CHAPTER 7

Organic Composts

ORGANIC COMPOSTS

Compost is a mixture of decaying organic matter, as from leaves and manure, used to improve soil structure and provide nutrients. It is a composition; a mixture to fertilize with a mixture of decaying organic matter or to convert (vegetable matter) to compost. Compost is the dark brown crumbly material that is produced when a collection of plant and animal material is decomposed into fine organic matter and humus. It is prepared from urine, dried blood, pig manure, poultry manure, comfrey, lawn trimmings, kitchen compost, farmyard manure, seaweed, garden compost, coffee grounds, horse manure, weeds, bracken, straw, woody prunings, bark, newspaper, cardboard, sawdust, etc.

Once the compost has been mixed into the soil it will undergo the process of mineralization in which the humus releases minerals into the soil, making them available to the plants.

The production of compost is the heart of the organic method. Dying and decaying matter, whether the falling leaves of the forest or the decaying bodies of more complex life forms, is constantly being used as the raw material of new life. In nature, the forest floor is the *workshop* for a continuous compost production operation. In agriculture fields, this normal cycle is interrupted by taking out some of the organic material produced. In setting up a compost-making operation, we are restoring the cycle and returning to the soil the humus, which is the single most important element in its fertility. The process of compost or *life renewal* is achieved by a remarkably complex interaction of billions of microscopic life forms with biological materials.

COMPOSTING

Composting is a biological decomposition process that converts organic matter to a stable, humus-like product under controlled conditions. During the composting process, microorganisms utilize the decomposable microbial substrates present in the organic compost both as an energy source and for conversion to microbial substances.

The composting process of simply a means of converting raw organic compost, a potential source of odor and public health problems, into a safe product called humus. By definition, composting is an alternative system for solving some of the compost handling problems existing on today's farms.

It is a natural process, which occurs in nature in which organic matter is decomposed by microorganisms forming a humus-like substance. The process itself is not new. It has been in practice for many centuries by farmers who have stacked animal manure into piles or gardeners who have placed garbage, leaves, grass cuttings, etc., into pits.

Despite its wide usage, no advances were made in the treatment process until 1925 when Sir Albert Howard, a British agronomist stationed in India, developed a systemized process for composting. The improved process was labeled the Indore Method after the stage in central India where it was conceived and tested. The method described by Howard (1935) involves the formation of a layered pile about 1.5 m high using garbage, animal composts, sewage sludge, straw, and leaves. Initially the process was anaerobic and required 6 months for completion to occur. The process was later modified by turning the pile over twice, which reduced the composting time to 3 months.

IMPORTANCE OF COMPOSTING

A great deal of organic compost from the kitchen and farm can be recycled and given back to the soil in the form of compost. When compost is added to the soil the level of organic matter increased, which is beneficial in many ways: (1) The finished product obtained from composting may have some fertilizer value but it should be strongly emphasized that compose is an excellent soil conditioning agent. (2) Incorporating compost into the soil increases the organic content and improves the texture, the permeability, and the water-holding capacity of that soil. (3) An improvement in humus content, hygroscopic moisture, water retention capacity, and absorption capacity when organic matter is added to the soil. (4) Compost can be used for improving the fertility of marginal and arable land and also for restoration of land that has been severely eroded or strip mined. (5) Compost can also be used as a mulch for nurserymen and vegetable farmers. Compost used as a mulch has advantages over peat moss of bark in that the compost releases absorbed water more readily than does peat moss, and imposes a lesser demand on soil nitrogen than does bark. (6) Compost is an excellent material for litter or bedding. It is moisture absorbent, odorless, and eliminates the need to purchase bedding from an outside source.

weeks before pasture is grazed. ... be applied at least four

Classification of Composting

It is classified into following general categories:

Oxygen Availability: Composting, categorized by the amount of oxygen available, is either **aerobic** or **anaerobic** in nature.

Aerobic composting: The composting of municipal refuse and large-scale agricultural composts should be carried out under aerobic (with oxygen) conditions. Aerobic composting is governed by the activity of aerobic microbes and hence required the availability of atmospheric oxygen during the period of decomposition. If the environmental factors are optimal, aerobic composting is characterized by high temperature, the absence of foul odors, and a short stabilization period. The high temperatures have a sterilizing effect by destroying weed seeds and pathogenic organisms.

The Aerobic Heap: A heap should contain enough bulk of food for the heat-loving bacteria for their growth and activity. If the pile is too small, there will be insufficient heat build-up. To obtain a suitable C : N mix on a garden scale, the materials may first need to be assembled over a period of time. This can best be achieved by creating a preliminary stockpile. Garden debris, mowings, weeds and so forth can be loosely stacked and covered in one pile or placed in plastic bags; likewise kitchen compost.

Anaerobic composting: It is governed by anaerobic bacteria that operate in the absence of atmospheric oxygen. The process is characterized by lower temperatures, the production of odorous gases, and longer stabilization times. Since anaerobic composting does not require atmospheric oxygen, the pile or bed can be sealed to prevent the escape of foul smelling gases and left alone. The major advantage of anaerobic composting is that the process can be carried on with a minimum of attention and as such requires little or no energy once the compost bed is established.

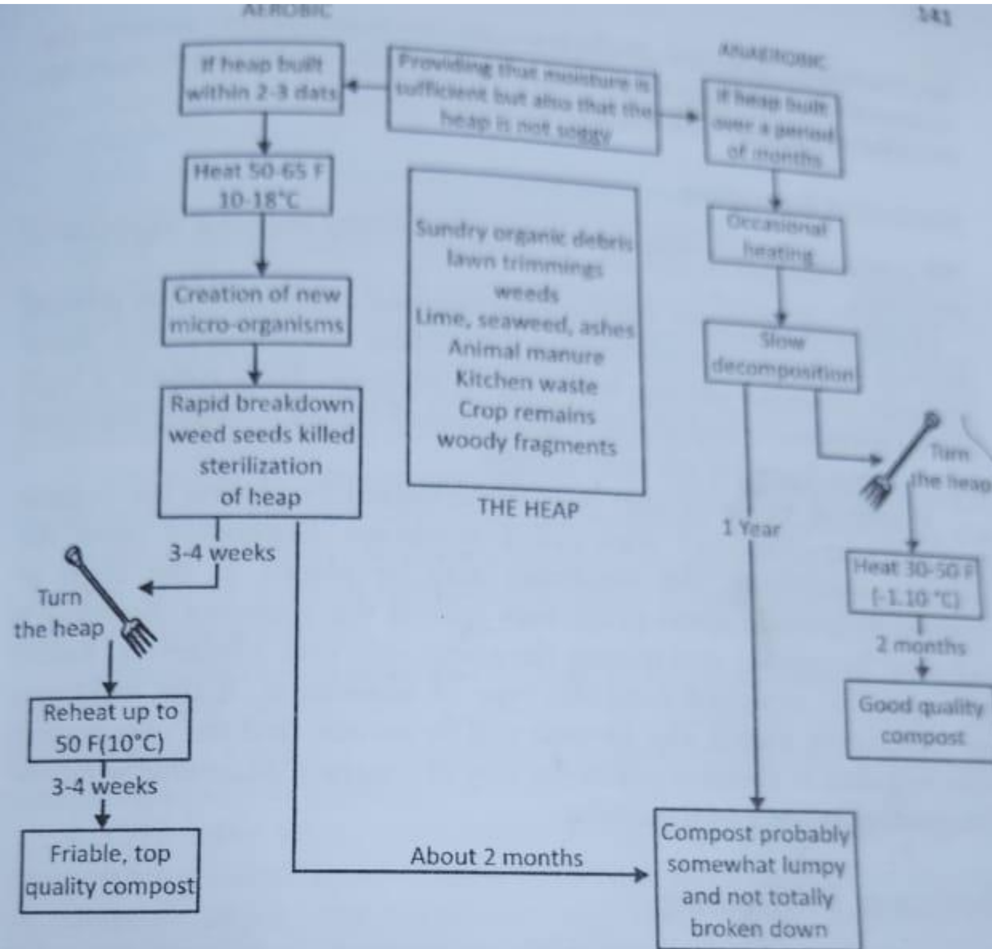

FIG. 7.2: The compost factory.

Temperature: The composting process can also be categorized by the operating temperature that exists within the pile. Temperature between ambient and 40°C support mesophilic organisms while temperatures between 40°C and 60°C support thermophilic organisms. The mesophilic bacteria are more efficient than thermophilic bacteria and, therefore, decomposition occurs more rapidly in the mesophilic region. Those favoring thermophilic composting claim that decomposition proceeds more rapidly at the higher temperatures and in addition pathogens and weed seeds are destroyed.

The temperature in both aerobic and anaerobic composting gradually rises to well within the thermophilic range due to the excess heat energy generated by microbial activity. For this purpose it is essential to understand the effects of temperature and its relationship to microbial activity. Sufficient air is required to sustain the temperature build-up. Compost, which may be ready in two summer months may require six months in winter.

Method of Operation

The composting processes are operated as either enclosed digesters or windrows.

Enclosed digester: They are mechanized composters that provide aeration by some type of continued tumbling or stirring action. Some methods combine stirring with forced aeration. Such require a high capital investment and utilize a great deal of energy. Composting times for enclosed digesters are 10 to 15 days.

Windrow composting: It is characterized by placing the organic composts in elongated piles called windrows. Depending upon the climatic conditions, the windrows may be placed in the open or covered to provide some protection against the elements. Aeration is provided by stirring and mixing the composter with a front-end loader or a specially designed rototiller type of implement. If the windrows are adequately mixed, the process will be aerobic and the composting time required is about 6 weeks. By way of contrast, anaerobic windrow composting takes 4 to 6 months.

Kinetics of Composting

The aerobic composting of all the municipal refuse plants are operated on aerobic process.

Biochemistry: The biochemistry or the rate at which organic matter decomposes is affected by the carbon-nitrogen relationship of the organic matter, moisture content, temperature, availability of oxygen, and the pH. The effects of these environmental factors on the decomposition of organic matter will help one to better understand the composting process.

The biochemical reactions during composting are ate also influenced by the moisture content of the organic matter. The optimum moisture content should be 100%, but this is impractical because the composting systems are based on the principle of dry handling. The maximum moisture content, therefore, is predicated on the ability of the composted material to be stacked. The optimum moisture content for greatest decomposition should be maintained between 50 and 60% (wet weight). Moisture content above 60% causes compaction of the material and also fills the voids with water, thus reducing the amount of air present. This may cause anaerobic conditions to occur, giving off foul odors and slowing down the decomposition process.

If this occurs, it is necessary to mix the compost in order to supply oxygen and restore the process to aerobic conditions.

Under aerobic conditions, it is also important for the composted material to form interstices which entrap air when the windrow is formed or the material is mixed. If these spaces are filled with water, no oxygen is available to the organisms. If composting is to be done anaerobically, a high moisture content is a desirable condition and can be obtained by saturating the windrow before sealing.

If the moisture content falls below 50%, high temperatures occur in the center of the pile. The high temperatures begin to destroy the microorganisms, seriously curtailing the decomposition process. The problem can be corrected by adding water to the organic matter to raise its moisture content.

Carbon-Nitrogen Balance: Carbon to nitrogen ratio controls the rate at which composting proceeds. As composting begins, the microorganisms require carbon as a source of energy for growth and nitrogen for protein synthesis.

A C/N ratio above this range results in a slowdown of the composting process. If the carbon is present in a form highly resistant to bacterial attack, the C/N ratio can exceed the optimum level indicated. Examples of material that have a large percentage of carbon in a resistant form are paper, fiber, wood, and straw. The C/N ratio and hence the time required for composting can be lowered by adding a nitrogen source such as manure or activated sludge.

A low C/N ratio results in the loss of nitrogen as ammonia. The loss of nitrogen is not detrimental to the composting process, one should attempt to conserve the nitrogen as a soil nutrient.

Ideal C : N Ratio in Heap: The art of making successful compost is largely associated with achieving a correct C : N balance. 30 parts carbon to 1 part nitrogen is ideal which reduces to 10-15:1 when turned into mature content. Fine grass mowings on their own will produce a treacly mass result, so straw, leaves or, possibly, cardboard would be good companions. If you include too much woody material such as bark and prunings without balancing this with sufficient green matter, the pile may not heat up at all.

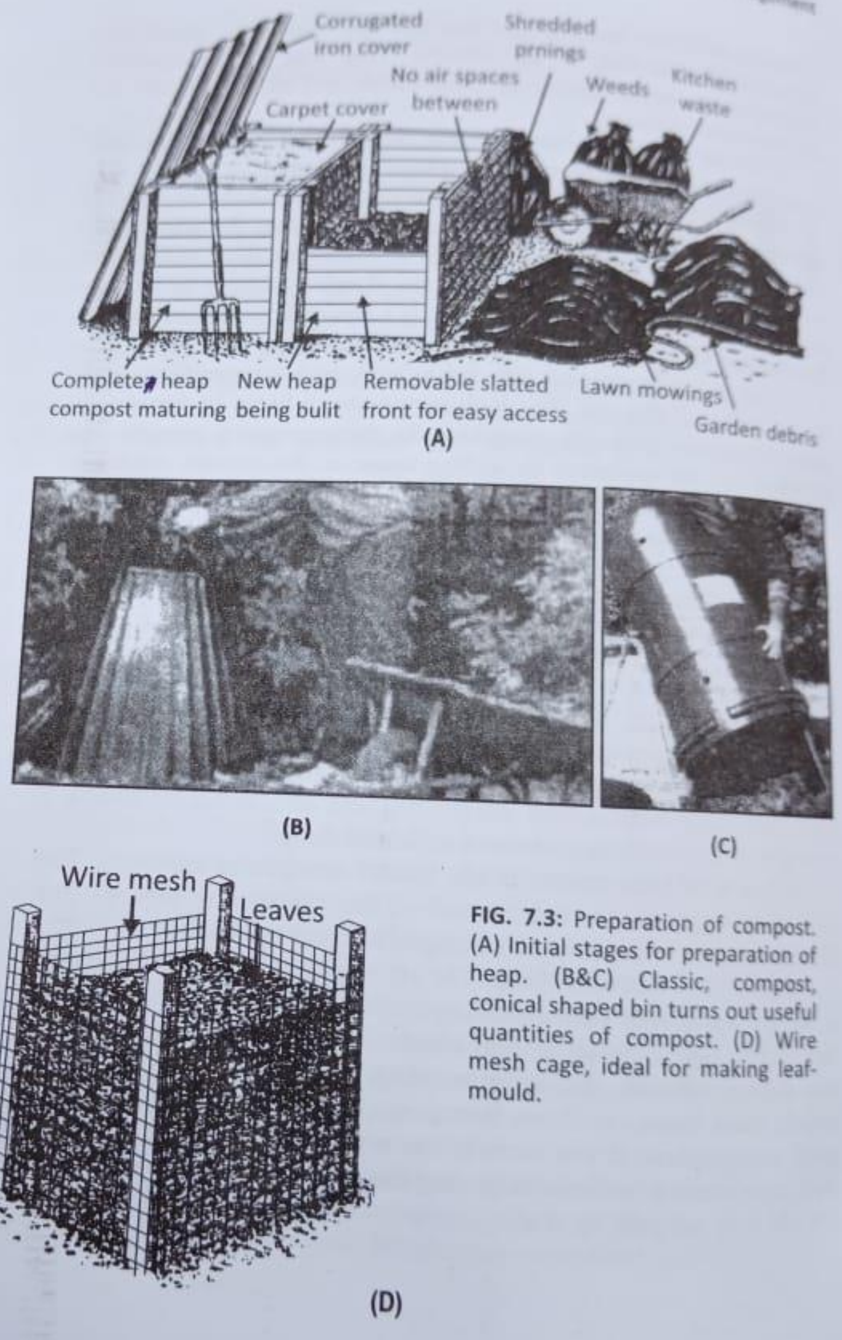

FIG. 7.3: Preparation of compost. (A) Initial stages for preparation of heap. (B&C) Classic, compost, conical shaped bin turns out useful quantities of compost. (D) Wire mesh cage, ideal for making leaf-mould.

A compost heap, in fact, is somewhere between a bonfire and nature's own method of decomposition, which is a slow rotting process culminating in incorporation by worms into the soil when breakdown is completed. By speeding up the decomposition process one can increase a soil's fertility very quickly, especially by making a well aerated heap where oxygen-loving organisms can flourish.

As composting proceeds, the C/N ratio continuously decreases with time, since the nitrogen remains relatively constant and the carbon is released as carbon dioxide gas. The compost is considered *ripened* once the C/N is lowered to a value between 12 and 20.

Moisture Content

Moisture is essential for microbial activity. In a dry summer the heap will definitely need some, preferably, added every so often while you are constructing it. Ingredients should be pretty damp. Too much moisture is unlikely at the time of making the heap, but it should be protected from rain with polythene on top.

Microbes Involved in Composting

Transformation of biological material is carried out by microbial flora. They requires moisture, heat and, depending on the type of production operation chosen, air. A single gramme of compost will contain up to a billion bacteria, 100 million actinomycetes, a million fungi, algae, protozoae and others in their hundreds of thousands.

Activators of Biodegradation: Animal manure is used to enhance the heating process; it must be fresh rather then already rotted. Fresh manure *activates* by seeding the heap with bacteria. If enough is added it will also bring a lot of heat into the compost heap. This can be very useful in winter when it is cold and there is a shortage of green matter to engender heat.

The right bacteria can also be introduced by adding some of last time's compost as the heap is constructed. Commercial activators are unnecessary if the above conditions are met, but you might find it interesting to experiment with herbal products, which definitely make a difference. Packaged bacterial activators are also available but since the types of bacteria at work vary with the temperature, air conditions and other factors, these may be of limited use.

Composting is the conversion of biodegradable organic matter to a stable product called humus. The microbes involved include bacteria, fungi, and actinomycetes. During aerobic composting there is a continual change in the qualitative and quantitative nature of the microbial population. At first, fungi and acid-producing bacteria appear, causing the temperature to rise (mesophilic range). When the temperature rises above 40°C, these microbes are replaced by thermophilic bacteria, actinomycetes, and thermophilic fungi.

Bacteria: Both mesophilic and thermophilic bacteria play an important role in the composting process. The mesophilic bacteria predominate during the initial and final phases of decomposition when temperatures are below 40°C. **Actinomycetes:** They exist in the thermophilic region and they utilize hemicellulose but not cellulose. Thermophilic actinomycetes are capable of decomposting cellulose. Thermophilic actinomycetes can grow at temperatures up to 72°C.

Fungi: They appear in both the mesophilic and the thermophilic stages of composting. mesophilic fungi utilize the simple carbon substrates as their source of food. During the late stages of decomposition they utilize some cellulose and hemicellulose Thermophilic fungi are less temperature tolerant than the thermophilic bacteria or actinomycetes. They operate in the range of 40°C to 60°C. Above 60°C, thermophilic fungi will die off.

DESIGN CRITERIA

work.

PRACTICAL METHOD OF MAKING COMPOST

Building a Compost Heap

Size of the compost heap: A good basic size for a compost heap is 2 to 2.5 metres (about 6.5 to 8 feet) wide and 1.5 and 2 metres (about 5 to 6.5 feet) high. If the heap is too broad or too high aeration will be poor. The minimum size of a compost heap is usually recommended to be 1 metre^3 (about 1 yard^3).

Frequently more organic matter is needed to build a compost heap to the desired size than the inexperienced compost builder would expect. This can only be learnt through trial and error.

If it is difficult for an individual to collect sufficient organic material to build a compost heap it might be worth working with other farmers or householders, or even organizing the whole community into building their compost heaps together. Alternatively, extra material such as roadside cuttings or the organic by-products from local processing plants could be considered. The correct balance of slow and fast decomposable material, however, must be maintained.

Labour: Building a compost heap should be timed to fit in with the slack periods of labour. Some composting procedures e.g., regular turning, and some methods are more labour intensive than others.

Availability of animal feed: Much of the organic material suitable for composting is also suitable as animal feed. If animal feed is scarce it maybe inappropriate to compost it. The farmer must make his decision based on his own circumstances. If organic material is used as animal feed (e.g., kitchen compost for pigs, crop residues for cattle) it is likely there will still be other types of unwanted organic compost. Even if it takes longer to collect sufficient material it can still be worthwhile.

Water availability: If water is scarce, it may be better to use available water directly for irrigation rather than for producing compost. However, compost added to the soil can improve its water holding capacity and, in the long term, would reduce the amount of the water required to irrigate the crops. Methods to reduce the water requirements of a compost heap include: (1) Covering the heap, thus reducing evaporation; (2) siting the heap in a shaded area; (3) enclosing the heap entirely within a wall of mud; (4) building the heap in a pit.

If a rainy season can be expected a good compromise is to concentrate on compost building when more water is available.

Pit or heap: A heap is the most common form of composting. However, where water is scarce composts can be built in pits. This minimizes water loss, although watering is still required. Where there are heavy rains of a high water table compost built in a pit can easily become too wet.

Managing the Compost Heap

Water content: In dry conditions, the heap will probably require water to be added about twice a week. The moisture content can be tested by placing a small bundle of straw in the compost heap. If the moisture is acceptable then the bundle will be damp when removed after about five minutes. If the heap becomes too wet it should be opened up and mixed with more dry organic material or allowed to dry in the sun before being rebuilt.

Ingredients: Nearly all organic material, plant or animal can be used in a compost heap. However, organic material breaks down at different rates ranging from a rapidly rotting fruit to the slow breakdown of a dry maize stalk. When building a managed compost heap it is important to have a good balance between slow and fast rotting material.

These two main categories of organic material he to be balanced correctly because of the proportions of carbon and nitrogen they contain. Broadly speaking, young, living material that decomposes fast contains low levels of carbon relative to high levels of nitrogen. Though, often dead material, for example straw, decomposes slowly and has a high ratio of carbon to nitrogen. This is called the C : N ratio; the higher the ratio the slower the rate of decomposition.

Building the heap: In order to produce the conditions required by a compost heap it should be built in a particular way. First, a layer of course plant material such as stalks or twigs to ensure good air circulation and drainage is needed. Following that, organic material should be placed in layers, alternating between material that is easily decomposed with material that decomposes slowly. A good thickness for each of these layers is 10 cm (about 4 inches). If manure is used it should be applied in layers of 2 cm (1 inch), and soil applied even thinner. Water should be applied after each sequence of layers. With each layer of organic material, the edges should be laid down first, followed by the centre. This ensures that the heap edges will be firm and not collapse. Alternatively, a wire mesh or similar supporting structure that allows air to pass through can be used.

Air vents: These are made of bamboo canes with holes cut in them and placed both vertically and horizontally throughout the heap, can improve aeration. A large pointed stick should be driven into the heap at a slant to monitor the temperature.

The heap should then be covered to protect it against moisture loss and/or heavy rain. Sacking, grass thatch or banana leaves are all suitable.

Within three week the volume of the heap will have decreased considerably.

Digestion: Aerobic composting or digestion of livestock composts can be accomplished by placing the manure in windrows.

The Super digested compost: Application of super phosphate at 5 % over the raw compost materials during composting improves the manurial value of compost. Application of this compost to acidic, calcareous and heavy soils increases the P availability.

1. Windrows: They are elongated piles that are turned periodically to aerate the organic composts. They can be of any convenient length, about 2.5 to 4.0 m wide and 1.5 to 2 m high. The height of the windrow is critical and should be carefully managed in order to obtain good results. If piled too high, the material will be compressed by its own weight which will destroy the spore space and cause anaerobic conditions.

2. The height of the pile: It is also critical from the standpoint of controlling temperature. Windrows stacked too high may retain too much heat and develop temperatures above 70°C. Temperature in this range will destroy many of the microorganisms, slowing down the process and causing anaerobic conditions. Shallow piles may dissipate heat too rapidly, preventing optimum conditions for thermophilic organisms to be reached. Loss of moisture may also be excessive, causing the rate of composting to be retarded. In drier climates, the cross-section of the windrow is usually trapezoidal, with the angle of repose being approximately 30°. In rainy climates, if no overhead protection is provided, the cross-section of the windrow should be semicircular in order to shed water.

3. Turning the pile frequently: It is essential for obtaining a rapid, nuisance-free composting action characteristic of the thermophilic aerobic process. In order to ensure a uniform and rapid decomposition, the compost must be thoroughly mixed. One method is to turn the outer edges into the center of the pile. This procedure causes weed-seeds, fly larvae, and pathogenic organisms which might survive near the cooler surface to be exposed to the lethal temperatures at the interior of the windrow. Turning is also useful for reducing the moisture content and aerating a pile that has become anaerobic. Turning can be accomplished by using a front-end loader or a clam-shell bucket. Commercially available machines are also available for mixing windrows. These machines are designed to straddle the windrow and mix the compost by means of long tines mounted on a rotating drum. Under normal conditions, when the moisture content is between 50 and 60%, the windrow should be turned at 3-day intervals. If the moisture level exceeds 60%, the windrow should be turned at 2-day intervals to prevent the occurrence a anaerobic conditions.

Curing: After the compost has gone through a period of active decomposition, the composted material must be removed from the windrow and allowed to cure. Curing is a process that allows the compost to continue its stabilization process at a slower rate under mesophilic conditions. Curing can be done in the open or placed under cover. After the compost is cured it is ready to be stored or utilized as a soil conditioner.

Maturation of the compost: Once the compost heap has cooled down the heap should be left to mature. However, as long as most of the original material is no loner recognizable, and has turned into a brownish-black colour the compost can be used. If left to mature a finer product will be produced with a wider range of uses.

Maturation can take place on the ground, although the heap should be kept covered to protect it from the rain and sun. If the compost is kept for too long before use it may lose some nutrients and may also become a breeding place for unwanted insects.

PRACTICAL APPLICATIONS COMPOSTING

Although composting is not widely used as a means of treating livestock composts, there are some farmers that are using it quite successfully. Whether or not composting fits into one's compost handling scheme is dependent upon the availability of labor, the degree of mechanization that can be afforded, whether the compost should be treated as a liquid or a solid, and how one plans to utilize the end products.