How Does Composting Work?

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Introduction

Composting is a general term that refers to aerobic decomposition, a process in which living organisms such as bacteria and fungi feed upon organic matter. The United States Department of Agriculture (USDA), the National Organic Program (which oversees organic food production), and other organizations use the term composting to refer to the process of active composting. Many homeowners use the term composting to refer to passive composting.

Active composting is the controlled decomposition of organic matter by microorganisms into a stable humus-like product (compost) under aerobic conditions. Active composting enhances and accelerates the decomposition process by optimizing microbial growth. Active compost can be mature and ready to use in a matter of weeks to a few months.

Passive composting is the process of piling up organic material and letting nature take its course. Temperatures and moisture are not monitored and may result in either poor decomposition (when not enough moisture), or anaerobic decomposition (no oxygen, often due to too much moisture). Passive composting may take years to develop a mature product that is ready to use.

Benefits of Composting

Both active and passive composting can turn organic materials into a usable, soil building product. Passive composting requires very little labor or management and can work well for those dealing with relatively small amounts of organic material. Active composting works for any size of operation. Active composting has some definite benefits over passive composting in that active composting:

- reduces odors
- destroys pathogenic bacteria and protozoa (disease causing organisms)
- kills most weed seeds
- kills fly larvae, and
- results in a product that has some disease suppression properties.

Figure 1. Mature compost

Composting Process

Much as humans need oxygen and food to live, aerobic bacteria also need oxygen and a source of food (organic matter) to live. Microorganisms consume complex organic compounds and break them apart to provide both a source of energy and an element used in the structure of their bodies (cell protoplasm). When the organic matter is used as a source of energy, the energy is burned up and the cells respire CO_2. This is similar to humans in that we also need oxygen to live, feed on organic materials (carbohydrates), and break down food to produce energy and respire CO_2.

When carbon is oxidized to form CO_2, energy is released -- much of it in the form of heat. If the pile is large enough, some of the heat is trapped and the temperature of the pile increases. The decomposition process can result in temperatures that get above 170° F. At temperatures above 160° F, bacterial activity decreases.

Aerobic decomposition is generally not a smelly process. If foul odors are present, it is likely that the either the process is not entirely aerobic, or other materials are present. To maintain aerobic conditions, oxygen must be added to the pile such as by turning the pile, or forced air.

Figure 2. Measuring compost temperature
Photo source: http://www3.abe.iastate.edu/pigsgone

Conditions Needed for Composting

Composting works best when the following conditions (Table 1) are maintained:

Carbon to Nitrogen (C:N) Ratio
Carbon (C) and nitrogen (N) are both present in organic matter, and are both needed for the microorganisms to grow and reproduce. Since C is also needed as an energy source, C is needed in larger quantities than N. Bacteria are the most efficient at breaking down organic matter when the C:N ratio is about 25:1 to 30:1.

Moisture
Composting is best when the moisture content is 40-60%. Microbial activity becomes limited when the moisture content drops below 40%. At higher levels, water fills the pore spaces that were filled with oxygen and the process becomes anaerobic, which can generate foul odors. As a general rule of thumb, the compost materials are too wet if water can be squeezed out of a handful of compost, and too dry if it does not feel moist to the touch.

Temperature
The composting process should be between 110-160° F. Temperatures in this range encourage bacterial growth and aerobic decomposition.

There are many different kinds of aerobic bacteria, with each type needing specific conditions to grow and thrive. Psychrophilic bacteria work best at 55° F, but can work down to 0° F (below freezing). Mesophylic bacteria flourish when the temperatures are between 70-90° F, but will survive at temperatures 40-70° F and 90-110° F. Thermophilic bacteria are heat loving bacteria that work fast. Their optimum temperature range is 104-160° F.

Pathogens, weed seeds, and fly larvae are destroyed or greatly reduced under high temperatures. Pathogenic bacteria start dying at temperatures above 140° F and are rapidly killed at temperatures above 149° F.[1]

Approximately 90% of weed seeds will die when the temperature is above 140° F for 3 hours or more.[2] And fly larvae can be killed with heat that is 120° F or higher. After 10-14 days of higher temperatures, the substrate (compost) becomes unsuitable for fly habitat.[3]

When developing a compost pile, it is important that the right conditions (C:N ratio, moisture content, and oxygen levels) are provided so the bacteria can multiply and start the decomposition process. Although composting can occur under a fairly broad range, it is helpful to start with a good C:N ratio so you have some room for variation in your substrates compared to average values.

Table 1. Compost Requirements*

Condition	Reasonable	Preferred
Carbon to Nitrogen (C:N) ratio	20:1-40:1	25:1-30:1
Moisture Content	40-65%	50-60%
Oxygen Concentrations	>5%	>>5%
Particle Size	1/8" – 1/2"	Varies
pH	5.5-9.0	6.5-8.0
Temperature	110-160° F	130-140° F

* Adapted from: On-Farm Composting Handbook, NRAES-54. Northeast Regional Agricultural Engineering Service

Selecting the substrates needed for a good C:N ratio can take a bit of skill. Table 2 lists some of the more common substrates and their C:N ratio. Online compost calculators can also aid in the development of the right ratios of compost substrates.

If more N is needed in the compost mix, one can add some nitrogen fertilizer. A good rule of thumb is to add 1 lb. of urea fertilizer per yd^3 of yard waste.

Table 2. Raw Material Characteristics*

Material	%N	C:N Ratio	% Moisture	Density (lbs/yd^3)
Food waste	1.9-2.9	16-16	69	--
Fruit waste	1.4	40	80	--
Vegetable produce	2.7	19	87	1585
Newsprint	0.6-0.14	398-852	3-8	195-242
Grass Clippings	3.4	17	82	300-800
Leaves	0.9	54	38	100-500
Hay – grass	1.3	32	--	--
Hay – legume	2.5	16	--	--
Straw - oat	0.9	60	--	--
Straw – wheat	0.4	127	--	--
Corn stalks	0.6-0.8	60-73	12	32
Sawdust	0.24	442	39	410
Woodchips (softwoods)	0.09	641	--	--
MANURES				
Broiler Litter	2.7	14	37	864
Turkey Litter	2.6	16	26	783
Laying Hen Manure	8.0	6	69	1479
Sheep Manure	2.7	16	69	--
Cattle Manure	2.4	19	81	1458
Dairy Manure	3.2	16	81	--
Horse Manure	1.6	30	72	1379
Swine Manure	3.1	14	80	--

* Adapted from: On-Farm Composting Handbook, NRAES-54. Northeast Regional Agricultural Engineering Service

Regardless of whether an active or passive composting process is used, composting results in a product that functions as a slow release fertilizer and helps build the soil structure.

Active composting has the added benefit of destroying or reducing pathogens, weed seeds, and fly larvae. If you have any livestock and neighbors close by, active composting can greatly reduce the potential for neighbor complaints.

Curing

After the temperature of the compost has dropped to near ambient temperatures, the compost process is nearly over. It is recommended that the compost be allowed to "cure" for another month or two.

During the curing process the mesophilic bacteria continue the degradation process of the complex, and difficult to degrade compounds that remain after the active composting process. Aerobic conditions should also be maintained during the curing phase. Curing the compost prevents the use of an immature compost, which can continue to consume oxygen and tie up nitrogen making them unavailable for plant use.

Figure 3. Curing compost
Photo: www.ematlantic.ca/images/compost/compost_farm_edited2.jpg

References

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