User's Guide - Produced by Cornell Waste Management Institute

Compost: Truth or Consequences

To be used in conjunction with Compost: Truth or Consequences 15-minute video about backyard composting;
for use with master composters; or anyone else interested in composting.

Contents

Purpose of Video

Compost: Truth or Consequences is designed to introduce viewers to the science of backyard composting. The goals of the video, presented in a game show format, are:

- to expose potential composters to the concept of composting, i.e., recycling organic matter into a useable soil enrichment product, and to reduce the amount of waste going to the landfill or incinerator;
- to provide an overview of the science involved in composting;
- to help home composters avoid problems; and,
- to motivate composters to educate and enthuse others about home composting.

Why Compost?

All organic matter, if left to Nature, eventually decomposes and becomes part of the soil supplying nutrients to enrich and replenish the earth. Composting is simply a way to help speed up the natural recycling process of decomposition.

Anything that is alive or was once alive is "organic". Some of the common organic materials that we use and dispose of daily are food, clothing and furnishings, building materials, paper products, animal wastes, and landscape trimmings. In fact, organic materials account for much of what we consume and throw away every day. According to a recent U.S. Environmental Protection Agency analysis of the total solid waste stream by weight, paper products alone make up 39 percent of our garbage, landscape trimmings comprise more than 14 percent, and food wastes account for almost 7 percent. Due to the sheer volume of organic wastes produced, the way that we choose to handle these materials is one of the most important waste management decisions that we face today.

Why compost? There are a number of reasons. When organic materials are separated from trash and allowed to decompose with an adequate supply of air, they can be turned into a valuable soil amendment that can be used for all sorts of things--plant and vegetable gardens, landscaping projects, land reclamation, and restoration or replacement of worn out or contaminated soils. Composting also provides a partial solution to some issues of great concern in many communities: landfills are filling up, garbage incineration is unpopular, and other waste disposal options are becoming harder to find. Composting provides a way of not only reducing the amount of waste that needs to be disposed of, but also of converting it into a product that is useful.

Do You Know the Answers?

VIDEO QUIZ

What do a picnic and a compost pile have in common?

Answer: A compost pile is a catered picnic for millions of guests. Like people, decomposers--bacteria, microbes, fungi, worms, and other invertebrates--require a balanced diet to survive. Many types of decomposers are at work in the compost pile. Each type thrives on special conditions and different types of organic materials. Understanding how to create the ideal composting conditions will help the home composter make compost quickly and to diagnose and solve any problems that might arise.

Microorganisms in the compost pile use carbon (C) for energy and nitrogen (N) for protein synthesis, just as people use carbohydrates for energy and protein to build and repair bodies. The balance of carbon and nitrogen in a compost pile is called the carbon-to-nitrogen ratio (C:N). Ideal composting conditions will have a 30:1 carbon-to-nitrogen ratio. Most materials available for composting, however, don't have the ideal carbon-to-nitrogen ratio. That's where a little "compost know-how" can go a long way towards creating those ideal compost conditions. A good composter focuses on the materials being composted and their preparation and provides the best conditions to ensure a healthy compost crop

VIDEO QUIZ

Help! How do I decide what to put in my compost bin?

a. **Call a rocket scientist.**
b. **Enroll in organic chemistry.**
c. **Consult your Ouija board.**
d. **Mix browns and greens.**

Answer: d. Mix "Browns" and "Greens"
Mixing "browns" and "greens" together in a compost pile can help to achieve the ideal 30:1 C:N. It helps to think of materials high in carbon as "browns" and materials high in nitrogen as "greens". One way to speed up decomposition is to combine carbonaceous "brown" materials such as autumn leaves with nitrogen rich "green" materials such as grass clippings to create a mix with a 30:1 carbon-to-nitrogen ratio. The following chart provides some approximate C:N ratios in various organic materials.

Average Carbon:Nitrogen Ratios

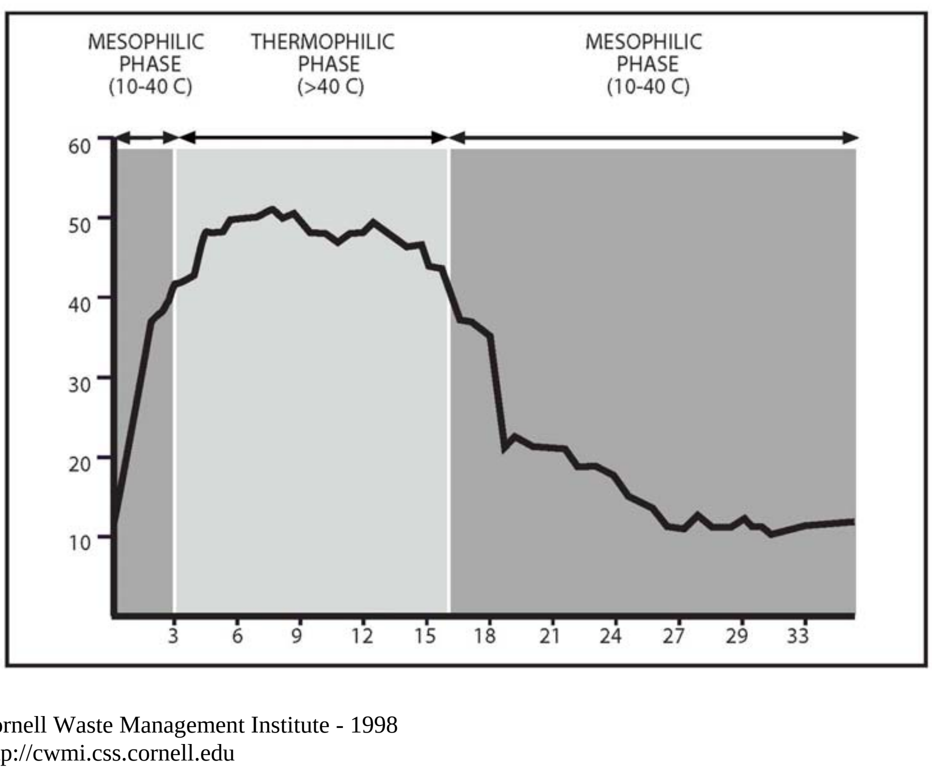
Food scraps	15:1	
Grass clippings	19:1	**GREENS**
Rotted manure	25:1	

		30:1	***IDEAL for Composting***
	Corn stalks	60:1	
	Leaves	40-80:1	
	Straw	80:1	**BROWNS**
	Paper	170:1	
	Sawdust, woodchips	500:1	

While you can get real scientific and calculate the Carbon:Nitrogen ratios using algebraic formulas, a good rule of thumb is to layer or mix materials in your compost pile so that you have roughly equal amounts of high-nitrogen "greens" and high-carbon "browns".

How Does A Compost Pile Work?

The most numerous organisms in a compost pile are bacteria. Most bacteria are too small to see individually, but it is easy to see the effects of bacterial work in a compost pile. Bacteria generate the heat associated with composting, and perform the primary breakdown of organic materials. Many types of bacteria are in the compost pile. Each type thrives on special conditions and different types of organic materials. Even at temperatures below freezing, some bacteria can be feeding on organic matter. These psychrophilic bacteria (a grouping of bacterial species that includes all those active in the lowest temperature range) do their best work at about 55°F (13°C), but they are able to carry on right down to 0°F (-17°C). As these bacteria eat the organic materials, they give off a small amount of heat. The temperature in the compost pile will rise whenever microbial heat production exceeds heat lost to the environment. Therefore, to increase the temperature, it is necessary to encourage heat production by supplying ideal conditions for the bacteria, or to prevent heat loss by constructing the pile appropriately. If conditions are right for them to grow and reproduce rapidly, this heat will be sufficient to set the stage for the next group of bacteria, the mesophyllic or middle-temperature-range, bacteria.



Mesophyllic bacteria thrive at temperatures from 70-90°F (21-32°C), and survive from 40-70°F (4-21°C) or from 90-110°F (32-43°C). In many compost piles, these efficient mid-range bacteria do most of the work. However, given optimal conditions, they will produce enough heat to kick in the next group of bacteria, the thermophilic or heat-loving, bacteria.

Thermophilic bacteria work fast, in a temperature range of 104°-170°F (33-76°C). Unless the pile is fed new materials or turned at strategic times, they will work for only 4 to 7 days until their activity peaks and the pile cools down below their optimum range. In that short time, they turn green, gold and tan organic material into a uniform deep brown. If the pile is turned to let more air in, the thermophilic bacteria will feast for another 4 to 7 days. (Large compost piles with a volume of several cubic yards or more can retain enough heat to keep thermophilic bacteria alive for several weeks or longer.)

In all of this work, the bacteria are not alone—though at first they are the most active decomposers. Other microbes, fungi, and a host of invertebrates take part in the composting process. Some are active in the heating cycle, but most organisms prefer the cooler temperatures of slow compost piles or proliferate only when hot piles start to stabilize at lower temperatures.

VIDEO QUIZ

Help! My compost reeks of ammonia! What do I do?

a. **Give up composting.**
b. **Move.**
c. **Use it to mop your floors.**
d. **Add more brown materials.**

Answer: d. Add more brown materials
A compost pile can start to emit an ammonia-like smell. This is usually caused by too much nitrogen in the pile. Bacteria use nitrogen to build proteins for new cells. If there isn't enough nitrogen, the bacteria won't be able to reproduce quickly, and the pile will remain cool. But if there is too much nitrogen for the available carbon, the microbes can't use all the nitrogen, and it is released as ammonia. Adding more carbonaceous "brown" materials and turning the pile will create a better C:N ratio and should eliminate the ammonia smell.

All compost organisms need a certain amount of water and air to survive. The amounts of air and water in a compost pile form a delicate balance that must be maintained for rapid decomposition to take place. Too much air circulating in the pile can make the pile too dry for bacteria to function. At less than 40 percent moisture, the bacteria are slowed by the lack of water. At greater than 80 percent moisture, the pore spaces between particles fill with water so there is not enough air for "aerobic" decomposition to continue. Anaerobic bacteria, which thrive in the absence of oxygen, can take over the pile. Anaerobic decomposition is slow and can produce unpleasant by-products.

Sometimes, a compost pile can start to smell like “rotten eggs”. This is usually due to anaerobic conditions.

VIDEO QUIZ

Help! My compost smells like rotten eggs. What do I do?

- **a. Hand out respirators.**
- **b. Spray with perfume.**
- **c. Garnish with cheese and salsa.**
- **d. Add a dry, coarse material.**

Answer: d. Add a dry, coarse material.

The compost must be moist enough to support microbial growth but not so water-logged that air can’t circulate through the pile. Porosity is essential for proper aeration. Air gets into the center of the pile by moving in the spaces between compost particles. Aerobic organisms in the film of water surrounding the particles use the oxygen in air to break down organic material. If there is too much water, the pores fill up, and oxygen can no longer penetrate the pile.

Adding a dry, coarse material, often called a bulking agent to a soggy bin can help dry it out and increase porosity. As a general rule, a compost mixture should be about as dry as a wrung-out sponge. The squeeze test for moisture content is a good indicator—only a drop or two of water should be expelled from the mixture when tightly squeezed by hand.

For fast, efficient composting, a compost pile must be large enough to hold heat and moisture, and small enough to admit air to the center. Heat loss depends on the size and shape of a pile—a higher surface area for a given volume results in greater heat loss.

VIDEO QUIZ

Help! I want hot compost. How big should I make my bin?

- **a. As big as a bread box.**
- **b. Smaller than the Hindenberg.**
- **c. No bigger than your head.**
- **d. At least one cubic meter.**

Answer: d. At least one cubic meter.

As a rule of thumb, home compost piles should be about as big as one cubic meter (3 ft. by 3 ft. by 3 ft. or 1 cubic yard). A smaller pile (unless properly insulated) will dry out easily, and cannot retain the heat required for quick composting. Larger piles have a smaller relative surface area and lose heat to the environment more slowly, but large piles must be turned frequently or have "ventilation stacks" placed throughout the pile to allow air into the interior so anaerobic conditions are prevented.

A home compost pile built with proper consideration of carbon-to-nitrogen ratios, temperature, moisture, aeration, surface area and volume can produce compost ready for curing as quickly as three weeks. With less attention to the details of materials used and the environment provided for them, a cooler, slower pile can also be built. Low-maintenance methods of composting will still create an excellent compost, but will take much longer, anywhere from 6 months to 2 years to yield finished compost.

Creating the Ideal Compost Conditions

- ❑ **Carbon-to-Nitrogen Ratio**
- ❑ **Temperature**
- ❑ **Moisture**
- ❑ **Aeration**
- ❑ **Surface Area**
- ❑ **Volume**

Accompanying Materials

Compost: Truth or Consequences can be used in conjunction with The Master Composter Program Implementation Guide and Master Composter Resource Manual (1998). This two-part manual provides the resources needed to create and implement a Master Composter program. Part 1, the "Master Composter Program Implementation Guide," is designed for staff developing and implementing a Master Composter Program within a community. It covers recruiting volunteers, responsibilities, and presents examples for community outreach and education programs.

Part 2, "Master Composter Resource Manual," is aimed at the Master Composter Volunteer. This section describes the Master Composter Program, teaches the science of composting, illustrates methods for composting at home, including vermicomposting, and contains education and outreach activities that can be conducted by Master Composters.

The Manual can be downloaded at: http://cwmi.css.cornell.edu/mastercompostermanual.pdf. The manual plus the video *Compost: Truth or Consequences* (free download at http://hdl.handle.net/1813/11313), can be purchased for $30 at: http://cwmi.css.cornell.edu/cupressorders.htm

Additional composting resources can be found on our web site:

http://cwmi.css.cornell.edu/composting.htm

General

http://cwmi.css.cornell.edu/resources.htm#composting

Youth and Teacher

http://cwmi.css.cornell.edu/resources.htm#youthteacher

Glossary

Actinomycetes - A type of bacteria, distinguished by their branching filaments called mycelia. Include both mesophilic and thermophilic species. In composting, actinomycetes play an important role in degrading cellulose and lignin.

Aeration - The process through which air in compost pores is replaced by atmospheric air, which generally is higher in oxygen.

Aeration, forced - Addition of air to compost using blowers, fans, or vacuum pumps.

Aeration, passive - Relying on natural forces, such as convection, diffusion, wind, and the tendency of warm air to rise, for movement of air through compost.

Aerobic - (1) Characterized by presence of oxygen, (2) Living or becoming active in the presence of oxygen, (3) Occurring only in the presence of oxygen.

Anaerobic - (1) Characterized by absence of oxygen, (2) Living or functioning in the absence of air or free oxygen, (3) Occurring only in the absence of oxygen.

Bacteria - Single-celled microscopic organisms lacking an enclosed nucleus. Members of the kingdom Monera. Commonly have a spherical, rod, or spiral shape.

Base - A substance with pH between 7 and 14.

Batch composting - Composting in which all of the ingredients are added at once rather than continuously over a period of time.

Biodegradable - Capable of being broken down through biochemical processes.

Bulk density - The mass per unit of volume of dry soil or compost, including air-filled pores.

Bulking agent - A material used in composting to maintain air spaces between particles.

Carbon-to-nitrogen (C:N) ratio - The ratio of the weight of organic carbon to the weight of total nitrogen in soil, compost, or other organic material.

Compost - (v) The process of decomposition of organic materials under controlled conditions, (n) the humus-like material produced by decomposing organic materials under controlled conditions.

Compost quality - The suitability of a compost for use with plants. Compost that impairs seed germination or plant growth is of low quality, either because it is not yet fully decomposed or because the initial ingredients contained contaminants that are phytotoxic.

Compost system - The method used to convert organic wastes into a stable end product. Examples range from large outdoor windrows or piles to small indoor bioreactors.

Curing period – The period required to finish the process and to develop the desired characteristics of a mature compost. It is recommended that the curing period be at least one month.

Debris - Dead organic matter.

Decomposer - An organism that feeds on dead organic matter and aids in its degradation.

Detritus - Dead organic matter.

Feces - Wastes discharged from the intestines of animals.

Food chain - A hierarchical sequence of organisms that feed on each other, starting with either green plants or organic detritus as the primary energy source.

Food web - The network of interconnected food chains found in an ecological community.

Fungi - Plural of fungus. A kingdom that includes molds, mildews, yeasts, and mushrooms. Fungi lack chlorophyll, feed on dead organic matter, and reproduce by spores. Unlike bacteria, fungal cells do have nuclei. Some fungi grow cellular filaments called hyphae or mycelia.

Heavy metals - Metallic elements with high molecular weights. Includes cadmium, lead, copper, mercury, chromium, silver, and zinc. High concentrations in soil can be toxic to plants or to animals that eat the plants or soil particles.

Holding unit - A simple container that holds landscaping, garden, and food wastes while they break down.

Humus - The stable organic complex that remains after plant and animal residues have decomposed in soil or compost.

Hyphae - Branched or unbranched chains of cells, as in fungi and actinomycetes.

Inoculant - Microorganisms that are introduced into compost or other culture media.

Inoculate - To introduce pure or mixed cultures of microorganisms into culture media.

Inorganic - Mineral, rock, metal, or other material containing no carbon-to-carbon bonds. Not subject to biological decomposition.

Invertebrate - An animal without a backbone, such as an insect or worm.

Leachate - The liquid extract that results when water comes into contact with a solid such as soil or compost. In composting, leachate containing dissolved and suspended substances drains from the system as organic matter decomposes.

Lignin - A series of complex organic polymers that are highly resistant to microbial decomposition. In wood, lignin cements cellulose fibers together and protects them from chemical and microbial decomposition.

Lime - Calcium compounds used to neutralize acidity in soils.

Macroorganism - An organism large enough to be observed with the naked eye.

Maturity - A measure of whether compost has completed not only the phase of rapid decomposition, but also the longer curing phase during which slow chemical changes make the compost more suitable for use with plants.

Mesofauna - Soil-dwelling invertebrates that are large enough to tunnel their way through soil or compost. Includes nematodes, mites, potworms, ants, insect larvae, and others.

Mesophilic - (1) Organisms that grow best at moderate temperatures (50-104°F, 10-40°C,), (2) The phase of composting that takes place at temperatures in the range of 50-104°F (10-40°C), (3) The type of composting that does not reach temperatures exceeding 104°F (40°C).

Microfauna - Soil protozoa and other microscopic fauna that are generally capable of moving through existing soil pores.

Microbe - A microorganism.

Microorganism - An organism that individually is too small to be observed without magnification through a microscope.

Mulch - Any material such as compost, bark, wood chips, or straw that is spread on the soil surface to conserve soil moisture, suppress weed growth, moderate temperature changes, or prevent soil erosion.

Mycelia - Branching networks of fungal hyphae.

Nitrifying bacteria - Bacteria that transform ammonium (NH_4^+) to nitrate (NO_2^-) and then to nitrate (NO_3^-).

Nitrogen-fixing bacteria - Bacteria that transform atmospheric nitrogen (N_2) to ammonium (NH_4^+).

Organic - (1) Pertaining to or derived from living organisms, (2) Chemical compounds containing carbon-to-carbon bonds.

Organic matter - Material that has come from something that is or was once alive.

Oxidation - A chemical reaction in which an atom loses electrons or increases in oxidation number.

Pathogen - Any organism capable of producing disease or infection in other organisms.

Percolation - Downward movement of water through pores in rock, soil, or compost.

Permeability - The ability of a soil to allow the movement of water through its pores.

pH - The degree of acidity or alkalinity of a substance, expressed as the negative logarithm of the hydrogen ion concentration. Expressed on a scale from 0 to 14. pH <7 is acidic, 7 is neutral, and >7 is alkaline or basic.

Phytotoxicity - A measure of the ability of a substance to suppress seed germination, injure plant roots, or stunt plant growth.

Pore - An open area between particles of compost or soil, filled by air or water.

Porosity - The percentage of the total soil or compost volume that is occupied by open spaces rather than solid particles.

Protozoa - Single-celled animal-like microorganisms belonging to the kingdom Protista. Many species live in water or aquatic films surrounding soil or compost particles.

Screening - The process of passing compost through a screen or sieve to remove large pieces and improve the consistency and quality of the end product.

Soil amendment - Any substance that is used to alter the chemical or physical properties of a soil, generally to make it more productive. Examples include compost, lime, sulfur, gypsum, and synthetic conditioners. Usually does not include chemical fertilizers.

Stability - A measure of whether compost has decomposed to the point at which it does not reheat, produce offensive odors, or support high rates of microbial growth when optimal moisture levels are supplied.

Temperature profile - A graph of temperature changes that occur during the process of thermophilic composting.

Thermophilic - (1) Organisms that grow best at temperatures above 104°F (40°C), (2) The phase of composting that takes place at temperatures exceeding 104°F (40°C), (3) The type of composting that includes a stage occuring above 104°F (40°C).

Turning - In a compost pile, mixing and agitating the organic material.

Turning unit - Three holding units built next to each other, so that compost can be turned from one into the next.

Vermicompost - (v) To decompose organic matter using worms, (n) The product obtained through decomposition of organic matter by microorganisms and worms.

Windrow - An elongated pile of organic matter in the process of being composted.

Yard and garden wastes - Grass clippings, dead leaves, small branches, weeds, and plant residues.