VERMICOMPOSTING OF PALM OIL MILL EFFLUENT SLUDGE (POMS) USING EARTHWORM (*Eisenia fetida*)

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DECLARATION

I hereby declare that the thesis is based on my original work except for the quotations and citation which have been duly acknowledged. I also declare that has not been previously or concurrently submitted for any other degree at UPSI or other institutions.

11.11.11

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DEDICATION

This work is dedicated to

Aisyah, Mohd Faris Imran, Danish Hakim and Daniel Arif

MAY THIS BE YOUR INSPIRATION

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Abstract

Research on stabilization of palm oil mill effluent sludge (POMS) has been successfully done by using earthworms, *Eisenia fetida*. Growth and reproduction studies were carried out in the mixture of cow dung (CD) and POMS. The result of the study shown the highest growth was in 60% POMS + 40% CD followed with 40% POMS+60% CD, 20% POMS+80% CD, 100% CD, 80% POMS+20% CD with maximum individual weight raised to 1210.67 ± 10.07 mg/earthworm, 1116.67 ± 5.77 mg/earthworm , 1036.67 ± 64.29 mg/earthworm , 980.00 ± 2.0 mg/earthworm , 699.33 ± 8.08 mg/earthworm respectively. The relative growth rate was determined through the slope of straight-line regression of the log phase of the growth profile. The highest relative growth rate was in the mixture of 60% POMS+40% CD and 40% POMS+60% CD which are significantly different ($P<0.05$) with the rate of 183.38 mg/week and 170.53 mg/week respectively. The relative growth rate decreased in 80% POMS+20% CD followed with 20% POMS+80% CD and 100% CD with the rate of 127.42 mg/week, 116.07 mg/week and 97.90 mg/week respectively. Experiment on reproduction was carried out through determination of cocoon production along the study process. The result shown that the highest cocoon produced was in 20% POMS+80% CD (67 cocoon) followed with, 40% POMS+60% CD (66 cocoon), 100% CD (64 cocoon), 60% POMS+40% CD (49 cocoon) and 80% CD+20% CD (18 cocoon). No growth occurred for the worms in 100% POMS, where mortality occurred started from the first week until 100% mortality on week 4. Although the highest growth rate and maximum body weight was achieved in 60% POMS+40% CD, the cocoon production was low. Nevertheless, the mixture of 60% POMS+40% CD has been chosen for as the most efficient for vermicomposting process of POMS. Study of vermistabilization process has been carried out using the mixture of 60% POMS+40% CD which was labeled as POMSCD1. The mixture undergone pre-treatment for 14 days and was labeled as POMSCD2. The result shown, the pH of POMSCD2 shifted from 7.5 to 7.0 after the vermicomposting process for 14 weeks. At the same time the organic matter also decreased from 69.17 ± 0.32% to 29.14 ± 0.44%, the carbon to nitrogen ratio also decrease from 38.38 to 14.44. Phytotoxicity also decreased after vermicomposting with the increased of germination index from 14% in POMSCD2 to 88%-89% in each vermicomposting replicate. Meanwhile the content of macronutrient and micronutrient such as potassium, sodium, calcium, iron, zinc and copper just had small changes. The metals that have a clear increment were magnesium and manganese. As a result, it is proved that earthworm, *Eisenia fetida* successfully stabilized palm oil mill effluent sludge (POMS).

Abstrak

Kajian bagi mengstabilkan sisa terenap (sluj) sistem rawatan air kilang sawit (POMS) telah dijalankan menggunakan cacing tanah, *Eisenia fetida*. Kajian pertumbuhan dan pembiakan cacing telah diuji dalam campuran antara tinja lembu (CD) dan POMS. Hasil kajian menunjukkan pertumbuhan yang paling tinggi dalam campuran 60% POMS+40% CD diikuti oleh 40% POMS+60% CD, 20% POMS+80% CD, 100% CD, 80% POMS+20% CD dengan berat maximum setiap cacing mencapai 1210.67 ± 10.07 mg/ cacing, 1116.67 ± 5.77 mg/ cacing, 1036.67 ± 64.29 mg/ cacing, 980.00 ± 2.31mg/ cacing, 699.33 ± 8.08 mg/cacing masing-masing. Tiada Pertumbuhan cacing tanah dalam 100% POMS di mana kematian telah berlaku mulai minggu pertama sehingga 100% kematian pada minggu keempat. Kadar pertumbuhan relatif yang ditentukan melalui kecerunan garis regressi bagi fasa log profil pertumbuhan. Kadar pertumbuhan tertinggi dalam campuran 60% POMS+40% CD diikuti oleh 40% POMS+60% CD adalah dengan signifikannya ($P<0.05$) berbeza, iaitu pada kadar 183.38 mg/minggu dan 170.53 mg/minggu masing-masing. Kadar pertumbuhan relative semakin berkurang dalam 80% POMS+20% CD diikuti oleh 20% POMS+80% CD dan 100% CD dengan kadar 127.42mg/minggu, 116.07 mg/minggu dan 97.90 mg/minggu masing-masing. Kajian pembiakan ditentukan melalui penentuan penghasilan kokun disepanjang eksperimen dijalankan. Didapati jumlah kokun terbanyak dihasilkan dalam 20% POMS+80% CD (67 kokun) diikuti oleh, 40% POMS+60% CD (66 kokun), 100% CD (64 kokun), 60% POMS+40% CD (49 kokun) dan 80% CD+20% CD (18 kokun). Walaupun kadar pertumbuhan dan maximum berat badan dicapai dalam 60% POMS+40% CD, penghasilan kokunnya adalah rendah. Walaubagaimanapun campuran 60% POMS+40% CD telah diambil sebagai campuran yang paling efisien untuk prosess vermi-penstabilan POMS. Kajian proses vermi-penstabilan (penstabilan menggunakan cacing) POMS telah dijalankan dengan menggunkan campuran 60% POMS+40% CD yang dilabelkan sebagai POMSCD1. POMSCD1 telah melalui pra-rawatan selama 14 hari dan dilabelkan sebagai POMSCD2. Didapati pH dalam POMSCD2 telah berganjak dari pH 7.5 kepada pH 7 setelah selasai process vermi-pengkomposan selama 14 minggu. Selain itu bahan organik juga telah menurun dari 69.17± 0.32% kepada 29.14 ±0.44%, nisbah karbon dan nitrogen juga menurun dari 38.38 kepada 14.44. kefitotoksikan juga didapati menurun setelah vermin-pengkomposan iaitu dengan pertambahan indeks percambahan dari 14% dalam POMSCD2 kepada 88%-89% dalam setiap replikasi rawatan tersebut. Manakala kandungan logam seperti potassium, sodium, kalsium, besi, zink and kuprum hanya mengalami pertambahan kecil. Logam yang bertambah dengan jumlah yang jelas ialah magnesium dan juga manganese. Ini telah menjadi bukti cacing tanah, *Eisenia fetida* telah berjaya melakukan proses penstabilan POMS.

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LIST OF ABBREVIATIONS

POMS	Palm oil mill sewage sludge
CD	Cow dung
POMSCD1	Mixture of 60%POMS and 40% CD
POMSCD2	Pre-composted of Mixture of 60%POMS and 40% CD
VC	Vermicast
C	Control medium
VC1	Replicate 1 of vermicomposting mixture with 60%POMS and 40% CD
VC2	Replicate 2 of vermicomposting mixture with 60%POMS and 40% CD
VC3	Replicate 3 of vermicomposting mixture with 60%POMS and 40% CD
C1	Replicate 1 of control mixture with 60%POMS and 40% CD
C2	Replicate 2 of control mixture with 60%POMS and 40% CD
C3	Replicate 3 of control mixture with 60%POMS and 40% CD
Medium A	Mixture of 20%POMS and 80% CD
Medium B	Mixture of 40%POMS and 60% CD
Medium C	Mixture of 60%POMS and 40% CD
Medium D	Mixture of 80%POMS and 20% CD
Medium E	100%POMS
Medium F	100% CD
cm	centimeter
mg	miligram
L	Liter
mL	mililiter
ppm	Part per million
TOC	Total Organic carbon
OM	Organic matter
C:N	Carbon to nitrogen ration
AAS	Atomic adsorption spectroscopy
CHNO-S analyzer	Carbon, hydrogen, nitrogen, oxygen an sulphur analyzer
GI	Germination index
RSG	Relative seed germination
RRG	Relative root germination

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Malaysia is the largest producer of palm oil in the world. In Malaysia, the palm oil industry contributes 83% of the single largest polluter (Kwon *et al*., 1989; Ojonoma and Nnennaya, 2007). Palm oil mill effluent sludge (POMS), commonly referred to, as palm oil mill effluent (POME) is brown slurry composed of 4–5% solids, mainly organic, 0.5–1% residual oil, and about 95% water (Onyia,2001). The industry also generates large amount of wastes such as empty fruit bunch (EFB) (23%), mesocarp fibre (12%), shell (5%) and palm oil mill effluent (POME) (60%) for every one tone of fresh fruit bunches (FFB) processed in the mills (Najafpour et al., 2005; Baharuddin *et al.*, 2010). In 2005, it was estimated that about 75.5 million tones of FFB has been processed in the country (Lau et al., 2008; Baharuddin *et al*., 2010).

POME is the most polluted organic residues generated from palm oil mills. In Malaysia, various treatments have been applied to treat POME in order to meet the discharge standard. The most common practices for the treatment of POME are the pond system, open tank digester, extended aeration system and land application system. Considering the highly organic character of POME, anaerobic process is the most suitable approach for its treatment (Zinatizadeh *et al*., 2007; Mumtaz, 2008). During POME treatment process, the slurry effluent that contained highly suspended organic matter will settle down dry up in the treatment pond, this organic solid matter is known as palm oil mill effluent sludge (POMS) which needs another proper action to be eliminated from the system.

Vermicomposting using earthworm, *Eisenia fetida* is a suitable technology for the decomposition of different types of organic wastes (domestic as well as industrial) into value-added material (Garg *et al*., 2006). In this study, *Eisenia fetida* will be used to decomposed the POMS. Since vermicomposting of POMS is new, researches has been done on the ability of *E. fetida* to grow and reproduce in the POMS, beside that the preparation of optimum condition for POMS vermicomposting to work efficiently and the changes of physicochemical properties of the POMS also has been studied. Besides, the phytotoxicity of the vermicast produced was determined since direct application of the vermicompost to plant was not carried out in this study.

1.2 Problems Statement

The constituents of raw POME have been reported to be a colloidal suspension of 95 - 96% water, 0.6 - 0.7% oil and 4 - 5% total solids including 2 - 4% suspended solids (Ahmad et al., 2003: Ojonoma and Nnennaya 2007). The raw POME has an extremely high content of degradable organic matter, which is due in part to the presence of unrecovered palm oil, thus, POME should be treated before discharge to avoid serious environmental pollution (Ojonoma and Nnennaya, 2007). The accumulation of the sludge would create another problem for the treatment process. Therefore, it is essential to provide as much as possible the method to utilize the sludge (POMS) in order to minimize the amount of sludge in the system.

Palm oil mill sludge (POMS) is one of the problems in the wastewater management in the palm oil industry. The POMS accumulation in the wastewater treatment pond should be overcome by finding the means to utilize it. One of the suitable ways is to convert the POMS into organic fertilizer using the Tiger Worm, *Eisenia fetida*. The potential of *Eisenia fetida* to decompose solid organic waste is very high but little study has been done on this worm species to decompose POMS. Investigation on the ability of *Eisenia fetida* to grow and reproduce in the POMS must be carried out. The growth and reproduction of *Eisenia fetida* might be better by treating the POMS with animal manure such as cow manure or goat manure, so the growth and reproduction of *Eisenia fetida* will be tested in different mixtures of POMS and animal manure.

In order to determine the effectiveness of decomposition process, the physicochemical changes of POMS through out vermicomposting process was analyzed.

Vermicomposting produces vermicast (compost) which can be used as plant fertilizer. It is necessary to determine the phytotoxicity of the vermicast before it can be used as fertilizer since the fresh POMS is known to be very phytotoxic to plant. Inhibition of plant growth has been closely associated with the presence of phenolic substances and these toxic substances could be leached out in high amounts from the organic residues into the soil or produced by microorganisms during decomposition (O. Radziah et al, 1997).

1.3 Objectives

Considering the above perspectives, the present study on vermicomposting of palm oil mill effluent sludge using earthworm, *Eisenia fetida* can be undertaken with the following objectives:

1. To study the growth and reproduction of *Eisenia fetida* in palm oil mill effluent sludge (POMS)
2. To find out the most suitable condition of the POMS, that most efficient for vermicomposting process.
3. To determine the physicochemical changes during by vermicomposting process.
4. To study the phytotoxicity of the vermicast produced from vermicomposting of POMS.