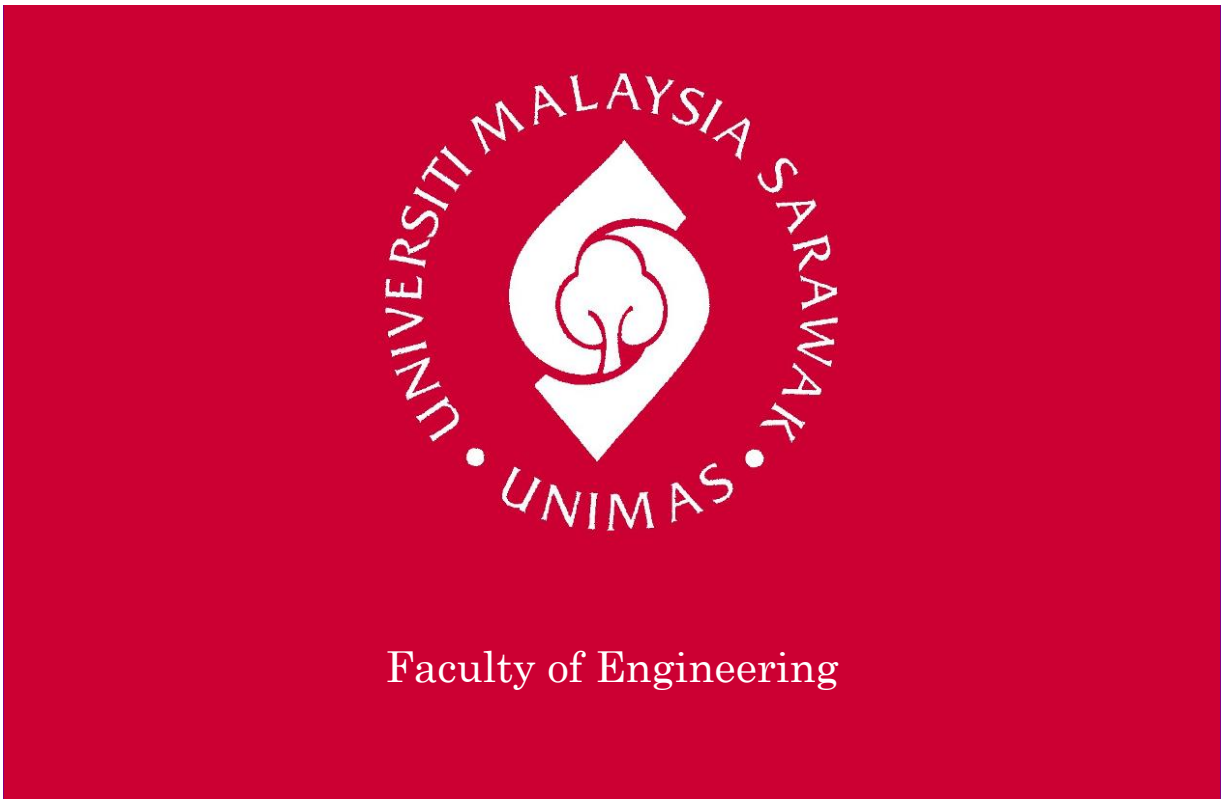

EVALUATION OF SLOW-RELEASE FERTILIZER FROM OIL PALM EMPTY FRUIT BUNCH

Vanessa Rhamas Anak Giles Gana (65253)

Bachelor of Engineering with Honours

(Chemical Engineering)

2022

UNIVERSITI MALAYSIA SARAWAK

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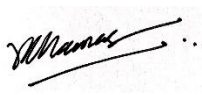
Student's signature: 

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This final year project 2, entitled **"Evaluation of Slow-Release Fertilizer from Oil Palm Empty Fruit Bunch"** was prepared by Vanessa Rhamas anak Giles Gana (65253) as KNC 4344 Final Year Project 2 course fulfilment for the Bachelor of Engineering with Honours (Chemical Engineering) is hereby read and approved by:

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(Final Year Project Supervisor)

Date

EVALUATION OF SLOW-RELEASE FERTILIZER FROM OIL PALM EMPTY FRUIT BUNCH

VANESSA RHAMAS ANAK GILES GANA

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 my beloved parents, family and friends, who always bestow me with sustainable motivations and encouragement

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ABSTRACT

Slow-release fertilizer (SRF) is developed to enhance the effectiveness of fertilizers in releasing nutrient content as well as to overcome environmental impact associated with nutrient leaching in soil. In this study, SRF was synthesised from oil palm empty fruit bunch which is one of the most abundant agricultural wastes from oil palm mill. Two samples of slow-release fertilizer were synthesised via extrusion method applying starch as its biodegradable coating. Two types of SRF where prepared whereby one with addition of urea and the other one was without the addition of urea. Dried SRF pellet is tested for its performance on the spinach growth. The results indicated that the SRF synthesised from OPEFB successfully helped in the spinach growth based on the changes observed in the stem height, the number of leaves and the surface area of spinach leaf. Additionally, the properties of SRF were characterized via several analyses such as Fourier Transform Infrared Spectroscopy (FTIR) analysis, Scanning Electron Microscopy with Energy Dispersive X-ray (SEM/EDX) analysis and Thermogravimetric analysis (TGA). The slow release behaviour of SRF was signified based on the cumulative percentage release of nitrogen. The release kinetics of SRF in soil was best described by the Zero order model indicating that the release behaviour was independent of SRF concentration.

Keywords: *Slow-release fertilizer, Oil palm empty fruit bunch, Starch, Release of nutrients*

ABSTRAK

Baja pelepasan perlahan dibangunkan untuk meningkatkan keberkesanan baja dalam membebaskan kandungan nutrien serta untuk mengatasi kesan alam sekitar yang berkaitan dengan larut lesap nutrien dalam tanah. Dalam kajian ini, baja pelepasan perlahan disediakan daripada tandan kosong kelapa sawit yang merupakan salah satu sisa pertanian yang paling banyak dari kilang kelapa sawit. Dua sampel baja lepas perlahan telah disediakan daripada tandan kosong kelapa sawit di mana satu daripada sampel baja tersebut ditambahkan dengan kandungan urea manakala satu lagi tanpa penambahan urea. Kanji digunakan sebagai bahan pengikat untuk menyalut baja pelepasan perlahan dan akan dihasilkan sebagai dalam bentuk pelet melalui kaedah penyemperitan. Pelet baja yang telah kering telah diuji untuk mengkaji keberkesanannya terhadap pertumbuhan bayam. Berdasarkan pemerhatian, baja pelepasan perlahan yang disediakan dari tandan kosong kelapa sawit dapat membantu pertumbuhan bayam yang telah dinilai melalui perubahan pada ketinggian batang, jumlah daun dan luas permukaan daun bayam. Selain itu, sifat baja pelepasan perlahan telah dicirikan melalui analisis seperti FTIR, SEM/EDX dan TGA. Sifat pelepasan perlahan yang ada pada baja yang disediakan dapat dibuktikan melalui nilai kumulatif peratus nitrogen yang dilepaskan oleh baja tersebut. Kinetik pelepasan baja pelepasan perlahan di dalam tanah dapat dijelaskan menggunakan “Zero-order model” menyifatkan pelepasan nitrogen dalam baja tersebut tidak begantung kepada kepekatannya.

Kata kunci: *Baja pelepasan perlahan, Tandan kosong kelapa sawit, Kanji, Pelepasan nutrien*

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N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
C	-	Carbon
H	-	Hydrogen
O	-	Oxygen
S	-	Sulfur
Ca	-	Calcium
Mg	-	Magnesium
B	-	Boron
Cl	-	Chlorine
Cu	-	Copper
Fe	-	Iron
Mn	-	Manganese
Mo	-	Molybdenum
Ni	-	Nickel
Zn	-	Zinc
SO_4^{2-}	-	Sulfate
Zn^{2+}	-	Zinc ion
%	-	Percent
Mf	-	Mass fraction
wt	-	Weight
cm	-	Centimeter
℃	-	Degree Celsius
h	-	Hour
cm^{-1}	-	Per centimeter
℃/min	-	Degree Celsius per minute
g	-	Gram
L	-	Litre
mL	-	Milliliter

M	-	Molar
V	-	Volume
HCl	-	Hydrochloric acid
NaOH	-	Sodium hydroxide
KNO_3	-	Potassium Nitrate
$CHCl_3$	-	Chloroform
$K_2S_2O_8$	-	Sodium persulfate

LIST OF ABBREVIATIONS

SRF	-	Slow-release fertilizer
SRFs	-	Slow-release fertilizers
OPEFB	-	Oil palm empty fruit bunch
EFB	-	Empty fruit bunch
FTIR	-	Fourier-Transform Infrared Spectroscopy
TGA	-	Thermogravimetric analysis
SEM	-	Scanning Electron Microscopy
ATP	-	Adenosine triphosphate
kC-SA	-	κ-Carrageenan-Sodium Alginate
IBDU	-	Isobutylidene-diurea
EC	-	Electrical conductivity

CHAPTER 1

INTRODUCTION

1.1 Background

The agriculture sector has evolved as a consequence of the growth of the world population. One of the important roles of the agriculture sector is in the food supply chain. Agriculture is an important part of the national economy to provide and secure the food supply with population growth. The agriculture sector that keeps evolving in Malaysia is beneficial for this country. The agriculture industry is not only focusing on the production of the main product, but also on the utilization of the agricultural wastes. Agricultural wastes from agro-based industries, namely palm oil, vegetables, rubber and cocoa have increased in the recent years. Few methods have been employed to utilize the agricultural waste by converting them into valuable products such as fertilizer, biofuels, compost and also bioplastics.

The development of the agricultural field in Malaysia also faces some challenges and limitations. According to Beig et al. (2020), one of the main limitations in the agriculture field to ensure the food supply is crop failure. Crop failure can significantly affect the agricultural activities as well as the food supply. Therefore, in order to prevent crop failure, the application of fertilizer is necessary to enhance soil fertility. Nutrient losses in the soil also contribute to the crop failure in the agricultural sector. The fertilizer is being applied to the soil to improve the soil nutrients to support plant growth. However, the efficiency of the fertilizer that is being supplied to the soil decreases due to leaching losses after its application and before being used by the plant as nutrients. The nutrient loss in soil commonly caused by soil erosion. This phenomenon usually involves the soluble nutrients, for instance, nitrate and potassium that can be carried away by the run-off and drainage water (Meena et al., 2017). In order to overcome this problem, the development of slow-release fertilizer has been extensively studied to improve the soil fertility by minimizing nutrient leaching.

Fertilizer is a term that refers to materials that are placed in the soil or on the surface of a plant with the goal of providing appropriate nutrients during growth (Purnomo &

Saputra., 2021). It is an integral part of current agricultural production due to the nutrients that it supplied to crop growth to meet the food demand of the growing human population (Gomes et al., 2021). Slow-release fertilizer (SRF) is a type of fertilizer that provide a steady supply of plant nutrients over a course of time. SRF is also known as time-release fertilizer. Slow-release fertilizers, according to Rajan et al. (2021), are fertilizers that release nutrients at a slower pace, but the rate, pattern, and duration of release are not well regulated and are influenced by soil chemical and physical conditions. The development of SRF started in the 1920s. However, the SRF did not get attention from that period until 1960s (Fu et al., 2018). Nowadays, SRF has received recognition from researchers all over the world whereby there are many publications that have reported on SRF according to Fu et al. (2018).

This research will be focusing on preparing and evaluating organic SRF from naturally produced raw material, particularly oil palm empty fruit bunch (OPEFB). Malaysia is one of the major oil palm producers (Ezechi & Muda., 2019). Oil palm plantations covers about 17.62% of the land in Malaysia. As this industry continue-growing, a massive amount of oil palm wastes is generated which leads to an abundant amount of biomass waste. Large amount of waste produced from oil palm mills has drawn the attention of researchers to explore the availability of the oil palm waste and its utilization through various beneficial ways in the agriculture sector.

1.2 Problem Statement

Good crop yields depend on an adequate supply of nutrients. For plants planted on inland soils in Malaysia, the macronutrients such as nitrogen (N), phosphorus (P) and potassium (K) generally have to be supplied as fertilizers. Proper fertilizer management practices are vital to sustaining production because soils require high fertilizer inputs to replace nutrients removed by cropping. However, the loss of nutrients from mineral fertilizers often occurred at a high level for several years. This phenomenon has left negative impacts on both the economic and environmental aspects (Vatn et al., 2006). Loss of nutrients from fertilizers not only affect the soil quality but also cause pollution to soil and groundwater (Bertol et al., 2017). Therefore, the enhancement of soil nutrients can be done by the continuous development of a better fertilizer. The performance of fertilizer can be improved by taking the control of the rate of release or dissolution into account during the development of fertilizer. Thus, the development of SRF has been extensively studied to prepare a fertilizer

that can provide comprehensive nutrient with a low cost of manufacturing and as well as safe for the environment. Next, selecting raw materials for fertilizer is another challenge in the preparation of SRF. Both economic and environmental aspects need to be considered to provide suitable raw material for SRF preparation. As OPEFB is often used as an alternative and cheaper organic fertilizer in oil palm farms, the study on OPEFB should be focused more on how to make use of the EFB in producing better fertilizer and at the same time help in maximizing the utilization of biomass waste (OPEFB) from oil palm industry. Various studies had been done to study the OPEFB potential as compost or fertilizer for oil palm plantations making OPEFB a potential raw material for SRF. Although there was some research on the utilization of OPEFB, the studies on the development of OPEFB for SRF are still lacking. Thus, based on the advantages provided by OPEFB, more studies should be done on the development and improvement of SRF using OPEFB as one of its raw materials.

1.3 Research Questions

This research project comes with a few questions as follow:

1. What is the method applied to the synthesis of slow-release fertilizer (SRF) from oil palm empty fruit bunch (OPEFB)?
2. How does the performance of oil palm empty fruit bunch-based slow-released fertilizer (SRF) on plant growth?
3. How do the properties of the slow-released fertilizer help in improving soil fertility and plant growth?

1.4 Objectives

The main objective of this research study is to evaluate the performance of SRF that is prepared from OPEFB. This research study also comes with three objectives as listed below.

1. To synthesise the slow-released fertilizer from oil palm empty fruit bunch.
2. To evaluate the performance of slow-released fertilizer from oil palm empty fruit bunch on plant growth.
3. To characterize the properties of the slow-released fertilizer.

1.5 Scope of Study

This study is focusing on the synthesis and evaluation of SRF from OPEFB. In this research, the SRF is prepared from OPEFB, as an organic source by using starch paste as its coating material. The addition of urea is done to the SRF prepared from OPEFB to improve its nutrient content and also to compare the performance of the SRF with and without urea addition. The characterization of SRF will be performed using Fourier-Transform Infrared Spectroscopy (FTIR) analysis, thermalgravimetric analysis (TGA), Scanning Electron Microscopy (SEM), and Brunauer-Emmett-Teller (BET) analysis. The nutrient release behaviour of SRF also will be studied and the total nutrient release over time is analysed using the spectrophotometric method. The performance of SRF produced from OPEFB on spinach oleracea growth will be further evaluated.

1.6 Significance of Study

There are several significances based on the findings resulting from this research project which are stated as follows:

1. An in-depth understanding of the SRF preparation from oil palm empty fruit bunch can help in the development of better fertilizers.
2. The result obtained from the evaluation of SRF is important to evaluate the OPEFB performances as a raw material for slow-released fertilizer.
3. The characterization of the SRF is vital to understanding the properties of fertilizers.

1.7 Summary

To conclude, the development of SRFs has been studied over the decades to overcome the problem of fertilization. The utilization of oil palm empty fruit bunch (OPEFB) has been maximized due to the increase in biomass waste from the agriculture sector, particularly oil palm plantation has attracted Thus, the main objective of this study is to evaluate the performance of slow-release fertilizer that is prepared from oil palm empty fruit bunch on the plant growth. The difference between this SRF and other SRF will be highlighted at the end of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Agriculture is a significant contributor to Malaysia's economy, accounting for 12% of the country's GDP and employing 16% of the population. Malaysian government focuses on increasing agriculture production to fulfill the food demand as well as develop exports in an efficient and competitive manner. This cause the need for more efficient use of agriculture inputs is highly required, particularly mineral fertilizer. The development of oil palm plantations in Malaysia also leads to the high production of biomass waste from oil palm mills. Thus, in this chapter, the fertilization issue will be discussed. The slow-release fertilizer will be deeply reviewed and analyzed based on the previous studies. Apart from that, the properties of oil palm empty fruit bunch as a source of fertilizer will be discussed.

2.2 Fertilizer in Agriculture

Fertilizers are the components that helps to increase plant productivity and development. Fertilizers increase soil fertility which can aid plant growth. Soil contains very fine rocks, various types of minerals, and organic matter due to the decomposition of living organisms. The development of agricultural production leads to the wide application of fertilization to promote soil fertility and crop yields. Over these past few years, some studies have been done to investigate the effect of fertilizers on soil fertility. As the result, some of the studies reported that the application of fertilizer was necessary and that fertilization can increase the concentrations of soil organic carbon, total nitrogen, and other nutrients (Liu et al., 2011). Based on a long-term study by Dong et al. (2012) on the soil fertility of paddy soils in the red soil region also proved that the fertilizer treatment increases soil pH which means acidification reduction in soil. According to USDA Natural Resources Conservation Service (1998), the ideal soil pH range is between 6.0 and 7.0. Thus, Dong et al. (2012) believed that the usage of fertilizer might be a practicable approach to maintain the proper range of soil pH. Nardi et al. (2004) emphasized that fertilization aids in maintaining soil available nutrient