UNIVERSITI PUTRA MALAYSIA

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By

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Faculty : Engineering

The problems of limited spaces for new opening of landfills and shortened life span of existing landfills have encouraged moves to reduce the amount of waste sent to landfills nationwide. Composting is a good recycling method to fully utilise all the organic materials from kitchen waste as it contains high nutritious matter within the waste. Optimisation of kitchen waste mixture proportions containing vegetable scraps, fish processing waste and newspaper or onion peels were investigated to find the optimum initial moisture content and carbon-to-nitrogen (CN) ratio to commence a more effective composting process. By applying the simplex-centroid mixture design method using a commercial software, the best mixtures proportion for blend with newspaper was at 48.5% of vegetable scraps, 17.7% of fish processing waste and 33.7% of newspaper, while for blend with onion peels, was at 44.0% of vegetable scraps, 19.7% of fish processing waste and 36.2% of onion peels to produce desired initial moisture content of 60% and CN ratio of 30.

Utilising the optimal mixture proportions, following composting studies were conducted. The evaluation of the performance of the composting process was through measurements of CN ratio while monitoring its changes in temperature, moisture content, volatile solids content, pH, electrical conductivity, bulk density, colour, microbial numbers, headspace oxygen and carbon dioxide content. A kitchen waste composter which enables controlled composting conditions was designed and fabricated. It allows control of temperature inside the composter by either switching on or off a bulb attached on top of composter, and for control of moisture content of composting materials, the small holes at the bottom of the composter allows excessive water to flow out and then collect from the underside of the composter. The composter is insulated with 2 mm thickness of cloth to reduce the heat loss.

The effects of using two bulking agents, newspaper and onion peels in kitchen waste composting were investigated by creating parallel composting using two kitchen waste composter. The optimum kitchen waste mixture compositing was used for a composting process of 30-days where temperature profiles were recorded and the CN ratio measured as indication of compost maturity. It was found that blends with onion peels decomposed more quickly than the newspaper, which by 30-days of composting period, the blends with onion peels produced end product with CN ratio of 8.15, while the newspaper with CN ratio of 37.04 and did not achieve any thermophilic stage. The results suggest that the onion peels are more suitable and the newspaper did not assist in acceleration of the composting process.

The effects of kitchen waste compost load size were then investigated using kitchen waste mixtures with onion peels at 2 and 6 kg. The smaller load, 2 kg, decomposed

more rapidly than the 6 kg because the temperature decreased to mesophilic temperature was 10 days earlier than in 6 kg and the CN ratio of 2 kg reaching 15 at 8 days earlier than 6 kg. Although the 2 kg of waste undergone shorter time of thermophilic phase at time range of about 3 days, it was still sufficient to kill the pathogens. This experiment suggests that a 2 kg of kitchen waste is enough to commence such composting.

In accelerating composting processes, the use of microorganisms as an accelerant for this kitchen waste composting tested at 6 kg of kitchen waste with onion peels blend. Microbes' cocktail consisting a mixture of seven types of bacteria and eight types of fungi priory isolated from soil, was added at the early stage of composting period in one composter while a control, a similar compost without adding the starter culture was compared. Analysis of variance (ANOVA) performed on the compost maturity indices did not show significant differences between the microbe added compost and control since $p = 0.8158$. The starter culture is therefore not necessarily to be added in the composting of food waste.

In conclusion, composting of kitchen waste can be made simple and efficient with the right mixture proportion and type of waste to begin, using a minimal load of about 2 kg and without additional accelerant microbes. The effort of recycling kitchen waste is important in helping to build a sustainable environment that promises balanced ecosystems.

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

PENGOPTIMUMAN BAGI PENGKOMPOSAN SISA DAPUR

Oleh

NORAZLIN BINTI ABDULLAH

Januari 2011

Pengerusi : Profesor Madya Chin Nyuk Ling, PhD

Fakulti : Kejuruteraan

Masalah ruang yang terhad untuk pembukaan tapak-tapak pelupusan yang baru dan jangka hayat yang pendek untuk tapak-tapak yang sedia ada telah menggalakkan tindakan untuk mengurangkan jumlah sisa yang dihantar ke tapak pelupusan seluruh negara. Pengkomposan merupakan satu kaedah kitar semula yang baik, menggunakan bahan organik sepenuhnya daripada sisa dapur yang mengandungi bahan berzat yang tinggi. Pengoptimuman bagi perkadaran campuran sisa dapur yang mengandungi cebisan sayur, sisa pemprosesan ikan dan surat khabar atau kulit bawang telah dikaji untuk mencari kandungan kelembapan dan nisbah karbon-kepada-nitrogen (CN) awal yang optimum bagi memulakan proses pengkomposan yang lebih berkesan. Dengan menggunakan kaedah rekabentuk campuran sentroid-mudah menggunakan perisian komersil, perkadaran campuran yang terbaik untuk adunan dengan surat khabar ialah pada 48.5% cebisan sayur, 17.7% sisa pemprosesan ikan dan 33.7% surat khabar, manakala untuk adunan dengan kulit bawang ialah pada 44.0% cebisan sayur, 19.7% sisa pemprosesan ikan dan 36.2%

kulit bawang untuk menghasilkan kandungan kelembapan permulaan yang diingini iaitu 60% dan nisbah CN iaitu 30.

Menggunakan perkadaran campuran yang optimum, kajian pengkomposan seterusnya telah dijalankan. Penilaian prestasi proses pengkomposan adalah melalui ukuran nisbah CN sementara memantau perubahannya dalam suhu, kandungan kelembapan, kandungan pepejal mudah ruap, pH, kekonduksian elektrik, ketumpatan pukal, warna, jumlah mikrob, kandungan oksigen dan karbon dioksida ruang tutupan. Satu pengkompos sisa dapur yang membolehkan keadaan pengkomposan dikawal telah direkabentuk dan difabrikasi. Ia membenarkan kawalan suhu dalam pengkompos sama ada dengan pembukaan atau penutupan suis mentol yang disertakan pada bahagian atas pengkompos, dan bagi kawalan kandungan kelembapan bahan-bahan pengkomposan, lubang-lubang kecil pada dasar pengkompos membenarkan air berlebihan untuk mengalir keluar dan dikumpul dari bahagian bawah pengkompos. Pengkompos ditebat dengan 2 mm ketebalan kain untuk mengurangkan kehilangan haba.

Kesan-kesan penggunaan dua ejen pemukalan, surat khabar dan kulit bawang dalam pengkomposan sisa dapur telah dikaji dengan mewujudkan pengkomposan selari menggunakan dua pengkompos sisa dapur. Gabungan campuran sisa dapur yang optimum telah digunakan untuk proses pengkomposan selama 30 hari di mana profil suhu telah direkodkan dan nisbah CN diukur sebagai petunjuk kematangan kompos. Ia telah didapati bahawa adunan dengan kulit bawang mengurai dengan lebih cepat berbanding dengan surat khabar, di mana dengan tempoh pengkomposan selama 30 hari, adunan dengan kulit bawang menghasilkan produk akhir dengan nisbah CN

8.15, manakala surat khabar dengan nisbah CN 37.04 dan tidak mencapai mana-mana peringkat termofili. Keputusan ini mencadangkan bahawa kulit bawang lebih sesuai dan surat khabar pula tidak membantu dalam pencepatan proses pengkomposan.

Kesan-kesan saiz muatan kompos sisa dapur telah dikaji menggunakan campuran sisa dapur dengan kulit bawang pada 2 dan 6 kg. Beban lebih kecil, iaitu sebanyak 2 kg, mengurai lebih cepat daripada 6 kg kerana suhu berkurangan kepada suhu mesofili ialah 10 hari lebih awal daripada dalam 6 kg dan nisbah CN bagi 2 kg mencapai 15 pada 8 hari lebih awal daripada 6 kg. Walaupun 2 kg daripada sisa mengalami masa lebih pendek untuk fasa termofili pada julat masa kira-kira 3 hari, ia masih memadai untuk membunuh penyakit. Eksperimen ini mencadangkan bahawa 2 kg daripada sisa dapur cukup untuk memulakan pengkomposan.

Dalam mempercepatkan proses-proses pengkomposan, penggunaan mikroorganisma sebagai pencepat untuk pengkomposan sisa dapur ini diuji pada 6 kg daripada sisa dapur dengan adunan kulit bawang. Adunan mikrob yang mengandungi satu campuran daripada tujuh jenis bakteria dan lapan jenis fungi pada mulanya diasingkan daripada tanah, telah ditambah pada peringkat awal daripada tempoh pengkomposan dalam satu pengkompos manakala satu kawalan, satu kompos serupa tanpa menambah kultur pemula telah dibandingkan. Analisis varians (ANOVA) yang dilakukan pada indeks kematangan kompos tidak menunjukkan perbezaan ketara antara kompos yang ditambah mikrob dan kawalan kerana $p = 0.8158$. Kultur pemula adalah dengan itu tidak perlu ditambah ke dalam pengkomposan sisa makanan.

Kesimpulannya, pengkomposan sisa dapur dapat dibuat dengan mudah dan cekap dengan perkadaran campuran yang betul dan jenis sisa untuk dimulakan, menggunakan satu muatan minimum kira-kira 2 kg dan tanpa tambahan mikrob pencepat. Usaha kitar semula sisa dapur adalah penting dalam membantu bagi membina satu persekitaran mampan yang menjanjikan ekosistem seimbang.

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I certify that a Thesis Examination Committee has met on 6th January 2011 to conduct the final examination of Norazlin Binti Abdullah on her thesis entitled "Optimisation of Kitchen Waste Composting" 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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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

NORAZLIN BINTI ABDULLAH

Date: 6 January 2011

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