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On-Farm Composting of Poultry Litter

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Introduction

As the poultry industry expands in Tennessee, farmers are faced with the challenge of disposing of increasing volumes of poultry litter. Composting is one option that producers should consider as a way of increasing the value and potential markets for their litter, while moving excess nutrients from their operations.

There are many potential on-farm and off-farm uses and markets for compost including the nursery industry, organic growers and vegetable producers, homeowners, golf courses, highways and land reclamation.

Composting is a simple, natural process poultry producers in Tennessee can use to produce a marketable product. Composted poultry litter has few, if any, odors. It is a more stable and more consistent material than fresh litter, so is less likely to damage plants. The off-farm removal of poultry litter as compost is an environmentally sound method of removing excess nutrients from many land limited operations, and can be an important way of protecting our ground and surface waters from the excessive loading of litter nutrients.



Figure 1. The nursery industry, landscapers and construction projects are potential markets for composted poultry litter

What is Compost and Composting?

Understanding the basic scientific principles and processes involved in composting is key to successfully producing high quality compost. Compost is the uniform, stable, odorless, soil-like product of a natural, biological process known as composting. The objective of composting is to encourage the growth of the naturally occurring, aerobic (oxygen-requiring) microorganisms in the poultry litter. In the presence of **oxygen** and **water**, microorganisms *feed* on the poultry litter. Some of the organic compounds in the litter are broken down into nutrients and become part of the growing microorganisms. When the microorganisms die, the nutrients are recycled again. Composting changes the physical and chemical characteristics of the original organic material. The more resistant organic compounds remain and combine with the microorganisms to form a humus-like material called compost.

As with other agricultural activities, poor management will result in a poor quality end product. The microorganisms involved in composting require balanced sources of organic materials, oxygen and water to produce compost.

An unbalanced source of organic materials, not enough oxygen, or too much or too little water can result in the production of foul odors and other undesirable compounds that can inhibit plant growth and result in an inferior compost product.

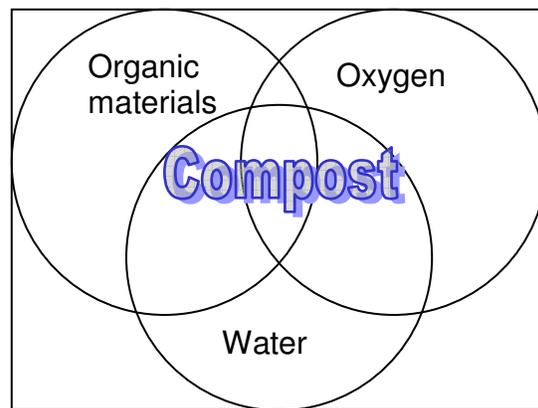


Figure 2. Management is the key to successful composting

In order to successfully compost poultry litter a suitable *recipe* must be developed to ensure a proper balance of organic materials for the microorganisms. Correct management of the composting litter will ensure adequate oxygen and water levels. After the initial composting stage, a 4- to 6-week curing stage is required to further stabilize the product and ensure no adverse reactions with the consumer. Compost that has not cured sufficiently can be highly odorous and can damage plants.

Good quality compost is a valuable soil conditioner. Compost improves soil quality by adding organic matter, nutrients and beneficial microorganisms. The addition of organic matter to many soils will improve the physical properties including structure, porosity, density, and water and nutrient holding capacity. The addition of a large number of different beneficial microorganism species and micro-arthropods contained in compost will benefit badly degraded or heavily eroded soils common in construction sites and highway projects.

Table 1. Recommended conditions for rapid composting¹.

| Conditions for Rapid Composting | Reasonable range | Preferred range |
|--|-------------------------|-------------------------|
| Carbon to nitrogen ratio | 20:1 - 40:1 | 25:1 - 30:1 |
| Water content | 40 - 65% | 50 - 60% |
| Oxygen concentration | 5% | 5 - 15 % |
| Particle size (diameter) | 1/8 - 1/2 inch | Depends on the material |
| pH | 5.5 - 9.0 | 6.5 - 8.0 |
| Temperature | 110 – 150 °F | 130 – 140 °F |

Types of Organic Materials

Organic materials including poultry litter, contain the carbon, nitrogen, phosphorus, potassium and other nutrients needed by microorganisms to grow and reproduce. In order to maximize the rate of composting of poultry litter there has to be an optimum balance between the **carbon** and **nitrogen** content, or **C: N ratio**, of the organic materials. Most organisms (including people) need about 25 to 30 times more carbon than nitrogen.

The C:N ratio of litter will vary with the type and quantity of litter materials used, the number of grow-outs produced on each batch of litter and any nitrogen losses (ammonia volatilization) from the litter during grow-outs. Most poultry litters have a C:N ratio of between 6:1 to 25:1. Poultry litter with a C:N ratio of 25:1 to 30:1 is ideal for composting. Litter with a lower ratio should be blended or co-composted with materials such as sawdust, wood chips, and leaves that have a higher C:N ratio.



Figure 3. Litter with a C:N ratio of less than 25:1 should be co-composted with carbon rich materials, such as wood chips

The C:N ratio of poultry litter can be determined from analysis at a commercial laboratory. Alternatively, a suitable composting recipe can be determined by on-farm experimentation.

¹ From: On Farm Composting, by R. Rynk, M. van de Kamp, G.B. Wilson, M.E. Singley, T.L. Richard, J.J. Kolega, F.R. Gouin, L. Laliberty, Jr., D. Kay, D.W. Murphy, H.A. J. Hoitink, and W.F. Brinton, 1992, Northeast Regional Agricultural Engineering Service, Ithaca, N.Y.

Water

Water is life. During composting water provides the medium for chemical reactions to take place, for nutrients to be transported and for the microorganisms to move. If there is too little water the compost process will slow down and stop. With too much water in a compost pile, the supply of oxygen becomes limited. This restricts the activity of the microorganisms that need oxygen, and less desirable microorganisms will dominate.

The optimum moisture content for composting is between **50 and 60%**. This can be estimated by squeezing a quantity of the organic material. If water can be squeezed out then it is too wet. If you can *almost* get one drop of water out of the material then it should be close to ideal. Other more sophisticated moisture measurement methods include oven drying a pre-weighed sample then re-weighing it, or the use of moisture meters.



Figure 4. Most poultry litter in Tennessee is too dry to compost

A recent survey in Tennessee has shown the moisture content of most poultry litters to be between 20 and 35 %, with an average moisture content of about **27 %**. This means that water must be added to poultry litter removed from the house, before composting can begin. During composting the moisture content should be monitored and if necessary, corrected, every one to two weeks.

Lack of water can be a major problem for composting poultry operations. If the composting process stops because of a lack of water, inexperienced operators may mistakenly think the material has cured. The addition of water to a partially composted pile that is allowed to dry out, will stimulate more composting, but can result in an odorous product, that could even be harmful to plants.

Oxygen

Composting is an aerobic process. Air (containing about 20 % oxygen) passes via pore spaces into the compost pile to supply the composting microorganisms with the oxygen needed for respiration. During respiration, the oxygen content of the air pores will fall and the carbon dioxide level will increase. When the oxygen content falls below 15 %, the risk of foul odors and the production of undesirable compounds increases rapidly and the pile can quickly become anaerobic. In some compost piles, such a drop in oxygen levels has been recorded within an hour of aerating the pile by turning.

Aeration and management of the oxygen levels in a compost pile are critical aspects of managing a compost pile. This can be achieved by regular turning of a pile, mixing the litter with bulking materials such as wood chips to improve porosity or by installing pipes to passively or actively force air through the pile.

Temperature

When provided with a balanced source of organic materials, oxygen and water, microorganisms will quickly be stimulated to use the most readily available, most readily degradable organic compounds. Metabolism and growth will be rapid, and will result in a rapid increase in **temperature**. Temperature of the compost pile is a simple and excellent indicator of how well the composting process is progressing and how much oxygen is being used.



Figure 5. Compost can be produced within 3 to 4 months

The temperature of the pile should be monitored daily to ensure that the pile is maintained within the 110 to 150°F or *thermophilic* temperature range during the first 30 days. This is the temperature range at which most pathogens, weed seeds and fly larvae are killed. If the compost fails to reach 110°F the C:N ratio of the organic materials may not be ideal. If the compost falls below 110°F anaerobic or dry conditions may be developing, or active composting may be slowing. Temperatures above 150°F will kill some of the beneficial microorganisms and should be avoided by turning and watering the pile immediately.

After the initial thermophilic temperatures, the temperature of the pile or windrow will cool down to between 50 and 105°F or *mesophilic* temperature range. When most of the readily available nutrients have been used by the microorganisms and only the more resistant organic materials remain, the *active* compost process is completed. At this time biological activity will slow to more or less constant levels. This stage will become evident when aerating or turning the pile has no effect on temperature. Once this stage is reached, after 2 to 3 months, an additional 4 to 6 week curing stage is recommended to further stabilize the product and ensure no adverse reactions with the consumer.

Compost Quality Control

Quality control in on-farm composting operations is an important factor in ensuring that a quality, consistent product is available for your market. Consistency will be maintained if organic materials from the same or similar

sources are composted using the same composting methods. With experience, an on-farm compost operator will learn how long it takes to initially compost then cure the product.

Sampling and Analysis

Use of the information collected from an analysis of compost will only be useful if the sample is representative of the whole compost batch. Samples should be obtained from the pile in an area that has been composted for the same time. Several samples should be collected at different locations 6 to 12 inches below the surface of the pile about one third of the height from the top of the pile. All the samples should be well mixed together before taking a composite sample and half filling a clear sandwich size plastic bag.

Some state laboratories as well as some commercial companies offer different laboratory tests on compost to assess the maturity, stability, as well as the nutrient, salt and heavy metal contents content of compost.

Site Considerations

The selection of an appropriate composting site on your farm is important. The location should be selected to adequately manage the anticipated volume of litter to be composted and cured, be large enough to maneuver equipment throughout the year and limit environmental risk from odor and runoff.

On some sites surface runoff and pollution control measures may be required. Your local Natural Resources Conservation Service (NRCS) office can offer assistance with site planning, including soils information and drainage control.

Compost Regulations in Tennessee

The Tennessee Department of Environment and Conservation (TDEC) Division of Solid Waste Management has the authority to regulate commercial compost operations in Tennessee. No permits are required for on-farm composting operations where the compost is considered to be part of *normal farming operations* and used on the same farm as part of *agronomic or horticultural operations*. Under the current TDEC Solid Waste Processing and Disposal Rules (Chapter 1200-1-7) all other composting facilities require a permit from TDEC.

Additionally, *unprotected* broiler litter in Tennessee is regulated under the Concentrated Animal Feeding Operations (CAFO) Class 1 permit, if the operation has 30,001 or more broiler or layer operations **with** a liquid manure management system. Under current CAFO regulations, an operation storing litter outside, unprotected and exposed for more than 5 days are considered to be a liquid manure management system.

Composting Methods

There are several methods by which compost can be made. Composting methods range from fairly simple **windrows** or **static plies**, to more sophisticated and capital intensive systems designed to improve aeration in these systems and in-vessel systems used by specialty compost operations. With good management, the end products from different methods can be of a similar high quality.

The key to successful commercial compost operations is good **management** combined with good **marketing**. Without good management you are unlikely to have the quality, consistent product demanded by the market place. Without a good marketing strategy and identified target clientele it is unlikely that your operation will succeed economically. Ultimately, the decision whether or not to invest capital in composting equipment will depend on the scale of the operation as well as considerations regarding how intensively you need to manage the compost to maintain quality and consistency of the product.

Poultry producers interested in starting on-farm composting would be advised to use equipment that they already have in their current farming operations and materials that available locally at little or no cost. At a minimum a front-end loader would be recommended to build and turn the compost pile or windrow. Suitable bulking agents can often be supplied from a variety of sources at little or no cost.

Windrow Composting

In windrow composting, poultry litter is placed in long windrows that are agitated or turned on a regular basis. The optimum height and width of these windrows will depend on the type of equipment used to turn them. Windrows can either be turned using bucket loaders or specialty windrow-turning machines.

Depending on the bucket loader, a width of 10 to 20 feet and height of 6 to 12 feet is possible. Most specialty windrow-turning machines require a height of between 3 and 9 feet (Figure 6).



Figure 6. Turning a windrow- with a tractor mounted windrow turner

The frequency of the windrow turning will depend on factors such as the type of materials being composted and the porosity of the windrow. In most situations, windrows should be aerated on a weekly to two-week cycles depending on the temperature and moisture conditions in the compost.

Static Pile Composting

Simply placing manure in piles, without blending with a bulking material or a method of aeration will encourage anaerobic conditions and will result in a poor quality, unfinished compost material even after several months. Litter piles need to be properly sized and managed to ensure successful composting. This will include:

1. Building the pile small enough to allow passive air movement: less than 6 feet high and 12 feet wide
2. Ensuring the mixture is porous enough to allow air penetration
3. Periodic mixing to rebuild and aerate the pile
4. Periodic monitoring and correcting of the moisture content of the pile

This type of system requires minimal labor but composting is relatively slow and there is a potential for odor problems.

This type of system is recommended for composting relatively small quantities of poultry litter or mortalities. In Tennessee, on-farm composting of poultry mortalities is recommended using constructed bins (see the University of Tennessee, Agricultural Extension Publication PB 1445, Dead Poultry Composting). A base of poultry litter is covered with a layer of straw in the primary composting bin. A layer of dead poultry is laid on top of the straw layer, then covered with another layer of litter and straw. After 7 to 14 days in the primary bin the compost is moved (and aerated in the process) to a secondary bin for a further 10 to 14 days to complete the process.



Figure 7. On-farm composting of poultry mortalities is recommended using constructed bins

Passively Aerated Windrows or Static Piles

Passively aerated systems are designed to eliminate the need for physical turning. Aeration is achieved through perforated plastic pipes embedded at 12- to 18- inch intervals in the base of each windrow. Air is drawn into the pipes from outside the pile and is forced through the pile from the chimney effect created by the hot gases escaping from the windrow.

The size of these windrows is similar to other windrows. Compared to forced aeration systems, there is a much greater risk of odors using this type of system. Odors are reduced by covering the base and the outside of the windrows with at least a 6 inch cover of finished compost.

Forced Aeration

This method is similar to the passively aerated method, but involves air being forced through the pile from the base through a system of pipes. This can speed up the whole compost process to around 30 days, but can increase the expense involved in operating the facility.

Due to the capital-intensive nature of the equipment used in this type of composting, this system is more commonly found in commercial composting operations.

Points to Remember

Composting is a simple, natural, aerobic process that produces a uniform, stable, odorless soil-like material called **compost**

Poultry litter will produce a high quality, compost within 3 to 4 months if the:

- **Nitrogen to carbon** ratio of the litter is between 25 to 30:1.
- **Moisture** content is maintained around 50 %.
- Litter is adequately **aerated**.

Mismanagement can result in a poor quality, odorous, even harmful product.

Good **management** and **marketing** are key for the success of a compost operation.

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