TERRASYSTEM®

TERRA-Microorganisms

Aerobic Composting process and techniques

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil.

As a result of these improvements, the soil:

1. becomes more resistant to stresses such as drought, diseases and toxicity;
2. helps the crop in improved uptake of plant nutrients; and
3. possesses an active nutrient cycling capacity because of vigorous microbial activity.

These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

Types of composting

Composting may be divided into two categories by the nature of the decomposition process. In anaerobic composting, decomposition occurs where oxygen (O) is absent or in limited supply. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. In the absence of Oxygen, these compounds accumulate and are not metabolized further. Many of these compounds have strong odours.

Aerobic composting takes place in the presence of ample O. In this process, aerobic microorganisms break down organic matter and produce carbon dioxide (CO_2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi-cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production.

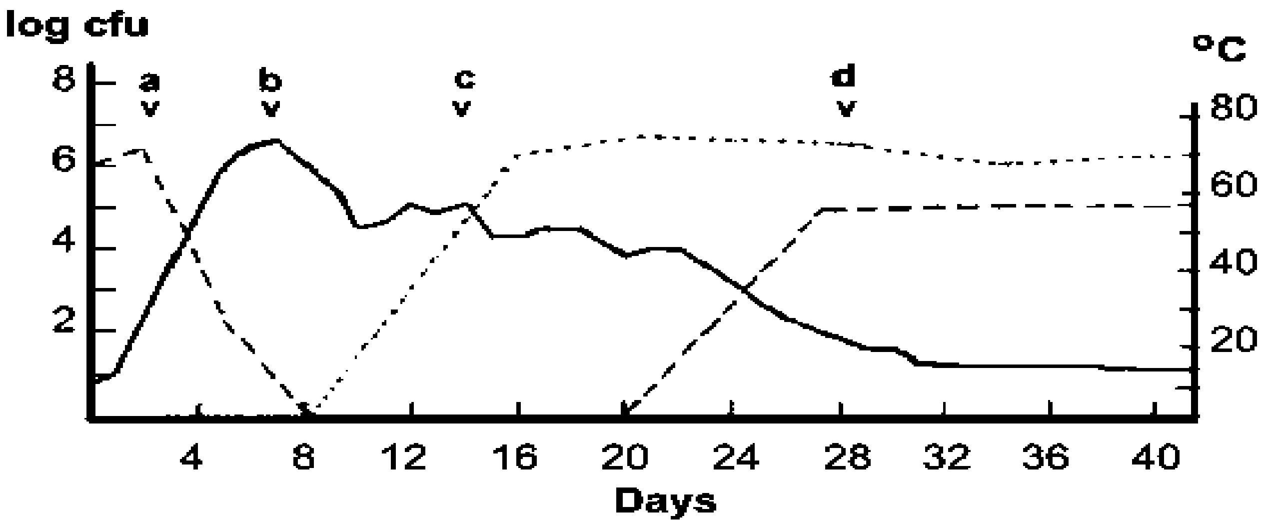
The aerobic composting process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70-80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20-45 °C) multiply rapidly on the readily available sugars and amino acids . They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. Then a few thermophilic fungi and several thermophilic bacteria (optimum growth temperature range = 50-70 °C or more) continue the process, raising the temperature of the material to 65 °C or higher. This peak heating phase is important for the quality of the compost as the heat kills pathogens and weed seeds.

The active composting stage is followed by a curing stage, and the pile temperature decreases gradually. The start of this phase is identified when turning no longer reheats the pile. At this stage, another group of thermophilic fungi starts to grow. These fungi bring about a major phase of decomposition of plant cell-wall materials such as cellulose and hemi-cellulose. Curing of the compost provides a safety net against the risks of using immature compost such as nitrogen (N) hunger, O deficiency, and toxic effects of organic acids on plants.

Eventually, the temperature declines to ambient temperature. By the time composting is completed, the pile becomes more uniform and less active biologically although mesophilic organisms recolonize the compost. The material becomes dark brown to black in colour. The particles reduce in size and become consistent and soil-like in texture. In the process, the amount of humus increases, the ratio of carbon to nitrogen (C:N) decreases, pH neutralizes, and the exchange capacity of the material increases.

Temperature changes and fungi populations in wheat straw compost



Note:
Solid line = temperature; broken line = mesophilic fungi population; dotted line = thermophilic fungi population; left y-axis = fungal populations (logarithm of colony forming units (cfu) per gram of compost plated onto agar); right y-axis = temperature in centre of compost. a, b, c and d = heating phases.

Factors affecting aerobic composting

Aeration

Aerobic composting requires large amounts of Oxygen, particularly at the initial stage. Aeration is the source of Oxygen, and, thus, indispensable for aerobic composting. Where the supply of Oxygen is not sufficient, the growth of aerobic micro-organisms is limited, resulting in slower decomposition. Moreover, aeration removes excessive heat, water vapour and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. It may be achieved by controlling the physical quality of the materials (particle size and moisture content), pile size and ventilation and by ensuring adequate frequency of turning.

Moisture

Moisture is necessary to support the metabolic activity of the micro-organisms. Composting materials should maintain a moisture content of 40-65 percent. Where the pile is too dry, composting occurs more slowly, while a moisture content in excess of 65 percent develops anaerobic conditions. In practice, it is advisable to start the pile with a moisture content of 50-60 percent, finishing at about 30 percent.

Nutrients

Micro-organisms require C, N, phosphorus (P) and potassium (K) as the primary nutrients. Of particular importance is the C:N ratio of raw materials. The optimal C:N ratio of raw materials is between 25:1 and 30:1 although ratios between 20:1 and 40:1 are also acceptable. Where the ratio is higher than 40:1, the growth of micro-organisms is limited, resulting in a longer composting time. A C:N ratio of less than 20:1 leads to underutilization of N and the excess may be lost to the atmosphere as ammonia or nitrous oxide, and odour can be a problem. The C:N ratio of the final product should be between about 10:1 and 15:1.

Temperature

The process of composting involves two temperature ranges: mesophilic and thermophilic. While the ideal temperature for the initial composting stage is 20-45 °C, at subsequent stages with the thermophilic organisms taking over, a temperature range of 50-70 °C may be ideal. High temperatures characterize the aerobic composting process and serve as signs of vigorous microbial activities. Pathogens are normally destroyed at 55 °C and above, while the critical point for elimination of weed seeds is 62 °C. Turnings and aeration can be used to regulate temperature.

Lignin content

Lignin is one of the main constituents of plant cell walls, and its complex chemical structure makes it highly resistant to microbial degradation. This nature of lignin has two implications. One is that lignin reduces the bioavailability of the other cell-wall constituents. The other is that lignin serves as a porosity enhancer, which creates favourable conditions for aerobic composting.

pH value

Although the natural buffering effect of the composting process lends itself to accepting material with a wide range of pH, the pH level should not exceed eight. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere.

Techniques for effective aerobic composting

Simple replication of composting practices does not always give the right answer to potential composters. This is because composting takes place at various locations and under diverse climates, using different materials with dissimilar physical, chemical and biological properties. An understanding of the principles and technical options and their appropriate application may be helpful in providing the optimal environment to the compost pile.

Improved aeration

In order to obtain the end product of uniform quality, the whole of the pile should receive a sufficient amount of Oxygen so that aerobic micro-organisms flourish uniformly.

Pile size and porosity of the material

The size of the pile is of great significance and finds mention in the sections on passive composting of manure piles and turned wind-rows. Where the pile or wind-row is too large, anaerobic zones occur near its centre, which slows the process in these zones. On the other hand, piles or wind-rows that are too small lose heat quickly and may not achieve a temperature high enough to evaporate moisture and kill pathogens and weed seeds. The optimal size of the piles and wind-rows should also consider such parameters as the physical property (porosity) of the materials and the way of forming the pile. While more porous materials allow bigger piles, heavy weights should not be put on top and materials should be kept as loose as possible. Climate is also a factor. With a view to minimizing heat loss, larger piles are suitable for cold weather. However, in a warmer climate, the same piles may overheat and in some extreme cases (75 °C and above) catch fire.

Ventilation

Provision of ventilation complements efforts to optimize pile size. Ventilation methods are varied. The simplest method is to punch holes in the pile at several points.
Aeration is improved by supplying more air to the base of the pile where Oxygen deficiency occurs most often.

Turning

Once the pile is formed and decomposition starts, the only technique for improving aeration is turning. In some cases, turning not only distributes air throughout the pile, it also prevents overheating as it kills all the microbes in the pile and terminates decomposition. However, turning too frequently might result in a lower temperature.

Inoculation

While some composters find improved aeration enough for enhanced microbial activities, others may need inoculation of TERRA-Micro-organisms (T-MO).
Inoculum organisms utilized for composting are mainly fungi such as *Trichoderma* sp.

Shredding

Downsizing, or chopping up the materials, is a sound and widely-practised technique. It increases the surface area available for microbial action and provides better aeration. This technique is particularly effective and necessary for harder materials such as wood.