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Sustainable Operation of Composting in Solid Waste Management

S. Vigneswaran*, J. Kandasamy, M.A.H. Johir

Faculty of Engineering and Information Technology, University of Technology, Sydney, Broadway, NSW 2007, Australia

Abstract

In this paper the optimum design of windrow composting is discussed. There are many reasons to consider implementing centralized open-windrow compost technology in developing countries, especially in municipalities which are not subject to the severe space restrictions. Compared to mechanized or in-vessel operations, windrow composting has many advantages as discussed in the paper. Design aspects of windrow composting facility such as process design, composting area sizing, runoff collection pond sizing, land treatment design for runoff, and capital and operating cost estimation are discussed in detail. In particular, the process design components such as feedstock (solid wastes) recovery, feedstock preparation, composting, stabilization, curing, refining and storing are analysed. A detail cost analysis (Capital and O&M Cost) is made based on processing 3000 tons/yr of yard waste, food waste, etc. to produced 1,500 tons/yr. of finished compost is made.

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1. Introduction

Composting is defined as “a process of biological decomposition and stabilisation of organic substrates under conditions, which allow development of thermophilic temperatures as a result of biologically produced heat, with a final product sufficiently stable for storage and application on land without adverse environmental effects”. Microorganisms such as bacteria, fungi, and protozoa are involved in the biological decomposition process. Decomposition comprises two stages of biochemical transformations, namely mineralisation and humification. During mineralisation, readily fermentable organic substances such as carbohydrates (sugars) and amino acids are degraded by the metabolic activities of microorganisms, producing heat, carbon dioxide and water. Mineralisation

* Corresponding author.
E-mail address: Saravanamuth.Vigneswaran@uts.edu.au

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results in partially stabilised organic residual. The typical biochemical reaction pathways that occur during mineralisation are:

Carbohydrates → Simple sugars → Organic acids → CO_2 + H_2O + Organic matter

Proteins → Peptides → Amino acids → NH_4 compounds → N_2 or ammonia

During humification, humic (loose and fluffy) characteristic are imparted to the dense and partially stabilised organic matter formed as a result of mineralisation. Fungal and actinomycetes organisms are involved in humification process. To give microbial transformation a good start, oxygen in excess quantities is needed during the first stage of composting. On the other hand, less aerobic conditions are preferred during the humus formation stage, to avoid excessive mineralisation of the organic substances. Microbial reactions that occur during mineralisation and the early part of humication stages are exothermic (heat releasing), thus increasing the temperature of the composting heap. The heat hastens the rate of decomposition, and helps to produce safer compost material, by inactivating pathogenic microorganisms in the solid wastes. In accordance with temperature patterns, composting occurs in four distinct phases, namely, Latent phase, Growth phase, Thermophilic phase, and Maturation phase.

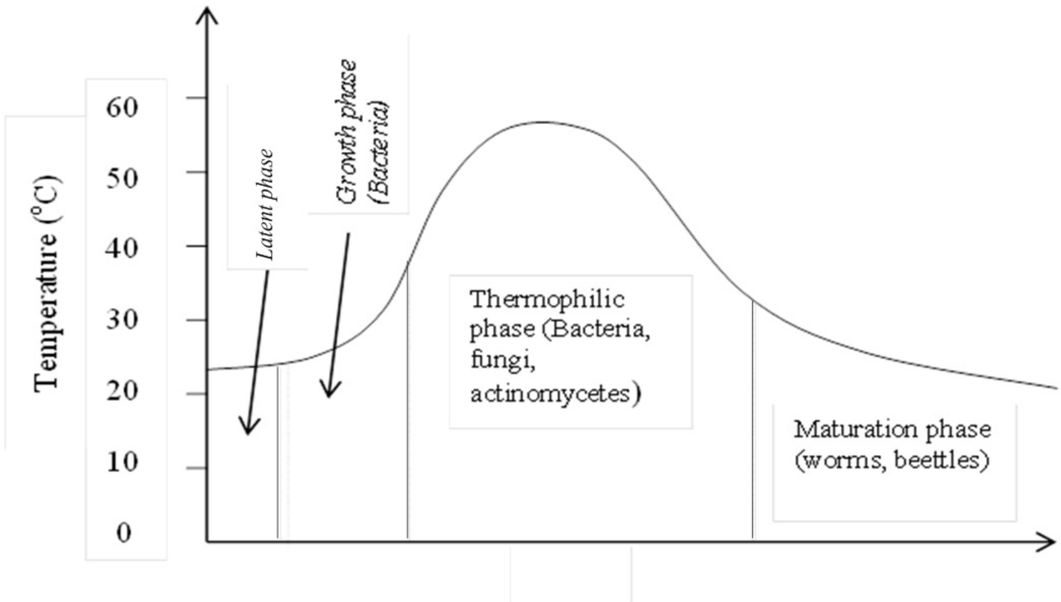

Fig. 1. Temperature pattern and microbial growth in compost piles[1]

Maturation phase: This phase is characterised by fall of temperature of the heap back to mesophilic level, and subsequently to the ambient level. Humification process completes resulting in mature compost.

Because microbes are the active agents in the composting process, factors that are conducive to their activities and proliferation are the determinants of the pace and effectiveness of the process. The ratio of carbon-to-nitrogen (C-N ratio), particle size, and moisture content are important factors. These factors depend on the composition of the waste composted. A C-N ratio in the range of 20 – 30 is generally recommended as optimal. Higher ratios lead to longer composting periods and, at lower ratios, nutrient nitrogen is lost more rapidly by conversion into gaseous forms (as ammonia or nitrogen), affecting the compost quality. Moisture content of the wastes affects the availability of oxygen for microbial reactions and, is to be maintained at an optimal range of 50-65%. Smaller particle sizes favour faster biodegradation.