Journal of Environmental Management xxx (2017) 1–8

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

# Evaluation of Effective Microorganisms on home scale organic waste composting

Yee Van Fan [a], Chew Tin Lee [a, b, c, *], Jiří Jaromír Klemeš [d], Lee Suan Chua [e], Mohamad Roji Sarmidi [c, e], Chee Woh Leow [a]

[a] Department of Bioprocess Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru, Johor, Malaysia
[b] Low Carbon Asia Research Centre, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru, Johor, Malaysia
[c] UTM Innovation Centre in Agritechnology for Advanced Bioprocessing, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru, Johor, Malaysia
[d] Sustainable Process Integration Laboratory – SPIL, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Technická 2896/2, 616 00, Brno, Czech Republic
[e] Institute of Bioproduct Development, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru, Johor, Malaysia

A R T I C L E I N F O

*Article history:*
Received 14 February 2017
Received in revised form
1 April 2017
Accepted 7 April 2017
Available online xxx

*Keywords:*
Effective microorganisms
Food and organic waste composting
Home scale
Nutrient content
Humic acid

A B S T R A C T

Home composting can be an effective way to reduce the volume of municipal solid waste. The aim of this study is to evaluate the effect of Effective Microorganism™ (EM) for the home scale co-composting of food waste, rice bran and dried leaves. A general consensus is lacking regarding the efficiency of inoculation composting. Home scale composting was carried out with and without EM (control) to identify the roles of EM. The composting parameters for both trials showed a similar trend of changes during the decomposition. As assayed by Fourier Transform Infrared Spectroscopy (FTIR), the functional group of humic acid was initially dominated by aliphatic structure but was dominated by the aromatic in the final compost. The EM compost has a sharper peak of aromatic C=C bond presenting a better degree of humification. Compost with EM achieved a slightly higher temperature at the early stage, with foul odour suppressed, enhanced humification process and a greater fat reduction (73%). No significant difference was found for the final composts inoculated with and without EM. The properties included pH (~7), electric conductivity (~2), carbon-to-nitrogen ratio (C: N < 14), colour (dark brown), odour (earthy smell), germination index (>100%), humic acid content (4.5–4.8%) and pathogen content (no *Salmonella*, <1000 Most Probable Number/g *E. coli*). All samples were well matured within 2 months. The potassium and phosphate contents in both cases were similar however the EM compost has a higher nitrogen content (+1.5%). The overall results suggested the positive effect provided by EM notably in odour control and humification.



## 1. Introduction

Solid waste management is a major challenge worldwide due to the rise in population and industrialization, leading to larger amount of solid wastes being generated (Wu et al., 2014). Composting can be a viable alternative of organic waste utilisation in the developing countries due to low cost. Its potential for environmental sustainability, cost-effectiveness and public acceptance is relatively well known (Lim et al., 2016). The practice of composting at home can be hindered by a lack of knowledge and technique to manage. Different composting system (Barrena et al., 2014), process parameters (Rasapoor et al., 2016), input materials and its formulation (De Mendonça Costa et al., 2017), and the environmental condition (Zhu et al., 2015) will result in a variation of compost quality. Composting at source (e.g. at home) is desirable to reduce greenhouse gaseous (GHG) emission due to the transportation of waste and avoidance of GHG emission at the landfill (Adhikari et al., 2013). Replacement of mineral fertiliser using compost also further reduces the footprint of GHG (Barrena et al., 2014). The use of mineral fertilizers on the soil over a longer period of time may affect its ability to sustain healthy plant growth and crop

* Corresponding author. Department of Bioprocess Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia (UTM), 81310, UTM Johor Bahru, Johor, Malaysia.
*E-mail address:* ctlee@utm.my (C.T. Lee).

http://dx.doi.org/10.1016/j.jenvman.2017.04.019
0301-4797/

production (Lim et al., 2015). Home scale composting has not been studied broadly as compared to the industrial-scale composting.

Barrena et al. (2014) show that home composting can produce similar or even better compost quality than the industrial composting when conducted appropriately. Food waste is classified as active waste having low carbon-to-nitrogen (C: N) ratio and high moisture content. Low C: N ratio leads to the production of unpleasant odour mainly by ammonia as a result of intense N mineralisation (Pagans et al., 2006). High moisture content limits the movement of $O_2$ and leads to an anaerobic reaction that causes odour (Gutiérrez et al., 2015). Home composting is usually undersized and insufficient to heat up effectively (Orthodoxou et al., 2015) to eliminate the pathogen. Various compost accelerators are available on the market for composting. The efficiency of the microbial inoculants (MI) could vary according to the composting condition. Maroušek et al. (2015) present a distinctive polemic on ethical aspects of MI utilisation in the compost business and suggested that inoculation composting (with a scale of 905 L) could produce compost of lower quality than that of the conventional procedure.

A few commercial microbial inoculants (MI) contain predominantly lactic acid bacteria, yeasts and photosynthetic bacteria are available in the market. One of these is the Effective Microorganisms (EM) originated from Japan (Higa and Wididana, 1991). EM was reported to reduce odour, increase the decomposition rate and producing compost with higher nutrient contents (Jusoh et al., 2013). Another study stated that the use of EM was not necessary to ensure good composting (Nair and Okamitsu, 2010). This shows diverse opinion about the effectiveness of EM for composting. EM may be a useful additive for composting when the microorganisms are compatible with the characteristics of the waste to be composed. Some authors stated that MI is able to increase enzymatic activities (Payel et al., 2011), promote biodegradation of organic matter (Patidar et al., 2013) and accelerate the composting process (Saad et al., 2013). Some suggested that the existing microbial community in the waste could degrade waste satisfactorily given the optimum environmental conditions (Abdullah et al., 2013). Nair and Okamitsu (2010) reported that the effect of EM was not significant in the small scale kitchen waste composting. Composts can enhance plant growth as well as chemical, physical and biological properties of soils but immature or low-quality compost can have an adverse effect on plants and the soil environment (Fernández-Hernández et al., 2014).

It is essential to monitor the composting efficiency by evaluating the biodegradation rate of the substrate and to maximize the decomposition rate (Malamis et al., 2016). Kinetic modelling and enzymatic assay based on the substrate consumption rates are among the approaches to monitor the rates. This study aims to evaluate the effects of EM on the home scale co-composting of organic waste. Various physicochemical and biological properties including temperature, pH, odour, C: N ratio, amylase activity, cellulase activity, lipase activity, protease activity and changes of humic acid and fat contents were monitored along the composting process. The quality of the final products was identified and compared in terms of the final pH, colour, C: N ratio, electric conductivity (EC), germination index, humic acid, pathogen, nitrogen, potassium and phosphate contents.

## 2. Materials and methods

### 2.1. Preparation of composting

The composting work was carried out in the perforated plastic bin as illustrated in Fig. 1 under "partially aerobic" condition defined by Golueke et al. (1954). The home scale composting was carried out in the bin because it is easily available and it helps the undersized compost pile to retain heat and moisture content. Dried leave and rice bran were used as a bulking agent to assist aeration. Each bin was covered by a cotton cloth and turned manually once in a week without the use of air pump or blower. Each bin contained 4 kg of feedstock (50% of simulated food waste, 25% of dried leaves and 25% rice bran) with an initial C: N of around 25:1. Each bin was added with 1.2 L EM or distilled water (control) to prepare the initial moisture content of 40–60% (Gómez-Brandón et al., 2008). The composition of the simulated food waste (Hafid et al., 2010) used in this study consists of 1.2 kg rice, 250 g meat and fish, 450 g vegetables and fruits, 70 mL oil, 15 mL salt, 15 mL sauce and 40 mL distilled water for each of the perforated plastic bin. It was simulated based on the proximate analysis results from the food waste collected from the restaurants in Sri Serdang, Selangor, Malaysia.

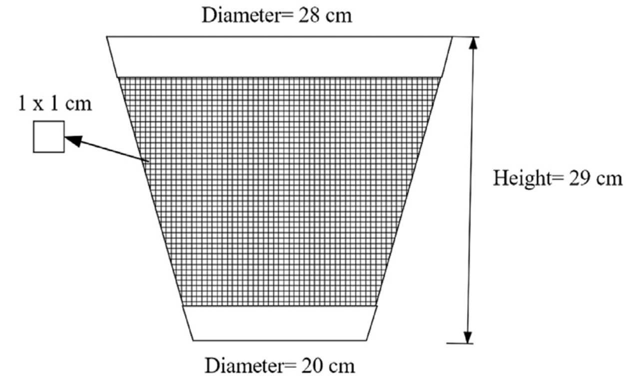


**Fig. 1.** Perforated plastic bin.

The rice bran was purchased from Syarikat Faiza Sdn. Bhd, Johor, Malaysia while the dried leave was collected from the landscape on the campus of Universiti Teknologi Malaysia (UTM), Johor, Malaysia. The 4 kg feedstock (2 kg model kitchen waste; 1 kg dried leave; 1 kg rice bran) was autoclaved at 121 °C for 15 min. The moisture content of the compost along the process was controlled within 40–60% (Hubbe et al., 2010) using activated EM or distilled water. The commercial EM (EM-1®, EM Research Organization Malaysia Sdn Bhd, Malaysia) was activated according to the user manual. One part of EM stock solution was mixed with one part of molasses and twenty part of water for 5–7 d at room temperature until the pH was below 3.5. The activated EM contained ~$10^7$ Colony Forming Unit (CFU)/mL of fungi and ~$10^8$ CFU/mL of bacteria. The activated EM is referred as EM hereafter. Each treatment (4 kg feedstock with and without EM) was prepared in duplicate for each run.

### 2.2. Monitoring of composting

Temperature, pH, EC, fat contents, odour, colour, C: N ratio, enzymatic activities and changes of humic acid were monitored along the composting process of the feedstock with and without EM (control). The composts were sampled at five different locations (Woods End Research Laboratory, 2005) using simple random sampling method (Food and Agriculture Organization of the United Nations, 2000) to obtain representative samples for composting analysis and final compost quality determination. The details for the monitoring of composting parameters is summarised in Table 1.

The humic acid was characterised using Fourier Transform Infrared Spectroscopy (FTIR), Spectrum One FT-IR (Perkin Elmer, United Stated). FTIR analysis was carried out by grounded the samples with potassium bromide (1:100) and pressed under the pressure of 10 t for 3 min before analysed in a detection range of

Please cite this article in press as: Fan, Y.V., et al., Evaluation of Effective Microorganisms on home scale organic waste composting, Journal of Environmental Management (2017), http://dx.doi.org/10.1016/j.jenvman.2017.04.019