftar.

10. Pengukuran pelepasan bendasing dari cerobong (stack sampling) hendaklah dibuat sekurang-kurangnya dua kali setahun mengikut kaedah yang ditetapkan oleh Malaysian Standard (**MS1596:2003**) dan laporannya hendaklah dikemukakan kepada Jabatan ini tidak lewat **14 hari** daripada tarikh pengukuran.

11. Alat pencatat ketumpatan asap dan "alarm" bagi semua cerobong hendaklah diselenggara dengan sempurna dan mestilah dapat beroperasi dengan baik pada setiap masa. Laporan analisa ketumpatan asap cerobong mestilah dikemukakan kepada Jabatan ini setiap bulan, tidak lewat **14 hari** bulan berikutnya.

12. Sebarang pelepasan asap cerobong mestilah tidak melebihi **warna No.2 Carta Ringelmann** dan sebarang pelepasan habuk cerobong mestilah tidak melebihi **0.4 g/Nm³**, pada setiap masa.

13. Kerja-kerja "desludging" hendaklah dilakukan sekurang-kurangnya 2 tahun sekali. Sebarang kerja "desludging/desiltation" sistem pengolahan effluen hendaklah mengikut "Garispanduan Perlaksanaan Kerja-kerja 'desludging' bagi Kolam-kolam Pengolahan di Kilang Kelapa Sawit dan Getah". Permohonan mengenainya perlu dikemukakan kepada Jabatan Alam Sekitar Pahang sekurang-kurangnya dua (2) bulan sebelum kerja-kerja tersebut dijalankan.

14. Tiada apa-apa kerja tambahan/pembesaran kilang atau sistem pengolahan effluen dibenarkan tanpa terlebih dahulu mendapat Kelulusan Bertulis daripada Pengarah Jabatan Alam Sekitar Pahang.

15. Persampelan effluen di takat pelepasan akhir hendaklah dilakukan setiap minggu dan keputusan analisa kima efffluen yang disahkan oleh Ahli Kimia Berdaftar mestilah dikemukakan ke Jabatan ini tidak lewat 7 hari selepas persampelan dilakukan.

16. Lesen ini **boleh ditarikbalik dan/atau dibatalkan** pada bila-bila masa jika Pengarah Alam Sekitar Negeri Pahang mendapati tuan gagal mematuhi syarat-syarat lesen dan/atau kehendak-kehendak Akta Kualiti Alam Sekeliling, 1974 serta Peraturan-Peraturan yang ada dibawahnya.

(DATO' HASSAN BIN MAT, DIMP)
Pengarah Alam Sekitar
Negeri Pahang Darul Makmur.

Tarikh : 16/10/2009