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Northside Charter High School Urban Ecology Class: Composting in the Curriculum

Prepared by La Casita Verde: May 2015

Composting is the process of combining organic materials such as grass clippings and food scraps under conditions that enhance the rate at which they decompose. In the United States, organic wastes make up a large percentage of what is thrown away. Composting provides an opportunity to keep organic materials out of landfills and to create a useful end product instead. A compost pile also provides opportunities for direct observation of succession.

Having access to a three bin-Aerated Static Pile on your school grounds will enable you to observe and analyze what is happening in the process.

Here are some guidelines, activities and resources:

MONITORING THE COMPOSTING PROCESS

As decomposition proceeds, a number of changes occur in the physical, chemical, and biological characteristics of the compost mix. Monitoring these changes allows you to assess the progress of your compost, identify potential problems, and compare systems with different initial conditions or ingredients.

Simple observation of the physical changes that occur during com- posting is one form of monitoring. It is useful to keep a log book, not only to record data but also to note daily observations about the appearance of the compost. Does it appear soggy or dry? Is it shrinking in volume? Is there any odor? Any leachate? At what point do the various types of ingredients become unrecognizable? Have flies or other pests become a problem? If problems do develop during the course of composting, steps can be taken to correct them - see the table below.

Another form of monitoring is to take periodic measurements of variables such as the temperature, moisture content, pH, and biological activity. This chapter presents techniques for monitoring these physical, chemical, and biological characteristics of compost. Students can design and conduct a wide array of experiments using these monitoring techniques.

TEMPERATURE

Temperature is one of the key indicators of changes occurring during thermophilic composting. If the compost does not heat up, it may be deficient in moisture or nitrogen. Once the compost does heat up, temperature provides the best indicator of when mixing is desirable

To take temperature readings, use a probe that reaches deep into the compost. There is one onsite. Leave the probe in place long enough for the reading to stabilize, then move it to a new location. Take readings in several locations, including various distances from the top and sides. Compost may have hotter and colder pockets depending on spatial variability in the moisture content and chemical composition of the ingredients. Can you find temperature gradients with depth? Where do you find the hottest readings? For systems in which air enters at the bottom, the hottest location tends to be in the core, about two-thirds of the way up.

You might expect it to be in the exact center, where insulation by surrounding compost is the greatest, but the core temperatures are affected by the relatively cool air entering at the bottom and warming as it rises through the compost.

Your students might decide to design compost experiments to look for variables or combinations of variables that produce the highest temperatures in the shortest amount of time, or perhaps those variables that maintain hot temperatures for the longest period. One useful way to pre- sent your data is to plot the maximum temperature and the time to reach maximum temperature for each compost system as a function of the experimental variable. For example, you could plot the maximum temperature versus the initial moisture content of the compost ingredients. A second graph could show the time to reach maximum temperature versus the initial moisture content.

MOISTURE

Composting proceeds best at moisture contents of 50–60% by weight. During composting, heating and aeration cause moisture loss. That's OK—you want finished compost to be drier than the initial ingredients. Sometimes, however, adding water may be necessary to keep the compost from drying out before decomposition is complete. If the compost appears to be dry, water or leachate can be added during turning or mixing. Below a moisture content of 35–40%, decomposition rates are greatly reduced; below 30% they virtually stop. Too much moisture, on the other hand, is one of the most common factors leading to anaerobic conditions and resulting odor problems.

After composting is underway, you probably don't need to repeat this measurement because you can observe whether appropriate moisture levels are being maintained. For example, if your compost appears wetter than a wrung-out sponge and starts to smell bad, mix in absorbent material such as brown leaves, dry wood chips, cardboard pieces, or newspaper strips to alleviate the problem.

Since your system blows air through your compost system, you will need to be careful not to create conditions that are too dry for microbial growth. If the temperature drops sooner than expected and the compost feels dry to the touch, moisture may have become the limiting factor. Try mixing in some water and see if the temperature rises again.

ODOR

A well-constructed compost system should not produce offensive odors, although it will not always be odor-free. You can use your nose to detect potential problems as your composting progresses. For example, if you notice an ammonia odor, your mix is probably too rich in nitrogen (the C:N ratio is too low), and you should mix in a carbon source such as leaves or wood shavings.

If compost is too wet or compacted, it will become anaerobic and produce hydrogen sulfide, methane, and other odorous compounds that are hard to ignore. If this occurs in indoor bioreactors, you may wish to take them outside or vent them to the outside, then mix in additional absorbent material such as wood chips or pieces of paper egg cartons. Make sure that you do not pack down the mixture; you want it to remain loose and fluffy to allow air infiltration. In an outdoor compost pile, turning the pile and mixing in additional high-carbon materials such as wood chips should correct the anaerobic condition, although initially the mixing may make the odor even more pronounced.

pH

Why is compost pH worth measuring? Primarily because you can use it to follow the process of decomposition. As composting proceeds, the pH typically drops initially, then rises to 8 or 9 during the thermophilic phase, and then levels off near neutral.

At any point during composting, you can measure the pH of the mixture. While doing this, keep in mind that your compost is unlikely to be homogeneous. You may have found that the temperature varied from location to location within your compost, and the pH is likely to vary as well. Therefore, you should plan to take samples from a variety of spots. You can mix these together and do a combined pH test, or you can test each of the samples individually. In either case, make several replicate tests and report all of your answers. (Since pH is measured on a logarithmic scale, it does not make sense mathematically to take a simple average of your replicates. Instead, either report all of your pH values individually, or summarize them in terms of ranges rather than averages.)

pH can be measured using any of the following methods. Whichever method you choose, make sure to measure the pH as soon as possible after sampling so that continuing chemical changes will not affect your results. Also, be consistent in the method that you use when comparing different compost mixtures.

pH PAPER

The least expensive option for measuring compost pH is to use indicator paper. If the compost is moist but not muddy, you can insert a pH indicator strip into the mixture, let it sit for a few minutes to become moist, and then read the pH using color comparison. If the compost is too wet, this technique will not work because the indicator colors will be masked by the color of the mud.

SOIL TEST KIT

Test kits for analysis of soil pH can be used without modification for compost samples. Simply follow the manufacturer's instructions. These kits also rely on color comparison, but the color develops in a compost- water mixture rather than on indicator paper. Soil pH kits are available from garden stores or biological supply catalogs for $5 or more, depend- ing on the number and accuracy range of the tests.

COMPOST CHEMISTRY

Many chemical changes occur during composting, either relatively rapidly in thermophilic systems or more slowly in worm bins or other systems that do not heat up (Figure 1–3). In all of these compost systems, chemical breakdown is triggered by the action of enzymes produced by microorganisms. Bacteria and fungi secrete enzymes that break down complex organic compounds, and then they absorb the simpler com- pounds into their cells. The enzymes catalyze reactions in which sugars, starches, proteins, and other organic compounds are oxidized, ultimately producing carbon dioxide, water, energy, and compounds resistant to further decomposition. The enzymes are specialized, such as cellulase to break down cellulose, amylase for starches, and protease for proteins. The more complex the original molecule, the more extensive the enzyme sys- tem required to break it down. Lignins, large polymers that cement cellulose fibers together in wood, are among the slowest compounds to decompose because their complex structure is highly resistant to enzyme attack.

As organic matter decomposes, nutrients such as nitrogen, phosphorus, and potassium are released and recycled in various chemical forms through the microorganisms and invertebrates that make up the compost food web. Proteins decompose into amino acids such as glycine or cysteine. These nitrogen- and sulfur-containing compounds then further decompose, yielding simple inorganic ions such as ammonium (NH_4^+), nitrate (NO_3^-) and sulfate (SO_4^{2-}) that become available for uptake by plants or microorganisms.

Not all compounds get fully broken down into simple ions. Microbes also link some of the chemical breakdown products together into long, intricate chains called polymers. These resist further decomposition and become part of the complex organic mixture called humus, the end product of composting.

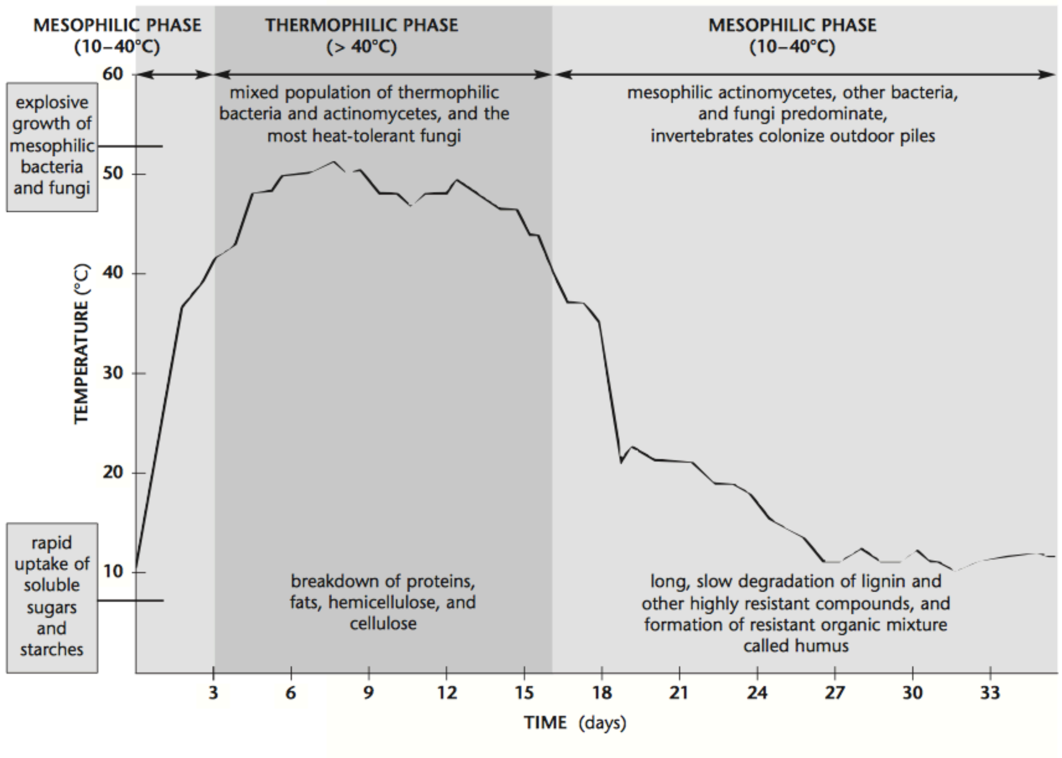
In thermophilic composting, any soluble sugars in the original mixture are almost immediately taken up by bacteria and other microorganisms. The resulting explosive microbial growth causes the temperature to rise. During the thermophilic phase, more complex compounds such as pro- teins, fats, and cellulose get broken down by heat-tolerant microbes. Eventually, these compounds become depleted, the temperature drops, and the long process of maturation begins. During this final phase, com- plex polymers continue slowly to break down. Those most resistant to decay become incorporated into humus.

Reference tables

Trouble Shooting Compost Problems

Symptom	Problem	Solution
Pile is wet and smells like a mixture of rancid butter, vinegar, and rotten eggs	Not enough air	Turn pile
	Or too much nitrogen	Mix in straw, sawdust, or wood chips
	Or too wet	Turn pile and add straw, sawdust, or wood chips; provide drainage
Pile does not heat up	Pile is too small	Make pile larger or provide insulation
	Or pile is too dry	Add water while turning the pile
Pile is damp and sweet smelling but will not heat up	Not enough nitrogen	Mix in grass clippings, food scraps, or other sources of nitrogen
Pile is attracting animals	Meat and other animal products have been included	Keep meat and other animal products out of the pile; enclose pile in 1/4-inch hardware cloth
	Or food scraps are not well covered	Cover all food with brown materials such as leaves, woodchips, or finished compost

The Three Phases of Thermophilic Composting


MESOPHILIC PHASE
(10–40°C)
THERMOPHILIC PHASE
(> 40°C)
MESOPHILIC PHASE
(10–40°C)
explosive growth of mesophilic bacteria and fungi
mixed population of thermophilic bacteria and actinomycetes, and the most heat-tolerant fungi
mesophilic actinomycetes, other bacteria, and fungi predominate, invertebrates colonize outdoor piles
rapid uptake of soluble sugars and starches
breakdown of proteins, fats, hemicellulose, and cellulose
long, slow degradation of lignin and other highly resistant compounds, and formation of resistant organic mixture called humus
TEMPERATURE (°C)
60
50
40
30
20
10
3
6
9
12
15
18
21
24
27
30
33
TIME (days)