BIOREACTOR CO-COMPOSTING OF SEWAGE SLUDGE AND RESTAURANT WASTE

By

ABDUL RAHMAN BIN ABDUL RAZAK

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

June 2004

DEDICATION

My beloved wife, Nur Azanah bte Abdullah @ Azanah bt Oleh

Thanks for your invaluable love, patience, understanding and support

My beloved father & mother

Who provided the opportunities & with your blessing and do'a

Teachers

For your advice and guidance

Friends

Thank you for the support and help

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
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Chairman : Professor Mohd. Ali Hassan, Ph.D

Faculty : Food Science and Biotechnology

Composting is an environmental-friendly method to tackle the disposal problem of sewage sludges and municipal solid waste. With appropriate nutrients, porosity, density and moisture content during composting, pathogens such as *Salmonella typhi, Escherichia coli* etc. will be destroyed and the organic matter will be stabilized producing a compost product that can contribute directly to soil fertility and conditioning. Composting process system has been modernized from the heap or windrow system to the reactor system, which is a comparatively fast process. A 200 liters rotating drum bioreactor/composter was designed, fabricated and used in this co-composting study. This bioreactor was designed in Universiti Putra Malaysia and was fabricated by Amsea Environment Sdn. Bhd. Three different types of dewatered sewage sludges, i.e. septic tank, oxidation pond and activated

sewage sludges were successfully co-composted with municipal solid waste in a two-stage process.

The physicochemical and biological characteristics of these municipal solid waste (restaurant waste) and sewage sludges were measured before being used as raw materials for the co-composting process. For the bioreactor composting, the raw materials were fermented for 7 days inside the 200 liters bioreactor before being matured outside the bioreactor in a windrow pile until fully matured and ready to be used. A 2:1 (w/w) ratio of municipal solid waste and sewage sludge was found to give the best initial C/N ratio for the composting process. The carbon content decreased and the nitrogen content increased towards the end of the composting process, which resulted in the reduction of C/N ratio during the composting process to below 20. The low C/N ratio of the final compost product was very important as the indicator of compost maturity and stability. The breakdown of organic materials inside the bioreactor did not increase the temperature to the thermophilic range (50-60°C), where breakdown of organic matter by microorganisms is at the optimum rate. In order to overcome the temperature problem, heated air was supplied to the bioreactor, increasing the temperature of the composting process. Shredded garden waste was added as bulking agent. Bioreactor co-composting took around 40-45 days to produce matured compost. The characteristics of the sewage sludge compost products were almost similar compared to commercial compost

available in the local market and also complied with the United States Environmental Protection Agency (USEPA) standard. By using bioreactor system the compost products were improved based on nutrient contents and duration of composting process. The planting out performance of spinach with the research compost showed satisfactory results.

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

PENGKOMPOSAN BERSAMA ENAPCEMAR KUMBAHAN DAN SISA PEPEJAL MAJLIS PERBANDARAN MENGGUNAKAN BIOREAKTOR

Oleh

ABDUL RAHMAN BIN ABDUL RAZAK

Jun 2003

Pengerusi : Profesor Mohd. Ali Hassan, Ph.D

Fakulti : Sains Makanan dan Bioteknologi

Pengkomposan merupakan kaedah mesra alam bagi mengatasi masalah pelupusan enapcemar kumbahan daan sisa pepejal majlis perbandaran. Dengan kandungan nutrien, keporosan, ketumpatan dan kandungan lembapan yang sesuai semasa proses pengkomposan, mikrob yang merbahaya seperti *Salmonella typhi*, *Escherichia coli* dan sebagainya akan dimusnahkan dan bahan organik akan distabil menghasilkan produk kompos yang boleh menyumbang kepada kesuburan tanah. Sistem bagi proses pengkomposan telah dimodenkan dari sistem “windrow” atau timbunan longgokan/batasan kepada sistem reaktor yang terbukti satu proses yang lebih pantas. Dalam kajian ini, sebuah bioreaktor/komposter jenis drum berputar bersaiz 200 liter telah direka dan dibina bagi digunakan didalam penyelidikan pengkomposan bersama ini. Bioreaktor ini telah direka bentuk

di Universiti Putra Malaysia dan telah dibina oleh Amsea Enviroment Sdn. Bhd. Tiga jenis enapcemar kumbahan yang berlainan jenis iaitu tangki septik, kolam pengoksidaan dan enapcemar teraktif telah berjaya dikompos bersama-sama dengan sisa pepejal majlis perbandaran melalui dua fasa berlainan semasa proses pengkomposan.

Ciri-ciri kimia fizikal dan biologi bagi enapcemar kumbahan dan sisa pepejal majlis perbandaran (sisa makanan dari restoran) telah dikenalpasti terlebih dahulu sebelum digunakan sebagai bahan mentah bagi proses pengkomposan bersama. Bagi proses pengkomposan menggunakan bioreaktor, bahan mentah yang telah dicampur bersama-sama telah difermentasikan selama 7 hari di dalam bioreaktor 200 liter sebelum melalui proses kematangan diluar bioreaktor melalui kaedah timbunan longgokan/batasan atau “windrow” sehingga matang sepenuhnya dan sedia digunakan. Nisbah 2:1 bagi sisa pepejal majlis perbandaran dan enapcemar kumbahan telah dikenalpasti sebagai kadar percampuran yang sesuai berdasarkan kepada nisbah karbon:nitrogen bagi proses pengkomposan bersama. Kandungan karbon berkurangan dan kandungan nitrogen meningkat dalam masa proses pengkomposan berlaku, yang menghasilkan pengurangan pada nisbah C/N sehingga kurang dari 20. Nisbah C/N yang rendah dalam hasil produk kompos adalah sangat penting sebagai penunjuk kepada kematangan dan kestabilan kompos. Namun begitu, penguraian bahan mentah di dalam bioreaktor tidak mennyebabkan peningkatan suhu

kepada julat termofilik (50-60ºC) dimana penguraian bahan organik oleh mikrorganisma berlaku pada kadar yang optima. Bagi mengatasi masalah suhu, udara panas telah dibekalkan ke dalam bioreaktor yang berjaya meningkatkan suhu semasa proses pengkomposan. Sisa serpihan tanaman/kayu telah ditambah sebagai agen pempukal. Pengkomposan bersama menggunakan bioreaktor mengambil masa sekitar 40-45 hari bagi menghasilkan kompos yang matang. Ciri-ciri akhir produk kompos enapcemar kumbahan dan sisa pepejal majlis perbandaran adalah hampir sama berbanding dengan kompos komersil yang ada dipasaran tempatan dan juga menepati piawaian Agensi Perlindungan Alam Sekitar Amerika Syarikat (USEPA). Dengan menggunakan sistem bioreaktor, produk kompos dapat diperbaiki berdasarkan kepada kandungan nutrien dan jangkamasa proses pengkomposan. Ujian tanaman pokok bayam bagi mengukur kualiti hasil produk kompos yang terhasil menunjukkan keputusan yang memuaskan.

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I certify that an Examination Committee met on 28th June 2004 to conduct the final examination of Abdul Rahman bin Abdul Razak on his Master of Science thesis entitled "Bioreactor Co-Composting of Sewage Sludge and Restaurant Waste" 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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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory 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.

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