COMPOSTING PRINCIPLES

Composting is a managed process which utilizes microorganisms naturally present in organic matter and soil to decompose organic material. These microorganisms require basic nutrients, oxygen and water in order for decomposition to occur at an accelerated pace. The end-product, compost, is a dark brown, humus-like material which can be easily and safely handled, stored and applied to land as a valuable soil conditioner. The composting process is dependent upon several factors, including: the population of microorganisms, carbon-nitrogen ratio, oxygen level, temperature, moisture, surface area and pH. These factors, which are described below, are dependent upon one another and understanding them is important for managing a successful composting operation.

Microorganisms

Decomposition of the organic material is achieved by billions of microscopic organisms naturally present in leaf and yard waste, including bacteria, actinomycetes, and fungi. These microorganisms multiply rapidly in the organic material, using it as a source of food, and produce heat, carbon dioxide, water vapor, and compost in the process.

Nutrients: Carbon to Nitrogen Ratio

The availability and proportion of nutrients, in particular carbon and nitrogen, can be a limiting factor in the composting process. The microorganisms require carbon for their energy and nitrogen for protein synthesis in order to grow and multiply. The rate of decomposition is dependent on the balance of carbon to nitrogen in the composting material. For rapid decomposition, the ideal carbon to nitrogen ratio is 30 to 1 (30:1). That ratio represents 30 parts carbon to 1 part nitrogen by weight.

If the carbon to nitrogen (C:N) ratio deviates from this ideal ratio, then the rate of decomposition will be slower, resulting in a longer composting time. With a ratio of greater than 30:1, nitrogen becomes a limiting factor, and the rate of decomposition slows. With a C:N ratio lower than 25 :1, the excess nitrogen will initially allow.for more rapid decomposition, creating anaerobic (lack of oxygen) conditions. This will slow down the decomposition and can cause serious odor problems . Some of the excess nitrogen may be given off as ammonia gas or nitrate . The resulting loss of nitrogen will lower the nutrient value of the compost product.

The carbon to nitrogen ratio in leaves tends to range between 40:1 and 80:1. For example, the C:N ratio of maple leaves is close to 40:1 while that of oak leaves is about 60:1. Depending on the composting method, leaves alone can take from 6 months to 3 years to compost. Organic materials can be mixed to achieve a more optimum carbon to nitrogen ratio for efficient composting. When grass (C:N ratio of 19:1) or other nitrogen-rich materials are mixed with leaves, the carbon-nitrogen ratio can be lowered to around 30:1, accelerating the composting process to 6 months or less.

Oxygen

Composting is an aerobic process which means that an adequate supply of oxygen is essential for the composting process. The microorganisms primarily responsible for the rapid decomposition of organic material require oxygen to convert organic waste to compost. If the oxygen content falls below 5%, these aerobic (oxygen needing) organisms begin to die off and are replaced by anaerobic organisms (which do not require oxygen). Anaerobic organisms operate less efficiently, resulting in a slower decomposition rate. In addition, under anaerobic conditions the organisms produce methane, ammonia and hydrogen sulfide, resulting in strong, unpleasant odors. If sufficient levels of oxygen (at least 5%) are maintained during the composting process, odors can be kept to a minimum. Adequate oxygen levels or aerobic conditions are maintained through the aeration of the composting material.

Moisture

The microbiological activity occurs in a film of moisture on the surface of the organic material. In leaf and yard waste composting, the optimal moisture content is 40% to 60%, by weight. Moisture is required to dissolve the nutrients utilized by microorganisms and to provide a suitable environment for bacterial population growth. A moisture content below 40% limits the availability of nutrients and inhibits bacterial population expansion. When the moisture content exceeds 60%, the flow of oxygen is restricted and anaerobic conditions begin to develop.

Temperature

Microorganisms generate heat when they decompose organic material. Much of this heat is maintained in the composting material as a result of the insulating effect of the compost pile or windrow. This results in a temperature increase, which affects the composition of the microbial population. The optimum temperature range for efficient composting is between 100 to 140 degrees F. In addition, in order for pathogens and weed seeds to be destroyed, temperatures in the composting material need to be maintained at 131 degrees F for at least 3 consecutive days.

Temperature is the best indicator of the rate of decomposition occurring in a composting pile. Two categories of microorganisms are active in aerobic composting. At temperatures above freezing, mesophilic organisms become active. As a result of their activity, the temperature within the compost pile increases. At temperatures in excess of 110 degrees F, the population of thermophilic organisms exceeds that of mesophilic organisms, increasing the rate of decomposition. As the temperature exceeds 140 degrees F, the rate of decomposition begins to decline rapidly as both mesophilic and thermophilic organisms begin to die off or assume dormant forms. When temperatures move out of the optimum range of 100 to 140 degrees F, it is usually because the level of oxygen has dropped too low (below 5%) or moisture level is no longer optimal (either too dry or too wet). Monitoring the temperatures in a composting pile provide a good guide as to when remedial measures may be needed to maintain or return to an efficient composting process. Monitoring methods will be discussed in the operation guidance section of this document.

Surface Area

The activity of the microorganisms during decomposition occurs on the surface area of organic material. With smaller particles, there is greater surface area per unit volume of material on which biological activity can occur. Also, nutrients are more readily available for the microorganisms when the material is physically broken down. Reducing the particle size results in more biological activity per unit of volume and a corresponding increase in the overall rate of decomposition.

Shredding organic material increases the surface area available for biological activity and therefore speeds up the rate of decomposition. As the decomposition rate increases, so does the oxygen demand and the need for aeration. The smaller particle size also results in greater compaction of the composting material which can restrict the flow of oxygen and result in anaerobic conditions if sufficient aeration does not occur.

pH

During the composting process, the material will become slightly acidic and then return to near neutral conditions as stability is approached. Decomposition is most efficient between a pH of 6.0 and 8.0. If the pH is too high, nitrogen is driven off as ammonia. If the pH drops below 6.0, the microorganisms begin to die off and the decomposition process slows. For leaf and yard waste composting the pH level does not generally need to be monitored, since it rarely presents an operational problem.