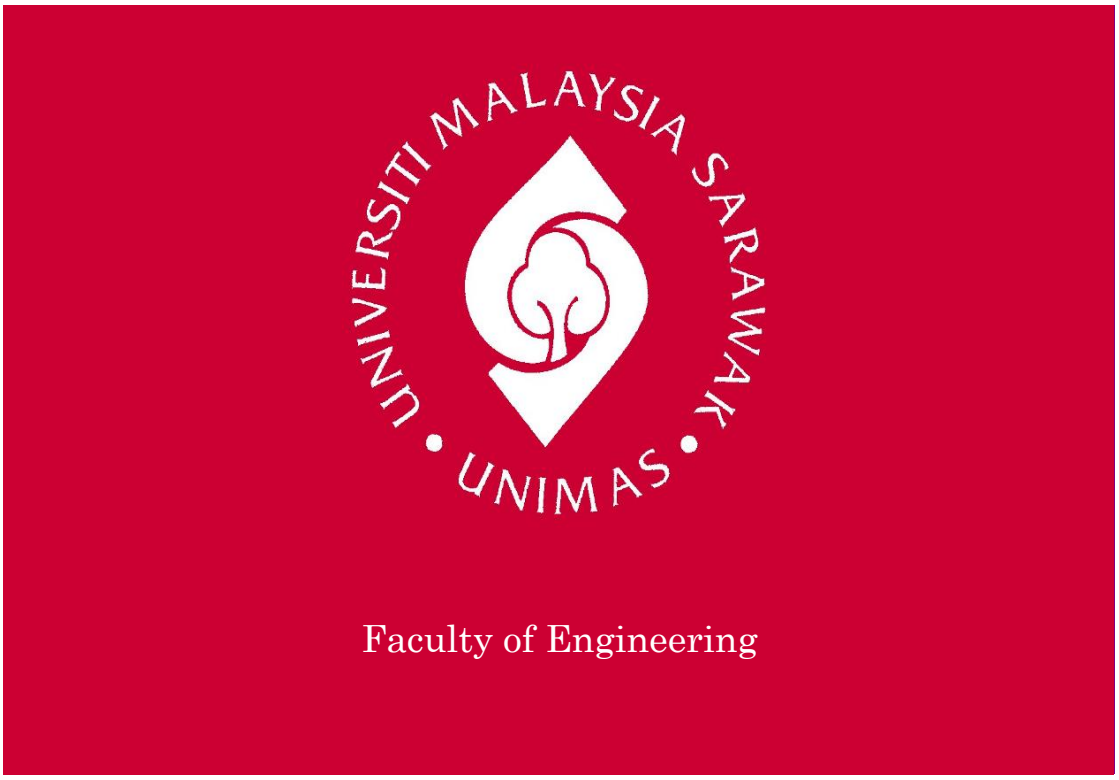

QUANTIFICATION OF GREENHOUSE GASES EMISSION FROM COMPOSTED COMMODITY WASTES IN SARAWAK

Nur Jihan Nazihah Binti Amin

Bachelor of Engineering with Honours

(Chemical Engineering)

2018

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report ☑

Masters ☐

PhD ☐

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This declaration is made on the 12 day of June.2018.

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12 JUNE 2018
Date submitted

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Name of the student (Matric No.)

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This research report which entitled **"Quantification of Greenhouse Gases Emission from Composted Commodity Wastes in Sarawak"** was prepared by Nur Jihan Nazihah Binti Amin (45886), as a partial fulfillment for the Bachelor of Engineering with Honours (Chemical Engineering) is hereby read and approved by:

_____ 12 JUNE 2018

ASSOC. PROF. DR. SHANTI FARIDAH BT SALLEH
(Supervisor) Date

QUANTIFICATION OF GREENHOUSE GASES EMISSION FROM COMPOSTED COMMODITY WASTES IN SARAWAK

NUR JIHAN NAZIHAH BINTI AMIN

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Chemical Engineering and Energy Sustainability)

Faculty of Engineering
Universiti Malaysia Sarawak

2018

Dedicated to my beloved family and supportive friends.

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ABSTRAK

Sarawak mempunyai tanah yang luas dan kaya dengan sumber asli dan memainkan peranan besar dalam sektor pertanian Malaysia secara keseluruhan, menghasilkan makanan dan minyak untuk kegunaan tempatan dan juga eksport. Kajian ini bertujuan untuk mengkaji pelepasan gas rumah hijau yang dihasilkan oleh sisa komoditi kompos di Sarawak. Komoditi pertanian yang dicadangkan ialah kelapa sawit, koko dan kelapa. Gas rumah hijau memberi tumpuan kepada pelepasan karbon dioksida dan metana. Pengkeberanian pelepasan gas rumah hijau dilakukan secara eksperimental dengan menggunakan kaedah perpindahan air dari pencerna anaerobik. Dalam kajian ini, gas rumah hijau yang menarik adalah karbon dioksida dan metana. Di samping itu, pelepasan gas rumah hijau juga diramalkan menggunakan pengaturcaraan maju menggunakan Microsoft Office Excel. Berdasarkan hasilnya, tandan buah kosong menghasilkan lebih banyak gas rumah kaca, 67.606 Mg CO_2 / tahun dan 614.606 Mg CH_4 / tahun. Pengurusan sisa penyumbang utama pelepasan Gas rumah hijau (tandan buah kosong) dipelajari di mana penulis mendapati bahawa pembakaran adalah pilihan terbaik untuk meminimumkan jumlah sisa dan meminimumkan pelepasan gas rumah hijau.

ABSTRACT

Sarawak has a vast amount of land and rich in natural resources and it plays a big role in Malaysia's agriculture sector as a whole, producing foods and oil for local consumption and also export. This research aims to study on greenhouse gas emissions generated by composted commodity waste in Sarawak. The suggested agricultural commodities are oil palm, cocoa and coconut. The greenhouse gases are focusing on the emission of carbon dioxide and methane. The quantification of greenhouse gas emissions a done experimentally by using water displacement method from anaerobic digester. In this study, the greenhouse gases of interest are carbon dioxide and methane. In addition, the greenhouse gas emission also predicted using a developed programming using Microsoft Office Excel. Based on the results obtained, empty fruit bunch produced more greenhouse gases, 67.606 Mg CO_2/year and 614.606 Mg CH_4/year. The waste management of top contributor of greenhouse gas emission (empty fruit bunch) is studied where the author found that incineration is the best option for minimizing volume of waste and minimizing the emission of greenhouse gases.

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LIST OF SYMBOLS

$cm\ h^{-1}$	Centimetre per hour
h	Hour
ha	Hectare
Gg	Gigagram
kg	Kilogram
L	Litre
mL/min	Flow rate
Mg	Megagram

LIST OF ABBREVIATIONS

3R	Reduce, Reuse and recycle
BBA	Biomass bottom ash
BFA	Biomass fly ash
CH_4	Methane
CO_2	Carbon dioxide
CO_2 eq	Carbon dioxide equivalent
CPO	Crude Palm Oil
EFB	Empty fruit bunch
EPI	Environmental Performance Index
F	Fluorine
FFB	Fresh fruit bunch
GHG	Greenhouse gas(es)
GWP	Global warming potential
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MSW	Municipal Solid Waste
N_2O	Nitrous oxide
PFA	Palm Fatty Acid
POME	Palm Oil Mill Effluent
RBDPO	Refined, Bleached, Deodorized Palm Oil
RBDPL	Refined, Bleached, Deodorized Palm Olien
RBDPS	Refined, Bleached, Deodorized Palm Stearin
SWPCMA	Solid Waste and Public Cleansing Management Act

CHAPTER 1

INTRODUCTION

1.1 Waste Composition in Malaysia

Waste is something that the producer no longer requires and therefore discards (Hand, 2009). Anything that is worn out, broken, and no longer useful that requires disposal such as unwanted surfeit substance, scrap material or effluent (CIPS,2007). Globally, Asia is known as the largest waste generator with a specific elements of policy dynamics in the waste management (UNCRD et al. 2009). A developing and growing population in Malaysia is expected to generate a vast amount of solid waste every year. The current population in Malaysia is approximately 32.0 million people with a growth at 1.3% in 2017 as compared to 31.6 million in 2016. (Department of Statistics Malaysia, 2017).

The daily waste generation for years 2007 and 2011 for Peninsular Malaysia, Sabah and Sarawak. In 2012, the total waste generation in Malaysia was about 33,130 tonnes per day which is 1.17 kg/capita/day (See **Table 1.1**).

Table 1.1: Waste Generations per Day in 2007 and 2012 (Ministry of Natural resources and Environment Malaysia, 2015)

Region	**Year**	
	2007	**2012**
Peninsular Malaysia (tonnes/day)	20,500	27,802
Sabah (tonnes/day)	1,210	2,984
Sarawak (tonnes/day)	1,988	2,344

The waste composition in Malaysia is displayed in **Figure 1.1** where food waste is a significant major component of generated waste. Mohamad Taha (2016) mentioned that about 70% of waste is generated by the household while 30% is generated by the commercial sector. Annually, biomass waste in Malaysia generated at approximately 168 million tonnes of biomass waste is generated in Malaysia (Abdul Aziz and Leon, 2012).

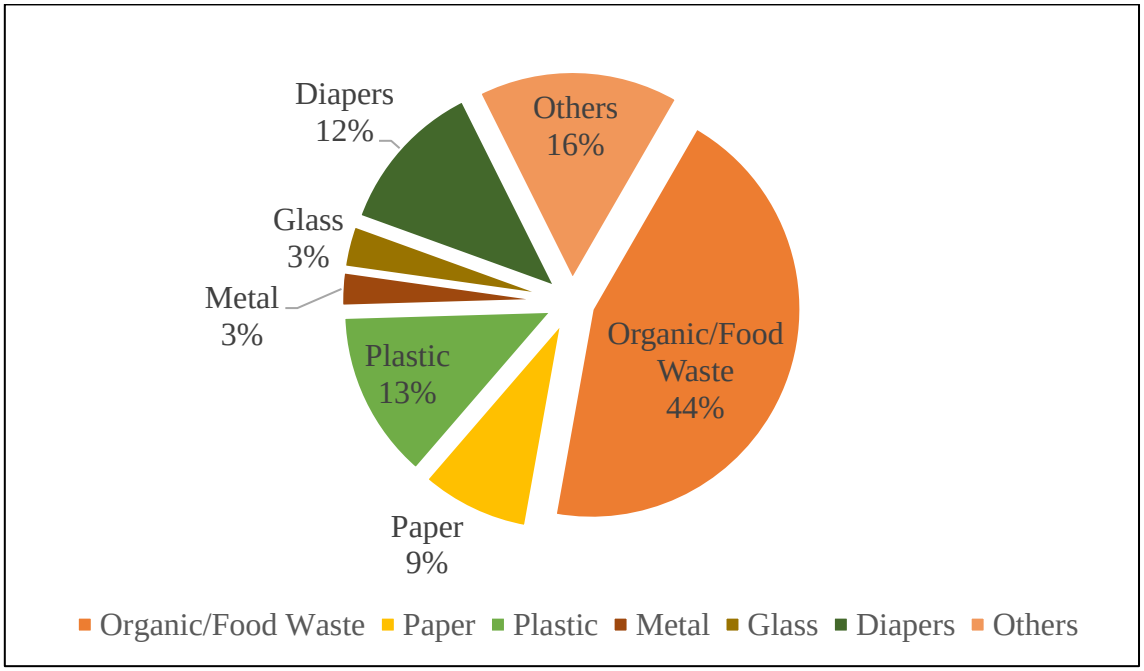

Figure 1.1: Main waste component in Malaysia (Mohamad Taha, 2016)

1.2 Agricultural Waste in Industry

Generation of the waste depend on the type of industry. Agricultural waste refers to the waste produced because of agricultural activities which includes manure and wastes from farms (fertilized soils, contaminated water due to fertilizer, slaughterhouses and harvest waste) (OECD, 2001). Approximately, 998 million tonnes of agricultural waste are generated annually worldwide while about 1.2 million tonnes of agricultural waste are disposed into landfills site annually in Malaysia (Agamuthu, 2009). After harvesting period, a massive landfill problem is major issue due to disposal of agricultural waste fibers such as empty fruit bunch, rice straw, oil palm empty bunch, cocoa pod husk, sugarcane baggase, pineapple leaf and many more biomass (Yusriah, Sapuan, Zainudin and Mariatti, 2012).

In general, for 94% of biomass feedstocks contributed by the palm oil industry while 4% is from wood residues from forestry sector, 1% from rice and another 1 % is

generated by sugarcane industry (Abdul Aziz and Teon, 2012). Wastes from coconut cultivation are shell, copra and husk generated from the coconut food processing and coconut fruits consumptions. Annually, about 0 0.374 million tonnes of coconut husk and 583 million tonnes of coconut shells were produced. (Chuah, Wan Azlina, Robiah and Omar, 2007). On the other hand, 25.2 million tonnes per hectare per year of dry organic biomass matter is expected to be produced from the pruning process of cocoa. Agriculture waste contributed to the greenhouse gases emission as shown in **Figure 1.2**.

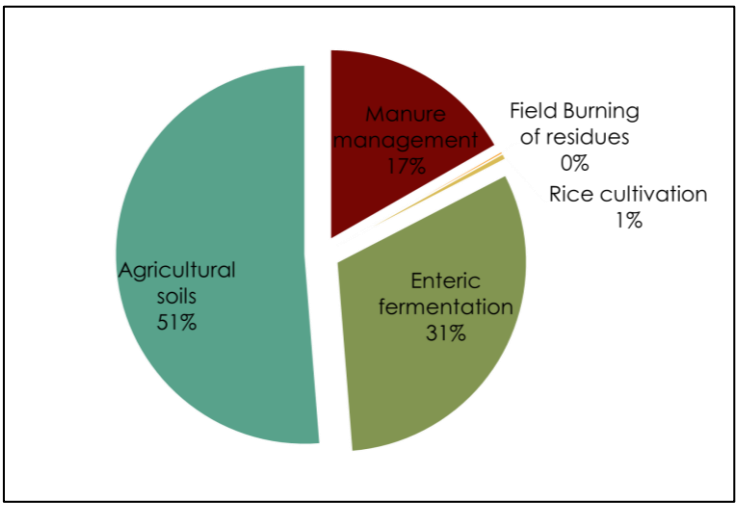

Figure 1.2: GHG Emission from Agriculture (Land Use, Land Use Change and Forestry, 2015)

1.3 Overview of Waste Management

Waste management refer to the process of dealing waste products, garbage and sewage either by collection, disposal or transportation (Conserve Energy Future, 2017). Waste management is one of the important environmental problems of the world. There are few options used to manage wastes which are stated as the following (Rao, Sultana and Kota, 2017):

1. Waste minimization by mechanical, physical, and chemical techniques
2. Ideal disposal of wastes
3. Waste treatment technologies such as biotreatment, solidification and stabilization

Figure 1.3 shows the waste hierarchy in waste management system. Waste hierarchy functions to manage the waste according to a suitable agenda. The most recommended waste approach is to reduce waste where the initiatives are by business or

household to minimize the amount of waste produced. Reuse waste is to avoid energy-consuming reprocessing and recycle option is a process where the waste is reprocessed for further purpose. The other option is energy recovery whereby the waste is processed to generate waste by using a variety of technologies. The least preferred option of waste management is waste disposal.

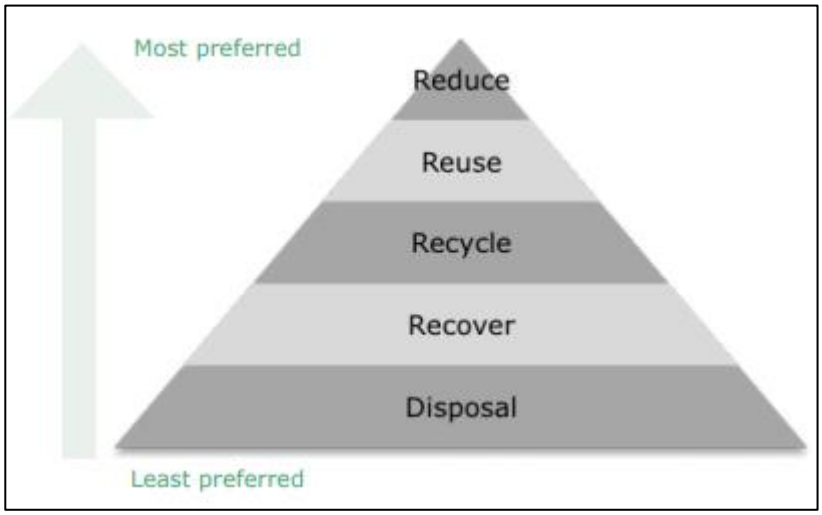

Figure 1.3: Waste hierarchy (Chin, 2011)

The example of recycling agriculture waste is composting as means of conserving natural resources. A research by Fidelis and Rao (2017) concluded that a cocoa pod waste can be co-composted with various materials such as super phosphate and poultry manure, and able to produce effective and high-quality fertilizer for cocoa seedlings. Recovering of agricultural waste option is where the waste considered as an energy source. A study by (Nasution, Wibawa, Ahamed and Noguchi, 2017) stated that biogas can be recovered from Palm Oil Mill Effluent (POME) which released biogas. Electricity generation uses a gas engine that converts the biogas to electricity.

1.4 Malaysia Waste Management Policies

Malaysian government had focused on "waste minimisation", "promotion of reuse and recycling" and developing projects for recycling in 8th Malaysian Plan. In 9th Malaysian Plan, the government emphasis one the continuation of reuse, reduce, recycling and recovery of waste and use more on environmentally friendly products. 10th Malaysian Plan emphasis on way to gauge the environmental management performance by applying environmental performance index (EPI).

i. *Solid Waste and Public Cleansing Management Act (SWPCMA) 2007*

This act focused on the management of public cleanliness or sanitation. Developed countries such as Japan, Switzerland and the United States of America had practiced SWPCMA. This act privatized solid waste management and since it was implemented, management of solid waste was reported to improve in Malaysia.

ii. *Master Plan on National Waste Minimization 2006*

Main aim of this master plan is to realise a *Material Cycle Society* and to achieve this, an awareness on importance of waste reduction among Malaysian citizen must be considered. The implementation of 3Rs activities (Reduce, Reuse and Recycle) and also strengthening the government policies with partnership of government, private sector and general public on waste minimisation.

1.5 Research Problem

Waste management problem, rapid development of industrialization, urbanization, society unawareness and weakness of law enforcement in has caused the worsening of environment (Noor Mohammad et al., 2013). The massive volume of waste, limited treatment capacity and inefficient waste management causes environmental hazards (Zeng, Zhu, Ma, Huang and Li, 2014). The current problem of the agricultural wastes is that it is not properly managed. The comprehensive utilization rate of crop residue is rather low and many them was abandoned or unreasonably used (Khanh, 2010). Composting is one of waste management option that is environmentally friendly where organic matter is biologically degraded. Although the advantages of composting are tangible, GHGs are still generated and emitted to the atmosphere during this process leading to global warming. Greenhouse gases like methane, have a global warming potential 25 times greater than of carbon dioxide, CO_2 and have a great impact on global warming.

In this study, the author interest is greenhouse gases (GHGs) from the composted waste. In 2011, percentage emissions of Greenhouse Gas for CO_2, CH_4, N_2O and F gases are 72%, 23%, 5% and 0% respectively (Ministry of Natural Resources and Environment Malaysia, 2015). The release of greenhouse gases in the atmosphere could affect the health of residents and caused global warming. In order to reduce the emission of GHG

and also saving the cost, and utilize wastes and turn it into profits, a research is made in order to investigate amount of greenhouse gases produced by the waste in different commodity.

1.6 Research Scope

This research focuses on the composting waste management of three top agricultural commodities in Sarawak, Malaysia which are oil palm, cocoa and coconut. The waste generated from the commodities are further studied on the greenhouse gases emission where by the GHGs quantification will be conducted for only two major gases; carbon dioxide and methane.

1.7 Aim and Objectives

The main aim of this research is to study on waste management of agricultural commodities in Sarawak with regards to Greenhouse Gas emissions. The following are the objectives that correspond to the main aim.

i. To determine greenhouse gas emission from the selected agricultural commodities
ii. To compare greenhouse gas emission between the selected agricultural commodities in Sarawak
iii. To suggest a proper waste management for top contributor of greenhouse gas emission

1.8 Summary

This chapter introduces the waste composition in Malaysia particularly in Sarawak and it focuses on the production of agriculture waste from industry. Due to the improper management of waste and rapid development of agriculture sector, it causes the increasing volume of waste generated every year in Malaysia. Thus, leading to the emission of greenhouse gases which contributes to the global warming and environmental pollutions. The government has implement few acts and policies in order to reduce the volume of waste generated. Subsequently, the study has been designed to determine the greenhouse gases emission from composted commodity waste in Sarawak.

CHAPTER 2

LITERATURE REVIEW

2.1 Agricultural Industry Commodity in Sarawak

Sarawak has a vast amount of land and rich in natural resources and it plays a big role in Malaysia's agriculture sector as a whole, producing foods and oil for local consumption and also export (Lim, 2016). According to Department of Agriculture Sarawak (2013), oil palm commodity is largest commodity with 70.9% distribution by crop followed by rubber by 10.7%, paddy by 9.1%, sago at 3.7% and fruit trees by 2.4 %. Other commodities percentage distribution by crop such as coconut, pepper, cocoa, vegetables and others are at 1.2%, 1.0%, 0.4%, 0.3% and 0.3% respectively.

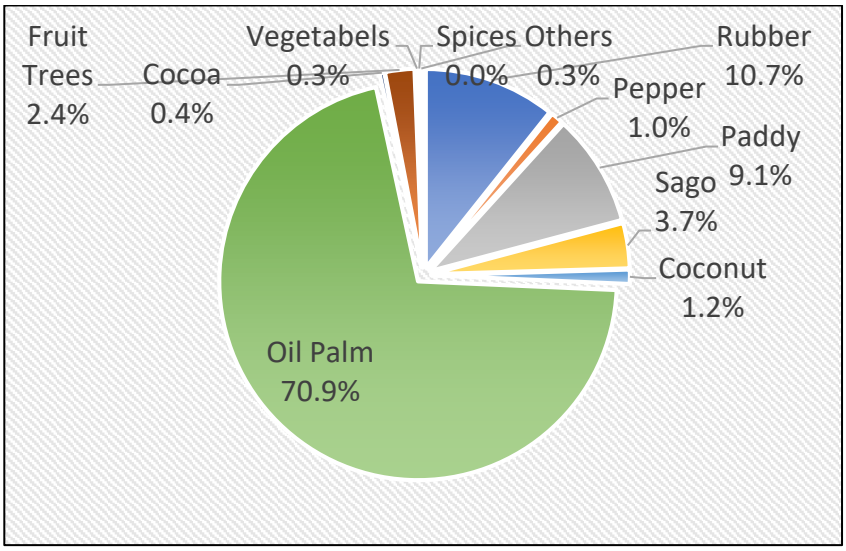

Figure 2.1: Percentage Distribution by Crop 2013 (Department of Agriculture Sarawak, 2013)

2.1.1 Oil Palm

According to Lim (2016), in Sarawak, there are 68 palm oil mills with capacity production of 16.2 million metric tonnes per year, four palm kernel crushers with 697,200 metric tonnes per annum and six refineries with 2.9 million metric tonnes per year. Oil palm industry has changed the scenario of Malaysian agriculture and economy. The trend of production of oil palm is stated in **Table 2.1** while **Table 2.2** is the planted area in Sarawak.

Table 2.1: The oil palm commodity (Sarawak Chief Minister's Department, (2015); Malaysian Palm Oil Board (2018); Sarawak Oil Palms Berhad (2017))

Year	Quantity (Tonne)	Value (RM '000)	Export price (RM/tonne fob)
2012	2,772,161	2,480,635	2,871
2013	3,122,912	2,467,148	2,352
2014	3,522,801	2,719,927	2,417
2015	3,719,909	3,030,413	2,179
2016	8,432,539	4,332,737	2,693
2017	9,343,411	4,273,671	2,913

Table 2.2: The oil palm planted area (Sarawak Chief Minister's Department (2015); Malaysian Palm Oil Board (2018))

Year	Area ('000 Hectares)
2012	1,076.2
2013	1,160.9
2014	1,263.4
2015	1,442.1
2016	1,506.8
2017	2,722.1

The processing of palm oil is shown in **Figure 2.2** whereby the production can be divided into 2 main process, milling and refining. At the mill, the fresh fruit bunches (FFB) are sterilized in a large pressure vessel and stripped into a rotating drum stripper. FFBs are then extracted in a homogenous oil mesh to obtain the palm kernel and purified