[1.]Mirela Nicoleta DINCĂ, [1.]Mariana FERDEŞ, [1.]Gigel PARASCHIV, [1.]Nicoleta UNGUREANU, [1.]Bianca ZĂBAVĂ, [1.]Mariana IONESCU, [1.]Georgiana MOICEANU

RECOVERY OF ORGANIC WASTE THROUGH COMPOSTING PROCESS

[1.]University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering, ROMANIA

Abstract: Waste treatment involves all chemical, physical and biological processes that have the role of modifying certain characteristics of the waste in order to reduce their volume and hazardousness, thus facilitating their recovery. Among the available technologies, composting is presented as one of the most promising options for recycling the organic fraction into a valuable organic fertilizer called compost. In the present paper are presented the main composting methods, namely: passive composting in piles, turned windrow composting, passive aerated windrows, aerated static pile and in – vessel composting.
Keywords: waste treatment, composting methods, aerobic fermentation, organic waste

INTRODUCTION

Today, the most urgent environmental problem is global warming, the main challenge in the waste management sector being waste avoidance. Solid waste management, especially the organic fraction, has become one of the major challenges of the 21st century from an economic, social and environmental protection point of view (*Fernandez et al.*. 2016). Organic waste, such as agricultural and forestry residues and municipal solid waste, has become a major issue in both developed and developing countries (*Rashad et al.*. *2010*). Waste treatment involves all the chemical, physical and biological processes which have the role to modify certain features of the wastes in order to reduce their volume and hazardous character, thus facilitating their recovery *(Căpățână & Simonescu. 2006)*. According to Eurostat statistics, at the level of EU member states, 15% of the municipal wastes generated by one person in 2013 were treated by composting (*http://ec.europa.eu/eurostat*).

Among the methods of biological waste treatment, composting is the simplest and most efficient technology for treating the organic fraction. Composting can be defined as an aerobic process of biochemical decomposition of organic matter resulting in a stable product without pathogenic germs that can be used in agriculture (*Haug. 1993*; *Zhang & Sun. 2014*). The substrate used in the composting process consists of different sources of organic waste, such as: biodegradable waste collected from dwellings and households (kitchen waste, garden waste - cut grass, leaves, tree bark, debris from trimming trees and hedges, animal manure). residues from the processing of vegetables and fruits, residues from meat and fish processing, biodegradable municipal waste (sludge from wastewater treatment plants, newspapers, cardboard), waste from wood processing (sawdust, wood chips) and residues from agricultural crops (*Francou et al..2005*).

Transformation of organic matter during the composting consists of two complex processes, namely: *degradation* and *humification*. Over time, special attention has been given to the humification process, especially the formation of humic substances (humic and fulvic acids), due to their efficiency in improving soil fertility and stimulating plant growth (*Fornes et al.. 2012; Zhao et al. 2016*). During the first phase of the process, the simple organic carbon compounds are easily mineralised and metabolised by the microorganisms, producing CO_2, NH_3, H_2O, organic acids and heat. The optimum temperature range for composting is 40–65°C but temperatures above 55°C are required to kill pathogenic microorganisms. The temperature variation during composting plays an important role in the development of microbial communities. During the various stages of the biodegradation phase, the organic compounds are decomposed into CO_2 and NH_3 with O_2 consumption (*Bernal et al.. 2009*). In Figure 1, it can be seen the temperature curve during the composting process.

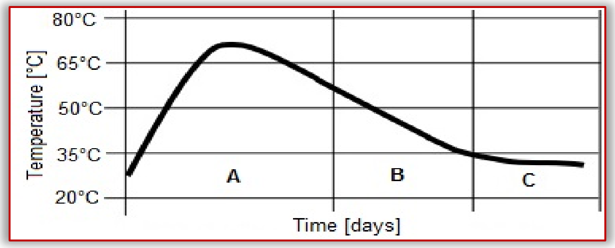

Figure 1 – The temperature curve during the composting process (Bachert et al.. 2008)
A – degradation; B – transformation; C – maturation

The pH level of the raw materials used in composting pile is also very important. The optimum pH range for microbial activity is between 6.5 and 8.0 (*Graves et al.. 2010*). Water is another important parameter for the survival of composting micro-organisms. The moisture content of the compost pile fluctuates during the composting as water is lost in evaporation process. If the substrate subject to composting is too dry, sprinkling with water must also be ensured during the decomposition process (*Paraschiv et al.. 2017*, *Graves et al.. 2010*).

Aeration is another key factor in the composting technology. A correct aeration controls the temperature, eliminates excess humidity and CO_2 and provides the O_2 required for biological processes. Optimal O_2 concentration is between 15 - 20% (*Bernal et al.. 2009*).

Maturation phase of substrate is the most important operation in the composting technique. The process is taking place in several phases and is decisively influenced by the composition, homogeneity and humidity of the organic substrate used and by the amount of air used in the decomposition process. The start-up phase of the maturing phase is the production of raw compost, the purpose of the operation being on the one hand ventilation and on the other hand the mixing of the raw materials at different stages of decomposition. In this phase, fresh compost is in a state of advanced decomposition, being semi mature. The mature compost is obtained after all organic components have been transformed into soil and humus aggregates, appearing in the form of black, loose and fine soil *(http://www.icpa.ro/documente)*.

Properly storing the finished compost product is the final step of the composting process. The finished compost should be stored in a manner that prevents dust or odours from developing and prevents contamination of the product from weeds, leachate or other contaminants (*http://www.compost.org*).

This paper was aimed to present the main composting methods used for organic waste treatment, namely: passive composting in piles, turned windrow composting, passive aerated windrows, aerated static pile and in – vessel composting.

MATERIAL AND METHOD

Composting methods differ in duration of decomposition, the potential for stability and maturity, depending on the type of substrate used (*Mengistu et al.. 2017*). The main five methods of composting developed for use in large-scale are passive composting piles, turned windrow composting, passive aerated windrows, aerated static pile and in-vessel systems.

RESULTS

Passive composting pile is the simplest form of composting and does not require special equipment, being used in principle for composting the leaves. The compost pile should be periodically turned for determining the porosity of the substrate. Aeration is done by passive air movement through the compost pile (Figure 2). This method requires that the pile be small enough to allow the passive air movement, otherwise the anaerobic zones will form (*Graves et al.. 2010*).

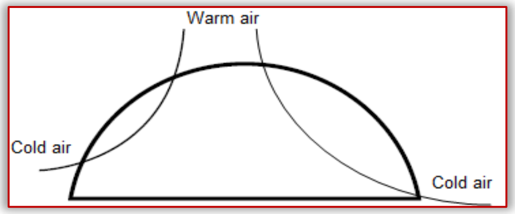

Figure 2 - Passive composting in pile (*Graves et al.. 2010*)

Turned windrow composting involves arranging the substrate in long and narrow furrows. The width of the compost pile is established depending on the size of the machine used to turn the organic material. The time required to finish the active phase of composting process using the windrow method ranges from 3 to 9 weeks (depending on the composted material), after that the maturation phase begins (Figure 3) (*http://esrd. alberta.ca/waste/composting-at-home, http://www.swrcb.ca.gov*).

Figure 3 - Turned windrow composting (*Bachert et al.. 2008*)

Passive aerated windrows does not require turning, the aeration being accomplished by passive air movement through the perforated pipes placed in the porous layer (peat moss, straw or matured compost) at the base of the pile (Figure 4). The porous layer can have a height of 15-20 cm and a width of 3 m. The main feature of this porous layer is to allow a uniform distribution of air in the pipes, but also to insulate the pile, which will ensure the optimum temperature during substrate degradation. The top layer (aprox. 15 cm) consists of peat moss or matured compost, which has the role of retaining moisture and unpleasant odors released during the decomposition process (*Graves et al.. 2010; http://esrd.alberta.ca/waste/composting-at-home)*.

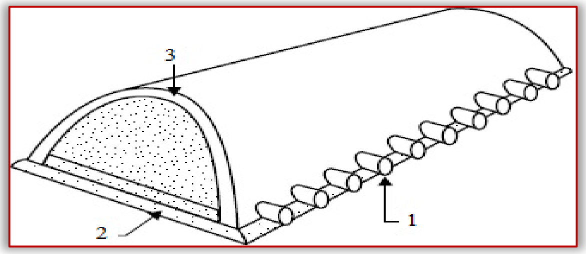

Figure 4 - Passive aerated windrow (*Graves et al.. 2010*)
1 – perforated pipe; 2 – base layer (compost. peat moss or straw base); 3 – coating layer (compost or peat moss)

Aerated static pile is one of the most used methods for composting and can last from 3 to 6 months, depending on the substrate used (Figure 5). The main difference between passive aerated windrow and aerated static pile is that the aerated static pile uses blowers that either suction air from the pile or blow air into the pile using positive pressure (*Stentiford. 1996*).

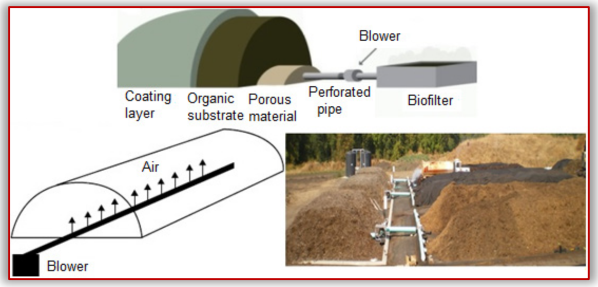

Figure 5 - Aerated static pile (*Graves et al.. 2010; http://compostingtechnology.com*)

At the base of the composting pile there are located perforated pipes for aeration connected to blowers that introduce or suck air from the composted substrate. The pipes are covered with a porous material made of wood chips or straw to allow a uniform air distribution in the pile. The final coating layer (15 cm) of the compost pile is often made of mature compost or sawdust to absorb unpleasant odors and moisture (*Graves et al.. 2010; http://compostingtechnology.com/)*. In this case, the composting pile is not turned. The dimensions of such a compost pile are: height between 1.5 and 2.5 m, the width of 3 – 5 m, while the length of the pile is limited by the air distribution in the pipes, but it should not be more than 21 - 27 m.

In – vessel composting involves the closure of organic waste in a container. Composting process can be done in bins (Figure 6) provided with aeration systems similar to those of aerated static piles or in bins without aeration systems to which it is necessary the regular turning of the substrate in order to maintain the aerobic conditions (*Graves et al.. 2010)*.

Figure 6 – Composting process in bins (*Storino et al.. 2016*)

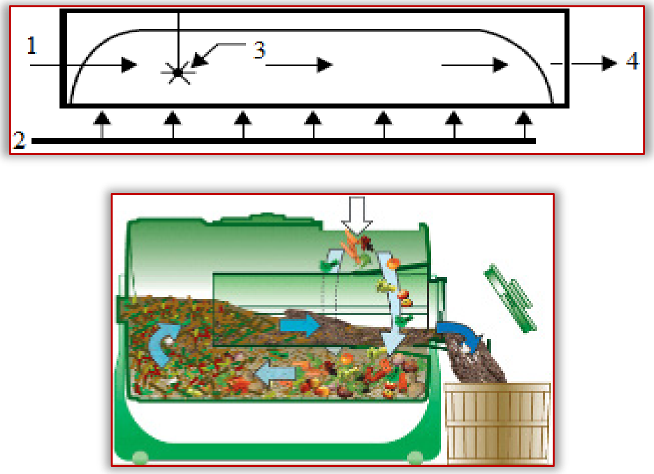

Figure 7 - Rectangular agitated bed (*Graves et al.. 2010*) and rotating drum composting (http://mtlion.com/gardencomposter/technology.html)
1 – organic substrate; 2 – air; 3 – turning device; 4 – compost

Another *in – vessel systems* are represented by rectangular agitated bed and rotating drum composting (Figure 7). The rectangular agitated bed system uses long and narrow beds where the composting taking place and an automated turner for periodic turning. In the case of rotating drum, the composting time is reduced to 2 – 3 weeks. These two systems require less work than windrows because they use an automated turning process or a self-turning mechanism (*Graves et al.. 2010*).

CONCLUSIONS

Composting cannot be considered a new technology, but amongst the waste management methods it is gaining interest as a suitable option for organic waste with economic and environmental benefits. This process reduces the risk of spreading pathogens and weed seeds and the final product, called compost, can be used to improve soil quality and fertility.

Note

This paper is based on the paper presented at ISB-INMA TEH' 2017 International Symposium (Agricultural and Mechanical Engineering), organized by University "POLITEHNICA" of Bucharest – Faculty of Biotechnical Systems Engineering, National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, Scientific Research and Technological Development in Plant Protection Institute (ICDPP), National Institute for Research and Development for Industrial Ecology – INCD ECOIND, Research and Development Institute for Processing and Marketing of the Horticultural Products "HORTING" and Hydraulics, Pneumatics Research Institute INOE 2000 IHP, University of Agronomic Sciences and Veterinary Medicine of Bucharest (UASVMB) – Faculty of Horticulture and Romanian Society of Horticulture (SRH), in Bucharest, ROMANIA, between 26 – 28 October, 2017.

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