UNIVERSITI PUTRA MALAYSIA

COMPOSTING OF SELECTED ORGANIC SLUDGES USING ROTARY DRUM AND WINDROW SYSTEM

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COMPOSTING OF SELECTED ORGANIC SLUDGES USING ROTARY DRUM AND WINDROW SYSTEM

By

ZAINAL BIN BAHARUM

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

December 2002

DEDICATION

Specially dedicated to,

My beloved grandmother who provided the opportunities

And my lectures, friends and wife (Aminaturrahiah),

For their invaluable love, patience and understanding………

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

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December 2002

Chairman : Associate Professor Dr. Mohd. Ali Hassan

Faculty : Food Science and Biotechnology

Various organic sludges were composted by using rotary drum system and windrow system. In this research i.e. palm oil mill effluent (POME), food factory, sewage and leachate were composted with shredded wood and sawdust as bulking agents with a ratio of 3:1. The rotary drum used was modified from a 75liter cement mixer with insulated drum. In composting of using windrow system, heap method was applied.

In composting using rotary drum, fermentation process for sewage sludge, POME sludge, food factory sludge and leachate sludge took around 5, 5, 10 and 13 days respectively. The pH of the compost products was ranged from pH 6.0 to pH 8.0. The highest temperature was achieved around 60°C when heated air was supplied by heat gun. The moisture content profiles during composting was maintained around 50-70%

moisture in the compost mass. The carbon content decreased and the nitrogen content increased towards the end of composting process, which resulted in the reduction of C/N ratio during composting process to below 20. The low C/N ratio of the final compost product was very important as the indicator of maturity. The compost substrates reduced around 50% based on wet weight basis at the end of the process. Overall, the composting for the whole process of organic sludges using rotary drum took around 30 to 35 days. Planting out test was performed with spinach, whereby the size of tree and colour of leaves were observed. The result showed that the best compost product was produced from sewage sludge compost.

In composting using windrow system, two experiments were carried using 0.1% EM and 1.0%EM. The results observed from both experiments were almost similar. The difference was reflected in compost product from windrow system, which contained a higher number of total coliforms at around 10^5-10^6 cfu/g because the temperature just increased to 37°C due to the small size of heap used. The whole composting process for windrow system only took around 30-35 days due to the high activity of EM during the composting process.

The physicochemical and biological characteristics of these sludges were measured and can be applied in composting process. By using rotary drum and windrow system the products were improved based on nutrient contents and duration of composting process. Overall, the characteristics of the end products for both systems were similar and also complied with the United States Environmental Protection Agency (USEPA) standards.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGKOMPOSAN BEBERAPA ENAPCEMAR ORGANIK TERPILIH MENGGUNAKAN DRUM BERPUTAR DAN SISTEM *WINDROW*

Oleh

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Pengerusi : Profesor Madya Dr. Mohd. Ali Hassan

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Beberapa jenis enapcemar organik dikomposkan menggunakan sistem drum berputar dan sistem *windrow*. Di dalam kajian ini, enapcemar kelapa sawit (POME), enapcemar industri makanan, enapcemar kumbahan dan enapcemar leachate dikomposkan bersama dengan serpihan-serpihan kayu dan habuk kayu sebagai agen *bulking* dengan nisbah 3:1. Drum berputar yang digunakan adalah dari pengubahsuaian pengaduk simen 75L dengan drum bersalut penebat haba. Dalam pengkomposan menggunakan sistem *windrow*, kaedah timbunan longgokan digunakan.

Dalam penggunaan drum berputar untuk pengkomposan, proses fermentasi bagi enapcemar kumbahan, enapcemar POME, enapcemar industri makanan dan enapcemar leachate mengambil masa 5, 5, 10 dan 13 masing-masing. Produk kompos mempunyai pH diantara pH 6.0 hingga pH 8.0. Suhu tertinggi yang dapat dicapai adalah sekitar 60°C

apabila dibekalkan dengan udara panas meggunakan pistol pemanas. Profil kandungan lembapan semasa pengkomposan dapat dikekalkan antara 50-70% lembapan dalam jisim kompos. Kandungan karbon berkurangan dan kandungan nitrogen meningkat dalam masa proses pengkomposan berlaku, yang mana menghasilkan pengurangan pada kadar nisbah C/N sehingga kurang dari 20. Kadar nisbah C/N yang rendah dalam hasil produk kompos adalah sangat penting sebagai penunjuk kepada kematangan. Substrat kompos berkurangan sekitar 50% berdasarkan, asas berat basah diakhir proses. Secara keseluruhan proses pengkomposan enapcemar organik menggunakan drum berputar mengambil masa sekitar 30 hingga 35 hari. Ujian tanaman dijalankan dengan menggunakan bayam, di mana saiz pokok dan warna daun diperhatikan. Keputusan menunjukkan, produk kompos yang terbaik dihasilkan dari enapcemar kumbahan.

Dalam kajian pengkomposan menggunakan sistem *windrow* pula, dua eksperimen dijalankan menggunakan 0.1% mikroorganisma efektif (EM) dan 1.0% EM. Daripada permerhatian keputusan dari kedua-dua eksperimen hampir sama. Perbezaannya adalah berdasarkan produk kompos dari sistem *windrow*, yang mana mengandungi jumlah kolifom yang tertinggi sekitar 10^5-10^6 cfu/g kerana peningkatan suhu sekadar 37°C berpunca dari saiz timbunan yang kecil digunakan. Keseluruhan proses untuk sistem *windrow* ini hanya mengambil masa sekitar 30-35 hari berpunca juga dari aktiviti EM yang tinggi semasa proses pengkomposan.

Akhir sekali, ciri-ciri kimia fizikal dan biologikal bagi bebrapa enapcemar organik ini dikenalpasti dan boleh diaplikasi dalam proses pengkomposan. Melalui kaedah drum berputar dan sistem *windrow* produk dapat diperbaiki berdasarkan kepada kandungan-kandungan nutrien dan jangkamasa proses pengkomposan. Secara keseluruhannya, ciri-ciri akhir produk untuk kedua-dua sistem adalah lebih kurang sama dan juga menepati piawai Agensi Perlindungan Alam Sekitar Amerika Syarikat (USEPA).

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I certify that an Examination Committee met on 28th December 2002 to conduct the final examination of Zainal Baharum on his Master of Science thesis entitled "Composting of Selected Organic Sludges Using Rotary Drum and Windrow System" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

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

ZAINAL BIN BAHARUM

Date: 24/2/2003

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LIST OF ABBREVIATIONS

NaCl	-	Sodium Chloride
NaOH	-	Sodium Hydroxide
HCl	-	Hydrochloric Acid
HNO_3	-	Nitric Acid
Zn	-	Zinc
Pb	-	Lead
Fe	-	Iron
Cr	-	Chromium
Cd	-	Cadmium
Cu	-	Copper
P	-	Phosphorus
K	-	Potassium
Ca	-	Calcium
Mg	-	Magnesium
Mn	-	Manganese
C/N	-	Carbon to Nitrogen Ratio
TKN	-	Total Kjeldahl Nitrogen
TS	-	Total Solids
TVS	-	Total Volatile Solids
C	-	Carbon
N	-	Nitrogen
USEPA	-	United State Environmental Protection Agency

POME	-	Palm Oil Mill Effluent
EM	-	Effective Microorganism
AAS	-	Atomic Absorption Spectrometer
BA	-	Bulking Agent
MSW	-	Municipal Solid Waste
FFSC	-	Food Factory Sludge Compost
SSC	-	Sewage Sludge Compost
LSC	-	Leachate Sludge Compost
PSC	-	POME Sludge Compost
CC	-	Commercial Compost

CHAPTER ONE

INTRODUCTION

The problem of sludges disposal is expected to intensify in the future due to a number of factors such as (i) increased in the total cost of sludge disposal, (ii) difficulty in finding suitable land within reasonable distance of large population centers and (iii) restriction loading rates for sludges with high heavy metals. In view of rapid urbanization and industrialization, Malaysia is facing a problem of waste disposal and management from large amounts of wastes generated everyday both by increasing population size and the change of lifestyle. Solid waste is one of the three major problems faced by the municipalities and also industries in Malaysia. The total amount of solid wastes generated in Malaysia in 1994 was about 9.535 tones per day or 3.5 million tones per year. The biotechnology alternative for solving this problem is to compost our organic sludges, and to use it as soil conditioner/fertilizer. Composting can be both an economically and an environmentally sound alternative for handling solid wastes (The World Bank, 1993).

Composting is a natural form of recycling that continually occurs in nature. Composting is a spontaneous process, similar to the breakdown, decomposition and stabilization of organic residues (Rodale, 1975; de Bertoldi *et al*., 1983). Some authors use the word composting for both anaerobic and aerobic decomposition of organic wastes (Stentiford, 1986). The composting used in this work is the controlled exothermic biooxidative decomposition of organic materials by indigenous microorganisms in a moist, warm, aerobic environment, leading to the production of carbon dioxide, water, minerals and stabilized organic matter (Diaz *et al*., 1993). The carbon:nitrogen ratio is the critical factor in the composting process, and the nitrogen- rich sludge must be mixed with a carbon-rich amendment to compost successfully. Compost is valued for its organic matter content, and is typically used as a soil amendment to enhance the chemical, physical and biological properties of soil. Compost is typically not a fertilizer, although when used at normal rates it can reduce the amount of required fertilizer (Outwater, 1994).

It is important to determine the nature and composition of the wastes to be composted. Such basic information will be used later when the time comes to choose appropriate composting system (Obeng and Wright, 1987). Compost can be derived from several different kinds of waste containing large amounts of organic matter produced by agricultural activities like yard trimmings, biosolids (organic sludges), wood by-products, animals manures, crop residues, biodegradable packing and food wastes. The organic substances undergo intensive decomposition under thermophilic and mesophilic conditions in heaps or pits with adequate moisture and finally yield a dark colored humified material in three to six months which is more stable in form, valuable for replenishment of plant nutrients (Gaur, 1975).

Several composting technologies are available, some proprietary and some non-proprietary. The technologies vary in the method of air supply, temperature control, mixing of the mass being composted and the time required for composting to reduce volume, destroy pathogens and weed seeds and stabilize the organic matter. The composting technologies can be classified into two general categories such as bioreactor system and windrow system. The windrow or open composting systems are characterized by having the composting taking place in the open by placing the ground refuse elongated or heap pile. Aeration is accomplished by periodically turning the piles in a manner such that all particles are exposed to comparable conditions at some time during the course of the active period of the composting process. The time required for composting using the windrow method is generally longer compared to the other methods of composting. The bioreactor systems are systems where the materials to be composted are enclosed in a chamber or reactor in which adequate mixing, aeration and moisture content are provided. Bioreactor systems vary in their requirements relative to pre-processing of solid wastes some require minimal pre-processing, while others require extensive pre-processing. Drum, silos, digester bins and tunnels are some of the common bioreactor type systems. A major advantage of a bioreactor system is that all environmental conditions can be carefully controlled to allow rapid composting process. The materials to be composted are frequently turned and mixed to allow homogeneity and promote rapid oxygen transfer (Golueke, 1973; Eweis *et al*, 1998)

In this study, four types of organic sludges were chosen, i.e. sewage sludge, palm oil mill effluent (POME) sludge, leachate sludge and food factory sludge. Composting process was conducted by using rotary drum and windrow system, which was a modified cement mixer. By using the rotary drum the important parameters such as aeration, pH, temperature and moisture content were easily controlled and monitored that are required to accelerate the composting process. In composting process of