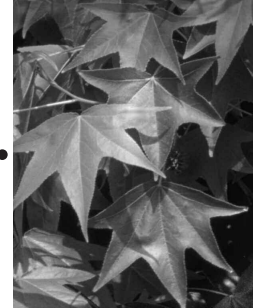


COMPOST PROPERTIES



The properties of compost vary widely, depending on the initial ingredients, the process used, and the age of the compost. What properties are important and how can we measure them? Because compost is used primarily in horticulture and agriculture, properties that affect soils and plant growth are important (Table 5–1). The stability and quality tests outlined in this chapter can be used to tell whether a compost is finished and ready to use with plants. We have also included a series of tests that measure how compost affects specific properties of the soil with which it is mixed. Although not covered here, you may want to determine the nutrient status of your compost or compost/soil mix by using standard soil-nutrient test kits available from garden stores or science supply catalogs.

Table 5–1. Tests of Compost Properties.

Type of Test	Name	Properties Tested	Page #
Stability	Jar Test	odor development	73
	Self-Heating Test	heat production	74
	Respiration Test	CO ₂ generation	75
Quality	Phytotoxicity Bioassay	effects on seed germination and root growth	79
Effects on soil properties	Porosity	volume of pore space	83
	Water Holding Capacity	ability to retain moisture	85
	Organic Matter Content	percent organic matter	87
	Buffering Capacity	ability to resist change in pH	89

One of the questions that arises in composting is how to tell when the process is finished and the compost is ready for use with plants. Thermophilic composting has two end points, one at the end of the rapid decomposition phase, after which the compost is called “stable,” and the second after a several-month period of slower chemical change called “curing.” It is after this curing stage that compost is “mature” and ready for use as a soil amendment to enhance plant growth.

To tell if your compost is mature, follow these steps:

1. Monitor the temperature changes. When compost cools and does not reheat after mixing, the period of rapid decomposition has ended.

2. Observe the appearance. Once compost cools, it has probably shrunk to one-half or less of its original volume. It should look brown and crumbly, and it should have a pleasant earthy odor and no recognizable chunks of the initial ingredients. (Wood chips might remain because they are quite slow to break down. They can be screened out for reuse in another batch of compost.) However, if less resistant ingredients such as leaves or banana peels have not decomposed, the process has slowed down because of some constraint other than available food. The moisture level might have become too low, or perhaps the system was too small for adequate heat retention. You may want to correct any problems by using the troubleshooting guide (Table 4–1, p. 51) before performing tests of the various compost properties.
3. Test the stability. If the compost appears to be fully decomposed, you may wish to test whether it is stable, meaning that the phase of rapid decomposition has been completed and the organic materials are no longer rapidly changing. The **Jar Test**, **Self Heating Test**, and **Respiration Test** provide three different ways to assess compost stability. (If used while unstable, compost can impair rather than enhance plant growth because the continuing decomposition uses nitrate and oxygen needed by plants.)



Research Possibility: *These tests for compost stability were developed for thermophilic composting. Can you design a research project to determine whether these tests are useful for vermicompost?*

4. Assess the quality. Once compost is stable, it is not necessarily ready to use with plants. A several-month period of curing allows ammonia, acetic acid, and other intermediate products of decomposition to transform into compounds that will not suppress seed germination, injure plant roots, or stunt plant growth. There is no definitive end point, and the degree of curing needed depends on how the compost will be used. The **Phytotoxicity Bioassay** provides a means of assessing whether the compost contains any substances that are likely to be detrimental to plant growth.

If the compost appears suitable for use with plants, you may want to test its effects on soil properties, including **Porosity**, **Water Holding Capacity**, **Organic Matter Content**, and **Buffering Capacity**, following the procedures outlined in this chapter. The ultimate test of the quality of a compost is its effect on plant growth (see Chapter 6).



Research Possibility: *How does age of compost affect various compost properties (e.g., phytotoxicity, water holding capacity)? How does the initial mix of ingredients affect compost properties?*



Research Possibility: *What is the relationship of various compost properties to growth of specific plants?*

COMPOST STABILITY

JAR TEST

USE: To determine if organic matter is thoroughly decomposed, based on odor development in an enclosed sample.

BACKGROUND

If compost is not yet fully decomposed, it will smell rotten after being moistened and enclosed for a few days. This is because anaerobic conditions develop and noxious compounds such as methane or organic acids are formed. In contrast, stable compost has an insufficient supply of readily degradable organic matter for significant odors to develop.

MATERIALS

- compost sample
- water
- jar or plastic bag that can be tightly sealed

PROCEDURE

Add enough water to a compost sample so that it feels moist but not soggy. Place it in a jar or plastic bag, seal the container, then let it sit for a week at room temperature (20–30°C).

ANALYSIS

When you open the jar or bag at the end of the week, you will be greeted by a pleasant earthy odor if the compost is mature. If it is immature, the smell will be putrid because continued decomposition has depleted the oxygen and caused anaerobic conditions to develop.

Another sign of instability is any visible growth of mold or other fungus. If the organic matter is fully broken down into humus, it will not look fuzzy or slimy after being enclosed for a week.

SELF-HEATING TEST

USE: To determine if organic matter is thoroughly decomposed, based on heat production by microorganisms under optimal conditions.

BACKGROUND

In compost that contains readily degradable organic matter and sufficient moisture, microbial populations will grow rapidly, and their metabolic heat will cause the temperature to rise. If the compost heats up, this is an indication that the organic matter is not yet fully decomposed.

MATERIALS

- compost sample
- gallon-size jar or thermos
- thermometer with 15-cm or longer probe

PROCEDURE

1. Fill a gallon-size container with compost at 40–50% moisture content (see p. 44 for moisture measurement). If your compost is too dry, add distilled water to achieve 50% moisture. If it is too wet, spread the compost in a thin layer to air dry.
2. Seal the container and insulate it with a layer of foam or other insulating material.

ANALYSIS

After two or three days, open the container and measure the compost temperature. If it is more than a few degrees above the ambient air temperature, the compost is not yet stable, meaning that the available organic matter is not yet fully decomposed.

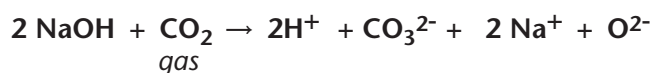
Lack of heating is a more ambiguous result; it does not necessarily indicate that the compost is stable. Perhaps microbial growth was inhibited by lack of nitrogen rather than because the phase of rapid decomposition was complete. See the steps listed on pp. 71–72 to more fully diagnose the meaning of your results.

RESPIRATION TEST¹

USE: To determine if organic matter is thoroughly decomposed, based on CO₂ production.

BACKGROUND

The CO₂ curve during thermophilic composting looks similar to the temperature curve (p. 2). This makes sense, since both heat and CO₂ are released by microbes as they decompose organic matter. The highest rates of CO₂ production occur during the thermophilic phase, when decomposition rates are at their peak. As the quantities of readily degradable organic matter diminish, the rate of CO₂ production also drops. The Respiration Test provides a measure of whether the rate of CO₂ production has dropped low enough for the compost to be considered stable. It works by capturing the CO₂ gas, which reacts with the NaOH in solution to produce carbonic acid, as shown in the following equation:



The goal of the Respiration Test is to determine whether the readily degradable organic matter has been depleted, causing microbial respiration rates to be low. However, you might find low CO₂ production rates even in an immature compost if microbial growth has been inhibited by unfavorable moisture, pH, or oxygen levels during the compost process. You can avoid this type of false result by also testing your compost with the **Jar Test** (p. 73).

MATERIALS

For the incubation:

- balance
- compost sample
- 2 1-gallon jars (plastic or glass), with lids that form tight seals
- 8 100-ml beakers or jars to hold NaOH (each needs to fit inside a gallon jar)
- tall thin jar, such as a jelly jar, to hold compost sample (needs to fit inside gallon jar, alongside one of the NaOH jars)
- 250 ml 1M NaOH
- 10-ml pipette
- incubator (optional)
- You may find it useful to run the respiration test using potting soil or well-aged compost for comparison with your own compost. In this case, you will need an additional gallon jar with a lid, 4 additional NaOH jars, and one more tall thin jar.

For the titrations:

- 300 ml 1M HCl
- phenolphthalein
- burette
- magnetic stirring plate and bar (optional)



PROCEDURE

This procedure takes about 1 1/2 weeks.

Wednesday to Friday: Standardize compost moisture content

Measure the moisture content of your compost following the procedure on p. 44.

Adjust the moisture level of your compost to 50%. This step is important because moisture content will affect the respiration rate and the stability rating. If the sample that you measured was drier than 50%, add water (to your fresh compost, not to the oven-dried sample), stirring in enough distilled water to bring the moisture level up to 50%.

If the measured sample was wetter than 50%, spread fresh compost into a thin layer to air-dry until the desired moisture level is achieved. Take care not to over-dry the compost because this will decrease its microbial activity.

Friday: Assemble the materials

Assemble the materials needed for the incubation vessels and the titrations. Using a 10-ml pipette, transfer 20 ml of 1M NaOH solution into each of eight 100-ml beakers or jars. Tightly seal the jars.

Weekend: Allow sample to equilibrate

The equilibration step is optional if your compost was fresh and close to the 50% moisture level before adjustment. However, if it was frozen or dried rather than fresh, it will need time for the microbes to adjust to the new conditions. After adjusting the moisture content, put the compost into a jar that has ample air space. Close the lid to preserve moisture, and let it sit over the weekend at room temperature in order to equilibrate.

Monday: Begin incubation

1. Stir compost thoroughly, then transfer 25 g into the tall sample jar.
2. In a 1-gallon jar, place next to each other the compost sample and a jar containing NaOH.
3. In a second 1-gallon jar, create a blank by using a jar of NaOH but omitting the jar of compost.
4. Tightly close the lids of the gallon containers. Record the date, time, and air temperature.
5. Store at room temperature (20–30°C), or warmer if possible. You want to provide a constant warm temperature. A sunny windowsill probably is not appropriate because it will get hot during the day but cold at night. An incubator set at 37°C is ideal. One possibility is to create your own incubator using a light or heating pad in a box.
6. Over the next four days, you will measure the amount of CO₂ absorbed by each NaOH trap. This is accomplished by titrating with 1M HCl according to the procedure outlined below.

Tuesday through Friday: Titration

Each day, open the incubation vessel containing compost and remove the jar of NaOH. Add a fresh jar of NaOH and reseal the incubation

vessel. At this point, you can either carry out the titration immediately, or you can save it until Friday if you prefer to carry out all the titrations at once. In this case, tightly seal each jar of NaOH and label it with the date and type of sample. Follow the same procedure for the blank jars containing no compost.

For the titration:

1. Add two to three drops of phenolphthalein indicator to the NaOH solution.
2. Fill the burette with HCl, and zero it. Titrate with acid until the NaOH solution begins to become clear. Agitate by hand or use the magnetic stirrer to mix the solution while adding acid.
3. As the end point gets closer, add acid, one drop at a time, mixing thoroughly between drops. The end point has been reached when the solution turns from pink to clear.

The greater the amount of CO₂ that has been released from the compost sample and absorbed into the solution, the less acid it will take to reach the titration endpoint. This is because as CO₂ is absorbed, the solution becomes increasingly acidic with the formation of carbonic acid (see equation on p. 75).

4. Record the date and time, the molarity of HCl used, and the volume of HCl required to reach the end point.
5. Friday: Clean out the incubation vessel and calculate your results.

ANALYSIS

Calculate the mass of CO₂ generated by your compost sample:

$$\text{CO}_2\text{•C (mg)} = \frac{\text{HCl}_b - \text{HCl}_s}{1000 \text{ ml/l}} \times \text{HCl molarity (mol/l)} \times 12 \text{ g C/mol} \times 1000 \text{ mg/g}$$

where:

HCl_b = ml HCl used in titration of blank

HCl_s = ml HCl used in titration of sample (from jar containing compost)

CO₂•C = mass of CO₂-carbon generated (mg)

which simplifies to:

$$\text{CO}_2\text{•C (mg)} = (\text{HCl}_b - \text{HCl}_s) \times 12$$

Plot CO₂ production over the course of the four days of readings. Compare your data to a baseline obtained by running the respiration test on potting soil or fully decomposed, well-aged compost. This baseline should be a fairly level line close to zero because the microbial activity is minimal in a fully decomposed sample. Unfinished compost should support more microbial growth, so CO₂ production would be expected to be higher.

If you have used an incubator, you can compare the peak respiration rate of your sample to a stability index (Table 5–2). To do this, you will need to express your results in terms of the organic carbon content of the sample. Carrying out the **Organic Matter Content** procedure on p. 87




will give you the percentage of carbon, which you can use to calculate the mass of organic carbon in your sample:

$$\begin{aligned}\text{organic carbon (g)} &= (\text{wet weight of sample})(100 - \% \text{ moisture})(\% \text{ carbon}) \\ &= 25 \text{ g} \times 50\% \times \%C \\ &= 12.5 \times \%C\end{aligned}$$

To standardize your respiration data, divide the $\text{CO}_2 \bullet \text{C}$ values by the mass of organic carbon in the compost sample. These standardized respiration rates can then be evaluated using the compost stability ratings in Table 5–2.

$$\text{mg CO}_2 \bullet \text{C/g organic carbon/day} = \text{mass CO}_2 \bullet \text{C (mg/day)/organic carbon (g)}$$

Table 5–2. Compost Stability Index.*

Respiration Rate (mg $\text{CO}_2 \bullet \text{C}$ / g organic carbon/day)	Rating	Trends		
<2	Very stable	Potential for odor generation 	Potential for inhibi- tion of plant growth 	Potential for inhibi- tion of seed ger- mination 
2–5	Stable			
5–10	Moderately stable			
10–20	Unstable			
>20	Extremely unstable			

**The values in this table are based on incubation at 37°C. If your incubation is carried out at a lower temperature, data interpretation using this table may be misleading.*

COMPOST QUALITY

PHYTOTOXICITY BIOASSAY²

USE: To determine whether a compost contains substances that inhibit seed germination or growth of the radicle (the embryo root).

BACKGROUND

Immature compost may contain substances such as methane, ammonia, or acetic acid that are detrimental to plant growth. These are created during composting and later broken down during the curing phase. Even mature compost may contain substances that inhibit plant growth, such as heavy metals, salts, pesticide residues, or other toxic compounds contained in the original compost ingredients.

One way of testing compost quality is to analyze it chemically. The trouble with this approach is that it is not feasible to test for every compound that might possibly be present. Bioassays, in which test organisms are grown in a water extract of compost, provide a means of measuring the combined toxicity of whatever contaminants may be present. However, they will not identify what specific contaminants are causing the observed toxicity.

To provide a useful measure of toxicity, a bioassay must respond predictably to a range of concentrations of a known compound, as well as to complex mixtures of contaminants. It should also be sensitive, rapid, and cost-effective. Garden cress (*Lepidium sativum*, L.) is commonly used for compost bioassays because it meets these criteria.

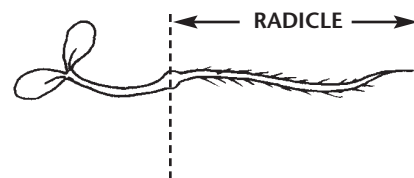
MATERIALS

- compost sample (roughly 200 g)
- small pan (5–10 cm for drying compost)
- balance
- drying oven (105°C)
- funnel
- ring stand with attachment to hold funnel
- double layer of cheesecloth, large enough to line funnel
- 100-ml graduated cylinder
- 1,000-ml beaker or jar
- 200-ml beaker or jar
- 15 9-cm petri dishes
- 15 7.5-cm paper filter disks
- tweezers
- metric ruler or caliper
- cress seeds (*Lepidium sativum*, L.)
- 1 liter distilled water
- litmus paper or pH test kit for water

PROCEDURE

Prepare a compost extraction:

1. In order to standardize the dilution from one compost sample to another, you need to correct for the water content of the compost. To do this, first measure the percent moisture of a compost sample (p. 44).



2. The next step is to calculate how much of your wet compost would be equivalent to 100 g dry weight:

$$\text{___ g wet compost} = \frac{100 \text{ g dry compost}}{(W_w - W_d) / W_w}$$

3. Moisture content varies from one compost to another, and this needs to be taken into account when determining how much additional water to use for the extraction:

$$\text{___ g (or ml) distilled water} = 850 \text{ g total} - \text{___ g wet compost}$$

to be added for extraction *from Step 2*

Add the amount of distilled water calculated in the above equation to the amount of wet compost calculated in Step 2. Stir well, then allow the compost to settle for approximately 20 minutes.

4. Skim off the top 200 ml, and filter it through a double layer of cheesecloth. The filtrate is your extract.
5. Measure and record the pH of the distilled water. If it is not near neutral, either find a new supply or add a small amount of baking soda to buffer the solution, then remeasure the pH.
6. Make a 10x dilution by mixing 10 ml of extract with 90 ml of distilled water.
7. Measure and record the pH of the compost extract and the 10x dilution.
8. In each of 15 9-cm petri dishes, place a 7.5-cm paper filter. Label five dishes "control," another five "10x dilution," and the remaining five "full strength." In addition, you may wish to include information such as the type of compost and the date.
9. To each petri dish, add 1 ml of the appropriate test solution: distilled water, diluted extract, or extract at full strength. Evenly space eight cress seeds in each dish, then cover.
10. Enclose the petri dishes in sealed plastic bags for moisture retention. Incubate for 24 hours in the dark at a steady warm temperature—27°C is ideal. (If you can't maintain this warm a temperature, you may need to lengthen the incubation time.)
11. Open each dish and count how many seeds have germinated. Of these, measure the length of the radicle, the part that looks like a root. Fill in Table 5-3.

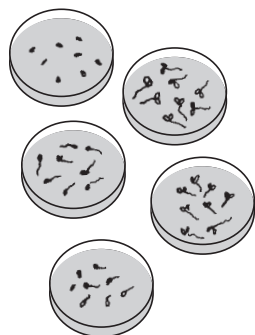


Table 5–3. Germination and Radicle Length in Compost Extract.

Treatment	# Germinated	Mean # Germinated	Radicle Length (mm)								Mean Radicle Length* (mm)
Distilled water											
dish #1											
dish #2											
dish #3											
dish #4											
dish #5											
Filtrate (10x dilution)											
dish #1											
dish #2											
dish #3											
dish #4											
dish #5											
Filtrate (full strength)											
dish #1											
dish #2											
dish #3											
dish #4											
dish #5											

* In calculating mean radicle lengths, include only seeds that germinated.

ANALYSIS

1. For each treatment, calculate the percent germination:

$$\% G = \frac{G_t}{G_c} \times 100$$

in which:

%G = percent germination

G_t = mean germination for treatment

G_c = mean germination for distilled water control

2. Calculate the percent radicle length for each treatment:

$$\%L = \frac{L_t}{L_c} \times 100$$

in which:

$\%L$ = percent radicle length

L_t = mean radicle length for treatment

L_c = mean radicle length for distilled water control

3. For each treatment, calculate the germination index (**GI**) and compare it with the ratings in Table 5–4:

$$GI = \frac{\%G \times \%L}{10,000}$$

Table 5–4. Garden Cress Germination Index.*

Germination Index	Rating
1.0–0.8	No inhibition of plant growth
0.8–0.6	Mild inhibition
0.6–0.4	Strong inhibition
<0.4	Severe inhibition

* It is possible for the germination index to be greater than one, in which case the extract enhanced rather than impaired germination and/or radicle growth.

Consider the following questions:

- How does radicle length compare with germination? (Does one indicator of phytotoxicity appear more sensitive than the other?) Why do you think a combination of the two measurements is used?
- What can you conclude about your compost? Is it suitable for use on sensitive plants?
- What do you think the results would be if you tried this test at various stages during the composting process?



Research possibility: What types of chemical conditions inhibit cress seed germination or radicle growth? Is pH important? Can you identify certain types of compounds, (e.g., salts, nutrients) or conditions (e.g., pH, age of compost) that cause inhibition?



Research possibility: Some leaves, such as those of black walnut or eucalyptus trees, contain chemicals that inhibit growth of other plants. Are these compounds broken down by composting?

EFFECTS ON SOIL PROPERTIES

Compost is referred to as a soil amendment or a substance that is added to soil to improve its physical or chemical characteristics. Many claims are made about how compost enhances soil drainage as well as the ability of soil to hold water so that it is available to microorganisms and plant roots. Are these claims valid? Does compost make clay soils less compact and better drained? Do compost amendments make sandy soils better able to hold water? The tests for **Porosity** and **Water Holding Capacity** will help you to answer questions such as these.

The procedure for measuring **Organic Matter Content** provides a means of comparing different types of compost and soil, or compost in various states of decomposition. Most soils contain less than 20% organic matter, whereas the percentage in compost is much higher. The final test, **Buffering Capacity**, provides a simple measure of one way in which compost can influence the chemistry of soil and of the water that percolates through it.

POROSITY

USE: To measure the volume of pore space in a compost or soil sample.

BACKGROUND

Porosity measures the proportion of a given volume of soil occupied by pores containing air and water. It provides an indication of whether the soil is loose or compacted, which affects both drainage and aeration.

A sandy soil has large particles and large pore spaces whereas a clayey or silty soil has smaller pore spaces. What may be surprising, though, is that the numerous small pores in the clayey or silty soil add up to a larger total pore volume than in a sandy soil. In general, addition of organic matter such as compost increases a soil's porosity.

MATERIALS

- petri dish
- balance with g accuracy
- 100-ml graduated cylinder
- stirring rod slightly longer than graduated cylinder
- sample of compost, soil, or compost/soil mixture

PROCEDURE

1. Fill the graduated cylinder about half full with compost, soil, or compost/soil mixture.
2. Tap the cylinder firmly against your hand several times to settle the sample, then record the volume after it has settled.
3. Pour the sample out and save it to use in Step 5.
4. Fill the graduated cylinder to the 70-ml level with water.
5. Slowly add the compost, soil, or compost/soil mixture saved from Step 3.
6. Stir with rod to break up clumps, then let stand for 5 minutes to allow bubbles to escape.
7. Record the final volume of the compost/water mixture.

ANALYSIS

1. Calculate the volume of solids in your compost or soil:

$$\text{vol. of solids (ml)} = \text{vol. of compost/water mix (ml)} - 70 \text{ ml water}$$

from Step 7

2. Calculate the total pore space volume:

$$\text{vol. of pore space (ml)} = \text{vol. of packed soil (ml)} - \text{vol. of solids (ml)}$$

from equation above

3. Determine the porosity:

$$\text{porosity} = \% \text{ pore space} = \frac{\text{vol. of pore space}}{\text{vol. of packed soil}} \times 100$$

WATER HOLDING CAPACITY

USE: To determine the ability of a soil or compost to retain moisture against drainage due to the force of gravity.

BACKGROUND

The water holding capacity of a soil determines its ability to sustain plant life during dry periods. Water is held in the pores between soil particles and in the thin films surrounding particles. Different types of soil retain different amounts of water, depending on the particle size and the amount of organic matter. Organic matter adds to a soil's water holding capacity because humus particles absorb water.

MATERIALS

- funnel
- tubing to attach to bottom of funnel
- clamp for tubing
- ring stand with attachment to hold funnel
- circular filter paper or coffee filter large enough to line funnel
- 100 ml of air-dried compost, soil, or compost/soil mixture
- balance with g accuracy
- 2 250-ml beakers
- 100-ml graduated cylinder
- stirring rod slightly longer than graduated cylinder

PROCEDURE

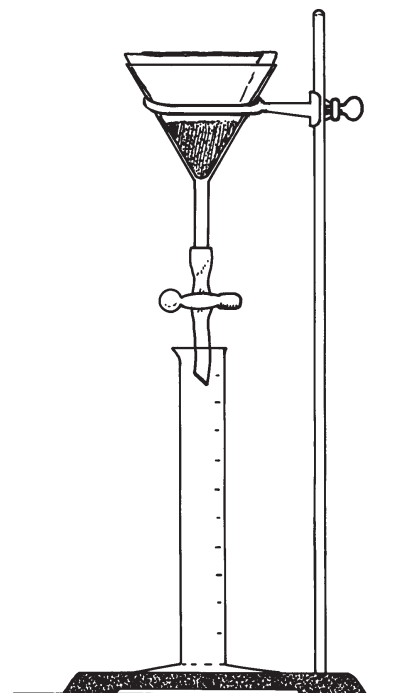
1. Spread out and thoroughly air-dry the compost, compost/soil mixture, or soil samples.
2. Attach tubing to the bottom of the funnel and clamp it shut. Attach the funnel to the ring stand, suspended above the graduated cylinder.
3. Line the funnel with filter paper or a coffee filter.
4. Place 100 ml of air-dried compost or compost/soil mixture into the funnel.
5. Using the graduated cylinder, measure 100 ml of water. Gradually pour enough water into the funnel to cover the compost sample. Record the amount of water added.
6. Stir gently, then let sit until the sample is saturated.
7. After the compost is saturated, release the clamp to allow excess water to flow into the graduated cylinder.
8. After the dripping stops, record the amount of water that is in the graduated cylinder.

ANALYSIS

1. Calculate how much water was retained in the 100-ml sample of compost or soil:

__ml water retained/100-ml sample =

$$\frac{\text{water added (ml)}}{\text{from Step 5}} - \frac{\text{water drained (ml)}}{\text{from Step 8}}$$



2. Water holding capacity is expressed as the amount of water retained per liter of soil, so the next step is to multiply by 10 to convert from the 100-ml sample to a full liter:

$$\text{water holding capacity (ml/l)} = 10 \times (\text{__ml water retained/100 ml sample})$$

from equation above

3. Compare the water holding capacities of various types of soil, with and without compost added.

ORGANIC MATTER CONTENT

USE: To determine the organic and mineral fractions of a compost or soil sample.

BACKGROUND

When an oven-dry sample of soil or compost is heated to 500°C, organic matter is volatilized. These “volatile solids” make up the organic fraction of soil, including living biomass, decomposing plant and animal residues, and humus, the relatively stable end product of organic decomposition. The residue left after combustion is ash, composed of minerals such as calcium, magnesium, phosphorus, and potassium. In general, 50–80% of the dry weight of a compost represents organic matter that is lost during combustion.

Organic matter makes up a much lower percentage of the dry weight of soils. Most are less than 6% organic matter, with higher percentages occurring in bog soils. Surface soils have higher organic matter contents than subsoils because humus is formed through decomposition of accumulated residues of crops or natural vegetation. The most productive soils are rich in organic matter, which enhances their capacity to hold both water and nutrients in the root zone where they are available to plants.

MATERIALS

- 10-g sample of compost or soil
- porcelain crucible
- tongs
- desiccator (optional)
- laboratory oven, Bunsen burner, or hot plate

If a Bunsen burner or hot plate is used for combustion:

- goggles
- glass stirring rod
- fan or other source of ventilation

PROCEDURE

1. Weigh the porcelain crucible, then add about 10 g of compost or soil.
2. Dry the sample for 24 hours in a 105°C oven.
3. Cool in a desiccator (or a nonhumid location), and reweigh.
4. Ignite the sample by placing it in a 500°C oven overnight. Using tongs, remove the crucible from the oven, and again place it in a desiccator or nonhumid location for cooling. Weigh the ash. A pottery kiln can be used if a laboratory oven is not available.

Another option is to ignite the sample using a Bunsen burner or a hot plate. To avoid breathing the fumes, set up a fan or some other type of ventilation system. Wearing goggles, heat the sample gently for a few minutes, then gradually increase the heat until the crucible turns red. Stir the compost occasionally, and continue the combustion until the sample becomes light colored and you can no longer see vapors rising.

ANALYSIS

Calculate the percentage of organic matter using the following equation:

$$\text{organic matter (\%)} = \frac{W_d - W_a}{W_d} \times 100$$

in which:

W_d = *dry weight of compost*

W_a = *weight of ash after combustion*

How does the organic matter content of your compost compare with that of the soils you tested? Does the organic matter content diminish during the composting process, or does it just change in form and chemical composition?

If you divide the percentage of organic matter by 1.8 (a number derived through laboratory measurements), you can get an estimate of the percentage of carbon in your sample:

$$\% \text{ carbon} = \frac{\% \text{ organic matter}}{1.8}$$

This may be useful if you know the C:N ratio and you want to figure out the percentage of nitrogen:

$$\% \text{ nitrogen} = \frac{\% \text{ carbon}}{\text{C : N}}$$

BUFFERING CAPACITY

USE: To determine whether adding compost to soil increases the soil's capacity to resist pH change.

BACKGROUND

Finished compost usually has a pH around neutral, in the range of 6–8. It also tends to have a high buffering capacity, meaning that it resists change in pH. Soils with high buffering capacities do not experience drastic pH fluctuations that may be detrimental to microbial life and plant growth. Buffering capacity needs to be taken into account when determining the amounts of lime, sulfur, or other chemicals that are applied to soil to alter its pH.

The buffering capacity of soil may be provided by either mineral or organic components. Quartz sand has almost no buffering capacity, so even small additions of acid will drop the pH of the sand and its drainage water. In contrast, a sand made of crushed limestone is highly buffered because it contains calcium and magnesium carbonates. The addition of organic matter such as compost tends to increase a soil's buffering capacity.

This procedure provides a way of demonstrating the concept of a buffer. Students may be surprised to discover that compost with pH near 7 can neutralize an acidic solution. They might think that the compost would need to be basic to counteract the acidity of the solution, or they might expect the pH of the compost to drop corresponding to the increase in solution pH.

MATERIALS

- funnel
- ring stand with attachment to hold funnel
- circular filter paper or coffee filter large enough to line funnel
- 125-ml samples of compost and sand
- 250-ml beaker
- acid solution: add 1 ml 1M H_2SO_4 to 500 ml distilled water
- pH meter, test kit, or litmus paper

PROCEDURE

1. Attach the funnel to the ring stand, suspended above one of the beakers.
2. Line the funnel with filter paper or coffee filter.
3. Measure the pH of the compost (see p. 54).
4. Measure the pH of the H_2SO_4 solution.
5. Place a 125-ml sample of compost into the funnel.
6. Slowly pour a few milliliters of H_2SO_4 solution into the compost in the funnel. Continue adding small amounts of acid, stopping as soon as the liquid begins to drain into the beaker below.
7. Test the pH of the drainage solution and of the compost sample.
8. Optional: Repeat Steps 4–7, using sand in place of compost, then using a 50/50 mixture of sand and compost.

ANALYSIS

Did the pH of the compost change after application of the H_2SO_4 solution? What about the sand? What happened to the pH of the acid as it filtered through the compost or sand?

What can you conclude about the buffering capacity of the compost and the sand? Which would be better capable of withstanding the effects of acid rain? Which would be more resistant to pH change through a soil amendment such as lime?



Research possibility: *Finished compost is near neutral pH. Can you design an experiment to answer one or more of the following questions: Is compost detrimental to use on acid-loving plants such as blueberries or azaleas? Does compost buffer the soil pH, making it harder to provide acidic conditions? How does it compare to peat moss in this regard?*

¹ The Respiration Test is adapted from Bartha, R., and D. Pramer. 1965. Features of a flask and methods of measuring the persistence and biological effects of pesticides in soil. *Soil Science* 100:68–70.

² The Phytotoxicity Bioassay is adapted from: Zucconi, F., A. Pera, M. Forte, and M. de Betoldi. 1981. Evaluating toxicity of immature compost. *BioCycle* 22(2):54–57.