



**UNIVERSITI PUTRA MALAYSIA**

***CO-COMPOSTING OF MUNICIPAL SEWAGE SLUDGE AND  
LANDSCAPING WASTE USING PILOT SCALE SYSTEM AND  
APPLICATION OF COMPOST TO AN ORNAMENTAL PLANT, (TAGETES  
ERECTA L.)***

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BERILMU BERBAKTI

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(*Tagetes erecta* L.)**

By

**ZULNAIM BIN DZULKURNAIN**

**Thesis Submitted to the School of Graduate Studies, Universiti  
Putra Malaysia, in Fulfillment of the Requirement for Degree of  
Master of Science**

**November 2016**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia  
in fulfillment of the requirement for the degree of Master of Science

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**November 2016**

**Supervisor : Professor Mohd Ali Hassan, PhD**  
**Faculty : Biotechnology and Biomolecular Sciences**

A high-value product with nutrient-rich organic matter namely biocompost can be produced from renewable biomass materials such as municipal sewage sludge and landscaping waste. In Malaysia, these materials are still not being utilized completely. By using aerobic fermentation, production of biocompost from these materials can be done. The objectives of this research are: (1) to investigate the effectiveness of pilot-scale windrow and bioreactor systems for co-composting of municipal sewage sludge and landscaping waste; and (2) to evaluate the potential of biocompost from municipal sewage sludge and landscaping waste in windrow and bioreactor systems on the growth performance of a selected ornamental plant, *Tagetes erecta*.

Co-composting process was carried out using different systems (windrow and bioreactor) with monitoring for the crucial parameters for composting such as temperature, oxygen level, moisture content and pH. Proximate and ultimate analysis of the product produced were determined to evaluate the process performance. Planting trial was conducted using an ornamental plant *Tagetes erecta*, with an experimental design using Randomized Complete Block Design (RCBD) method. The plant was applied with different types of fertilizer, using inorganic fertilizer as a control to compare with biocompost from windrow and bioreactor system. The plant and soil (before and after treatment) were analysed physically and analysis was done using statistical analysis software, Statistical Analysis System (SAS) software. C/N ratio of the compost product for

windrow system reduced from 20 to 17 and from 18 to 9 for bioreactor system, with the maturity index of 7 based on Solvita test kit. Germination test was carried out with 80% success compared to the control. The NPK ratio of the biocompost produced for windrow and bioreactor systems were 2.1: 0.49: 0.59 and 3.01: 0.27: 0.68 respectively, which showed that the compost from bioreactor system was better to be used on planting trial for the ornamental plant. The heavy metals content and pathogenic microorganisms content in the final compost from both systems were within the US EPA standard and SIRIM Malaysia standard.

For planting trial, there is no significant difference in terms of the physical appearance of *T. erecta* between different applied fertilizer treatments. However, in terms of statistical analyses, there are significant differences between the applied fertilizer treatments for the growth performance of *T. erecta*, the effect on the plant tissue analyses and soil, before and after treatment applied for both biocompost from windrow and bioreactor systems. The results of the present study clearly demonstrate that biocompost from municipal sewage sludge and landscaping waste produced from both windrow and bioreactor systems can be used as fertilizer for the ornamental plants.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**KO-PENGGKOMPONAN ENAPCEMAR KUMBAHAN PERBANDARAN DAN SISA LANDSKAP PADA SISTEM SKALA PANDU DAN APLIKASI KOMPOS TERHADAP TANAMAN HIASAN, (*Tagetes erecta* L.)**

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Satu produk bernilai tinggi dengan bahan organik yang kaya dengan nutrien iaitu biokompos boleh dihasilkan daripada bahan biojisim yang boleh diperbaharui seperti enapcemar kumbahan perbandaran dan sisa landskap. Di Malaysia, bahan-bahan ini masih tidak digunakan sepenuhnya. Dengan menggunakan pengkomposan aerobik, pengeluaran biokompos dari bahan-bahan ini boleh dilakukan. Objektif utama kajian ini ialah: (1) untuk menyiasat keberkesanan bagi proses pengkomposan enapcemar kumbahan perbandaran dan sisa landskap menggunakan sistem batas dan bioreaktor pada skala-pandu; dan (2) untuk menilai potensi biokompos daripada enapcemar kumbahan perbandaran dan sisa landskap dari system batas dan bioreaktor terhadap prestasi pertumbuhan tumbuhan hiasan dipilih, *Tagetes erecta*.

Proses pengkomposan dijalankan menggunakan sistem yang berbeza (sistem batas dan bioreaktor) dengan pemantauan terhadap parameter penting untuk membuat kompos seperti suhu, paras oksigen, kandungan kelembapan dan pH. Analisis proksimat dan mutlak produk dilakukan untuk menilai keberkesanan proses pengkomposan. Cubaan penanaman dijalankan menggunakan tanaman hiasan *Tagetes erecta*, dengan rekaan bentuk eksperimen menggunakan cara Randomized Complete Block Design (RCBD). Pokok tersebut telah dibajakkan menggunakan jenis baja yang berbeza, baja organik sebagai kawalan untuk membandingkan dengan biokompos dari sistem batas dan sistem bioreaktor. Pokok dan tanah (sebelum dan selepas rawatan) dianalisis dari segi fizikal dan keputusan analisis yang telah dilakukan dianalisa

dengan menggunakan perisian analisis statistik, Statistical Analysis System (SAS). Nisbah C/N produk kompos untuk sistem batas dikurangkan daripada 20 ke 17 dan 18 ke 9 untuk sistem bioreaktor dengan indeks kematangan 7 berdasarkan ujian kit Solvita. Ujian percambahan telah dilakukan dengan kejayaan 80% berbanding dengan kawalan. Nisbah NPK daripada biokompos yang dihasilkan untuk sistem batas dan bioreaktor masing-masing adalah 2.1: 0.45: 0.59 dan 3.01: 0.27: 0.68, menunjukkan bahawa kompos daripada sistem bioreaktor adalah lebih baik untuk digunakan pada percubaan penanaman untuk tumbuhan hiasan. Kandungan logam berat dan kandungan mikroorganisma patogenik dalam kompos akhir daripada kedua-dua sistem berada dalam lingkungan standard US EPA dan standard SIRIM Malaysia.

Untuk penanaman percubaan, tidak ada perbezaan yang signifikan dari segi penampilan fizikal *T. erecta*, antara rawatan baja gunaan yang berbeza. Walau bagaimanapun, dari segi analisis statistik, terdapat perbezaan yang signifikan di antara rawatan baja digunakan untuk kadar pertumbuhan *T. erecta*, kesan ke atas analisis tisu tumbuhan dan tanah, sebelum dan selepas rawatan digunakan untuk kedua-dua biokompos dari sistem batas dan bioreaktor. Hasil kajian ini jelas menunjukkan biokompos daripada enapcemar kumbahan perbandaran dan sisa landskap dihasilkan daripada sistem batas dan bioreaktor boleh digunakan sebagai baja untuk tanaman hiasan.

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I certify that a Thesis Examination Committee has met on 2 November 2016 to conduct the final examination of Zulnaim bin Dzulkurnain on his thesis entitled "Co-Composting of Municipal Sewage Sludge and Landscaping Waste by Pilot Scale System and The Application Of Compost To An Ornamental Plant, *Tagetes erecta*" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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## LIST OF ABBREVIATIONS

As	Arsenic
B	Boron
BAM	Bacteriological Analytical Manual
C/N	Carbon per nitrogen ratio
Cd	Cadmium
CEC	Cation Exchange Capacity
Co	Cobalt
Cr	Chromium
CRBD	Complete Randomized Block Design
DSS	Dewatered sewage sludge
EFB	Empty fruit bunches
FBSB	Faculty of Biotechnology and Biomolecular Sciences
FDA	Food and Drug Administration
g	Gram
GHG	Greenhouse gas
ICP	Inductively Coupled Plasma
IWK	Indah Water Konsortium
kg	Kilogram
LW	Landscaping wastes
m	Metres
Mn	Manganese

Mo	Molydenum
MSS	Municipal sewage sludge
n.d	Not detectable
n.s	Not stated
Ni	Nickel
NO <sub>3</sub>	Nitrate
P	Phophorus
Pb	Lead
PFRP	Processes to Further Reduce Pathogens
POME	Palm Oil Mill Effluent
PPj	Perbadanan Putrajaya
SAS	Statistical Analysis System
Se	Selenium
t	Tonnes
TOC	Total Organic Carbon
UPM	Universiti Putra Malaysia
US EPA	United States Environmental Protection Agency
w/v	Weight per volume

## CHAPTER 1

### INTRODUCTION

By 2030, the global energy consumption will increase to 53%, with 70% of the growth demand coming from developing countries, according to the estimation of International Energy Agency (Oh *et al.*, 2010). As one of the developing countries in ASEAN countries, IMF (2010) recorded that Malaysia has GDP of US\$15,400 per capita (purchasing power parity basis), and steady GDP growth of 4.6% in 2009. According to Saidur *et al.* (2009), the expected energy demand increased at an average of 6% per annum, as the economy of Malaysia keeps growing at 5% since 2005. As a developing country, Malaysia will have more energy requirement as the country needs to carry out such industries which can establish Malaysia as a developed country in the future.

Due to the development of Malaysian economy, nowadays the country is focusing more towards the utilization of renewable energy as a new source of energy for human use. There are many types of renewable energy such as wind power, hydropower, solar energy, biofuel and others. Among these various sources of renewable energy, biomass seems to be a promising option for Malaysia due to the generated biomass and by-products in abundant masses, which may become a major concern for people as well as the industry itself. The energy that has been produced from biomass sources is then either being used back by the factories or being sold to the grid to generate income for them.

Biomass can be defined as organic material that is available from living, or recently living organisms, including forest and mill residues, wood wastes, agricultural crops and wastes, animal wastes as well as municipal solid waste (MSW). Biomass can either be used directly or can be converted into value-added products such as biofuel and biofertilizer in the future. Production of biomass in Malaysia is estimated at more than 70 million t being collected per year. Due to this, it has been reported that biomass can be the main sources of alternative renewable energy in Malaysia (Ahmad *et al.*, 2011). Even though the usage of biomass has been done for some time for Malaysia, there still the barriers for biomass to being completely utilized in the country. The utilization of biomass is hampered since the process itself required high initial investment from other parties and also limited to local technologies as well as the equipment itself. Other than that, there are limited incentives on biomass utilization, which makes it difficult to be introduced into the community.

One example of biomass in Malaysia is landscaping waste (LW). Generally, LW is produced during the process of trimming, landscaping and others. LW is one of the wastes that contains mainly organic material that can be utilized to produce renewable energy in the future. It has been reported by Ahmad *et al.* (2011) that the wood industry is the third largest industry that contributes to the high biomass generated in Malaysia other than oil palm industry and municipal solid waste. Other than that, the generation of municipal sewage sludge (MSS) from wastewater treatment system in Malaysia increased every year with the increase in population. Due to the increment of MSS generation annually, the public authority such as Indah Water Konsortium (IWK) Sdn. Bhd. should take progressive actions for treating the waste to protect the environment and also the community. Normally LW is thrown away into the waste bins, disposed into the landfill or burned in open burning; whereas for MSS, the authority carried out water removal process prior to direct disposal of the waste into the landfill. In this study, by utilizing both materials (LW and MSS) using biotechnology approach, we can produce biocompost as a value-added biofertilizer.

The objectives of this study were as follows:-

1. To investigate the effectiveness of pilot-scale windrow and bioreactor systems for co-composting of municipal sewage sludge and landscaping waste.
2. To evaluate the potential of biocompost from municipal sewage sludge and landscaping waste in windrow and bioreactor systems on the growth performance of a selected ornamental plant, *Tagetes erecta*.



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## LIST OF PUBLICATION

### Manuscript published:-

- 1) Dzulkurnain, Z., Hassan, M.A., Zakaria, M.R., Wahab P.E.M., Hassan M.Y. and Shirai, Y. Waste Biomass Valor (2016). doi: 10.1007/s12649-016-9645-7. (IF 2015 = 0.915)

### Proceeding of conferences

- 1) Zulnaim Dzulkurnain, Muhamad Yusuf Hasan, Mohd Hafif Shamsudin, Siti Suliza Salamat, Mohd Rafein Zakaria , Puteri Edaroyati Megat Wahab, Mohd Ali Hassan. Compost performance of municipal sewage sludge and landscaping waste by windrow system process. AFOB Regional Symposium 2014 (ARS2014), Kuala Lumpur, Malaysia. (Poster Presentantion).
- 2) Zulnaim Dzulkurnain, Mohd Rafein Zakaria, Puteri Edaroyati Megat Wahab, Yoshihito Shirai, Mohd Ali Hassan. Compost performance of municipal sewage sludge and landscaping waste by pilot-scale system. Symposium of Applied Engineering and Science (SAES). 20-21th December 2014, Kyushu Institute of Technology, Japan. (Poster Presentation).
- 3) Zulnaim Dzulkurnain, Mohd Hafif Shamsudin, Mohd Rafein Zakaria, Puteri Edaroyati Megat Wahab, Yoshihito Shirai, Mohd Ali Hassan. Co-composting of municipal sewage sludge and landscaping waste by pilot scale system. Asian Congress on Biotechnology 2015 (ACB2015). November 15-19th, 2015. Kuala Lumpur, Malaysia (Poster Presentation).



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