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FUNDAMENTAL PRINCIPLES OF COMPOSTING

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Introduction

The composting process is basically aerobic respiration of microorganisms using organic carbon compounds as a source of energy. The process generates heat and brings about chemical, physical and microbiological changes in the organic materials. Compost is the solid residue resulting from the composting process of humification. It is primarily decomposed organic matter with possibly some inert contaminants.

Accordingly, composting could be described as the aerobic biodegradation of solid organic materials in a process that reduces their weight and volume by generating heat, carbondioxide, water, minerals, other gases, volatile compounds and stable organic matter (compost). Finally the organic materials are converted into humic like substances.

COMPOSTING – THE PROCESS

The composting process proceeds in stages.

(a) Initially, the readily available carbon and nitrogen (mainly soluble organic matter) and energy sources are rapidly consumed by microorganisms. This results in the rapid growth of microbial biomass accompanied by the release of energy in the form of heat, consumption of oxygen and generating carbon dioxide, ammonia, amides and other volatiles.

(b) The process then continues at a steady pace. The less easily consumed cell wall carbohydrates, cellulose and hemicellulose are broken down and metabolized in this stage.

(c) Thereafter, the process slows down and begins to cool as the readily available energy sources are exhausted and microorganisms are left with highly resistant structures like ligno-cellulose compounds and polyphenol derivatives.

(d) The system now becomes aerobically more stable and the re-condensation process dominates producing humic like substances and intermediate by-products and enters the mature stage.

(e) Chemical and microbiological processes continue to manufacture stable heterocyclic humic like substances. At this stage the compost is mature (stable) and less phytotoxic. These stable compounds are highly resistant to further microbial and other biological action.

BASIC PRINCIPLES AND KEY FACTORS

There are many different methods of composting. However, the underlying fundamental principles are common to all. Therefore irrespective of the methodology employed a clear understanding of these principles will help to produce high quality compost.

A wide range of microorganisms is involved in the break down of organic materials into compost. Clearly, the key to achieving peak effectiveness and efficiency in composting is to provide optimum conditions for these microorganisms to thrive. The most important factors in this regard are a favourable Carbon:Nitrogen ratio (C:N ratio), sufficient moisture, and an adequate supply of oxygen in the organic substrate.

C:N ratio:

All organic materials contain C and varying amounts of N. Microbes require N in order to break down materials that are high in C. An acceptable balance of these two elements in the mixture is important.

If the materials for composting contain high C and low N (high C:N ratio) the process will proceed slowly as the microbes lack N to break down the high C material. On the other hand, if the material is high in N and low in C (low C:N ratio), then microbial action will release the excess N to the atmosphere as ammonia, and a valuable resource will be lost. To ensure that the process proceeds at an optimum rate without undue losses of N, the ideal C:N ratio in a composting mixture is 30.

Moisture level:

Most microorganisms are very sensitive to moisture. In actively composting mixtures, moisture content falls to about 30-40%. At low moisture levels the decomposition rates slow down significantly, and the metabolic activities of microorganisms will cease when it goes below 30%. It should be noted that dry compost cannot be considered as mature, because it will not undergo re-heating. If the phenomenon of re-heating is used to establish maturity, the material must be at a moisture level favourable for microbial activity. On the other hand, too much moisture could quickly lead to anaerobic conditions as water displaces the air in the composting mixture inactivating the aerobic microorganisms and activating the anaerobic microorganisms. The decomposition processes of anaerobic microorganisms have a different pathway and result in producing an offensive odour. The desirable upper limit of moisture content depends on the size and structure of the particles of the composting material. In most compost mixtures, 55-60% is the recommended upper limit for the starting moisture content. Compost recipes usually specify starting with a high moisture content. The medium tends to dry out as composting proceeds and the water evaporates due to heat generated by the microbial activity.

Oxygen level:

Aerobic decomposition takes place when aerobic microorganisms have enough oxygen to meet their requirements. Insufficient oxygen favours anaerobic microorganisms, which results in a less efficient process and undesirable odours. It is evident that oxygen and moisture levels are linked. It is important to ensure an adequate supply of oxygen to the composting materials. In methods where piles or windrows will not be turned during composting, they should be constructed to maximize the airflow through the material using either an active or passive form of aeration. The physical turning of composting materials will resettle the mass and allow air to flow into the piles more easily.

OTHER IMPORTANT FACTORS

Temperature:

In tracking the composting process, many operators choose to monitor the temperature instead of oxygen. The rise in temperature in the composting mass is due to the heat produced by microorganisms as they break down the organic materials. Hence, temperature is a useful indicator for monitoring the process.

If the temperature fails to rise, it is an indication that the process has not commenced or is proceeding very slowly. There are many possible reasons for this. The mixture may be too dry or too wet; or its C:N ratio is too high and it does not have sufficient N; or the ambient temperature is too low. On the other hand a very high temperature (above 65 ^{0}C) indicates that the process is too active and the microbes can quickly run out of both oxygen and moisture bringing the process to a standstill. At high temperatures, microbes are killed or become inactive.

If the temperature exceeds 65 ^{0}C, composting will be less effective and the risk of fire increases.

It is important to note that the temperature can be used to control pathogens. Maintaining the temperature at 60-65 ^{0}C for three days or at 55 ^{0}C for a week will eliminate pathogens like E-coli and Salmonella.

Particle size:

The particle size of composting materials is important. When the pile contains large particles such as branches of trees, large chunks of manure or other solid materials, there will be a good airflow through it. However, the pile could dry out quickly, and since only the outer surface of large pieces are exposed to microbial activity decomposition will be slow. Particles which are too small will increase water retention but could create anaerobic conditions by restricting the infiltration of air into the pile. Generally, particles ranging in size from 1.5-5 cm will provide the best balance between moisture retention and oxygen diffusion.

pH:

The pH of the mixture could determine the quality of the compost. The best pH range is 6.5-8.0. If the pH is greater than 8.5, there is a possibility of releasing ammonia and this will lower the quality of the final product.

ODOUR MANAGEMENT IN COMPOSTING

The natural break down of organic materials under optimum conditions generates CO_2, water and heat. Unbalanced conditions may lead to the production of other gases with unpleasant odours. As noted earlier when the oxygen levels are low anaerobic processes take over and often release strong smelling gases. Mixtures with low C:N ratios will release ammonia as a part of the degradation process. Odour management is an important aspect of composting. Adherence to the following steps will help to minimize the production of unpleasant odours

TRI has developed an effective method to control odour in compost. In this method activated C made from cheap materials such as saw dust or paddy husk is incorporated into the composting material to absorb unpleasant odour. To make activated C first burn the sawdust or paddy husk under controlled conditions to produce coal (but not ash). Then spray water on the coal to develop porosity and yield activated C.

1. First check the C/N ratio when preparing the composting piles or windrows. The ratio should be 25-40, and ideally 30.
2. Check moisture content of the compost material. It should be about 40-60%.
3. Regulate the pH of the composting mixture. A pH above 8.5 will release ammonia.
4. Consider porosity in building the composting heap. It is necessary to maintain the porosity of the heap so that air can flow through the medium as it breaks down.
5. The material should be turned or aerated often in order to maintain aerobic conditions.
6. Ensure the pile is not too large. Air will not be able to infiltrate into the center of a large mass. Consequently, the temperature will be very high at the center.
7. Check local weather conditions when turning or moving compost.

STABILITY OF COMPOST

The stability of compost is usually defined as a stage in the composting process or in terms of its rate of biological activity. As the stability of a compost increases its biological activity decreases.

The rate of aerobic respiration is the best parameter to assess aerobic biological activity or stability in compost. Under aerobic conditions, one carbon atom derived from catabolism is attached to two oxygen atoms to form a carbon dioxide molecule releasing energy and heat in the process. Therefore respiration can be measured using respirometric techniques such as self-heating, oxygen uptake or carbon dioxide evolution.

Self-heating is a convenient and practical method for routine purposes but it is an indirect method of measuring respiration. It measures the temperature rise due to all exothermic biological and chemical activities. Therefore strictly, temperature is not a true measure of respiration as many biological and chemical reactions that are not connected to respiration are exothermic.

Oxygen is consumed in biological and non-biological oxidation of matter and minerals. Hence oxygen uptake measures the biological and chemical oxygen demand and again it is not an accurate measure of respiration.

Carbon dioxide evolution is the most direct accurate measure of respiration and aerobic biological activity (stability). Alkali traps are widely used as the standard technique for measuring carbon dioxide evolution.

MATURITY OF COMPOST

Maturity is a characteristic of the end product that indicates its readiness for the intended use. It must be clearly understood that this does not make the product is fit for all possible uses. Compost maturity is chosen as one of the parameters in determining the grade of compost.

The maturity of compost is an organo-chemical condition, which indicates the presence or lack of organic phytotoxic chemicals in a generally stable to very stable compost. Also, it indicates the degree, to which a biomass sample is free of organic phytotoxic substances that can cause delayed seed germination or inhibit plant growth.

Many methods to assess the stability or maturity of compost, by using plants, are reported in literature. Generally, most authors do not differentiate between stability and maturity. Many researchers have used phytotoxicity to determine the maturity of compost. It is important to differentiate between persistent phytotoxicity and temporary effects of compost instability or immaturity. Instability or immaturity may produce phytotoxic effects. However, persistent phytotoxicity in stable or mature compost is due to substances that are not removed in the composting process (e.g. heavy metals, persistent herbicides and some intermediate organic molecules formed in the process of humification).

There are four types of plant tests to determine maturity viz. germination tests, growth tests, combination of germination and growth tests and other biological methods (e.g. enzyme based methods).

BENEFITS OF COMPOST APPLICATION

Applying compost to the soil results in numerous benefits to the plants as well as the soil. They are:

Transportation functions: Humic like substances and other organic matter in compost have the ability to bind macro and microelements and transport them to the plants. Unlike mineral fertilizers, compost acts as a slow releaser of nutrients.

Increased water-holding capacity: Compost helps to increase the water holding capacity in the root zone. Mulching with compost conserves soil moisture reduces evaporation of water and the drying of soils.

Improved soil structure: Application of compost promotes aggregation of soil particles by organic substances. This helps to reduce erosion.

Biological activity: Compost activates a vast range of microorganisms that enhance both soil and crop productivity and may even suppress some plant diseases..

Insulator: Compost acts as an insulator and prevents drastic changes in temperature. Dark colour helps the soil to warm quickly in cold weather.

Buffering action: Some functional groups that occur in compost act as a buffer and helps to maintain soil pH at desirable levels.

Supply trace elements: Compost binds with trace elements and provides a useful source for plants.

These are the main benefits/functions of using compost. It must be noted however that a proper balance of mineral and organic fertilizers; is essential for an economically viable cultivation. If a proper equilibrium is maintained between these two factors, healthy plants and better yields could be achieved.