Life Cycle Analysis Of Palm Oil

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Thesis submitted in partial fulfilment of the requirements

for the award of the degree of

Bachelor of Chemical Engineering

Faculty of Chemical & Natural Resources Engineering

UNIVERSITI MALAYSIA PAHANG

JAN 2014

ANALISIS KITAR HAYAT KELAPA SAWIT

ABSTRAK

Dalam kajian ini, analisis hayat kelapa sawit di Malaysia telah dijalankan. Kajian ini mengfokuskan tiga aktiviti di dalam sektor kelapa sawit iaitu perladangan kelapa sawit, pemprosesan dan penghasilan minyak kelapa sawit mentah serta pengurusan air kumbuhah kilang pemprosesan minyak kelapa sawit diikuti dengan kerja-kerja pengangkutan yang terlibat dalam sektor industri kelapa sawit yang berkenaan. Kelapa Sawit merupakan salah satu tumbuhan penanaman yang mempunyai kandungan minyak tertinggi. Penanaman kelapa sawit adalah sesuata akitiviti yang amat biasa di Malaysia dan Indonesia, di mana kedua-dua negara ini adalah negara pengeluar eksport minyak sawit terbesar di dunia. Minyak kelapa sawit dan produk sampingan ia mempunyai pelbagai kegunaan dan sumbangan kepada industry tempatan. Ini telah menyumbang kepada peningkatan status ekonomi tempatan dengan laburan modal secara langsung dari pelabur-pelabur negara asing ke dalam tempatan negara Malaysia. Aktiviti-aktiviti yang terlibat termasuk penanaman dan pennuaan buah kelapa sawit, penghasilan produk serta pengunaan produk kelapa sawit telah menarik perhatian dari pihak ramai tentang isu pencemaran alam sekitar yang dibawanya sekiranya ia tidak diurus dengan cekap. Ini telah membawa kepada pencemaran ecosystem dan juga akan memberi kesan sampingan kepada alam sekitarnya, gejala ini juga akan mengakibatkan satu kitaran negatif di mana kesan negatif tersebut akan mengganggu keselesaan hidup and kesihatan orang ramai. Hasil daripada kerja ini amat penting untuk menganggakan kerosakan atau kesan industri kelapa sawit kepada alam sekitar serta kemungkinan solusi untuk memgurangkan kesan tersebut dengan kitar guna semula sisa-sisa bahan buangan untuk menjana pendapatan sampingan daripada membiarkan ia sebagai sampah yang akan dilupus dengan dibuang ke alam sekitar. Kajian ini dijangkakan akan menghasilkan satu sistem pengurusan yang mampan di mana kesihatan ecosystem dapat dikekalkan tanpa menjejaskan kegiatan ekonomi industry kelapa sawit.

LIFE CYCLE ANALYSIS OF PALM OIL

ABSTRACT

This paper present the Life Cycle Analysis studies of Palm oil in Malaysia. This research focus on three activity of the palm oil industry, the plantation activities of palm oil industry, the process and production of the Crude Palm Oil with the Palm Oil Mill Effluent treatment and the transportation process involved. Oil palm is one of the planting crops with the highest oil yield. Oil palm plantation is very common in Malaysia and Indonesia where both are the major exporter country of palm oil. Palm oil and its by-products have a lot different usage and contribution to the industry and the related co-industry. This has generated a significant amount of economic surplus of foreign investment into the nation domestically. The activity involving planting and harvesting of palm oil to the manufacturing of products and usage of palm oil product has alert a lot different party as palm oil is an oil based products, if not handle properly it may lead to a very serious environmental impact. This has resulted in a damaged ecosystem and may lead to a domino effect to the surrounding system and most likely would create a negative cycle where the negative impact would affect the life and health of mankind. Finding from this work is vital to estimate the damage or effect of palm oil industry to the environment and the possibility solution to mitigate the effect or recycle the waste to gain profit instead of leasing to the environment and create a pollution scenario so that the sustainable of the system is retained.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
CDM	Clean development program
CER	Certified emission reduction
COD	Carbon oxygen demand
CPO	Crude Palm Oil
CPKO	Crude palm kernel oil
COD	Chemical Oxygen Demand
EFB	Empty fruit bunch
EP	Economic Potential
FFA	Free fatty acid
FFB	Fresh fruit bunch
GHG	Green House Gaseous
HDDV	Heavy Duty Diesel Vehicle
LCA	Life cycle analysis
LDDV	Light Duty Diesel Vehicle
MPOB	Malaysia Palm Oil Board
POMW	Palm oil mill waste
POME	Palm oil manufacturing effluent
RO	Reverse Osmosis
UASFF	Up-flow Anaerobic Sludge Fixed Film
UNFCCC	United Nations framework convention on climate change

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Palm oil fruit is one of the planting crop with most agricultural land coverage and highest organic plant oil yield crops. Since 1980, a vast blooming agricultural initiate the growth of palm oil activity in Malaysia (Subramaniam et al., 2010). In Malaysia, palm oil industry is the fourth largest contributor to the national economy (Yoshizaki et al., 2012). The industry activity of processing palm oil until it forms the end products which generate a very vast niche of industry growth in Malaysia, which also caused different degree of impact on the environment. Evaluating opportunities and possible outcome to overcome the potential impacts and possible formulate a mitigation options that are proven available at the moment.

From the palm oil trees plantation, fresh fruit bunches harvesting to the palm oil mill operation and production. A general life cycle of palm oil was studied to understand its importance and usage in general also how the process bring an effect to the economy and environment (Varanda et al., 2011). A general guides to be made so that it would be cost effective and environmental friendly at the same time. To eliminate the most

non-renewable energy consuming usage such as fossil fuel and start to implement the usage of renewable sources such as biomass and biofuel (Sabri, 2009). The effect was compared and shown in this project with comparing and understanding of some other research that had been done beforehand that uses the conventional fossil fuel based fertiliser (Goh, 2004). The waste treatment and recycle was also highlighted to minimize the environmental impact and intended to maximize the revenue by eliminating part of the operating cost by subsequently using the recycle material or energy that are produced in the process which was considered as waste in the past. Examples are the harvest of methane from the palm oil mill effluent treatment and also the use of palm oil fibre as natural biofuel for boiler (Salsabila et al., 2010). This allows us to have a better understanding on the overall usage and life cycle impact of the palm oil.

The analysis was done using Life Cycle Analysis method, start with oil palm plantation, harvest of product, transportation involved, processing in relative plant and the waste treatment. Which cover the ranges of studies from upstream usage of palm oil and subsequent by-products. The transportation, waste treatment, usage of recyclable waste resource was as being studied as it is part of the system. The transports of goods by truck and lorry using fossil fuels, mostly they contribute certain amount of Green House Gases yet did not been taken into account or neglected in most studies (DIESEL, 2004). Local agriculture activities still depend heavily on imported nonorganic fertilizer thus looking for a different approach of using organic fertilizer in a more cost effective and or environmental friendly ways (Sabri, 2009). Also limiting and mitigation the negative impacts caused by the palm oil industrialization activities and create sustainable value for a better long term goal. For time being most of the

plantation methods, palm oil mill system and the overall management system still being very conventional with only the highlights of the economic aspect, tend to avoid usage and application of latest energy to harvest renewable resource and energy as it require a very high capital cost. This Life cycle analysis was done using software rather than laboratory work and testing due to its low costs, no chemical waste, save time, high quality data available and no human error.

The sustainability of palm oil remained as a doubt and there are claims by certain third party that palm oil system do not being environmental friendly. Thus a simple analysis on the economic will be done also to evaluate how the application of new system could bring a change into the economic growth instead only applied to the environmental condition changes. Highlight include the POME treatment, harvest of biogas, recycle of nutrient; usage and substitution of more environmental friendly substance into the process and the overall system to reduce the impact such as using biomaterial, biodiesel instead of fossil fuel and also create a mitigation option available in different scenario (Somporn and Shabbir, 2009).

1.2 Problem Statement

Palm oil had a big demand in the future and had a very steady growth. This was because palm oil had wide application in many fields. However, the conventional management system of crude palm oil (CPO) mill and the conventional Palm Oil Mill Effluent (POME) treatments is not efficient enough to minimise the waste discharge and pollution done to the environment. The waste treatment contain large amount of

green-house gases which could be harvested as renewable energy such as methane in biogas released by the palm oil mill effluent (POME) digestion. The usage of fossil fuel to produce fertilizer, herbicide and diesel as transport fuel for trucks and lorry for locomotive transport of material and product also further polluting the environment and further speed up the fossil fuel depletion. Therefore, it is feasible to have a sustainable system which runs on environmental friendly policy and being cost effective at the same time.

1.3 Research Objectives

This work aims to understand the sustainable of palm oil system with the utilisation of palm oil resource and waste product to achieve minimum amount of discharge by integrating biomass and waste water recycle usage into the energy analysis of the overall process.

1.4 Scope of the Study

At first is to obtain an overall picture of the plantation, harvesting, transportation, processing, by product and waste treatment studies. To study the sustainability of palm oil with respect to the technology and planning applied. To conduct a Life Cycle analysis on the palm oil on the environmental impact and energy consumption. To identify how the utilisation of biomass and waste water could benefit in term of

economy and environmental aspect include the energy consumption and carbon credits. The tools, software that would be used are Microsoft Excel and Aspen Plus for data tabulation and simulation purpose for all the details obtained, identified.

1.5 Expected Outcome

i. The integration of biomass and biofuel utilisation into the palm oil life cycle would benefit both economically and environmentally.
ii. The waste discharge and treatment cost would be compared and understand
iii. The degree of pollution to the environment (carbon credit & energy consumption) is tabulated.

1.6 Significance of the Study

The life cycle analysis purposed to identify the impact of palm oil industry activities to the environment. Also, the study was able to utilise the usage of the waste product to generate additional revenue and save the consumption of fossil fuel energy and electricity. Production expenditure was reduced due to the reduced of energy consumption and additional revenue income from the activity of recycling the waste product.

CHAPTER 2

LITERATURE REVIEW

2.1 Agricultural Activity of Palm Oil and Its Significant

Palm oil in Malaysia is considered as the largest agricultural activities, with 67% of agricultural land covered with oil palm (Salsabila et al., 2010), which encounter for 11% of Malaysian land area (Sumiani et al., 2007). Till December 2012, total palm oil plantation area in Malaysia is 5076929 hectare with an average of 1568667tonnes of Crude palm oil production every month. Malaysia is the second largest palm oil producer and exports after Indonesia (MPOB, 2013).

Table 2.1 Oil Palm Planted Area by States as At December 2012 in Hectare (MPOB, 2013)

State	Mature	%	Immature	%	Total	%
Johore	618,353	86.59	95,777	13.41	**714,130**	14.07
Kedah	76,181	90.13	8,342	9.87	**84,523**	1.66
Kelantan	91,182	66.23	46,497	33.77	**137,679**	2.71
Malacca	48,718	92.75	3,806	7.25	**52,524**	1.03
Negeri Sembilan	143,580	85.94	23,496	14.06	**167,076**	3.29
Pahang	595,799	85.09	104,402	14.91	**700,201**	13.79
Perak	338,100	88.99	41,846	11.01	**379,946**	7.48
Perlis	197	69.37	87	30.63	**284**	0.01
Penang	13,264	97.85	292	2.15	**13,556**	0.27
Selangor	124,080	90.77	12,611	9.23	**136,691**	2.69
Terengganu	136,509	79.60	34,984	20.40	**171,493**	3.38
P. Malaysia	**2,185,963**	**85.45**	**372,140**	**14.55**	**2,558,103**	**50.39**
Sabah	1,292,757	89.61	149,831	10.39	**1,442,588**	28.41
Sarawak	874,152	81.22	202,086	18.78	**1,076,238**	21.20
Sabah & Sarawak	**2,166,909**	**86.03**	**351,917**	**13.97**	**2,518,826**	**49.61**
MALAYSIA	**4,352,872**	**85.74**	**724,057**	**14.26**	**5,076,929**	**100.00**

The general production of oil palm was 35% in the world trade of oils and fats (Syura and Tsan, 2005). The demand for palm oil is expected to increase due to the competitive process and energy efficient production of palm oil with the growing markets. The oil palm industry is an export-orientated industry which relies heavily on the world market. The major import country of palm oil raw material, products and by product is USA, followed by China, Europe nation and Japan (Vijaya, 2010). Thus palm oil industry contributed significantly towards the country foreign exchange earns and the increase standard of living for the population who related to the palm oil industries. The statistic of monthly local price of palm oil product in 2012 and 2013 is used to be compared and for data tabulation, simulation and calculation for the palm oil industry economy and potential later on.

Table 2.2 Local Monthly Price of Palm Oil Product (MPOB, 2013)

Months	Crude Palm oil				Palm Kernel		Fresh Fruit Bunches	
	Peninsular Malaysia		Malaysia					
	2012	2013	2012	2013	2012	2013	2012	2013
January	3,188.50	2,232.00	3,182.50	2,221.00	1,957.50	1,145.00	34.44	22.31
February	3,116.00	2,407.00	3,108.50	2,391.00	1,863.00	1,229.50	33.42	24.54
March	3,291.00	2,343.00	3,278.00	2,332.00	2,023.50	1,204.50	35.75	23.75
April	3,493.00	2,302.50	3,480.00	2,294.50	2,090.50	1,233.00	37.83	23.42
May	3,197.00	2,277.50	3,188.50	2,270.00	1,828.50	1,208.50	34.23	23.13
June	2,961.50	2,392.00	2,955.50	2,386.50	1,712.00	1,278.50	31.59	24.40
July	3,033.00,	2,329.50	3,031.50	2,325.00	1,696.50	1,277.00	32.24	23.79
August	2,811.00	2,341.50	2,805.50	2,334.00	1,501.00	1,345.00	29.55	24.05
September	2,729.00	2,362.00	2,719.50	2,355.00	1,386.50	1,387.50	28.18	24.30
October	2,243.00	2,361.00	2,243.50	2,356.00	1,126.00	1,368.50	22.40	24.23
November	2,220.00	2,575.50	2,214.00	2,570.00	1,155.50	1,643.50	22.09	27.12
December	2,060.00		2,052.00		1,039.00		20.39	
Average	2,772.50	2,357.50	2,764.00	2,352.00	1,522.50	1,326.50	30.18	24.09

2.2 Oil Palm Seedling

Oil palm nursery is the very first step for the supply of palm oil chain. It usually start with germinating a seed in a small polyethylene bag until it was few month matured, which later on would be transferred into a larger polyethylene bag and remain till it almost 1 year old than it was ready to be planted in the plantation field. Two major environmental impacts of of the plantation is the polyethylene bag used and the herbicide, fungicide used which both main ingredient are made of fossil fuel source (Halimah et al., nd).

2.3 Crude Palm Oil Mill Operation

Crude palm oil was produced in palm oil mills. Till up to date for October, 2013 the total Crude Palm Oil in Malaysia is 15686678 tonnes (MPOB, 2013). The impact to the environment involved with production of crude palm oil mainly involved with fossil fuel usage, respiratory inorganics and climate change. These impact come from the upstream activities and the palm oil mill effluent (POME) in the mill (Vijaya et al., 2010). The treatment of POME and recycle of its usage would be highlighted in this research to reduce the impact and benefit to the plantation of palm oil. The main air emission from the POME pond or tanks when it undergoes the anaerobic digestion was biogas which mainly consisted of methane, carbon dioxide and traces of hydrogen sulphide. If the biogas is not harvested it would be a greenhouse gas, if it was harvested than it would be considered as a renewable energy source. Also comes with selective production of value-added products such as fertiliser from the waste treatment process. Next challenge would be the usage of diesel to fire up the engine and also the poorly maintained transportation. The depletion of fossil fuel in this two process accounted for both cost and also energy analysis. Therefore an integrated would be done to access the depletion of fossil fuel in the process (Sumiani and Hansen, 2007).

2.4 Crude Palm Oil Mill Production Flow

The palm oil milling process is mostly the same for all the mills throughout the country, with the block flow diagram shown below.

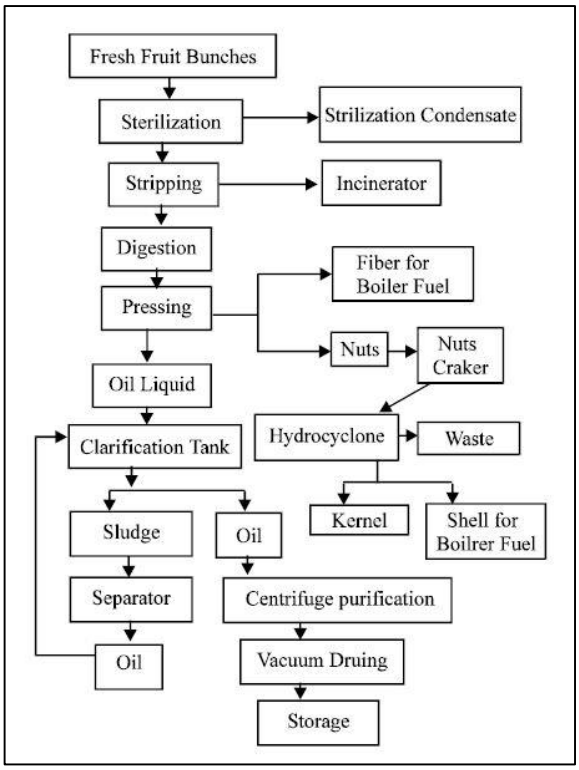

Figure 2.1 Block Flow Diagram of the Palm Oil Mill Process

(Igwe and Onyegbado, 2007)

For the brief description for CPO mill operation it stated below in sequence.

1) Sterilization:

The first step is the sterilisation of the fresh fruit bunches in steam sterilizers for 50 min at condition of 140 degree Celsius and pressure of 3 bar or 105 Pascal. This would stop the rapid formation of free fatty acids in the process. This also loosened the fruits that are attached to the bunches. In this step, the amount of effluent from the sterilizer condensate is about 0.9 tonnes for each tonnes of Crude Palm Oil produced.

2) Stripping, digestion and pressing:

In this step, the sterilise fruit are stripped of the bunches using a rotary drum thresher. Rotary drum-stripper is used where fruits are stripped from the fresh fruit bunches, the fruits is than collect by a bucket conveyor and discharged into a digester which that mashed by the rotating arms. After the stripping process, the sterilised fruits is digested under the condition of 80 to 90 degree Celsius by using a heated vessel, the mesocarp is further loosened and prepared for pressing. Then the digested mash is feed into a screw press to separate the oil from the spend mesocarp and nuts. Screw press used operate under high pressure and high temperature water to facilitate the flow of the oil that has been pressed out.

3) Clarification:

The crude oil from the digester is a mixture of oil and water with some impurities. The water is removed via settling in a mill operation. The total solids content of the clarification sludge is higher when compared to the other waste streams.

4) Nut and fibre separation

The pressing process, left a leftover product that made up of nuts and fibre in a cake form. A preliminary breaking treatment is given before the cake being fed into the separator which operated by mechanical movement or with an air stream for the separation of kernel and nuts to occur.

5) Kernel extraction and drying

After the separation of fibre from the nuts, the nuts are than used to obtain the palm kernel. A hydrocyclone is used to separates the kernel from the empty shell after the shell has been cracked. Approximately 0.1 tonnes of liquid effluent per tonnes of produced crude palm oil is generated in this process. Any uncracked nuts are recycled for separation again so that all shells are separated from the kernel that are going to be sold soon (Yeong Wu et al., 2010).

Palm oil mills are generally self-sufficient in term of energy requirement due to the availability of adequate quantities of fibre and shell materials as boiler fuel. Fibre an shell materials as boiler fuel. Palm kernel sold to palm kernel oil producers for CPKO production

2.5 Transportation

In this research, the palm oil plantation and crude palm oil mill are located in Malaysia, with palm oil mill being established close to palm oil plantation area. This help to preserve the freshness of the fresh fruit bunches as it needed to be processed within 24 hour to limit the formation of free fatty acid (FFA) and having a higher oil extraction percentage (Seksan et al., 2009). The palm oil mill is located next to palm oil refinery for production of crude palm oil. Usually lorries with capacity of 5 tons courier weight is used to transport Fresh Fruit Bunches from oil palm field to palm oil mill. Truck with load of 20 tons load transport crude palm oil from CPO plant to further distance for end product production or related activity. The 5 ton truck is categorised under the

Light Duty Diesel Vehicle and the 20 ton truck is Heavy Duty Diesel Vehicle. The diesel consumption and energy efficiency of both LDDV and HDDV used for data tabulation and calculation is obtained from the status report of Developing Integrated Emission Strategies for Existing Land Transport, DIESEL. The data is summarised in data form as below.

Table 2.3 Fuel Efficiency, Discharge of Different Type of Diesel Vehicle (DIESEL, 2004)

Type		**LDDV**	**LDDV**	**HDDV**
Fuel Injection System		DI	IDI	DI
Total Vehicles Tested		228	375	176
Test Mode		Cold	Cold	Hot
Driving Cycle		NYBC	NYBC	TISI
THC		0.105	0.065	4.189
Emission (g/km)	**NO_X**	1.224	1.020	17.427
	CO	0.562	0.502	30.239
	CO_2	261.072	270.00	1671.548
PM		0.090	0.085	4.633
Fuel Efficiency (km/l)		10.787	10.116	1.628

2.6 Palm Oil Mill Effluent

The palm oil mill effluent is the waste water product from the palm oil mill operation. It has several usage and function and could being very beneficial if used wisely and also could lead to a threat to the environment if it is not being taken care of properly. The POME is brown slurry which is composed of 4-5% solids, 0.5-1% residual oil and about 95% water and high concentration of organic nitrogen (Singh et al., 2010).

Table 2.4 Typical Characteristic of Raw Pome (Ma, 1999)

Parameter	**Average**	**Metal**	**Average**
pH	4.7	Phosphorous	180
Oil and Grease	4000	Potasium	2270
Biochemical Oxygen Demand (BOD_5)	25000	Magnesium	615
Chemical Oxygen Demand (COD)	50000	Calcium	439
Total Solids	40500	Boron	7.6
Suspended Solids	18000	Iron	46.5
Total volatile Solids	34000	Managanese	2.0
Ammonical Nitrogen	35	Copper	0.89
Total Nitrogen	750	Zinc	2.3

All in mg/l except Ph

This show that the threat to the aquatic life if the untreated POME is released to the environment, the high BOD and COD of the POME could bring a harmful effect to the aquatic life as the significant drop of oxygen content in the water which may lead to death of aquatic life. The high nutrient content of POME indicate that the possibilities of POME to be a substituent of fertiliser which generally derived from fossil fuel, as an organic fertiliser, it would be more environmental friendly as compared. One of the main contribution and recycling usage of POME could be the harvesting of Biogas during the anaerobic treatment of POME as mentioned earlier.

The Palm Oil Mill Effluent can serve as a good composting material but the major practice is the sludge would be discharged with treated POME into a treatment pond where nutrient recollected from the bottom of the pond recycled for plantation fertilisation purpose. However the activity has a relative low economic benefit compared to the effort done. So it is not so effective to do so. In another scenario, composting of empty fruit bunches with raw POME is still being practiced in several palm oil mills which have no biogas and sludge recycling. The composting of EFB