



Faculty of Engineering

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

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Bachelor of Engineering (Hons)

Chemical Engineering

2022



**UNIVERSITI MALAYSIA SARAWAK**

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THE PHYSICO-CHEMICAL EVALUATION AND ENVIRONMENTAL  
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  
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2022

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



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# 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 (CO<sub>2</sub>e) 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 CO<sub>2</sub>e 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 kemampunan 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<sub>2</sub>e) telah direka untuk menganalisis kemampunan 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<sub>2</sub>e 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

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# LIST OF ABBREVIATIONS

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

**SG**

Specific Gravity

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# LIST OF NOMENCLATURE

<b>%</b>	Percentage
<b>Cd</b>	Cadmium
<b>CH<sub>4</sub></b>	Methane
<b>cm<sup>-1</sup></b>	Per centimetre
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>CO<sub>2</sub>e</b>	Carbon Dioxide Equivalent
<b>Cu</b>	Copper
<b>g/cm<sup>3</sup></b>	Gram per centimetre cube
<b>g/kg</b>	Gram per kilogram
<b>HFCs</b>	Hydrofluorocarbons
<b>H<sub>3</sub>PO<sub>4</sub></b>	Phosphoric acid
<b>K</b>	Potassium
<b>KBr</b>	Potassium bromide
<b>kg/ton</b>	Kilogram per tonne
<b>kWh</b>	Kilowatt-hours
<b>MT</b>	Metric tonne
<b>N</b>	Nitrogen
<b>Ni</b>	Nickel
<b>(NF<sub>3</sub>)<sup>3</sup></b>	Nitrogen trifluoride
<b>N<sub>2</sub>O</b>	Nitrous oxide
<b>P</b>	Phosphorus
<b>Pb</b>	Lead
<b>PFCs</b>	Perfluorocarbons
<b>SF<sub>6</sub></b>	Sulfur hexafluoride
<b>Zn</b>	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 ( $CH_4$ ) 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