MASTER'S THESIS

# Reduction of odor generation through composting process control

Fung, Shun On

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# Reduction of Odor Generation Through Composting Process Control

**FUNG Shun On**

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**Principal Supervisor: Prof. Jonathan WONG Woon Chung**

**Hong Kong Baptist University**

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# Abstract

Composting has recently been considered by the government as an alternative to treat the enormous amount of food waste produced in Hong Kong. However, in a densely-populated city like Hong Kong, the location of the composting facilities and the nuisance caused by such amenities become the major concerns. To strike a balance between environmental consideration and economic development, it is important that the space of the composting facilities is fully utilized and that the nuisance generated during the composting operation should be minimized. Therefore, the operating parameters of composting should be optimized to achieve greatest efficiency during the composting process such that odor generation can also be minimized. It is therefore the aim of the present study to develop a combined method in optimizing the composting process as well as reducing the odor generation using different approaches.

The first phase of the study aims to optimize the composting process by controlling the aeration and amount of bulking agent (wood chips) during the composting of food waste. The food waste was collected from canteen and composted for 63 days in a batch composting system applying either different aeration rates (0.5 L $kg^{-1}$ $min^{-1}$, 1.0 L $kg^{-1}$ $min^{-1}$ or 2.0 L $kg^{-1}$ $min^{-1}$) on a fixed wood chips amount (30 %) or a fixed aeration rate of 1.0 L $kg^{-1}$ $min^{-1}$ dry weight on different wood chips amount (0 %, 15 % or 30 %). After the composting study, it was found that the use of higher aeration rate had resulted in lower emission of volatile fatty acids (VFAs) but the use of 1.0 L $kg^{-1}$ $min^{-1}$ aeration rate had resulted in the lowest total emission of them. Both treatments with 1.0 L $kg^{-1}$ $min^{-1}$ and 2.0 L $kg^{-1}$ $min^{-1}$ aeration rate could produce mature compost after 63 days of composting. On a fixed aeration rate of 1.0 L $kg^{-1}$ $min^{-1}$, treatments with 15 % or 30 % v/v wood chips had successfully reduced all kinds of volatile fatty acids (VFAs) with an increase in pH of the compost material, which indicated a normal composting process. However, the treatment without any wood chips addition persisted the acidogenic phase throughout the composting period. Using 15 % v/v wood chips was more efficient in reducing the lag phase in which pH started to increase to above neutral on day 7 compared to day 21 in the treatment with 30 % v/v wood chips. Therefore, a combination of 1.0 L $kg^{-1}$ $min^{-1}$ aeration rate with 15 % v/v wood chips provided optimum operating parameters for reducing the VFAs generation without affecting the organic decomposition.

In the second phase of the study, attempts were made in using alkaline materials of lime and coal fly ash (CFA) or both to co-compost with food waste material to investigate whether enhanced decomposition efficiency and odor reduction could be achieved. Artificial food waste was prepared by mixing bread, rice, cabbage and fully boiled pork in the ratio of 13:10:10:5 respectively. The first part of this study evaluated the effect of different amounts of industrial lime (0 %, 1.5 % or 3 % w/w) on food waste composting. It was found that only treatments with the addition of 3 % industrial lime could effectively increase the pH of the food waste composting by buffering against the acids released during the composting of food waste material. This in turn reduced the emission of all kinds of VFAs. The enhanced pH also altered normal organic decomposition of food waste and compost maturity was achieved on day 42. Then, different amounts of CFA (5 %, 10 % or 15 %) were used to replace part of the industrial lime in the second part of the study, which had a final $CaCO_3$ equivalent of 1.88 %. It was interesting to find that the addition of 5 % or 10 % CFA with lime could further reduce the extractable VFAs as well as the gaseous emission of VFAs and

ammonia compared to the addition of 3 % w/w lime alone. The reduction of odor emission was due to the adsorption effect by the CFA which allowed microbial breakdown of the odorous compounds.

Therefore, the final phase of the study combined the chemical amendments with microbial inoculation to investigate whether the composting process could be enhanced further by inoculation of mesophiles and thermophiles (M+T) or only thermophiles (THB). It was found that the inoculation of a consortium of thermophilic bacteria, including *Bacillus subtilis, Bacillus megaterium, Bacillus laevolacticus, Bacillus cereus* and *Staphylococcus schleiferi* was very effective to prevent the drop of pH during the composting process. The inoculation of either both mesophiles and thermophiles or only thermophiles had resulted in a higher organic carbon loss of around 12 % compared to only 10.7 % in the control treatment. Also, total microbial populations and VFA-degrading microbial populations were enhanced in both treatments compared to the one without inoculation. Inoculation of bacterial cultures also reduced the emission of acetic acid by 34 % in THB and by 56 % in M+T. Both treatments also successfully eliminated iso-butyric acid which appeared at day 3 and day 7 in the control. Inoculation of only thermophiles had the added advantage of controlling ammonia emission and successfully reduced the cumulative ammonia emission by 50 % while that of M+T did not differ significantly from the control.

The present study demonstrates that using 5 % CFA, 2.25 % industrial lime as the chemical amendment, and the inoculation of a consortium of thermophilic bacteria ($10^8$ CFU $kg^{-1}$ food waste) was effective in reducing the composting time for food waste composting to prevent acid formation of the composting mass and at the same time minimized the formation of VFAs and ammonia produced from the putrefaction process. Hence, this amendment strategy can be used as an integrated approach in maintaining the composting time as well as reducing the odorous compounds generation from the composting process. This could act as an inexpensive method for solving the adverse effect of acidification during food waste composting and allow the normal decomposition of food waste during composting. The reduced odor generation makes food waste composting more feasible for densely population cities like Hong Kong to adopt the technology for food waste treatment.

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