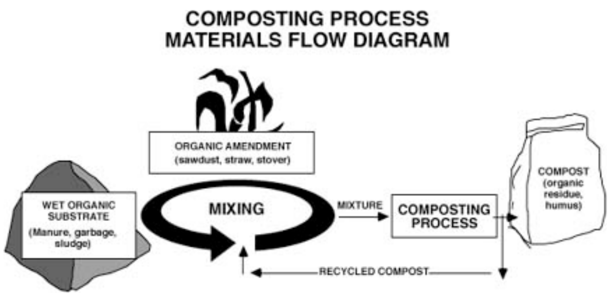
THE OHIO STATE UNIVERSITY Bulletin Extension

The Composting Process

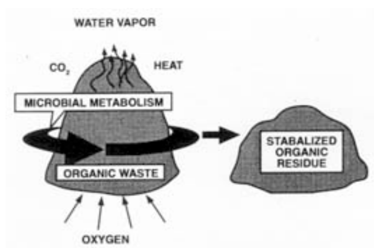
Bulletin 792

Introduction

Management of solid wastes is a problem of increasing concern throughout the world. The biodegradable fraction in wastes that cannot be recycled or converted into new products, increasingly is treated through composting. It is the lowest cost alternative to landfilling for many wastes. The number of composting plants operated in the U.S. by industries and municipalities has tripled since 1990. Over 3000 sites are registered today. Backyard composting also is starting to play an important role in the U.S. Industries use composting as a process for the destruction of toxic by-products through a process known as "bioremediation". Finally, the composting process is starting to replace more costly treatment procedures for the destruction and control of human, animal and plant pathogens. Composting, therefore, is becoming a commonly used process.



Various forms of composting have existed since life on earth began. Nature provides an extensive, native population of microorganisms that are generally attached to all organic wastes. When conditions are right, these microbes grow and multiply by decomposing the material to which they are attached (an example is decay of crop residue in soil). From a scientific viewpoint, the composting process is started and managed under controlled environmental conditions rather than accepting the results of natural, uncontrolled, decomposition.



Composting is associated with concepts of reclamation, recycling, treatment and disposal. Reclamation and recycling are parts of the stewardship of saving and reusing natural resources. Treatment and disposal have been a more typical way to cope with wastes for many decades, particularly as a part of the "industrial revolution." Because of concerns for our environment, "disposal" has become a less desirable option.

When are conditions right for composting?

The composting process is essentially a biological one that compares to the raising of plants or animals. The rate of composting, like the rate of plant or animal growth, can be affected by many factors.

Four key ones are:

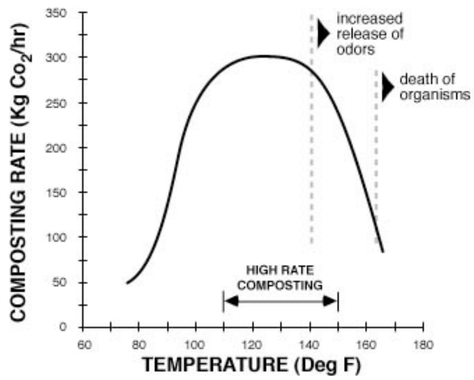
1. nutrient balance,
2. moisture content,
3. temperature, and
4. aeration.

Nutrient balance is determined primarily by the ratio of carbon to nitrogen in the compost mix (C/N ratio). It is like balancing carbohydrates and protein in a diet. Bacteria, actinomycetes, and fungi also require carbon and nitrogen for growth. These microbes use 30 parts of carbon to 1 part of nitrogen. Composting is usually successful when the mixture of organic materials consists of 20 to 40 parts of carbon to 1 part of nitrogen. However, as the ratio exceeds 30, the rate of composting decreases. As the ratio decreases below 25, excess nitrogen is converted to ammonia. This is wasted into the atmosphere and results in undesirable odors.

Phosphorus is another principal element required by compost microbes. Trace elements are needed in very small quantities. Normally, these elements are available in satisfactory amounts in compost when the C/N ratio is properly established.

The **moisture content** of compost should ideally be 60 percent after organic wastes have been mixed. Depending on the components of the mixture, initial moisture content can range from 55 to 70 percent. However, as the moisture content exceeds 60 percent, the structural strength of the compost deteriorates, oxygen movement is inhibited, and the process tends to become anaerobic. Low C/N ratio materials (e.g. meat wastes) putrefy when anaerobic. High ratio materials ferment. Both processes produce odors and must be avoided. As the moisture content decreases below 50 percent, the rate of decomposition decreases rapidly. As a rule of thumb, a mixture of organic wastes that contains 50 percent moisture feels damp to the touch but is not soggy.

The **temperature** increase that occurs during composting results from the breakdown of organic material by bacteria, actinomycetes, fungi and protozoa. The temperature can range from near freezing to 160 degrees F. Starting at ambient temperature when the components are mixed, the compost can reach 150 degrees F in less than two days. Applying heat to compost from an external source serves no purpose unless ambient temperatures are far below freezing. Heat is generated from within the compost medium.



The hundreds of types of microorganisms involved with composting are generally classified into three categories according to temperatures most favorable to their metabolism and growth:

Psychrophilic	less than 40 degrees F
Mesophilic	40-100 degrees F
Thermophilic	100-150 degrees F

As the microorganisms decompose (oxidize) organic matter, heat is generated and the temperature of the compost is raised a few degrees as a result. In composting, as in the decomposition of any complex substance, the breakdown is a dynamic process accomplished by a succession of microorganisms with each group reaching its peak population when conditions have become optimum for its activity. One group of microorganisms dies and another group thrives until the next incremental change in nutrition and temperature occurs, etc. Composting rate is generally measured by rate of carbon dioxide production. The maximum rate occurs when compost temperatures range from 110-150 degrees F. As the temperature exceeds 150 degrees F, the composting rate drops rapidly and becomes negligible at temperatures higher than 160 degrees F.

Most composting should include temperatures in the thermophilic range (100-150 degrees F). At these temperatures the rate of organic matter decomposition is maximum, and weed seeds and most microbes of pathogenic significance cannot survive. It takes three days at 131 degrees F (55 degrees C) to kill parasites, fecal and plant pathogens. It is important that piles are turned frequently to ensure that all parts are exposed to high temperatures.

Aeration is a key element in composting. Proper aeration is needed to control the environment required for biological processes to thrive with optimum efficiency. A number of controllable factors are involved.

1. Temperature should be controlled to a 140-150 degrees F upper limit. Above these temperatures even thermophilic microbes either self-destruct or become less effective. ***[DONE BY KEEPING C/N AND MOISTURE IN DESIRABLE RANGES, BEGINNING RIGHT AWAY IN THE BIO-BUCKET]***

2. Moisture is removed naturally from the compost medium. Over two-thirds of the original water content of compost may be lost during decomposition. Often water must be added during the process to maintain activity. ***[OUR AREA'S NORMAL RAINFALL IS***

APPROPRIATE FOR MAINTAINING MOISTURE AT THE NEEDED LEVEL. ONLY EXTREME RAIN EVENTS NEED TO BE PROTECTED AGAINST]

3. Carbon dioxide is a product of the biochemical reactions that are part of composting. This gas must be removed from the compost microenvironment to avoid toxic concentrations that inhibit the process. ***['REMOVAL OF GAS' BY MIXING IS ONLY NECESSARY WHEN THE ADDITIONS TO THE PILE ARE HEAVIER/DEEPER (12 FT DEPTH MINIMUM) THAN THE RESIDENTIAL FLOW OF CONTINUOUS ADDITIONS. CO2 IS NOT A PROBLEM IN SMALLTIME OPERATIONS DONE CONTINUOUSLY YEAR ROUND WITH THE USE OF OPEN AIR BINS AND STRAW COVER.]***

4. Oxygen must be available to microbes in sufficient quantities to ensure vitality of the aerobic types and to minimize odors. The amount and type of bulking agent added during preparation of the compost determines the free air space in the pile. Pore space should range from 35-50% to maintain adequate aeration. Air may be forced through the pile to speed up the process. However, forced aeration adds complexity to the process. ***[YARD WASTE, STRAW AND OUTDOOR-DAMP SAWDUST ARE ALL NATURALLY AERATED AS NEEDED]***

Is generation of ammonia a potential problem during composting?

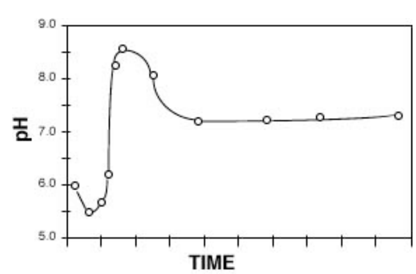
Because of the nature of the process, predominately aerobic composting usually leads to the loss of at least some nitrogen. The loss is associated with high temperatures, low moisture content and eventual alkaline conditions that are attained during the process. The presence of excess nitrogen in the form of ammonium carbonate or ammonia can be traced to the microbial metabolism of protein or other sources of nitrogen. If the C/N ratio is too low, the energy source (carbon or carbohydrates) may be less than that required for converting available nitrogen into microbial cells. In such an event the organisms make full use of available carbon and the excess nitrogen is eliminated as ammonia. If excess nitrogen in a decomposing mass is too great, ammonia may be formed in amounts sufficient to be toxic to the microbial population and cause air pollution as well.

Ammonia losses can be minimized when compost ingredients are adequately mixed in proper proportions and all other factors discussed above are taken into account. Wastes which are high in nitrogen such as poultry manure generally cannot be sufficiently and economically amended with carbon (bulking agents) to avoid ammonia losses. The exhaust air from such compost piles must be scrubbed with water to prevent a serious air pollution problem. ***[THIS REMARK ABOUT CHICKENS IS OBVIOUSLY REQUIRED FOR FACTORY FARMING-STYLE OPERATIONS WHERE MASSIVE AMOUNTS OF CHICKEN WASTE ARE GATHERED WITHIN LIMITED TIME FRAMES, NOT IN DISTRIBUTED ORGANIC FARMING OPERATIONS ALA SALATIN.]***

[When household bio-buckets are done indoors -- A LITTLE EACH TIME -- the NORMAL animal instinct to cover one's waste is the balancing factor that KEEPS the C/N balance CONSTANTLY IN BOUNDS with the use of household carbon sources, such as shredded paper and bath tissue or peat-moss from gardening. With the Humanure Handbook instructions and guidance, the ordinary functions of human-excretion composting are mastered quickly. No ammonia problem normally occurs and for any briefly developed imbalance, the correction is easy and quick (just add more carbon), and monitoring is constant, natural and automatic.]

Is control of pH and moisture important during composting?

In a practical operation, very little evidence exists that pH should be artificially adjusted. Generally, the pH begins to drop during initial stages of composting. This results from the activity of acid-forming bacteria which break down complex carbohydrate material (polysaccharides and cellulose) to organic acid fermentation intermediates under anaerobic conditions. ***[NOT APPLICABLE TO AEROBIC COMPOSTING]*** These materials give off strong odors! The microorganisms that produce the acids also can utilize them as food after higher oxygen concentrations are established. This typically occurs within a few days after the most readily biodegradable substances have been destroyed. The net effect is that the pH begins to rise after a few days. The rise continues until a level of 7.5 to 9.0 is reached, and the mass becomes alkaline. Attempts to control pH with sulfur compounds are often difficult to justify because of the cost involved. It is more important to manage aeration so that fermentation and odor formation is reduced.



Water management critically affects composting. When excess water is allowed to accumulate at the base of compost piles, anaerobic conditions are the result, followed by odors and leachate formation. ***[WITH COVER OVER THE BIN TO PROTECT THE CONTENTS FROM EXTREME RAIN, THE BALANCE THAT IS ESTABLISHED IN NORMAL GOOD HOUSEKEEPING DOES NOT BECOME 'EXCESSIVE'. WITH SIMPLE DRAINAGE AROUND THE AERO-BINS, NO WATER ACCUMULATES IN THE***

BINS, because the bio-bucket inputs are 'sponge damp' only, extra water is user controlled, and rain events are controlled with the sheltering roof.]

Inadequate water retards the process. Grass in dry yardwaste mixtures, for example, is preserved as musty (moldy) hay. This factor is most often overlooked by operators of composting systems. *[LOCAL RAINFALL LEVELS ARE QUITE COMPATIBLE WITH MAINTAINING COMPOSTING MOISTURE LEVELS ESTABLISHED IN GOOD HOUSEKEEPING PRACTICES OUTLINED SIMPLY IN THE HUMANURE HANDBOOK. OUR BIN DESIGNS EASILY MODERATE THE MOISTURE.]*

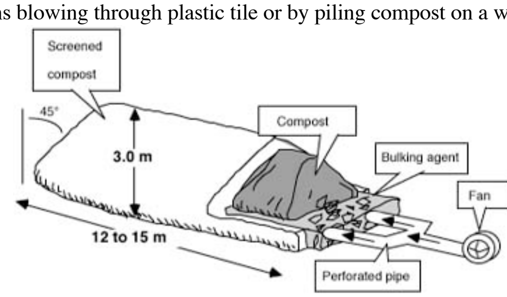
What structures and equipment are required for composting? *[COMMERCIAL OPERATIONS ONLY, ARE REGULATED BY THESE DESIGN RULES. OBVIOUSLY FROM THE CONTENT AND PHOTOS.]*

Investment in structures and/or equipment for the composting process can range from practically none to completely enclosed buildings with automated handling, computerized process control and monitoring systems.

The Com-Til Facility in Columbus, Ohio, composts biosolids. Wood chips, recycled compost and sawdust are added as bulking agents. The facility handles 50,000 wet tons of biosolids each year-25 dry tons per day. One eighth of the volume produced is sold as bagged compost and the remainder as bulk compost. The facility features an open concrete pad. Compost is piled 10- to 12-feet high on perforated plastic tile to achieve updraft aeration.

Static piles

- Compost ingredients are mixed and piled outdoors or under a roof in a windrow.
- The size and shape of the windrow is designed to optimize the effects of natural ventilation.
- Aeration can be enhanced with fans blowing through plastic tile or by piling compost on a wood chip base.



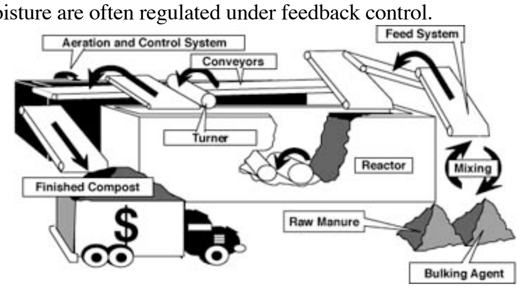
Windrow

- Windrows can be remixed or turned with a front-end loader or a mechanical device designed for that purpose.
- Aeration can be provided either by natural ventilation or a fan system.
- Piling on hardened surfaces facilitates handling and is essential in wet climates.

The Greater Lake County Composting Plant in Mentor, Ohio, composts anaerobically digested biosolids. Sawdust and woodchips are used as bulking agents. The plant handles 33 wet tons of biosolids per day (8-9 dry tons). The composting facility is a three-acre enclosed building with a concrete floor. A turning machine is used to stir windrows daily. The windrows are 4 to 4 1/2 feet high by 12 feet wide. Downdraft aeration is used and air exits through a biofilter consisting of compost, bark, and woodchips in which microorganisms destroy compounds responsible for odors.

Reactor vessels

- The vessels consist of concrete bins with false floors or air plenums installed in the bottom.
- Height is limited to about ten feet. Excess height leads to excessive settling. Compost that is too dense cannot be properly aerated.
- The width is determined by design requirements for turning and loading equipment. A 20-foot width has worked well in many units but some are 100 feet wide.
- The length of the vessel can be based on anticipated capacity, available space, and turning and loading requirements.
- Automated mixing and conveying equipment are normally a part of the system.
- Reactor vessels operate well in open buildings (roof only) or in enclosed buildings.
- Temperature, oxygen level and moisture are often regulated under feedback control.



Other techniques

- There are many variations of the above methods described in composting literature. The ultimate design for a system depends on needs and financial resources.

What can be done with the end product? *[COMMERCIAL OPERATIONS ARE REGULATED BECAUSE OF SIZE OF PRODUCT BUT HOME USE IS NOT RELEVANT IN OHIO LAWS BASED ON SEARCHES OF ORC AND OAC.]*

The uses for compost as a soil amendment can be evaluated on the basis of characteristics: (1) fertilizer value, (2) value as a soil conditioner, (3) value for land reclamation, (4) value as livestock bedding, and (5) value as nursery container media.

Fertilizer value

The fertilizer value of compost is low. The nitrogen, phosphorus, and potassium (NPK) contents are approximately 11/2% N, 2% P and 1% K. (11/2% N, 4.6% P_20_5, 1.8% K_2O) HOWEVER...

Compost has advantages over standard, inorganic fertilizers. The fertilizer elements will not leach unless compost is excessively applied. Compost possesses a full complement of trace elements while inorganic fertilizers on the market generally are lacking in these elements. It is important to know the amount of each nutrient released per year from the composts.

Value as a soil conditioner

A superior value of compost is its potential as a soil conditioner. Compost eventually becomes humus and improves soil tilth. Compost provides soil aggregation or a tendency to "crumb" which in turn enhances the air-water relationships of the soil. Soil water-holding capacity and water infiltration are increased, erosion and soluble nitrogen leaching are reduced, cation exchange capacity is increased. The landscaping and nursery industries utilize most of the composts produced today.

The Paygro Company, Inc., in South Charleston, Ohio, composts beef cattle manure with sawdust, bark, and other wastes. Some sawdust is added for bulking in addition to that already mixed with the manure before delivery to the plant. Fifty dry tons are handled daily and are packaged for retail sale in 8-, 25- and 40-pound polybags. The plant consists of two 10' x 20' x 400' reactor bins under a 100' x 500' roof with partiality enclosed sides.

Value for land reclamation

The value of compost for land reclamation is clear. The main concern is environmental effects of phosphorous, trace elements, or certain heavy metals if compost is applied excessively. However, loadings up to 40 to 50 tons per acre have been found acceptable, particularly when applied early in the spring.

Livestock bedding

An important value for properly cured compost in livestock operations is its use as bedding. It is dry enough to be moisture absorbent. However, its main advantage over other types of bedding is its tendency to resist propagation of flies.

Nursery container media

Another successful application for compost has been its use as an amendment in container media for nurseries and florists. Incorporation of disease suppressive composts in media with appropriate chemical and physical properties has successfully solved soilborne disease problems in nursery and greenhouse crops. Some of the container media not only suppress the diseases, but they eradicate pathogens as well. Again, proper use requires experience. For example, incorporation of excessively high levels of compost into container media increases fungus gnat problems.

What alternative composting methods are being evaluated?

Research on composting alternatives continues. These research efforts address odor control, toxic contamination, disease suppression, aeration requirements, moisture control, materials handling and ways to measure compost maturity.

Research and demonstration results of new compost handling methods are reported in trade magazines, scientific journals and conference proceedings. When considering these new approaches, do your homework:

- Look for controlled studies that compare statistically evaluated results. ***[SEE HUMANURE HANDBOOK FOR LISTS OF SUCH STUDIES]***
- Avoid reports based on testimonials.
- Contact and/or visit operations using a new technology to evaluate the system firsthand.
- When adopting a new approach, **start small**. Establish a pilot-scale treatment system or rent new equipment before making a major investment. ***[SMALL IS CONTROLLABLE, RESIDENTIAL IS SMALL, LOGICALLY START RESIDENTIAL!]***
- Work with registered professionals and consultants. ***[THE AUTHOR OF THE HUMANURE HANDBOOK IS CONSULTED BY UNITED NATIONS PROJECT MANAGEMENT. WE USE THE HUMANURE HANDBOOK FOR EXCELLENT GUIDANCE OF FIRST QUALITY DETAILED INFORMATION.]***

Composting is the biological decomposition of organic wastes under controlled conditions to a state where storage, handling and land application can be achieved without adversely affecting the environment.

Under ideal conditions, a single microorganism can multiply into millions. The typical life span for a microorganism is only 20 to 30 minutes.

Bacteria and fungi in compost can decompose nearly everything. They can usually produce the enzymes needed to digest whatever material they find themselves on. People working in composting plants tend to be as healthy as the average person in society. However, individuals with an impaired lung capacity should not be employed in dusty environments such as composting plants. ***[SUCH HAZARDS ARE DESIGNED INTO FACTORY COMPOSTING OPERATIONS, WHICH IS WHY THOSE ARE THE ONLY OPERATIONS THAT REQUIRE LAWBOOK REGULATION.]***

http://ohioline.osu.edu/b792/index.html