THE PHYSICO-CHEMICAL EVALUATION AND ENVIRONMENTAL SUSTAINABILITY OF OIL PALM DECANTER CAKE IN LUBOK ANTU, SARAWAK

Anjelina Joffery Kalimuthu

Bachelor of Engineering (Hons)

Chemical Engineering

2022

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report	√
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the 30 day of JUNE 2022.

Student's Declaration:

I, ANJELINA JOFFERY KALIMUTHU (64647), DEPT. OF CHEMICAL ENGINEERING AND ENERGY SUSTAINABILITY, FACULTY OF ENGINEERING hereby declare that the work entitled THE PHYSICO-CHEMICAL EVALUATION AND ENVIRONMENTAL SUSTAINABILITY OF OIL PALM DECANTER CAKE IN LUBOK ANTU, SARAWAK is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

30 JUNE 2022	ANJELINA JOFFERY KALIMUTHU (64647)
Date submitted	Name of the student (Matric No.)

Supervisor's Declaration:

I, ASSOCIATE PROFESSOR DR. SHANTI FARIDAH BINTI SALLEH hereby certifies that the work entitled THE PHYSICO-CHEMICAL EVALUATION AND ENVIRONMENTAL SUSTAINABILITY OF OIL PALM DECANTER CAKE IN LUBOK ANTU, SARAWAK was prepared by the above-named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of BACHELOR OF ENGINEERING WITH HONOURS (CHEMICAL ENGINEERING), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by : AP Dr. Shanti Faridah binti Salleh Date: 30 JUNE 2022

(Name of the supervisor)

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 972) *

☐ **RESTRICTED** (Contains restricted information as specified by the organization where research was done) *

☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirm with free consent and willingly declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature _____ Supervisor signature: _____

(30 JUNE 2022) (30 JUNE 2022)

Current Address:

NO 106, LORONG 6C, TAMAN BEVERLY BATU 13, JALAN KUCHING-SERIAN, 93250 KUCHING, SARAWAK, MALAYSIA

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

APPROVAL SHEET

This final year project thesis which entitles “The Physico-Chemical Evaluation and Environmental Sustainability of Oil Palm Decanter Cake in Lubok Antu, Sarawak” is prepared by Anjelina Joffery Kalimuthu (64647) as a partial fulfillment for the Degree of Bachelor of Engineering with Honours (Chemical Engineering) is hereby read and approved by:

	30 JUNE 2022
ASSOCIATE PROFESSOR DR. SHANTI FARIDAH BINTI SALLEH (Final Year Project Supervisor)	Date

THE PHYSICO-CHEMICAL EVALUATION AND ENIRONMENTAL SUSTAINABILITY OF OIL PALM DECANTER CAKE IN LUBOK ANTU, SARAWAK

ANJELINA JOFFERY KALIMUTHU

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering (Hons)
Chemical Engineering

Faculty of Engineering

Universiti Malaysia Sarawak

2022

Dedicated to our cherished parents, who have never failed to inspire and encourage us.

ACKNOWLEDGEMENT

The author wishes to firstly express her sincere gratitude to her supervisor, Associate Professor Dr. Shanti Faridah binti Salleh from the Department of Chemical Engineering and Energy Sustainability, Universiti Malaysia Sarawak (UNIMAS), and the mill manager, Mr. Ubang anak Balang from Lubok Antu Palm Oil Mill 1 (LAPOM 1), for their ongoing guidance and support in finishing this final year project thesis. Also acknowledged are the examiner and panels, Mr. Khairul Anwar, Dr. Ibrahim bin Yakub, and Dr. Nazeri Abdul Rahman, for their suggestions and assistance in enhancing this final year project thesis.

The academic and technical staffs of the department of chemical engineering and energy sustainability as well as the mill engineer, supervisors, and laboratory assistants in LAPOM 1 are all thanked on behalf of the author for helping and supplying with the necessary materials and equipment for conducting the research without any restrictions.

Besides, the author would also like to thank her devoted parents and other family members for their unwavering support and encouragement in helping her finishing her Final Year Project thesis. The author's sincere appreciation also goes out to her beloved classmates from the batch of 2018/2019 and friends, who are always prepared to give a hand and offer their expertise to help her in finishing the final year project thesis.

Last but not least, special thanks are also dedicated to parties who are not mentioned for their willingness to help the author directly or indirectly towards the completion of this thesis.

ABSTRACT

Oil Palm Decanter Cake (OPDC) is one of the large quantity leftovers in the oil palm mill that has been shown to have nutritional value. As a result of its widespread production, its proper disposal has become a major source of concern especially when it comes to the environmental contamination in the palm oil industry in Malaysia, with a particular focus on the palm oil mill located in Lubok Antu, Sarawak, it has been observed that Palm Oil Mill Waste (POMW) is one of the major problems that need to be taken into consideration by the mills, particularly when it comes to wastes related to OPDC, because both the disposal and the utilisation of wastes related to OPDC are not being properly disposed of and managed. It is critical that significant efforts to be made to ensure appropriate OPDC waste management in Lubok Antu Palm Oil Mill 1 (LAPOM 1) are to be done to address rising environmental concerns, hence the purpose of this project is to evaluate the physical and chemical characteristics of OPDC, besides to analyse the environmental sustainability of the potential applications of OPDC as raw material focusing on organic fertilizer and biomethane gas. In evaluating the physico-chemical (physical and chemical) analysis of OPDC for organic fertilizer and biomethane gas applications, seven analyses have been done which includes Scanning Electron Microscope (SEM), density, moisture, oil, heavy metals, Nitrogen Phosphorus Potassium (NPK), and Fourier Transmission Infrared Spectroscopy (FTIR) analysis. Besides, the inventory structure for the Carbon Dioxide Equivalent (CO2e) have been designed in order to analyse the environmental sustainability of OPDC for organic fertilizer and biomethane applications by conducting the inventory analysis. Consequently, based on all of the evaluation and analysis which have been done, biomethane gas application are selected to be the potential application of OPDC as raw material in which it emits lower CO2e compared to organic fertilizer application, besides sludge is produced upon biomethane production in which can be used as soil conditioner based on the physical and chemical characteristics that have been analysed. Biomethane is a chemical alternative to natural gas and can be used in gas distribution and transport, and electricity generation, as it has zero emissions and is interchangeable with natural gas as it can absorb methane emissions from landfills and manure production, reducing environmental methane emissions.

Keywords: Oil Palm Decanter Cake, Physico-chemical analysis, Environmental sustainability

ABSTRAK

Kek Decanter Kelapa Sawit (OPDC) merupakan satu daripada sisa kuantiti yang banyak di kilang kelapa sawit yang telah terbukti mempunyai nilai pemakanan. Hasil daripada pengeluarannya yang meluas, pelupusan OPDC telah menjadi sumber kebimbangan utama terutamanya apabila ia berkaitan dengan pencemaran alam sekitar dalam industri minyak sawit di Malaysia, dengan tumpuan khusus kepada kilang minyak sawit yang terletak di Lubok Antu, Sarawak, telah diperhatikan bahawa Sisa Kilang Sawit merupakan masalah utama yang perlu diambil berat oleh kilang, terutamanya apabila ia berkaitan dengan sisa yang berkaitan dengan OPDC, kerana kedua-dua pelupusan dan penggunaan sisa yang berkaitan dengan OPDC tidak dilupuskan dan diurus dengan betul. Bagi memastikan pengurusan sisa OPDC di Kilang Kelapa Sawit 1 Lubok Antu (LAPOM 1) diurus dengan betul, segala usaha perlu dilakukan bagi menangani kebimbangan alam sekitar yang semakin meningkat, justeru tujuan projek ini adalah untuk menilai ciri-ciri fizikal dan kimia OPDC, selain menganalisis kemampanan alam sekitar bagi aplikasi yang berpotensi bagi menjadikan OPDC sebagai bahan mentah yang memberi tumpuan kepada baja organik dan gas biometana. Bagi penilaian analisis fiziko-kimia (fizikal dan kimia) OPDC untuk aplikasi baja organik dan gas biometana, tujuh analisis telah dilakukan yang merangkumi Mikroskop Elektron Pengimbasan (SEM), ketumpatan, lembapan, minyak, logam berat, Nitrogen Fosforus Kalium (NPK), dan analisis Fourier Transmission Infrared Spectroscopy (FTIR). Selain itu, struktur inventori bagi Setara Karbon Dioksida (CO_2e) telah direka untuk menganalisis kemampanan alam sekitar untuk aplikasi baja organik dan biometana dengan menjalankan analisis inventori. Oleh itu, berdasarkan semua penilaian dan analisis yang telah dilakukan, aplikasi gas biometana dipilih sebagai potensi penggunaan OPDC sebagai bahan mentah di mana ia mengeluarkan CO_2e yang lebih rendah berbanding penggunaan baja organik, selain daripada enapcemar terhasil semasa pengeluaran biometana boleh digunakan sebagai perapi tanah berdasarkan ciri-ciri fizikal dan kimia yang telah dianalisis. Biometana ialah alternatif kimia kepada gas asli dan boleh digunakan dalam pengedaran dan pengangkutan gas, serta penjanaan elektrik, kerana ia mempunyai pelepasan sifar dan boleh ditukar ganti dengan gas asli dimana ia boleh menyerap pelepasan metana dari tanah bagi mengurangkan pelepasan metana ke alam sekitar.

Kata kunci: Kek Decanter Kelapa Sawit, Analisis fiziko-kimia, Alam Sekitar

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CPO	Crude Palm Oil
EFB	Empty Fruit Bunches
EDX	Energy Dispersive X-ray Spectroscopy
FFB	Fresh Fruit Bunches
FT-IR	Fourier Transmission Infrared Spectroscopy
FYP	Final Year Project
GHG	Green House Gas
GWP	Global Warming Potential
ISO	International Organisation for Standardisation
LAPOM 1	Lubok Antu Palm Oil Mill 1
LCA	Life Cycle Analysis
LCI	Life Cycle Inventory
OER	Oil Extraction Rate
MPOB	Malaysian Palm Oil Board
OPDC	Oil Palm Decanter Cake
PBD	Process Block Diagram
PK	Palm Kernel
PKC	Palm Kernel Cake
PKO	Palm Kernel Oil
PMF	Palm Mesocarp Fibre
PO	Palm Oil
POME	Palm Oil Mill Effluent
POMS	Palm Oil Mill Sludge
POMW	Palm Oil Mill Waste
RI	Refractive Index
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
SDG	Sustainability Development Goals
SEM	Scanning Electron Microscope

SG	Specific Gravity
UNIMAS	Universiti Malaysia Sarawak

LIST OF NOMENCLATURE

%	Percentage
Cd	Cadmium
CH_4	Methane
cm^{-1}	Per centimetre
CO_2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
Cu	Copper
g/cm^3	Gram per centimetre cube
g/kg	Gram per kilogram
HFCs	Hydrofluorocarbons
H_3PO_4	Phosphoric acid
K	Potassium
KBr	Potassium bromide
kg/ton	Kilogram per tonne
kWh	Kilowatt-hours
MT	Metric tonne
N	Nitrogen
Ni	Nickel
$(NF_3)^3$	Nitrogen trifluoride
N_2O	Nitrous oxide
P	Phosphorus
Pb	Lead
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Research Background Study

Malaysia's oil palm industry is one of the country's most valuable, as the oil palm tree (Elaeis guineensis) is said to have originated in Africa. The British colonialists introduced oil palm to Malaysia from Nigeria in 1917, and it has rapidly become a substantial contributor to the country's GDP, bringing in approximately $7 million each year. According to the most recent statistics, Malaysia produces approximately 89 million tonnes of fresh fruit bunch (FFB) per year (Singh et al., 2010). In 2016, Malaysia was the world's second largest palm oil exporter, trailing only Indonesia, with 2.83 million tonnes (or 17.6%) of total palm oil exports going to India (Kushairi, 2017). Palm oil is used for a variety of things, such as deep frying, margarine, and shortening for cakes, snacks, and instant noodles. Cosmetics, soaps, and synthetic detergents all include these. Palm oil has become a popular fuel alternative as crude oil prices have risen throughout the world. Given its various applications, it may be referred to as the "Future Crop." Environmental management in the palm oil sector has become a key concern as a result of this growth in demand. Mills are frequently found in plantations, and the common practise is to collect waste and dispose it in an unethical way, as excess nutrients may be damaging to both developing plants and the environment as a whole. Increased oil content in the mill's effluent is caused by oil losses owing to process instabilities and leaks. It has been claimed that a total oil loss of 10 to 15 kg/t FFB has occurred (Chavalparit et al., 2006). Moreover, inefficient equipment, faulty machinery, and leakage which is due to tank failure or overflow are frequently the cause of further oil losses.

Palm Oil Mill Wastes (POMW) generally refers to all wastes from the palm oil sector in Malaysia. The milling process and plantation activities produce a considerable quantity of solid waste, which includes plantation trunks, fronds, and leaves, as well as empty fruit bunches (EFB), palm oil mill sludge (POMS), palm oil mill effluent (POME), palm kernel cake (PKC), oil palm decanter cake (OPDC), palm mesocarp fibre (PMF),

and shells. According to Liew et al. (2014), aside from being one of the world's leading producers of palm oil, Malaysia also produces a huge amount of industrial waste which includes POME, EFB, PMF, and OPDC. As declared by Sahad et al. (2014), a typical palm oil mill generates between 0.6 and 0.8 m^3 of POME, 22 to 23 percent of EFB, 13.5 percent of PMF, and 4 to 5 percent of OPDC per tonne of FFB.

The palm oil mill contributed significantly to environmental contamination through its waste, such as OPDC, which is a major source of concern in Malaysia. Due to the obvious high amount of OPDC produced, composting will require a large amount of land, posing environmental risks such as soil and water contamination. Furthermore, increased biomass waste production has harmed the palm oil industry's overall oil extraction rate (OER) due to oil losses in the waste (Sahad et al., 2014). The OER shows how much oil is extracted from FFB as well as the overall efficiency of typical palm oil mills. As a result, methods for converting biomass waste into another kind of energy or even usage should be discovered. OPDC's usefulness as ruminant feed, plant fertiliser, and composting material has only been examined by a few researchers (Bakri, 2013; Sahad et al., 2014), besides the demand for biogas is continuously growing, as proposed by Szulczyk and Atiqur (2018). Biodiesel is a biomass-based sustainable motor fuel, as proposed according to research, palm oil may be used as a biodiesel for vehicles with diesel engines (Archer et al., 2018) whereas biomethane may be utilised as a direct alternative for natural gas and as a fuel in applications including heating, transportation, and power production because it has the same qualities as natural gas, attaining methane (CH4) concentration levels greater than 96 percent.

Due to the expected expansion of oil palm acreage in the next years, it is imperative that substantial efforts be made to guarantee appropriate OPDC management in order to address rising environmental issues, whereby the selection on the potential applications of OPDC as raw material via environmental sustainability analysis in the palm oil industry are to be evaluated throughout these research study.

1.2 Research Problem Statement

Malaysia is one of the world's leading producers of palm oil, and it is currently expanding its production rate in response to rising worldwide demand for oil products, biodiesel, and oleo compounds generated from palm oils whereby about 25% of