Extension FactSheet

ANR-15-03

The Ohio State University Extension

School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210-1085

Testing Compost

Maurice E. Watson
Extension Soils Specialist

Importance of Testing Compost

The aerobic composting process involves the oxidation of relatively complex organic compounds by microorganisms, resulting in simpler organic compounds than originally present. The compost produced has many chemical and physical characteristics that allow it to be used in different ways. The primary reasons for testing compost are 1) worker safety, 2) avoidance of environmental degradation, 3) maintenance of the composting process, and 4) verification of product attributes. Product attributes are those attributes that relate to safety requirements and to the marketing and use of the compost. The main reasons why compost is not tested are 1) it is too costly or 2) producers and users are uncertain as to what parameters to test and what the results mean. Knowledge about how the compost will be used is important in deciding which parameters should be measured.

Principal uses of compost are to mix it with soil or to use it as a mulch. However, just because an organic material has undergone the composting process and is designated a "compost," doesn't necessarily mean that its use will be beneficial. The chemical and physical characteristics of compost depend on the kind of material originally used. This original material is usually referred to as feedstock. Chemical and physical constituents of some composts can be detrimental to the soil environment. Consequently, since characteristics of compost can vary greatly, tests have been developed to measure various important parameters of the compost. Parameters that are typically measured are shown in Table 1. Therefore, the main purpose of testing compost is to determine the concentrations of components and characteristics of the compost so that an evaluation of its quality can be made. Knowledge of a compost's quality enables it to be used responsibly.

Currently there are no nationally mandated requirements for testing composts. However, many states have established their own testing requirements. In some cases, classes of compost have been established with specific tests required for each class (1).

In general, tests for composts can be organized into those that evaluate the chemical, physical, or biological characteristics of compost. A discussion of tests in each of these categories follows.

Tests of Chemical Characteristics

pH and nutrients—Typical ranges for pH of compost and the concentration of macronutrients in compost are given in Table 1. However, these ranges can be substantially different depending on the kinds of feedstock used. The predominant use of compost is to mix it with soil to form a good growing medium for plants. Whether or not the compost-soil mixture is a good medium for plants depends on the quality and quantity of the compost used. The pH value of the compost is important, since applying compost to the soil can alter the soil pH which in turn can affect the availability of nutrients to the plant (2, 3). A pH of 7.0 is neutral in reaction. A pH less than 7.0 designates an acid condition, while a greater value than 7.0 is an alkaline condition. Deciduous leaf compost tends to be slightly alkaline while coniferous leaf compost is acid. How the soil pH is altered when compost is mixed with the soil depends on the pH of the soil, its buffering capacity, the pH of the compost, how much compost is used and how thoroughly it is mixed with the soil, and how rapidly the compost breaks down in the soil environment. The pH of the soil-compost mixture should be determined with a soil test.

Important nutrients are contained in compost. The concentrations of both the macronutrients and micronutrients can be determined by testing the compost. Nitrogen, phosphorus, po-

Table 1. Typical ranges of test parameters in quality compost (17).

Test Parameter	***Range***
pH	6.8–7.3
Soluble Salts	0.35–0.64 dS/m (mmhos/cm) (1:5 v/v method)
Nitrogen	1.0–2.0%
Phosphorus	0.6–0.9%
Potassium	0.2–0.5%
Moisture Content	45–50%
Organic Matter	35–45%
Particle Size	passes 3/8" screen
Bulk Density	900–1,000 lbs/yd^3

tassium, calcium, magnesium, and sulfur are designated as macronutrients. The micronutrients are manganese, iron, zinc, copper, and boron. Usually the unit of expression is percent for macronutrients and mg/Kg (parts per million) for micronutrients. All of these nutrients are important to growing plants, but the macronutrient concentration of compost is usually of major interest (3). Of the macronutrients, the availability of nitrogen to plants is the most complex. Nitrogen can be found in two significant forms in the compost. It can be present in the inorganic forms of nitrate-nitrogen and ammonium-nitrogen. Immature compost will contain more ammonium-nitrogen than a mature compost. Most of the nitrogen in compost is bound within organic molecules. This form of nitrogen is often referred to as "organic nitrogen." The inorganic nitrogen forms are immediately available for absorption by plants while the availability of the organic form depends on how rapidly the microorganisms break down the compost (4). The rate of breakdown will depend on many factors, predominant of which are temperature and moisture. All the organically bound nitrogen in the compost is usually not available the first growing season. Depending on the feedstock, approximately 10 to 30% of the organic nitrogen is available to the plant during the growing season (4).

The nutrients of phosphorus and potassium are also very important in compost. A high percentage of these nutrients is usually available to the plant the first growing season. However, the availability may depend on the kind of soil, and the moisture and temperature of the soil (5, 6, 7). The other macronutrients of calcium and magnesium in compost are similar in their plant-availability to that of phosphorus and potassium.

The concentrations of micronutrients found in compost depend on the feedstock used. Very high concentrations of micronutrients can be toxic to plants. The most toxic are boron and copper. However, these elements are bound in the organic matrix of the compost and are not readily available to the plants. Whether or not the compost should be tested for these nutrients is largely dependent on the feedstock used and the intended use of the compost (8).

Soluble salts—The soluble salts test is a very important test. A high concentration of soluble salts in the plant growth medium is detrimental to germinating seeds and to plant growth. Death of the plant can result if the soluble salt level is too high (Table 2). Soluble salt is a term used for chemical compounds, predominantly nutrients, that dissolve in water and form ions. Once the compounds have ionized, electrical current can be conducted through the solution. The soluble salts test measures the conductance of electrical current in a liquid slurry or extract from the compost. Thus, the test is often called an "electrical conductivity test." The unit of conductance is decisiemens per meter (dS/m), equivalent to mmhos/cm. The greater the electrical conductance, the greater the concentration of soluble salts in the compost. It is a measure of the combined amount of salts in the compost. Salts that become soluble and commonly found in compost are potassium chloride; sodium chloride; various nitrates; compounds involving sulfates; and calcium, magnesium, and potassium carbonates. The kinds of feedstock influence which salt will be predominant. Feedstock that has a rich nutrient source, such as animal manure, will result in compost with higher soluble salt levels than those not containing animal manure. If animal fluids make up part of the feedstock, then the compost can be especially high in the soluble salts of sodium chloride and potassium chloride.

Composts that are high in soluble salts can be used with soil. However, superior management is required as compared to compost not containing high soluble salts concentration. Less amount of compost containing high levels of soluble salt should be mixed with soil as compared to composts with low soluble salt concentrations. Generally, compost containing concentrations of soluble salts of 0.35 dS/m or less is safe to use (Table 2). More intensive management in using the compost is required when the range is from 0.36 to 0.65 dS/m. The concentration of soluble salts needs to be reduced prior to use when greater than 0.65 dS/m. Leaching the compost with water will reduce the concentration of soluble salts. In addition, the usefulness of the compost will depend on the soil to which it is added, the amount and frequency of adding the compost to the soil, the plant's tolerance to high salt concentrations, and the amounts and frequency of irrigation water or rainfall.

Carbon/Nitrogen ratio—The carbon/nitrogen ratio is not a test in itself, but requires two separate tests: the test for organically bound carbon and the test for total nitrogen. This ratio provides an indication of the kind of compost and how it must be managed when mixed with soil. Generally, composts that have carbon/nitrogen ratios greater than 30 to 1 will require additional nitrogen when mixed with the soil for the purpose of growing plants. The larger the ratio, the greater the amount of nitrogen that will be needed. The extra nitrogen allows the soil microorganisms to multiply rapidly, without taking nitrogen from the soil and causing nitrogen deficiency in the plant.

Table 2. Interpretation of soluble salt concentrations of compost if used as greenhouse growth media (18).

*Soluble Salts Results (1:5 v/v method)**	*Interpretation***
dS/m (mmhos/cm)	
0.0–0.12	Very low; indicates very low nutrient status; seeds may germinate
0.13–0.34	Low; suitable range for seedlings and sensitive plants; plants may show deficiency and grow slowly
0.35–0.64	Desirable range for most plants, but upper range may be too high for some plants
0.65–0.89	Higher than desirable for most plants; loss of vigor in upper range
0.90–1.10	Reduced plant growth and vigor; wilting and marginal leaf burn
1.10+	Plant growth severely stunted; plants usually die

* One volume of compost to five volumes of water
** Interpretation is different for other methods

Heavy metals—A major concern about heavy metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium) is that if their concentrations in edible portions of plants are excessively high, then there can be a danger to humans. A plant root mechanism operates to help protect the plant from high concentrations of some heavy metals. The plant will exhibit toxicity symptoms or even death before the heavy metal concentration would become high enough to be detrimental to the human food chain. However, some heavy metals exhibit an exception to the root barrier protection mechanism. They can be present at concentrations in the plant that would be harmful to human health without being toxic to the plant. Cadmium is a prime example. In some plants, selenium can also accumulate to very high concentrations without showing toxicity.

Because of the toxic nature of excessive concentrations of heavy metals, governmental environmental protection agencies are in the process of establishing upper concentration limits in compost (Table 3).

Table 3. Heavy metal concentration limits for compost proposed by the Ohio Environmental Protection Agency (1).

Heavy Metal	*(mg/Kg or ppm)*
Arsenic	41
Cadmium	35
Copper	1500
Lead	300
Mercury	7.8
Nickel	420
Selenium	100
Zinc	2800

Tests of Physical Characteristics

Air capacity, bulk density, water infiltration and conductivity, and water holding capacity—These tests provide information on how well the compost will retain air and water. The pore space between the compost particles should be such that optimum retention of air and water are attained. If the particles are too close together, then the compost tends to compact, resulting in low air capacity, low water infiltration and water holding capacity. These characteristics are especially important if the growing medium will be solely or principally compost. Different kinds of compost will exhibit differences in these characteristics.

Solids content—This test measures the amount of solid material in the compost and is the converse of moisture content. The quantity of solids is usually expressed as a percentage of the sample weight, oven-dried at 70±5°C to constant weight. The moisture content is the value obtained from subtracting the percent solids from 100%. Knowledge of the solids content is important in storing, handling, and using the compost. Compost that has become very dry will be very dusty and it will often be resistant to rewetting and good water retention. Compost that is extremely wet for a few days will become anaerobic with the production of offensive odors.

Ash content—This test is a measure of the inorganic residual material left after burning the oven-dried compost sample at 500±50°C. The amount of ash will vary depending on the kind of feedstocks composted. Feedstocks that have a high mineral constituent, e.g., that contain soil, will have a high ash content.

Total volatile solids and biodegradable volatile solids—This test is the converse to the ash test in that it measures the quantity of the organic constituents converted to carbon dioxide at 550°C, essentially the same as the Loss on Ignition organic matter test for most compost (16) . When the inerts are removed from the sample prior to combustion, the amount of dry weight converted to carbon dioxide is termed biodegradable volatile solids. Total volatile solids are measured when the inerts are not removed prior to combustion. The results from these tests along with the results from the ash test provide information about the completeness of the composting process. However, knowledge about the kind of feedstock used along with the information from these tests is important in evaluating compost regarding its intended use.

Film plastics—This test provides an estimation of the surface area of the compost sample attributed to film plastics. Composts that contain substantial amounts of film plastics are considered poorer quality than those without film plastics. The film plastic is not only of aesthetic concern but in large enough quantities can affect soil color. Accumulations in the cultivated layer of the soil can become a moisture barrier and can wrap in tillage implements. In addition, pieces of film plastic can be injurious to birds and animals if they consume the compost.

Glass shards, metal fragments, and hard plastics inerts—This test provides an estimate of inert materials that will not break down during the composting process. Consequently, a significant percentage of these inerts in the compost will make the compost difficult and dangerous to handle, resulting in compost of little value.

Organic Chemical Contaminants

The effectiveness of the degradation of organic chemical contaminants by the composting process depends on the chemical structure of the contaminants. Tests are available to determine the concentration levels of various organic chemical contaminants that may be in some composts. Testing protocols are available for chlorinated herbicides, dioxins, organochlorine pesticides, organophosphorus pesticides, polychlorinated biphenyls, semi-volatile organic compounds, and volatile organic compounds. The importance of whether or not a compost should be tested for any or all of these compounds largely depends on the feedstocks involved and the intended use of the compost.

The most widespread concern in regard to organic contaminants involves residues of herbicides. The composting process generally does a good job of reducing herbicide residues below concentration levels that would be harmful to plants if the compost was used in the growing medium. It has been reported that diazinon and 2,4-D, the most common herbicides, are at or near the level of detection after composting (9). Other reviews have reported that although pesticide residues are found in composting feedstocks, herbicides are degraded sufficiently during composting and rarely detected (10, 11). In a study that involved testing 12 compost samples for 200 pesticides, only four pesticides were detected, mainly persistent chlorinated insecticides

(12). The use of organochlorine class of insecticides has been banned in the United States for many years. However, in the last few years two persistent herbicide residues have been found in some composts at parts per million to sub-parts per million concentrations which are harmful to some plants. These residues are clopyralid and picloram and are from herbicides designed for broadleaf weeds found in pastures and lawns (13). The common names of the herbicides containing these compounds are Confront, Curtail, Stinger, Millenium, Tansline, Tordon, and Grason (14). It is thought that these residues can be harmful to plants, depending on the kind of plant, for a year or more.

Consequently, because of the resistance of these herbicide residues to breakdown, it is important to test compost if it is thought that the compost may contain these compounds. Laboratory tests can be performed to determine the concentration of clopyralid and picloram, but they may be very expensive, depending on the detection level sought. Before doing a laboratory test, it is best to perform a bioassay with the compost (15).

Pathogens

Organisms and microorganisms that can cause infection or disease in a susceptible host are pathogens. Examples of pathogens are yeasts, bacteria, mold, fungi, virus, protozoa, and helminths. Pathogens are rarely found in compost at concentrations that would cause a problem in using the compost, provided the composting process is completed correctly. However, tests for pathogens in compost are available if it is suspected that there may be a problem.

Miscellaneous Characteristics

Indirect tests can be conducted that will help determine various quality characteristics of compost. These are the seed germination test that measures the ability of seeds to germinate and grow either directly in the compost or a water extract of the compost. A respirometry test is used to estimate the degree of maturity of compost. Crude tests for odor will also allow a rough judgment to be made about the quality of compost.

Composting organic waste materials is an excellent way to reduce the volume of the waste and often to make it more useable than in its original form. However, since the composting process tends to concentrate many chemical constituents and alter physical characteristics, testing for specific parameters is important. Since composts are variable, testing is necessary to determine the values of the parameters and the variability of these parameters through time. Compost producers that maintain records of test results over time allow for responsible use of compost.

Details for individual tests of compost can be found in the U.S. Composting Council's manual entitled "Test Methods for the Examination of Composting and Compost" (TMECC)(16).

References

1. Ohio revised code 3745-27-46, proposed rules.
2. Tester, C. F. 1990. Organic amendment effects on physical and chemical properties of a sandy soil. Soil Sci. Soc. Am. J. 65:1284-1292.
3. Tisdale, S. L., W. L. Nelson, and J. D. Beaton. 1985. *Soil Fertility and Fertilizers*, Fourth Edition. Macmillan Publishing Co., New York, 754 pp.
4. Hadas, A. and R. Portnoy. 1994. Nitrogen and carbon mineralization rates of composted manures incubated in soil. J. of Environ. Qual. 23:1184-1189.
5. Hue, N. V., H. Ikawa, and J. A. Silva. 1994. Increasing plant-available phosphorus in an ultisol with a yard-waste compost. Comm. Soil Sci. Plant Anal. 25:3291-3303.
6. Wen, G., T. E. Bates, R. P. Voroney, J. P. Winter, and M. P. Schellenbert. 1997. Comparison of phosphorus availability with application of sewage sludge, sludge compost, and manure compost. Comm. Soil Sci. Plant Anal. 28:1481-1497.
7. Wen, G., J. P. Winter, R. P. Voroney, and T. E. Bates. 1996/1997. Potassium availability with application of sewage sludge, and sludge and manure composts in field experiments. Nutrient Cycling in Agroecosystems 47(3):233-241.
8. Ryan, J. A. and R. L. Chaney. 1993. Regulation of municipal sewage sludge under the clean water act section 503: A model for exposure and risk assessment for MSW-compost. P. 422-506. *In* H. A. J. Hoitink and H. M. Keener (ed.) Science and engineering of composting: design, environmental, microbiological and utilization aspects. Renaissance Publishing, Worthington, OH.
9. Michel, F. C., D. Graeber, L. J. Forney, and C. A. Reddy. 1996. The fate of lawn care pesticides during composting. BioCycle. 37(3):64-67.
10. Buyuksonmez, F., R. Rynk, T. G. Hess, and E. Bechinski. 1999. Occurrence, degradation and fate of pesticides during composting. Part I: Composting, pesticides and pesticide degradation. Compost Science and Utilization. 74(1):66-82.
11. Buyuksonmez, F., R. Rynk, T. G. Hess, and E. Bechinski. 2000. Occurrence, degradation and fate of pesticides during composting. Part II: Occurrence and fate of pesticides in compost and composting systems. Compost Science and Utilization. 8(1):61-81.
12. Richard, T. and M. Chadsey. 1990. Environmental impact of yard waste composting. BioCycle. 31(4):42-47.
13. Bezdicek, D., M. Fauci, D. Caldwell, and R. Finch. 2000. Compost quality: New threats from persistent herbicides. Agrichemical and Environmental News. 174:9-13.
14. Bezdicek, D., M. Fauci, D. Caldwell, R. Finch, and J. Lang. 2001. Persistent herbicides in compost. Biocycle. 42(7):25-30.
15. Fauci, M., D. Bezdicek, D. Caldwell, and R. Finch. 2002. Development of plant bioassay to detect herbicide contamination of compost at or below practical analytical detection limits. Environmental Contamination and Toxicology. 68:79-85.
16. Thompson, W. H., P. B. Leege, P. Millner, and M. E. Watson. 2002. Test methods for the examination of composting and compost. U.S. Composting Council. [Online]. Available at http://www.tmecc.org/tmecc/ (posted 1 May 2002; verified 15 Oct. 2002).
17. Alexander, R. A. 1994. Standards and guidelines for compost use. Biocycle. 35(12):37-41.
18. Warncke, D. D. and D. M. Krauskopf. 1983. Greenhouse growth media: Testing and nutrition guidelines. Michigan State Univ. Coop. Ext. Serv. Bull. E-1736.

Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension

TDD No. 800-589-8292 (Ohio only) or 614-292-1868/605709139670

4/03—klw