CHAPTER I
INTRODUCTION

1.1 Research Background

The palm oil industry is economically significant and one of the leading suppliers of oil and fat that meet global demand. It is widely cultivated in Malaysia, Indonesia, Thailand, Nigeria, Colombia, and Guatemala (Imam et al., 2025). Over the past 60 years, palm oil production has increased significantly due to the growing global population and increased demand from the food and beverage, oleochemical, and biodiesel industries. However, this expansion also generates large amounts of biomass waste, particularly palm oil mill effluent (POME), which is a byproduct of palm oil production (Tang et al., 2024).

Palm oil mill effluent (POME) is a byproduct of the sterilization, extraction, and clarification phases of palm oil production. Due to its acidic nature and very high biological oxygen demand (BOD), proper treatment is necessary (Tang et al., 2024). The biological treatment system has been identified as the most used method for effluent treatment in palm oil mills (85%), primarily due to its numerous advantages (Mohammad et al., 2021). Commonly applied biological treatment processes are anaerobic digestion, aerobic digestion, and facultative (Dominic & Baidurah, 2022).

Currently, biological treatment processes are also generating a large quantity of waste, including digestate. In Malaysia, due to its high organic content, POME digestate (POMED®) was treated through composting in open ponds (Isa et al., 2015). When POMED® undergoes composting in a dumping pond for approximately six months, it is called treated POMED®. Additionally, POMED® collected directly from biological processing ponds without subsequent treatment in a dumping pond is classified as untreated POMED®. According to Khairuddin et al. (2017) POMED® was possible to be dried and used as a fertilizer due to its high nutrient content and exhibits substantial microbial diversity.

The drying POMED® process (resulting treated POMED®) was carried out in the open ponds, this process was impeded during the rainy season due to slow drying rates and overflow issues. Therefore, the industries were focussed on cost-effective

and sustainable technologies to dispose POMED® (Khairuddin et al., 2017). Moreover, data of untreated digestate also remain limited (Lamolinara et al., 2022). Compared to treated POMED® and anaerobic POMED®, untreated POMED® has higher levels of of nitrogen, total solids, volatile solids, iron, and calcium (Khairuddin et al., 2017)

According to Khairuddin et al. (2016), with proper management and treatment processes, POMED® in the ponds can be converted into valuable organic matter beneficial for plant uptake. A study by Amelia et al. (2017) found that applying POME to soil raised the nitrogen content from 0.21% to 0.85%. In addition, according to Coelho et al. (2020), these biofertilizers contain large quantities of various microorganisms. Genes from nitrifying and denitrifying bacteria, plant growth-promoting bacteria (PGPB), nitrogen-fixing bacteria were identified in the digested waste.

Nitrogen (N) is a macronutrient that is important for plants because it is a component of amino acids which are useful as building blocks for proteins and enzymes for plants. (Zayed et al., 2023). Its availability to plants is mediated by nitrification, the microbial process where ammonia (NH_3) is oxidized to nitrite (NO_2^-) and then to nitrate (NO_3^-) by ammonia-oxidizing (AOB) and nitrite-oxidizing bacteria (NOB). Nitrate (NO_3^-) is a form of nitrogen that is readily absorbed by plant roots (Tao et al., 2017). A study by Sawada & Toyota (2015) found that applying large amounts of digestate to soil can lead to the rapid growth of AOB. The findings indicate that digestate can promote nitrification in soil by enhancing AOB abundance, affecting nitrate (NO_3^-) availability for plant growth. The amount of nitrate available for absorption by plants depends on the abundance of nitrifying microbes in the soil.

Based on the background presented, it is essential to conduct research on the utilization of untreated POMED® as a bio-organic fertilizer. This is due to the overflow of POMED® in dumping ponds and the significant potential of untreated POMED® to enhance soil nitrification by promoting the growth of nitrifying bacteria. However, limited data on the composition of nitrifying microbial communities and effective agricultural use of untreated POMED® highlight the

need for a study to identify nitrifying bacteria. The characterization of these microbial communities will provide insights into how the presence and abundance of specific nitrifiers influence nitrification potential in soil once the untreated POMED® is applied. Therefore, this research aims to provide sustainable and effective solutions for untreated POMED® management while improving agricultural productivity through the utilization of this organic waste as a plant nutrient source.

1.2 Aim and Objective

The objective of this study is to evaluate the potential use of untreated POMED® as bio-organic fertilizer by identifying nitrifying microorganisms molecularly using 16S rRNA and quantifying its ability to enhance nitrification in soil. The objectives of this study are:

1. To characterize the composition of nitrifying microbial communities in untreated POMED® using a 16S rRNA sequencing method, in order to understand its effect on soil nitrification.
2. To determine the inorganic nitrogen dynamic and nitrification potential in soils applied with different application rates of untreated POMED®, using the ISO 15685:2012 method assessing its functional impact as a bio-organic fertilizer.
3. As a complementary analysis to Objective 2, to examine the correlation between changes in soil chemical parameters (pH and C/N ratio) and the application of untreated POMED®, as supporting evidence in evaluating its potential as a bio-organic fertilizer.

1.3 Significance of Study

Significances of this study are :

1. To evaluate the potential utilization of untreated POMED® as a sustainable solution for agricultural waste management.
2. To provide a scientific basis and reference for future research on the application of untreated POMED® as a bio-organic fertilizer.
3. To offer practical insights for palm oil mills on the adoption of untreated POMED® as a sustainable alternative to inorganic and synthetic fertilizers.

4. To contribute towards achieving relevant United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) by promoting sustainable agriculture, SDG 12 (Responsible Consumption and Production) by valorizing waste streams, and SDG 9 (Industry, Innovation, and Infrastructure) by innovating in palm oil industry waste management.

1.4 Scope of Study

Scopes of this study are :

1. The research was conducted using samples of untreated dried POMED® collected from a dumping pond at TDM Plantation Sdn Bhd in Sungai Tong, Terengganu.
2. The group of microorganisms studied focused only on nitrifying microorganisms using the 16S rRNA sequencing approach.
3. This study on the utilization of untreated POMED® as raw bio-organic fertilizer is solely focused on its nitrification testing in soil using the ISO 15685:2012 method.
4. The soil chemical parameters measured after untreated POMED® application are the C/N ratio and pH, and tools used are CHNS-analysis and pH meter respectively.
5. The methods and equipment used are meticulously selected to match the available laboratory technologies and techniques, which influence the accuracy and depth of the findings.

1.5 Writing Structure

The writing structure of this research are :

CHAPTER I **INTRODUCTION**

This chapter contains the research background, aims, objectives, signification of study, and scope of study.

CHAPTER II **LITERATURE REVIEW**

This chapter contains theory discusssed about POME, POMED®, potential utilization of untreated POMED®, nitrifying bacteria, nitrification, microbial

profiling, and previous research related to this research.

CHAPTER III **RESEARCH METHODOLOGY**

This research contains explanations about research stages that will be carried out, methods used for analysis, and experimental design.

CHAPTER IV **RESULT AND DISCUSSION**

This chapter contains the result of the reasearch and discussion about the result.

CHAPTER V **CONCLUSION AND RECOMMENDATIONS**

This chapter contains conclusions and suggestions based on the discussion that has been described.