MASTER'S THESIS

Optimizing food waste composting process in fed-batch composter

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Date of Award:
2015

ABSTRACT

Composting is considered as an effective and sustainable food waste treatment technology from the perspectives of volume reduction, stabilization and releasing the pressure on landfills. Community composter is a decentralized composting facility in fed-batch operational mode which is usually being installed in the backyard of institutes, hospitals, housing estate etc. to handle the food wastes generated daily. Albeit numerous operational issues including high initial acidity and oil content, poor decomposition and odor generation are commonly encountered in these facilities, which make it difficult to be accepted by the public. Therefore, the aim of the present study is to develop a composting mix formulation that can provide a solution to all these issues in a fed-batch food waste composting process.

The first phase of this study aims at finding out an optimized formulation in a batch-scale food waste composting process through the use of alkaline amendments and microbial inoculum. For the first two experiments, artificial food wastes were prepared by mixing 1.3kg bread, 1kg boiled rice, 1kg cabbage, 0.5kg fully boiled pork and mixed with sawdust to obtain a C/N of 30 and adjusted moisture of the mixtures to 55%. The effect of different concentrations of zeolite compared to lime was studied in the first experiment. Zeolite was amended with food wastes and sawdust mixtures at 2% (ZI-2), 5% (ZI-5), 10% (ZI-10) to compare with lime in 2.25% (L-2.25) w/w (dry weight basis) and composted for 56 days. Results demonstrated that 10% of zeolite was optimal amendment rate compared to lower dosage of zeolite (2% & 5%) with stronger pH buffering capacity and greater decomposition efficiency. Addition of 2.25% of lime buffered the pH efficiently but increased the ammonia loss significantly which eventually reduced total nitrogen (TN) content of final product and posed odor emission problem. Amendment of 10% zeolite provided a higher adsorption affinity on ammonia resulting in 2.05% of TN value of final product which was higher than 1.72% of lime treatment. Furthermore, significantly higher seed germination 150% was achieved of ZI-10 compost compared to 135% of L-2.25 due to low ammonium content of product.

The first experiment showed that application of less than 10% zeolite was not sufficient to buffer the acidity; as a result, organic matter decomposition was inhibited. However, the cost and reduction in treatment percentage of food waste in 10% application rate of zeolite is an issue of concern. To tackle this dilemma, food waste was amended with struvite salts at 1:2 molar ratio of MgO and K_2HPO_4 (Mg:P) with or without zeolite amended at either 5% or 10% amendment (Mg:P, Z5 + Mg:P & Z10 + Mg:P) and a control treatment with food waste only was also included. Results showed that treatment of Z10 + Mg:P was synergistically achieved of pH and EC buffering, and N conservation but not for the case of 5 % zeolite. Treatment of Z10 + Mg:P further reduced the N loss to 18% compared to 25% and 27% of Mg:P and Z5 + Mg:P respectively. However, there was insignificant difference in the final nitrogen content and decomposition rate among all treatments with struvite salts amendment. Comparing to the treatment of Z-10 of the first experiment to Z10 + Mg:P of the second experiment, Z-10 showed superior performance since better decomposition efficiency, shorter time to require to pass the GI (28 Days) and lower cost because of salts exclusion.

To develop a multipurpose formulation for the fed-batch operational food waste composter, high lipids problem in food waste cannot be neglected because it is a critical factor to hinder the decomposition efficiency. Inoculation of oil degradative microorganisms was reported as an effective approach to facilitate the lipids. Therefore, the third experiment was to investigate the overall composting performance supplemented with 10% zeolite and microbial consortium. 10% zeolite with bacterial consortium significantly reduced the lipid contents from 7% to 1%

compared to control treatments. Furthermore, treatments amended with 10% zeolite was proved to reduce ammonia emission and total volatile fatty acids level in the composting mass, therefore the total odor emission level can be reduced. Zeolite at 10% was found to be a suitable optimum additive for both synthetic and real-food wastes. Therefore, treatment of 10% zeolite with bacterial consortium is selected as an optimized formulation for further study of its application in a fed-batch composter.

Following the food waste zeolite composting formulation obtained in Phase I, the aim of Phase II was to develop an ideal composting mix formulation for on-site commercial composters. Although the results have been demonstrated 10% zeolite with bacterial consortium facilitated the composting efficiency in batch composter, those amendments may be over-estimated if applied in a fed batch composter by using real food wastes. With this constraint, the applicability of these additives in commercial fed-batch composter needs to be assessed using locally generated food wastes. Treatments included food waste and sawdust mixtures at 4:1 mixing ratio (wet weight basis) were mixed with 2.25% of lime (L2.25), 10% of zeolite (Z10) and 10% zeolite with bacterial inoculum (Z10+O) and a control of food waste with sawdust mixture only was also included. 35 kg compost mixture was fed into each composter respectively daily for a period of 42 days. Only Z10+O was the most suitable composting mix for fed-batch food waste composting process with continuous sustained high temperature (55-60^{o}C), optimal moisture (55%-60%), alkaline pH and low EC during the experimental period. Bacterial inoculum significantly improved the lipids decomposition from 22.16% (C) to 3.10% (Z10+O) after the composting period. In contrast, lime and zeolite alone treatments could not maintain the optimal pH that led to reduce degradation and longer stabilization period. Only compost taken from Z10+O treatment could be classified as mature compost.

The aim of the third study phase was to examine an optimal application rate of food waste compost produced from decentralized food waste composter for plant. A plant growth experiment was conducted in this phase to evaluate the change in soil properties and plant growth of *Brassica chinensis* and *Lycopersicon esculentum.* The experiment was conducted in a loamy soil amended with 0%, 2.5%, 5% and 10% food waste compost amendment rate compared to the control soil with chemical fertilizer amendment only. Results indicated that 5% was the optimal application rate of food waste compost for both crops among all treatments which can be evidenced by the highest biomass production and nutrients value of the plant tissues. Plant available nutrients such as NH_4^+, NO_3^-, PO_4^{3-} were proportionally increased with increase in compost application rate. However, 2.5% of the food waste compost did not provide sufficient nutrients for plant growth and 10% showed negative effects due to increased salts content. Plants amended with chemical fertilizer had relatively low biomass production compared to compost amended treatments due to soil compaction and fast leaching of nutrients.

It can be concluded that application of 10% zeolite with microbial consortium is an ideal composting mix formulation for on-site commercial composters and 5% is an optimal application rate of food waste compost of *Brassica chinensis* and *Lycopersicon esculentum.*

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