A COMPARISON OF VERMICOMPOSTING AND COMPOSTING

What are the similarities and differences in composting systems that can be operated in open or in-vessel systems — with or without worms?

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THE IMPORTANCE of biological processes in the management of animal organic wastes has been widely recognized. Within the broad range of bioprocesses available, this report deals with the two which are the most efficient for converting solid organic residuals into useful products — composting and vermicomposting. The purpose is to compare the advantages and disadvantages of the two processes.

DEFINING THE PROCESSES

Composting is an accelerated biooxidation of organic matter passing through a thermophilic stage (45° to 65°C) where microorganisms (mainly bacteria, fungi and actinomycetes) liberate heat, carbon dioxide and water. The heterogeneous organic material is transformed into a homogeneous and stabilized humus like product through turning or aeration.

Vermicomposting is also a biooxidation and stabilization process of organic material that, in contrast to composting, involves the joint action of earthworms and microorganisms and does not involve a thermophilic stage. The earthworms are the agents of turning, fragmentation and aeration.

Application of composting and vermicomposting has often been unsuccessful due to the mythology that these are "natural processes" and need little management. Successful composting and vermicomposting require adequate processing systems and control criteria. Moreover, research in vermicomposting is not developed to the same level as for composting; it is necessary to know and understand the whole process better in order to make it more efficient.

COMPOSTING METHODS

Open systems of composting can be summarized as follows:

Windrow composting consists of placing the mixture of raw materials in long narrow piles or windrows which are turned mechanically on a regular basis to aerate the piles. Turning alone often does not ensure consistent oxygenation. Within an hour after turning, oxygen levels in a pile often drop drastically, and microbial activity is correspondingly reduced. For this reason, the pile must be turned frequently, leading to technical and economic problems. Moreover, pile size is another important consideration, because piles higher than three meters become difficult to aerate.

In *forced aerated static piles*, a blower provides air to the composting mass. No turning of the materials is needed once the pile is formed. There are basically two ways to oxygenate the piles: Bottom suction draws air through the pile by the imposition of negative pressure. In this kind of ventilation, height is a critical factor. With piles greater than 2.5 to three meters, it becomes almost impossible to get uniform aeration. These piles must be blanketed with an insulating layer (usually cured compost) to ensure a uniform distribution of temperature. Bottom blowing is used where aeration is provided by blowing air through the pile (positive pressure). This method tends to cool and dry the bottom layers of the pile, leaving the outer layers warm and moist. In alternative ventilation systems, bottom blowing aeration is alternated with bottom suction aeration. The alternative air movement leads to a homogenization of temperature and moisture throughout the pile.

A loading device attached to a tractor adds feedstock to a worm bed.

In-vessel composting refers to a group of methods which confine the composting mass within a building, container or vessel. There are a variety of in-vessel methods with different combinations of vessels, aeration devices, and turning mechanisms. Among these, the most widely utilized are continuous vertical reactors, and horizontal reactors.

In *continuous vertical reactors*, the materials usually are loaded through the top of the reactor and discharged from its bottom. Oxygenation is provided by forcing air up from the bottom through the composting mass. These reactors can process large amounts of material (as much as 2,000 cubic meters) and may be as high as nine meters. However, the height is extremely critical and masses higher than three meters lead to a serious problems in ventilation

In *horizontal reactors*, the materials are arranged along the length of the unit and the depth never exceeds two or three meters. The principal advantage of these systems is the possibility to control the process, resulting in a shorter duration of the thermophilic stage than in the open systems. Because oxygen is supplied either by turning or by aeration, the composting mass can be uniformly oxygenated and the temperature can be readily controlled.

VERMICOMPOSTING METHODS

The traditional open systems of vermicomposting have been based on *beds or windrows on the ground* containing materials up to 18 inches deep, but such methods have numerous drawbacks. They require large areas of land for large scale production

TESTING THE IMPACT OF VERMICOMPOSTING

AN EXPERIMENT at the Soil Ecology Laboratory of Ohio State University studied a continuous vermicomposting process for different mixtures of pig manure slurries and agroforestry by-products. The research project analyzed the effects of earthworm populations on the process and also evaluated the vermicomposts produced at different times.

Biosolids and pig manures — when mixed with bulking agents — are probably the most productive residuals for growing earthworms. Covered wooden boxes with drainage holes to avoid leachate accumulation were filled with a layer of digested vermicompost (air dried). On top of this layer, a 0.5 cm wire mesh — which allows earthworm migration — was placed and additional layers of pig manure/bulking agent mixture were added, separated by the same type of wire mesh. Every 2-1/2 to three months, the boxes were sampled, noting numbers and total weight of earthworms and cocoons. A subsample of each layer was taken to determine several physical and chemical parameters of the fresh samples and chemical ones after air dried.

NITROGEN AND HUMIFICATION IN VERMICOMPOSTING

As regards total nitrogen, in all treatments and also at the different times, the net content decreased — being more marked at the final stages when earthworm activity was higher. The different nitrogen fractions followed a similar tendency to the total nitrogen. In all treatments, at the final stages of the process, when the earthworm population was bigger and active, important reductions of the organic nitrogen content and a high nitrification rate were observed. The nitrification was 50 to 65 percent higher in the earthworm treatments than in the controls.

A decrease in the carbon from fulvic acids and an increase in the percentage of the carbon from humic acids were observed through the vermicomposting process; the latter was more marked at the end of the process when there was a higher and active earthworm population. Through vermicomposting the humic substances showed an increase of 40 to 60 percent which was higher than the value obtained for the composting process.

Pig manure before (right) and after the vermicomposting process.

The results obtained with the germination test indicated that the initial mixtures were toxic, probably due to their elevated ammonium content, but this toxicity was gradually removed through the vermicomposting process. Differences regarding the possible effect of the earthworms were not detected since the germination percentages were very similar both at the first stages when the earthworm activity was low and at the end of the process when the earthworm populations were bigger. However, the results obtained for the germination index showed a beneficial effect of earthworms and the highest values of this index were recorded at the final stages of the process. The germination index was 65 to 70 percent higher in the treatments with earthworms than in the control (no earthworms).

HEAVY METALS AND PATHOGEN DESTRUCTION

We studied the evolution of the total and available content of zinc and copper during the vermicomposting process, because these are problematic in the pig manure. Although as a consequence of the carbon losses by mineralization during the process, the total amount of heavy metals increases (between 25-30 percent), the amounts of bioavailable heavy metals tends to decrease. We found a decrease of between 35 percent and 55 percent of the bioavailable metals in two months.

Preliminary data, obtained in small-scale vermicomposting systems, indicate that human pathogens may not survive vermicomposting. After 60 days of vermicomposting, fecal coliform bacteria in biosolids dropped from 39,000 MPN/g to 0 MPN/g. In that same time period, salmonella sp. dropped from <3 MPN/g to <1 MPN/g.

— *Jorge Dominguez*

Batch reactors allow feedstock to be added at the top from modified spreaders or mobile gantries.

and are relatively labor intensive, even when machinery is used for adding materials to the beds. More importantly, such systems process organic wastes relatively slowly. There is increased interest in developing in-vessel vermicomposting systems. Some systems have used *bins* or larger containers, often stacked in racks. Although container methods and other small scale-systems are widely used , they have drawbacks when applied on a larger scale. They require considerable handling and lifting machinery, and also have problems adding water and additional layers of material inputs.

Much more promising techniques have used *batch reactors* — containers raised on legs above the ground. These allow feedstock to be added at the top from modified spreaders or mobile gantries and collected mechanically at the bottom through mesh floors using breaker bars. Such methods — developed and tested at the National Institute for Agricultural Engineering in Silsoe, England, and currently used in several places in the U.S. — range from relatively low technology systems using manual loading and collection, to completely automated and hydraulically driven continuous flow reactors. Such reactors can fully process three feet deep layers of suitable organic wastes in less than 30 days.

ADVANTAGES OF VERMICOMPOSTING

Organic wastes can be broken down and fragmented rapidly by earthworms, resulting in a stable nontoxic material with good structure which has a potentially high economic value as soil conditioner for plant growth. Vermicompost is a finely divided peat like material with excellent structure, porosity, aeration, drainage and moisture-holding capacity. Low, medium and high technology systems are available. The low tech systems can be easily adapted and managed on small farms or livestock operations. Vermicompost supplies a suitable mineral balance, improves nutrient availability and could act as complex-fertilizer granules. As with the composting process, vermicomposting provides a great reduction in waste bulk density, although this tends to take longer.

Preliminary research in our laboratory showed that vermicomposting involves great reduction in populations of pathogenic microorganisms, thus not differing from composting from this point of view. Generally it is accepted that the thermophilic stage during the composting process eliminates the pathogen organisms, but we have shown that pathogens are eliminated during vermicomposting. As an aerobic process, composting leads to a nitrogen mineralization and the use of earthworms in vermicomposting increases and accelerates this nitrogen mineralization rate. The humification processes that take place during the maturation stage of composting are greater and faster during vermicomposting. Vermicomposting may also bring about a greater decrease of bioavailable heavy metals than in the composting process, and there is evidence that the final product may contain hormone like compounds which accelerate plant growth.

The application of composting and vermicomposting processes to waste management have sought generally to obtain products which are commercially valuable. For this reason, many of the other possibilities they offer have been disregarded and left unstudied. We consider it to be of utmost importance to apply one of these two processes in order to stabilize organic wastes, at the same time managing to solve, or at least minimize, the environmental problems arising from their disposal, without needing in many cases to complete the process. Alternatively, if the composition and characteristics of the waste to be treated will allow, the processes may be taken to completion so that the end products are of better structure and utility.

The conventional composting process is suitable for the rapid treatment of large amounts of wastes, in order to eliminate contamination problems more quickly than the traditional vermicomposting systems and is currently widely utilized in this way. However, the newer, and at the moment not fully established, vermicomposting continuous reactor systems seem to be equally applicable to large scale processing. Traditional batch and bed vermicomposting systems may be an alternative way to manage wastes produced on a smaller scale in order to eliminate those problems and at the same time obtain a valuable organic fertilizer. Vermicomposting, either small scale or large scale, may have an important role to play in animal waste management and we think that both vermicomposting and composting are not necessarily mutually exclusive; both systems could be used in sequence to take advantage of unique and valuable features of each. ■

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Preliminary research has shown that pathogens are eliminated during vermicomposting.