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 is 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 is 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.

FACTORS AFFECTING AEROBIC COMPOSTING

Aeration: Aerobic composting requires large amounts of O, particularly at the initial stage. Aeration is the source of O, and, thus, indispensable for aerobic composting. Where the supply of O 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, making the actual C:N ratio (viz. ratio of biodegradable C to N) lower than the one normally cited. The other is that lignin serves as a porosity enhancer, which creates favourable conditions for aerobic composting. Therefore, while the addition of lignin-decomposing fungi may in some cases increase available C, accelerate composting and reduce N loss, in other cases it may result in a higher actual C:N ratio and poor porosity, both of which prolong composting time.

Polyphenols: Polyphenols include hydrolysable and condensed tannins. Insoluble condensed tannins bind the cell walls and proteins and make them physically or chemically less accessible to decomposers. Soluble condensed and hydrolysable tannins react with proteins and reduce their microbial degradation and thus N release. Polyphenols and lignin are attracting more attention as inhibiting factors. Palm et al. suggest that the contents of these two substances be used to classify organic materials for more efficient on-farm natural resource utilization, including 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 O so that aerobic micro-organisms flourish uniformly. The methodologies deliberated in this publication made use of the techniques as presented below.

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. The high temperature compost method of Chinese rural composting involves inserting a number of bamboo poles deep into the pile and withdrawing them a day later, leaving the pile with ventilation holes. Aeration is improved by supplying more air to the base of the pile where O deficiency occurs most often. In addition to the above-mentioned vertical poles, Ecuador on-farm composting uses a lattice of old branches at the base to allow more pile surface to come into contact with the air, and the composting period is reduced to two to three months in warm seasons. This technique is also practised in the rapid composting method developed by the Institute of Biological Sciences (IBS) in the Philippines, where the platform should be 30 cm above the ground. The passively aerated wind-rows method uses a more sophisticated technique. It entails embedding perforated pipes throughout the pile. As the pipe ends are open, air flow is induced and O is supplied to the pile continuously. The aerated static pile method takes this aeration system a step further; a blower generates air flow to create negative pressure (suction) in the pile and fresh air is supplied from outside.

Turning

Once the pile is formed and decomposition starts, the only technique for improving aeration is turning. Frequency of turning is crucial for composting time. While the Indian Bangalore method requires six to eight months to mature, the Indian Coimbatore method (turning once) reduces the time to four months, and the Chinese rural composting pit method (turning three times) reduces the time to three months. An extreme example is the Berkley rapid composting method, which employs daily turning to complete the process in two weeks. 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 micro-organisms. Inoculum organisms utilized for composting are mainly fungi such as *Trichoderma* (IBS rapid composting and composting weeds and *Pleurotus* sp. (composting Coir Pith and composting weeds). This publication also features ‘effective micro-organisms’ (EMs) (EM-based quick compost production process). The inoculums are an affordable choice for those with access to the market and also for resource-poor farmers. The production cost could be reduced by using inoculums taken from compost pits (pit method of the Indian Indore method), by purchasing the commercial product and multiplying it on the farm (EM-based quick compost production process), and by utilizing native inoculums derived from soils or plant leaves.

Supplemental nutrition

The techniques mentioned above often need to be complemented by the provision of nutrients. One of the most common practices is to add inorganic fertilizers, particularly N, in order to modify a high C:N ratio. Similarly, P is sometimes applied as the C:P ratio of the material mix is also considered important (the ratio should be between 75:1 and 150:1). When micro-organisms are inoculated, they require sugar and amino acids in order to boost their initial activities; molasses is often added for this purpose.

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.

Other measures

An example of other measures mentioned in this publication is the practice of adding lime. Lime is thought to weaken the lignin structure of the plant materials and enhance the microbial population. However, in some cases, liming is not recommended as the pile may become too alkaline, resulting in significant N loss.