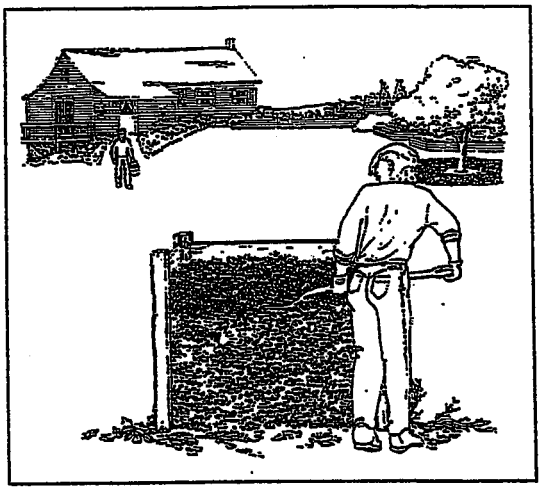
MAKING AND MAINTAINING A COMPOST PILE

From: Composting to Reduce the Waste Stream
Available from Cornell Cooperative Extension



This fact sheet discusses materials, construction, maintenance, and troubleshooting for a compost pile. These principles can be applied to turning units, holding units, and heaps. Turning a compost pile weekly can yield compost in one to two months with the right combination of materials an moisture content. Without turning, decomposition takes six months to two years. Excellent-quality compost can be made either way. When selecting a composting method, consider economy, neatness, permanence, need for finished compost, and time available for maintenance.

MATERIALS

The art of composting is discovering the mix of materials that will provide the best environment for the compost process.

Almost all natural, organic material will compost, but not everything belongs in the compost pile. Some wastes attract pests; others contain pathogens that can survive the compost process, even if the pile gets hot.

As shown in Table 1, fatty food wastes, such as meat or bones, should be avoided. They attract rodents, raccoons, dogs, cats, flies, and other pests; and they can cause odors. Cat and dog manures can contain harmful pathogens that are not always killed by the heat of the compost pile.

Plants harboring diseases, or suffering severe insect infestations, should not be added to the compost pile, Certain pernicious weeds, including morning glories, buttercups, and grasses (such as quack grass) with rhizomatous root systems, may not be killed if the pile does not heat up. Piles containing these types of weeds must be turned to encourage the high pile temperatures that will kill them.

Another consideration in choosing materials to go into the compost pile is the time they need to break down. Woody materials, such as wood chips, branches, twigs, and paper, can take up to two years to break down unless they are finely chipped or shredded. Their high C:N ratios indicate that they require a lot of nitrogen to decompose, so they may slow the decomposition of other materials. Other materials that break down slowly include: corn cobs, husks, and stalks; sawdust; straw; apple pomace; and some nut shells. These materials should be cut into small pieces to increase their surface areas and mixed with high-nitrogen materials, such as manure or fresh grass clippings.

TABLE 1

MATERIALS THAT SHOULD AND SHOULD NOT BE A IN COMPOST PILE

Yes		No	
Aquatic weeds	Leaves	Butter	Mayonnaise
Bread	Paper	Bones	Meat
Coffee grounds	Sawdust	Cat manure	Milk
Egg shells	Straw	Cheese	Oils
Evergreen needles	Sod	Chicken	Peanut butter
Fruit	Tea leaves	Dog manure	Salad dressing
Fruit peels and rinds	Vegetables	Fish scraps	Sour cream
Garden wastes	Wood ash	Lard	Vegetable oil
Grass clippings	Wood chips		

Materials that break down slowly should be mixed with easily decomposed materials to allow the pile to get hot. If a high-nitrogen source is not available, high-carbon wastes should be used as mulches. While materials such as wood chips and straw break down slowly, they also are bulking agents that improve the pile structure, allowing air circulation. If composting dense, high-nitrogen materials, such as manure, the addition of a bulking agent may be required to facilitate the process.

The art of composting is discovering the mix of materials that will provide the best environment for the compost process. Mixing materials of different sizes and textures helps to provide a structurally stable and well-drained compost pile. Diverse material also helps maintain the right C:N ratio and an efficient process.

Some gardeners are concerned about composting grass clippings that have been treated with pesticides. Table 2 lists the persistence of some common lawn herbicides in soil. Composting, as an accelerated decomposition process, biodegrades many compounds faster that soil degradation. If yard waste has been composted at least one year, pesticide residues should not be a problem when the compost is used.

TABLE 2

PERSISTENCE OF SOME COMMON HERBICIDES IN SOIL

Common Name	Trade Names	Longevity in Soil (Months)
Benefin	Balan, Balfin	4-8
DCPA	Dacthal	4-8
Bensulide	Betasan, Prefar	6-12
Glyphosate	Roundup, Kleenup	<1
2, 4-D	(many formulations)	1-2
MCPP	(many formulations)	1-2
Dicamba	Banval	3-12

Source: Rosen, et. al., 1988.

ADDITIVES

Inoculants, activators, and lime are compost pile additives. Inoculants are - dormant microorganisms; activators contain sugar or a nitrogen source, such as ammonium sulfate; and lime increases compost pile pH. Inoculants are rarely needed, since earth, leaves, kitchen

scraps, and finished compost already contain ample bacteria that can work readily on their own. The only activator that may be needed is a nitrogen source, since nitrogen is usually the limiting nutrient. Nitrogen accelerates the decomposition process if the materials to be composted do not include a material with a low C:N ratio, such as manure or grass clippings. Other nutrients added through the application of organic or chemical fertilizers will have little effect on the composting process.

If additional nitrogen is needed, approximately 0.15 pounds actual nitrogen per 3 bushels (approximately 4 cubic feet) of leaves should be added. Table 3 lists estimated amounts of particular nitrogen sources that should be added to leaves. For instance, 7 ounces (about 1 cup) of ammonium nitrate is equivalent to 0.15 pounds. The nitrogen source is usually mixed with water and sprinkled on a compost pile as it is constructed.

During the initial stages of decomposition, the compost pile produces organic acids and the pH may drop. However, since composting organisms perform best at a pH between 4.2 and 7.2, it is best not to add lime to adjust pH. Adding lime converts ammonium nitrogen to ammonium gas, creating an odor problem. As the compost matures, pH will rise, typically to between 6.0 and 8.0 for finished compost.

TABLE 3

AMOUNTS OF VARIOUS NITROGEN SOURCES NEEDED

To Apply 0.15 Pounds (2.4 oz) Nitrogen

Nitrogen Source	%Nitrogen	Ounces to Apply
Ammonium nitrate	33	7.0
Calcium nitrate	15	16.0
Urea	46	5.2
Dried blood	12	20.0
Fish meal	10	24.0

LOCATION

A good location is helpful for a successful compost pile. Direct sunlight in the summer dries the pile. Exposure to high winds can dry and cool the pile, slowing the decomposition process. The pile location should not interfere with lawn and garden activities. Water should be readily available. There should also be enough space for temporary storage of organic wastes. Good drainage is important; otherwise, standing water could impede the decomposition process. The compost pile should not be located against wooden buildings or trees; wood in contact with compost may decay.

VOLUME

A pile should be large enough to hold heat and small enough to admit air to its center. As a rule of thumb, the minimum dimensions of a pile should be 3 feet x 3 feet x 3 feet (1 cubic yard) to hold heat. The maximum dimension to allow air to the center of the pile is 5 feet x 5 feet x any length.

A pile should be large enough to hold heat and small enough to admit air to its center.

If space is a limiting factor, the pile sides should be insulated so that higher temperatures can be maintained in a much smaller volume. Smaller, commercially available units can be insulated with foam board. Piles larger than 5 feet tall and wide may need to be turned to prevent their centers from becoming anaerobic. As the material decomposes, the pile will become smaller.

PILE CONSTRUCTION

Compost piles can be in batches or by placing materials in the piles as they become available. The batch method accelerates the composting process if the combined materials have the right C:N ratio and if the materials are mixed.

PILE MAINTENANCE

Maintenance of the compost pile involves turning the pile and adding water to maintain conditions conducive to the composting process. If the pile is not turned, decomposition will occur, but at a slower rate. The following maintenance procedure will yield compost in the shortest time.

About a week after construction of the compost pile, the pile should be opened to the air and any compacted material should be loosened. Then the pile should be reconstructed; material previously on the top and sides of the pile should be moved to the center.

Maintenance of the compost pile involves turning the pile and adding water to maintain conditions conducive to the composting process.

At the second turning (after about another week), the material should be a uniform coffee-brown color and moist. The relatively undecomposed outer layer can be scraped off and turned back into the center of the pile. The center material should be spread over the outer layer of the reconstructed pile. By the third turning, the original materials should not be recognizable. At each turning, the moisture content should be checked using the squeeze test. The material should feel damp to the touch, with just a drop or two of liquid expelled when the material is tightly squeezed in the hand. Water should be added, if necessary.

During the first few weeks of composting, the pile should reach a peak temperature of about 140°F. If temperatures surpass 140°F, the pile should be turned to cool it off. Extremely high temperatures can kill many beneficial organisms. If the pile does not reach at least 120°F, more nitrogen or water may be needed. Cold weather can also prevent the pile from heating. Piles that give off strong ammonia smells contain too much nitrogen, and may need more high-carbon ingredients.

Simple carbohydrates and proteins provide most of the energy for the initial, rapid stages of decomposition. When the more resistant materials, such as lignins and cellulose, become the main food sources, the activity in the pile will slow down. Less heat will be produced, and the temperature will begin to fall to about 100°F. Even after the temperature falls, the compost will continue to stabilize slowly.

The compost will be finished when the pile cools off and decreases to about one-third of its original volume (depending on the original ingredients). It will be dark, crumbly, and have an earthy odor. The C:N ratio will be less than 15.1, approaching the value of humus in soil, and the temperature usually will be within 10°F of ambient air temperature. Unfinished compost can be phytotoxic, especially to seedlings and newly established plants. Compost must be allowed to decompose thoroughly before use.

AVOIDING PESTS

Given a comfortable, or even nourishing, environment, rodents and other animals may be attracted. Rats are probably the most undesirable pests. In a hospitable environment with plenty of food, they can multiply very quickly and can become disease transmitters. Therefore, it is crucial to keep high-protein and fatty food wastes out of the compost pile in areas where pests may be a problem. Meat and fish scraps, bones, cheeses, butter, and other dairy products should be excluded if pests are a problem. Bread and other high-carbohydrate or high-sugar wastes can also attract pests.

Many flies, including houseflies, can spend their larval phase as maggots in compost piles. To control their numbers, compost piles with food in them must be turned frequently to encourage heating (larvae die at high temperatures). Piles should also be covered with finished compost or a dry material that has a lot of carbon in it, such as straw. Food waste can be incorporated into soil to avoid pest problems in compost piles. Pest-proof sides and covers may also be installed on compost units to help control pests.

FACTORS AFFECTING THE COMPOSTING PROCESS

All natural organic material eventually decomposes. The length of the composting process depends on a number of factors:

- carbon and nitrogen contents of the material
- amount of surface area exposed
- moisture
- aeration
- temperatures reached during composting

Carbon to Nitrogen Ratio
Microorganisms in compost digest (oxidize) carbon as an energy source, and ingest nitrogen for protein synthesis. The proportion of these two elements should approximate 30 parts carbon to 1 part nitrogen by weight. C:N ratios within the range of 25:1 to 40:1 result in an efficient process with rapid decomposition.

Blending of materials to achieve a workable C:N ratio is part of the art of composting. Table 1 is provided as a guide.

TABLE 1

CARBON TO NITROGEN RATIOS FOR SELECTED MATERIALS (By Weight)

Material	C:N
Materials with High Nitrogen Values	
Vegetable wastes	12-20:1
Coffee grounds	20:1
Grass clippings	12-25:1
Cow manure	20:1
Horse manure	25:1
Horse manure with litter	30-60:1
Poultry manure (fresh)	10:1
Poultry manure (with litter)	13-18:1
Pig manure	5-7:1
Materials with High Carbon Values	
Foliage (leaves)	30-80:1
Corn stalks	60:1
Straw	40-100:1
Bark	100-130:1
Paper	150-200:1
Wood chips and sawdust	100-500:1

Surface Area/Particle Size
The surface area of material to be composted can be increased by breaking it into smaller pieces. Increased surface area allows the microorganisms to digest more material, multiply faster, and generate more heat. Although it is not essential to break materials into small pieces for composting, it does accelerate the process.

Aeration
Rapid aerobic decomposition can only occur in the presence of sufficient oxygen. Regular mixing or turning of the pile fluffs up the material and enhances aeration.

Moisture
A moisture content of 40-60 percent provides adequate moisture without limiting aeration. The "squeeze" test is an easy way to gauge the moisture content of composting materials. The material should feel damp to the touch, with just a drop or two of liquid expelled with the material is tightly squeezed in the hand.

Temperature
Heat generated by microorganisms as they decompose organic material increases compost pile temperatures. Pile temperatures between 90° and 140° (32°-60°C) indicate rapid composting.

From: Composting to Reduce the Waste Stream
Available from Cornell Cooperative Extension (716) 394-4110

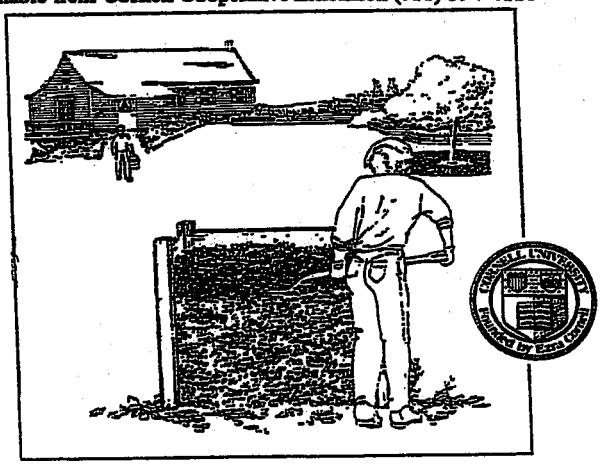


TABLE 6

COMPOST TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSES	SOLUTION
ROTTEN ODOR	• excess moisture (anaerobic conditions)	• turn pile, or add dry, porous material, such as sawdust, wood chips, or straw
	• compaction (anaerobic conditions)	• turn pile, or make pile smaller
AMMONIA ODOR	• too much nitrogen (lack of carbon)	• add high carbon material, such as sawdust, wood chips, or straw
LOW PILE TEMPERATURE	• pile too small	• make pile bigger or insulate sides
	• insufficient moisture	• add water while turning pile
	• poor aeration	• turn pile
	• lack of nitrogen	• mix in nitrogen sources such as grass clippings or manure
	• cold weather	• increase pile size, or insulate pile with an extra layer of material such as straw
HIGH PILE TEMPERATURE (> 140°F)	• pile too large	• reduce pile size
	• insufficient ventilation	• turn pile
PESTS rats raccoons insects	• presence of meat scraps or fatty food waste	• remove meat and fatty foods from pile, or cover with a layer of soil or sawdust, or build an animal-proof compost bin, or turn pile to increase temperature

From: COMPOSTING TO REDUCE THE WASTE STREAM
Available from the Northeast Regional Agricultural Engineering Service (607) 255-7654

Using Organic Matter in the Garden

Charles P. Mazza, *Senior Extension Associate, Cornell University*
Sally J. Cunningham, *Extension Educator, Cornell Cooperative Extension of Erie County*
Ellen Z. Harrison, *Waste Management Institute of the Center for the Environment, Cornell University*

Health of the garden depends on organic matter. What happens below the soil line may not be as romantic as roses, but it does make the garden more healthy and those roses more beautiful. In gardening, many products are called organic matter. Animal manures, peat moss from bogs, leaves, straw, newspaper, sludge, yard and garden waste, kitchen scraps, and green manures or cover crops - all are forms of organic matter that can be incorporated directly into the soil. Often such products are composted, rather than used directly, and the compost is used in the garden. Compost can be made at home from kitchen, garden, and yard wastes, or it can be produced by an industry or local municipality.

Organic matter is used in the garden and landscape for many reasons, beginning with its effect on soil structure. Organic matter helps soil particles bind together into aggregates, or clumps, which makes it easy to dig or penetrate. We often call this quality *tilth* In this way, adding organic matter helps all poor soils, whether they are too sandy or made of too much clay. A soil with good tilth also has good nutrient-holding and water-holding ability. In addition, organic matter improves soil by stimulating or feeding the life of the soil. It provides nutrients to bacteria, fungi, earthworms, and other organisms in the soil, which in turn recycle the nutrients into forms that are readily available for plants to absorb through their roots. Organic matter also helps to prevent soil and wind erosion by binding sandy soil particles together. Organic matter also prevents caking, cracking, and water run-off that occurs when clay soil dries out.

This publication describes some of the more familiar organic materials available to home gardeners, their effect on soil, plants, and soil life, and how they are commonly used.

When to Use Organic Matter

The short answer is "as often as you can." Amending the soil of planting areas for landscaping -- trees, shrubs, lawns and herbaceous plants -- is an important gardening practice for new homeowners or those who are revamping their property. Adding organic matter to a vegetable garden, a fruit orchard, or to an existing lawn is equally important for success. Experienced gardeners often consider soil building or soil replacement, i.e. bringing in and incorporating organic matter, nearly half the work of gardening.

Community projects often begin with substandard soil that needs amendment. In the rush to set out plants, gardeners sometimes do not add any or add insufficient amounts of organic matter. In reality, the soil preparation for planting beds is more important than the act of planting.

There is some disagreement about using any organic matter amendments in *backfilling planting holes* for trees, shrubs, or woody perennials. There is little data about long-term benefits. Some professionals have demonstrated that amending the original soil hole with a backfill mix encourages a *teacup effect*. That is, the artificial well or teacup of improved soil is so different from the surrounding soil that the roots never

leave their comfort zone, becoming entrapped in the teacup over time. Other professionals have shown that there is early root growth and possibly reduced soil-borne pathogens in soil that has been amended with organic matter. Currently, backfilling planting holes with organic matter, when planting new trees or shrubs, is not recommended for homeowners unless the soil quality is exceptionally poor. Incorporating organic matter over an entire site or planting bed, however, is recommended

In most situations, gardeners should add organic matter to "poor" soils, whether they are too clayey, too sandy, compacted or poor in nutrients.

Compost

Compost is often called *black gold* and many consider it the most important form of organic matter. It is universally recognized for improving soil structure and water-holding capacity. Compost helps the soil stay loose and easy to cultivate. Compost is, in fact, the end-product of the decomposition of organic matter. Making and using compost is also a way to *recycle* organic matter, especially products which might otherwise have been treated as home or industrial wastes.

In addition to soil improvement and the economic and social benefits of recycling organic matter, composting can provide other benefits. Composts help fight soilborne pathogens that cause plant diseases. However, not all composts are suppressive to all diseases. Compost, along with other organic matter, improves the capacity of soil to hold nutrients through a complex process called *cation exchange capacity*. In addition, compost indirectly provides nutrients for plant use when earthworms and other organisms digest the organic matter, producing nutrient- rich castings, or excrement. These products are significantly richer in nutrients than the surrounding soil, and in a form, which is readily available to plant roots. While compost provides some nutrients and makes other nutrients more available, it is not considered fertilizer. However, in many organic gardening or farming systems, compost is the major amendment to enrich soil.

Not all composts are alike. Composts vary greatly, depending upon what goes into them and how they are processed. Quality also varies depending on maturity, pH, presence of weed seeds, concentration of toxic substances, and the population of soil-dwelling organisms, such as earthworms, insects and microorganisms. Higher quality compost has good water holding capacity and nutrient availability.

Maturity makes a difference. Use of immature composts can cause problems. Maturity means that the compost has decomposed extensively and has become fairly stable. Immature compost may still contain some plant inhibitors. When immature compost is added to the garden, its bacteria compete with plants for nitrogen in the soil. The result is unhealthy plants with symptoms such as yellow leaves or stunted growth. If compost is still hot, smells like ammonia, or you can still recognize the original form of organic matter, then it is not ready to use. When in doubt, let compost mature longer.

Maturity is not the same as quality. Maturity means the energy and nutrient containing materials have merged into a stable organic mass. Mature compost (also called "finished" compost) is dark-

colored and has an earthy odor. Quality is the chemical composition of that mass. For example, a compost could be mature, but of poor quality, if nutrients had leached away or it contained contaminants.

Source materials affect quality. Soluble salts, nutrients and contaminants vary, depending on what the source material of the compost is. Soluble salts are actually chemically charged particles (ions), usually from dissolved fertilizer and irrigation water, but may come from the composted material itself. While not a human health concern, concentrated soluble salts can cause problems in plant growth. Compost made from food (fruits and vegetable scraps, fish residues, coffee grounds, brewery and bakery wastes) is typically richer in nutrients, but may have high salt content. The concentration of soluble salts, as well as the concentration of contaminants like lead and other heavy metals, in composted sewage sludge varies greatly, depending upon which industrial waste products are discharged to the sewage treatment plant. Yard waste compost is typically low in nutrients, contaminants and soluble salts. Composted manure is generally high in nutrients and soluble salts, while low in contaminants.

Hot is different from cold. Composts may or may not heat up during decomposition. Particularly in small-scale home composting systems, compost may not get hot. Some tests have shown that finished cold compost may actually have a higher nutrient content than products from a hotter compost. However, weed seed and disease organisms are more likely to be destroyed in hot compost.

Uses of Compost. Gardeners and landscapers use compost in many ways. It is used in establishing a planting bed; improving soils; mulching gardens or landscape plantings; backfilling during the planting of trees, shrubs, or perennials; establishing or topdressing lawns; sidedressing vegetables; or controlling erosion.

The **amount** of compost to use varies, depending upon soil and site characteristics, plant selection, compost quality, and availability. Most mature composts can be used in most planting situations without serious concern for precise amounts. In estimating how much compost is needed, measure the overall planting area, and calculate how much compost you will need to cover the area with 1 inch (or your preferred amount) of compost in a season. For instance, to apply 1 inch of compost over a 10 x10-foot area, you'll need about 8 cubic feet , or about 300 pounds, of compost. For a home garden, two 4 x 4 x 4-foot piles of compost can provide enough compost to accomplish this. Experienced compost users rarely have enough compost for its many functions and are concerned with dispersing the *black gold* equitably among the garden and landscape plants.

There are easy ways **to apply compost** for different horticultural uses. Compost in **planting beds** for perennials is often applied at a rate of 1 to 2 inches. This could be about 8 to 16 cubic feet of compost per 100 square feet of the planting beds. Incorporate the compost evenly about 6 to 8 inches into the soil. The prepared bed for trees and shrubs, however, should be 30-50% by volume to change structure, as well as to improve drainage, and root penetration into the site. To achieve this, add 4 inches of compost and incorporate it into the top 12 inches of the planting bed. This is about 32 cubic feet of compost per 100

square feet of planting bed. To use it as a **landscape mulch**, apply compost 1-3 inches deep over the soil surface. This could be 8-24 cubic feet of compost per hundred square feet of mulched area. A few inches of compost may also be layered under other landscape mulches, such as wood chips, to provide improve the soil without working the compost into the soil. In using sludge composts, apply no more than 2 inches. Limit sludge compost to one inch if you are mulching around salt sensitive plants. In **establishing a lawn**, mix compost with the planting soil, in order to improve drainage, especially in a heavy clay soil. Compost may also suppress specific soil-borne diseases and plant pathogens in lawns. Before seeding a new lawn, evenly apply 1-2 inches of compost over the entire area. This could be 8-16 cubic feet of compost per hundred square feet of lawn. Incorporate into the top 5-7 inches of soil, resulting in a final volume of 30% compost content. **Established lawns** may be top-dressed, that is, sprinkled with compost over the top of the grass and watered into the top layer of soil. However, it is important not to apply more than a quarter of an inch at a time, as the compost could smother established lawns, if it is applied more thickly.

Compost may be added in many ways to **vegetable gardens**. Prior to planting, compost may be spread 3 inches over the surface and worked into the top 3-6 inches of soil. Other guidelines suggest 2-3 bushels of compost per hundred square feet should suffice. Side-dressing, or digging in compost next to growing plants, is often done a month or two after planting. Compost is also an excellent vegetable garden mulch, which breaks down slowly, encourages soil life and maintains an even soil temperature in the heat of summer.

For **erosion control**, compost may be added to a sloped area to increase the soil's ability to retain water and discourage run-off. To do this, spread a 3-4 inch layer of compost over the entire area and work into the top 6-8 inches of soil.

Biosolids or Sludge

What does sludge have to do with gardening? Biosolids or sewage sludges are the semi-solid residue from wastewater plants that treat residential, commercial and pre-treated industrial wastewater. Sludge is typically about half organic matter and is half inorganic and may be available to homeowners.

The goal of wastewater treatment is to clean up the water, and most pathogens and contaminants are deposited in the sludge. Before distribution for use, sludges must be treated to essentially **eliminate pathogens.** Sludges are also treated to regulate the level of 9 **metal contaminants** often found in municipal and industrial sludge. Standards for legally acceptable levels of these metals is regulated by NYS Department of Environmental Conservation (DEC) and by the U.S. Environmental Protection Agency (EPA). Testing for those contaminants is required with a frequency determined by the size of the treatment plant. There are no requirements for providing such quality information to users.

Biosolids are fairly rich in plant nutrients (similar to manure) and the pH level is generally 6.0-7.5. Some biosolids used to produce composts have been treated with liming agents, which can affect pH, buffering capacity and soluble salts

level, thus limiting their horticultural use with certain plants.

NYS regulations prohibit the use of sludge products made in NYS on crops for human consumption, such as in the home vegetable garden. There is a concern that crops can potentially be affected by pathogens in the sludge. In addition, there is concern that crops may take up heavy metals (such as cadmium, lead, zinc, mercury, etc.) from sludge. Cadmium could be taken up in all parts of the plant; it is very soluble at lower pH's. Keeping the pH at 6.8-7.0 or higher is useful in decreasing solubility of cadmium and other heavy metals. However, higher pH alone is not enough to reduce uptake of lead. Increasing the organic matter or phosphorus is also necessary to tie up lead in the soil, making it less likely to be absorbed by the crop.

Use of sludge products presents a special risk to children, who might unknowingly eat particles of soil. The exposure of children to lead, cadmium and other potential metal contaminants in soil enriched with sludge is the chief concern. When sludge is used, it should only be incorporated as an amendment to soil growing ornamental plantings. Using sludge in ornamental plantings in limited amounts where young children aren't in contact with the sludge in the soil is a relatively low risk. If sludge has already been applied, a concerned resident can dilute it with additional topsoil or cover it with mulch.

Milorganite as a Fertilizer and Deer Repellent. Milorganite is a commercially available dried sludge aerobically digested sewage. It has been available from Milwaukee since the 1930's as an organic-slow release fertilizer for lawns, gardens and citrus production in Florida. Because brewery waste contributes to the production of Milorganite, it has a higher nitrogen content than most other sewage sludges. The processing of Milorganite kills pathogens and adds iron as a clumping agent.

Milorganite has also achieved some popularity as a possible deer repellent for landscape plantings. In a demonstration project in Dutchess County, New York in the mid-nineties, Milorganite, used as a deer repellent, provided some protection for perennials and woody plants during the summer and early fall. These are times when deer have much alternative forage available. It provided almost no protection during winter and early spring, when either snow covered the ground or deer were short of food.

Sludge products like Milorganite are not legally registered as deer repellents by federal EPA and therefore cannot be recommended.

Manures

Animal manures have long been a popular form of organic matter as well as fertilizer for farms and gardens. Farm manure is still the most readily available manure, purchased directly or sometimes free from the farm. It is sometimes bagged and sold in garden centers - with a wide range in its quality, nutritional content, age, and weed seeds present. It is not recommended that homeowners use any manure from dogs, cats, or other meat-eating animals, since there is risk of parasites or disease organisms that can be transmitted to humans.

Characteristics of animal manures: Farm animal manures provide NPK - nitrogen (N), phosphorus (P), and potassium (K). Generally, cow and horse

manures are more readily available than other kinds of animal manures. For nutrient analysis of manure from eight kinds of farm animals, as well as other kinds of organic matter, refer to Cornell's Eco-Gardening Factsheet #8, "A Guide to the Nutrient Value of Organic Materials."

Using manure: Manures differ from each other because of their source, their age, how they were stored (piled, spread, turned over or not), and the animal bedding material, which may be mixed in. For that reason it is difficult to provide precise guidance about how long manure should be aged before use, or how much to use. Composting is the safest way to make the most of manure's nutritional potential - if the logistics of making and hauling compost are viable. For direct use in the garden, first aging manure for 6 months is a good rule of thumb. Many farmers and gardeners spread fresh manure in the fall or winter, and till or turn it in at spring planting time. When manure is spread in the spring, even if aged, it is safest to wait for at least one month before planting crops, since the microbial activity it stimulates may interfere with seed germination or plant growth before that time.

When composted manure is spread directly over the soil, it is helpful to add about 40 lbs. per 100 square feet, turned into the top 6 to 9 inches. Aged manure is often used in home vegetable gardens as a side-dressing, or placed directly in holes under the soil where vine crops such as pumpkins are planted.

Manure tea, made by soaking bags of manure in tubs of water, is a nutrient-rich liquid that is full of microbial life. It is another way to use manure as a fertilizer, whether it is poured on the leaves of plants (called *foliar feed)* or into the soil.

Problems with manure: While it is one of the most readily available forms of organic matter and fertilization for many gardeners, manure can present some problems.

- The relatively high nitrogen content makes manure extremely valuable in composting, where it activates soil bacteria and contributes to rapid decomposition of organic matter. But, as a direct soil amendment, that same high nitrogen content can be a deficit. Fresh, raw, or hot manure activates and builds up soil microbial activity to the extent that the nutrients *volatilize*, or burn up, before plants can use them.

- Fresh manure also can damage plant tissue and kill seedlings. An excessive amount of soil nitrogen can produce plants with a high nitrate content. These high nitrate levels are not only potentially harmful to humans; they also are more attractive to pests than crops grown with less nitrogen, and do not store as well either.

- Manure also is notorious for adding undigested weed seeds to the garden, particularly from horses and other animals that eat hay. Composting in a hot system (when the pile reaches over 155 degrees) destroys most weed seeds, but most composting systems are inexact and seeds can come through. For that reason, those who use manure usually plan on weed-control techniques such as mulching, interplanting (growing cover crops between rows), mechanical or hand-weeding, or herbicides in some situations.

- Particularly in agriculture, manure use can pose pollution problems when rain or irrigation systems carry nitrogen from the fields before it is used by plants. Nitrogen from manure or synthetic fertilizers has been identified in New York State as a pollutant found in groundwater.

- Fresh manure must be used with caution in the garden because it may contain pathogenic bacteria such as *E. coli, Listeria,* and *Salmonella.* Although the chance of contamination is slim, severe sickness and even death may occur if contaminated produce is eaten. To be safe, either compost your manure or apply it in the fall after harvest. Try to leave at least 120 days between application of fresh manure and harvest of a crop.

Green Manures or Cover Crops

Several grasses, grains, and legumes are used in gardening and farming and referred to as cover crops or green manures. The term *cover crops* describes an important function of these crops: to cover the soil, block weeds, prevent erosion, and maintain soil moisture, among other benefits. *Green manure* refers to the other primary function of using these crops: to add organic matter to the soil. Green manure crops are grown during fallow seasons (when a garden or field is not in use), during part of the growing season, or over winter, to add biomass to the soil. *Biomass* is the quantity of organic matter that living crops provide. Some green manure crops are also used between crop rows or plants while they are growing, called *intercropping* or *interplanting*. Cover crops are sometimes broadcast over existing crops a few weeks before harvest, so that the cover crop is already growing before the area is left bare. There are as many systems for green manuring or covercropping as there are garden layouts, and many ways to add organic matter with these plants.

Crops used for green manure: There are many choices of green manure crops, with a variety of benefits for using them. The crops are divided into legumes (beans, peas, alfalfa, clovers, hairy vetch, and soybeans) and non-legumes. The latter includes annual ryegrass, buckwheat, oats, winter rye, sudan grass, and winter wheat. The legumes provide the benefit of fixing nitrogen, actually taking nitrogen from the air and holding it as nodules on plant roots. As plants are turned under or cut off at the stem this nitrogen becomes available in the soil for future plant use. Other cover crops are biological *subsoilers*, such as alfalfa, with roots that reach down into the subsoil up to 8 feet, bringing valuable hard-to-reach nutrients up to the soil surface as the crops are harvested.

Which green manure to choose In choosing a green manure crop, many factors have to be considered: the amount of biomass, the nitrogen-fixing factor, time required to grow, and most of all how the crop coordinates with the other plants in the particular garden's system. Even the equipment available, or your individual strength, are factors in choosing. For instance, taller crops, such as oats or winter wheat offer the most biomass, but they require serious equipment or massive effort to cut them down or turn them under.

Crops that over-winter, such as winter rye, protect the soil during the winter and provide spring growth, which is later cut down and turned under. However, to incorporate these into the soil in late spring requires powerful equipment.

Tilling earlier in the spring is possible, but getting into the garden or onto the field during a wet spring can be a problem. Other crops, such as buckwheat, do an excellent job of blocking weeds and attracting beneficial insects, but offer less biomass. The governing factor in most cases is the timing. Once the summer crops are harvested there are only a few choices that can be established in September (annual ryegrass or oats) or as late as October (winter rye or winter wheat). For additional information on seeding rates and selection of cover crops, please refer to: Cornell's Eco-Gardening Fact Sheet #9, "Improve your soil with cover crops".

Peat Moss

For many years, bales of peat moss have been on our list of garden supplies and we've never given it a thought. Now, gardeners around the world wonder if peat companies are destroying these fragile and unique bog ecosystems by removing the peat. They ask whether these companies are harvesting this abundant resource in a responsible, sustainable manner. Canada, where we get most of our peat moss in the United States, has 25% of the world's peatlands and only .02% of them is being harvested. The industry is regulated and practices restoration and reclamation to attempt to keep peat a sustainable resource. Environmental assessments are conducted before opening a virgin bog to harvest. Horticulturally, peat is used in a variety of ways. It is a soil amendment, an ingredient in potting soils and planting mixes, and used as a bulking agent and carbon source in composting.

Can you use North American peat without feeling guilty Perhaps the answer to this question can be found by using peat conservatively. Use peat in your growing mixes for starting seeds and cuttings. Since peat is sterile, it minimizes disease problems. However, focus on composting to supply the larger quantities of organic matter needed to improve your garden soil. By substituting compost for some of your garden needs, you can help to cut down on the rate of peat moss mining.

If you choose to use peat moss in the landscape, plan to add 33% (by volume) of peat moss before tilling it into garden beds. This could be 1-6 inches laid over the top of the planting bed before tilling. The actual amount will depend on how deeply you incorporate it into the soil. A shallow incorporation may only require a one inch layer, while deep digging will require more in order to achieve the 33% volume of peat moss to the entire soil mass.

A highly decomposed form of peat, dark brown to black in color, is peat *humus*. It has a much lower water-holding capacity and is more expensive than peat moss. It is, however, an excellent soil conditioner.

Because of its tight, fibrous structure, peat moss should not be used as a soil surface mulch. As it dries, it has the tendency to absorb water to itself, robbing the soil underneath from valuable water from rain or irrigation. Peat should only be mixed into the soil, not laid on top of it.

Since compost is often considered a substitute for peat moss, the following chart may help to delineate the **differences and similarities between peat moss and compost.**

Peat Moss	Compost
Expensive	Often free
Poor in nutrients	Relatively rich in nutrients (but not a fertilizer)
Low pH	pH usually neutral or slightly alkaline
Doesn't compact	May compact
Excellent at holding water	Good at holding water
Hard to re-wet	Re-wetting capacity varies
Uniform in composition	Variable in composition and contaminants
Might contain pathogens	Full of microorganisms (mostly beneficial)
Contains no weed seeds	May have weed seeds if not composted properly*
No disease suppressing qualities	Capable of suppressing some plant disease-causing pathogens
Uses a natural resource, obtained by mining	Recycles organic waste matter
Not a mulch	Excellent as a mulch

* "Not composted properly" refers to situations where the compost has not gotten hot enough for a long enough period of time or where the compost goes anaerobic or where it has not been turned adequately to assure that all particles have been exposed to hot temperatures.

Other kinds of Organic Matter

In various regions of the state and across the country, plant and animal products from lakes, orchards, vineyards and fields are available. Such products as fruit pomace (seeds, pulp, skins), seaweed, brewery waste, buckwheat hulls, mushroom waste, fish industry, zoo, fair and circus waste are only a few kinds of organic mater that may only be available in specific regions.

Paper

Several paper products - especially newspaper and cardboard - are useful in the garden and landscape. While it provides no nutrients, paper is organic material, made primarily of wood fibers. It decomposes slowly but provides structure when used in a compost pile. Shredded newspaper or telephone book paper are good paper choices for composting or digging into soil directly; they decompose well when mixed with high nitrogen products such as a manure. Shredded newspaper may also be used under other mulches in the landscape, where it is broken down by earthworms. Shredded computer or other office paper may be used although it breaks down slowly. Glossy magazine-style paper decomposes even more slowly and contains dioxin. There are enough concerns about the dioxin in glossy paper that it would be wise not to use it in the garden. Waxed paper almost never breaks down.

There has been concern about using colored paper or ink, which contains heavy metals. Evidence shows such low concentration of heavy metals - if any at all - that colored paper may be used without danger. Many inks currently used are soy-based.

Cardboard and newspaper (several sheets thick) are effective mulches around vegetables or flowers, used to block weeds and retain soil moisture. For similar reasons, in landscape plantings, cardboard or paper may be used under other mulches such as wood chips. This method has several other benefits: the paper products may block the light and prevent weeds longer than less solid mulches, and may decrease the amount of wood chips or other surface mulches needed. In addition, there is the benefit of reusing paper products, which reduces costs and the need for their disposal in overcrowded landfills.

Direct Incorporation of Organic Matter

Composting is not always a viable option for the home gardener. However, there are many other ways to add organic matter to the soil and still reap the benefits. Some of the methods of *direct incorporation* include:

- **Sheet method**: spreading organic matter such as leaves and grass clippings, straw, rotted hay or raw manure directly over the soil. Some users turn it under whenever it is applied and others let it cover the soil in winter and turn it under in spring. When opaque (black or red) plastic is used, a variation on sheet composting is to spread the organic matter under the plastic, where it decomposes more quickly using the heat created by the plastic.
- **Trench method**: one of the oldest and simplest ways to add organic matter is simply digging a trench or one hole at a time and burying organic matter as it becomes available. The trench can even be made between plants or rows during the growing season. The organic matter is typically kitchen waste, such as food scraps or coffee grounds, but any organic matter can be added this way.
- ***Hugel* method**: often called **in-place composting**, the gardener creates a mound or hill (*Hugel*, in German) of organic matter in the garden. While there are several variations, all include piling up organic materials in layers, usually with the coarsest on the bottom and letting the materials decompose in place. In most systems, crops are planted in the top layer, while the lower layers are still in the original undecomposed form. Possible materials from bottom to top are: twigs, leaves, manure, straw, grass clippings and compost or soil.

Mulch

Another way that organic matter is used in the garden is to cover the soil. Mulches can be applied in winter or summer. Winter mulches protect young perennials, while summer mulches retain soil moisture and limit weed seed germination. Tree bark, branches and trunks can be chipped and spread as a mulch. Plant residues from locally grown crops such as buckwheat, peanut, cocoa, wheat, corn, and salt marsh grasses can serve the same purpose. Even newspaper is used. Almost any composted material can be used as a mulch, while peat moss cannot. Mounding compost mulch (or any mulch) against tree trunks poses serious dangers of disease, rodent or insect damage to the tree.

Summary

Far from being a luxury, organic matter is essential to the life of the soil and the plants growing in it. Knowing what to use, when to use it, how much to use and what effect each will have ultimately results in better success in the art and science of gardening.

References

1. Beneficial Uses of Biosolids/Sludge, Cornell-Center for the Environment, 1996.

2. Case for Caution: Recommendations for Land Application of Sewage Sludges and An Appraisal of the U.S. EPA's Part 503 Sludge Rules, by Ellen Z. Harrison, Murray McBride, and David R. Bouldin, Cornell Waste Management Institute Working Paper, 1997. Posted on website www.cfe.cornell.edu/wmi

3. Compost: Truth or Consequences, video on home composting, Cornell Waster Management Institute, 1997.

4. Compost for the Home Garden, by L.H. MacDaniels and R.E. Kozlowski, Cornell Cooperative Extension Home-Grounds-Garden FactSheet, 1985.

5. Composts as Soil Amendments, by Mary Thurn, CUTT, Cornell Cooperative Extension, 1995.

6. Current status and future prospects for the biological control of turfgrass diseases by Eric B. Nelson, in Biological and Cultural Tests for the Control of Plant Diseases 13: 1-8, 1998

7. Field Guide to Compost Use, Composting Council, Alexandria, VA, 1996.

8. Great Garden Companions, by Sally Cunningham, Rodale Press, Emmaus, Pa. 1998.

9. Guide to the Nutrient Value of Organic Materials, EcoGardening Fact Sheet #8: Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY, 1993.

10. Improve Your Soil with Cover Crops, EcoGardening Fact Sheet # 9, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY, 1993.

11. Master Composter Program Implementation Guide, Cornell Waste Management Institute, 1998.

12. Organic Manual, J. Howard Garrett, Lantana Publishing Co., 1989.

13. Peat Conservation, Cornell Cooperative Extension, NYC, 1992 (reprints no longer available).

14. Reducing the Lead Uptake in Lettuce, by Dr. Nina Bassuk, Urban Horticulture Institute, Cornell University, in Hortscience 21(4): 993-995, 1986.

15. Rodale Book of Composting, edited by Deborah Martin and G. Gerhony, Rodale Press, Emmaus, Pa, 1992.

16. Soil Amendments in Landscape Plants, by Don Rakow, Cornell Cooperative Extension, 1992.

17. Suppression of plant diseases by composts, by H.A. J. Hoitink, A.G. Stone and D.Y.Han , in HortScience 32, 184-187, 1997.

Acknowledgements

Special thanks to the following for their contributions:

Nina Bassuk, Cornell University Urban Horticulture Institute, information on managing soil pH to minimize heavy metal uptake and information on applying compost to planting beds for trees.

Bonhotal, Jean, Cornell University Waste Management Institute, information on dioxin in glossy paper.

Paul Curtis, Cornell University Dept. of Natural Resources, information on milorganite as a deer repellent.

Eric Nelson, Cornell University Department of Plant Pathology, information on compost-pathogen relationships.

Marty Petrovic, Cornell University Dept. of Floriculture and Ornamental Horticulture, information on milorganite use in agriculture.

Steve Reiners, Cornell University Dept. of Horticultural Sciences at Geneva, information on pathogen concerns in manure.

Index