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On-farm Turkey Carcass Composting and Management Issues Under North Dakota Climatic Conditions

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Turkey mortality is part of a turkey production system. Environmentally safe disposal of turkey carcasses is vital to a farm's biosecurity and for prevention of disease outbreaks. The North Dakota Department of Health prefers burning, burial, landfilling, rendering or composting of carcasses as part of normal carcass management.

During any disease outbreak, burning, incineration or rendering is recommended. However, on-farm carcass composting is considered to be a viable disposal option in the U.S. and around the world due to biosecurity issues. Although a number of studies in the U.S. have shown that composting animal carcasses is viable, questions remain about whether the colder temperatures of North Dakota and locally available co-composting material would prohibit animal carcass composting as a viable disposal option. The climate in North Dakota is very unique: Summer months are hot, winter months are very cold and rainfall amount is moderate with periods of drought.

In turkey carcass composting, turkey litter typically is used as the co-composting material. The composition of turkey litter varies depending on bedding materials. Bedding materials typically are selected based upon their local availability. For example, in Iowa, oat hulls typically are used, and in Minnesota, wood shavings are used as bedding for turkey production. In North Dakota, sunflower hulls typically are used for bedding in turkey production facilities.

This publication focuses on typical on-farm turkey carcass composting under North Dakota climatic conditions and management practices.

Composting Bin and Compost Pile Preparation

Construction of composting bins and storage areas can take many forms, depending on the farm-specific conditions and regulatory requirements. However, a roof with an impervious foundation, such as concrete or a compacted clay layer, is a typical composting facility. The roof prevents rainwater from reaching the compost and prevents runoff from the compost leaching into ground or surface water. Typically, a static pile is prepared using a front-end loader or skid-steer (Figure 1).

Turkey carcasses alone cannot be composted; they need to maintain a proper carbon-to-nitrogen (C-to-N) ratio (25-to-1 to 30-to-1), a pile moisture content of 40 to 60 percent, aeration and thermophilic (in excess of 105 degrees Fahrenheit) conditions. Knowing the C and N content and

Figure 1. Composting bins and compost pile preparation using a skid-steer loader.

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moisture content of the co-composting material in advance is important to facilitate optimum conditions during carcass composting process. Usually, 12 to about 18 inches of turkey litter is used as a base layer; thereafter, carcasses are placed on top of the base layer and covered with another layer (12 inches) of turkey litter (Figure 2a).

Pile temperature during the composting process is a good indicator of whether composting is progressing or has stopped. Monitoring pile temperatures in several piles from the beginning to the end of a composting process might be very useful for determining pile temperature trends. Once producers have a good idea of pile temperature generation and temperature declination trends, they can follow a schedule for maintenance.

Many options are available to monitor pile temperature. A temperature probe with a long stem is one of the easiest ways to check pile temperature. However, to monitor pile temperature continuously, HOBO Pro V2 T/RH sensors (Onset Computer Corp., Bourne, Mass.) can be placed at predetermined depths and locations (bottom, center and top of a pile) in a compost pile at day one to record temperature changes during the composting process (Figure 2b).

Turning the compost pile from time to time to facilitate aeration, provide proper mixing and sustain a high temperature (greater than 131 degrees Fahrenheit) during composting also is important. Turning is needed when the pile temperature is either too high (greater than 160 degrees Fahrenheit) or too low (less than 90 degrees Fahrenheit). However, frequent turning of the compost pile may cause compost pile moisture loses, and it may hinder carcass degradation, especially when the pile moisture content is lower than the recommended moisture content (40 to 65 percent).

Typically, a front-end loader or skid-steer is used due to its availability, mobility and flexibility. Turning frequency can be varied depending on animal types, pile temperature and pile moisture content. Once producers have a clear idea about pile temperature declining trends, provided other conditions are satisfactory, pile turning may be initiated. After several composting events, producer will have a good idea when they need to turn piles.

Monitoring the Compost

During the composting process, compost samples need to be collected and analyzed for pile moisture content, nutrients, carbon, pH, conductivity and maturity. These parameters are important indicators of compost. The typical compost pile moisture content in an on-farm turkey carcass composting facility ranges from 35.6 to 46.9 percent at day zero, which is either low or within the lower limit of the recommended moisture range (that is, 40 to 65 percent).

(a)

(b)

Figure 2. a) Static compost pile preparation and b) installed HOBO Pro V2 T/RH sensors.

Moisture content during composting is an important environmental factor. It provides a medium for the transport of nutrients required by microorganisms for their metabolic and physiological activities (Ahn et al., 2008; Liang et al., 2003). Low moisture content (less than 40 percent) can slow the biological process of composting. As a result, microbial activities affecting the composting process will require more time for complete degradation of carcasses.

In North Dakota, typically sunflower hull-based turkey litter is used as co-compost. Sunflower hulls are composed of cellulose and hemicelluloses embedded in a lignin matrix. Degradation of high-molecular organic compounds is highly dependent on the availability of water and oxygen (Conghos et al., 2006). The incomplete sunflower hull degradation likely will happen due to low moisture and high lignin content. A producer could address the incomplete degradation issue by using the remnants of one compost pile to prepare a new pile. This would provide enough time to degrade the remaining sunflower hulls and produce a better compost end-product. Additional moisture likely would increase degradation of sunflower hulls, which would decrease the time needed for carcass degradation, produce higher heat and increase pathogen destruction.

To estimate compost moisture content, producers can perform a "squeeze test" in which they can grab a handful of compost from the center of a pile, form a fist and squeeze the compost into a ball. If the material stays together as the fist is released, rather than falling apart, and if very little or no water drips from the ball, the moisture content is 40 to 50 percent or more. If the compost material does not form a ball, then the pile moisture content is less than 40 to 50 percent. If the material is very moist and water drips heavily when squeezed, the moisture content is above 60 percent. Therefore, beginning a compost pile with

optimum moisture content to expedite the carcass composting process and to obtain a high-quality compost product is important.

Compost Pile Temperature and Turning

The temperature in a compost pile will rise soon after the pile is prepared. Peak temperature will be reached within 48 hours of pile preparation, and this temperature will be sustained for some time before the temperature begins to drop. To kill most pathogenic agents (bacteria, viruses and parasites), the co-compost material should sustain a pile's internal temperature of 131 degrees Fahrenheit or greater for at least three consecutive days. This on-farm carcass composting process demonstrates that sunflower hull-based turkey litter is able to reach a sustained temperature of 131 degrees Fahrenheit or greater and maintain that temperature for more than three days, which would ensure the maximum pathogen kill.

Pile turning is necessary to facilitate aerobic conditions in the pile and to facilitate reaching the high pile temperature needed for carcass decomposition. When the temperature drops, either the oxygen level drops or the pile moisture content is too high. Turning will ensure an oxygen supply and mixing of composting materials, as well as reduce the moisture content in the pile and generate greater heat in an active composting pile. Typically, the more moisture in the pile, the more turning is required. However, if the pile moisture content is low, less turning is better.

C-to-N Ratio and Nutrients

Carbon (C) and nitrogen (N) are the primary nutrients required by the microorganism involved in composting. Ideally, a carbon-to-nitrogen ratio between 25-to-1 and 30-to-1 is required for proper composting. A C-to-N ratio lower than 25-to-1 will result in excess nitrogen losses through ammonia volatilization, whereas a C-to-N ratio in excess of 30-to1 will result in greater composting time. If C-to-N ratios of co-composting material are lower than the recommended range, additional carbon sources may need to be added to raise the C-to-N ratio to recommended ratios. Carcass compost end products are rich in nutrients and can be used as a nutrient source for crops.

pH and Electrical Conductivity

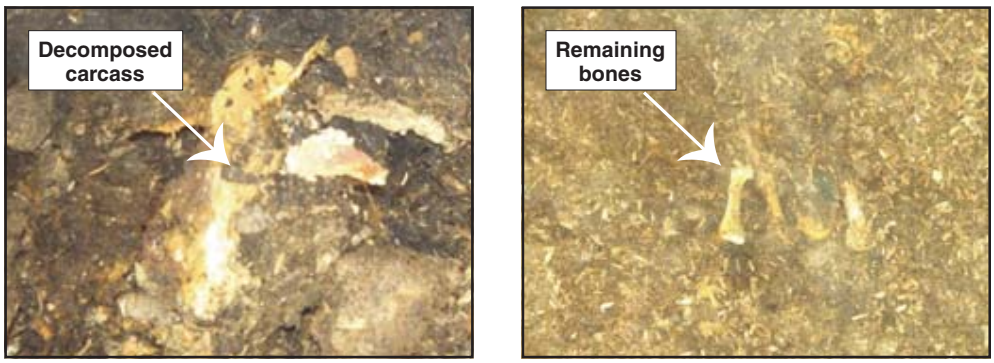
Typically, finished compost is applied to crops. Alkalinity or acidity values (pH) and electrical conductivity (EC) are two important parameters producers need to know when compost will be used as an organic amendment to soil. Typical pH values observed in an on-farm turkey compost pile in North Dakota were between 8.12 and 8.61.

The EC value of the final compost is of great importance from a cropland point of view because it can be a limiting factor for plant growth and seed germination (Banegas et al., 2007). Typical EC values in compost samples measured ranges from 5.23 to 7.42 microSiemens per centimeter (mS/cm) in North Dakota. An EC value less than 8 deciSiemens per meter (dS/m) or 8 mS/cm is considered detrimental for plant growth and seed germination, and EC values greater than 4 mS/cm are an indication of phytotoxicity when compost will be used as a growing substrate (Francou et al., 2005). Higher proportions of a carbon source (sunflower hulls, straw) could be used during composting to reduce the EC values (Banegas et al., 2007).

Visual Observation of Carcass Degradation

Bones in carcass composting are a concern, especially when finished compost is applied to soil as a growing substrate because bones can interfere with tillage and planting equipment. Bone disappearance depends on the livestock and poultry carcass sizes. For a large animal (such as cattle), the bones might not disappear for years; for smaller animals, bone disappearance may take less time.

An on-farm turkey carcass demonstration in North Dakota revealed that following the first turning at seven to 10 days, soft tissues started to decompose (Figure 3a). Following the second turning at 20 to 21 days, decomposed tissues were separated from bones, but following the third turning in 41 to 42 days, minimal tissues were noticed and large bones were visible (Figure 3b). Since moisture content and C-to-N ratios were low, additional moisture and C-to-N ratios in the compost pile would enhance the decomposition process. Also, recommended compost pile moisture content may expedite bone degradation (Murphy et al., 2004; Stanford et al., 2009).



(a) (b)

Figure 3. a) Status of carcass following first turn at seven to 10 days and b) remaining bones at the end of the composting trial at 42 to 65 days.

Compost Maturity

Physically, composting is complete when the pile temperature declines and reaches the ambient temperature and the temperature remains below approximately 105 degrees Fahrenheit, even after pile turning. Other analytical methods can be used to measure compost maturity, but special skills are needed. However, the Solvita® CO_2 and Solvita® NH_3 test kits have been used as an indication of compost maturity. They are easy to use, and this test can be done at any stage in the composting process, but testing at a later stage of composting process, especially during the curing stage, is especially important. Maturity index numbers of 1 to 2 indicate "raw" compost, 3 to 6 indicate "active" compost and 7 to 8 indicate "finished" compost.

Compost curing does not begin or end at a specific time. However, when the pile temperature no longer reheats after turning, the curing stage begins. Typically, a curing period of two to six months is required for the compost to mature, after which it will not overheat or produce unpleasant odors during storage and can be used beneficially.

Summary

Although a number of studies in the U.S. have shown that composting animal carcasses is viable, questions remain about whether the colder temperatures of North Dakota and locally available co-composting material would prohibit animal carcass composting as a viable disposal option.

On-farm composting in North Dakota showed that colder temperatures may lengthen the composting process, but the process still is viable. Locally available sunflower hull-based turkey litter was able to sustain a temperature of 131 degrees Fahrenheit that is required to kill most pathogens. However, managing the moisture content in the compost is very important, especially when nontraditional carbon additives such as sunflower hulls are used in combination with turkey litter.

The resulting compost would be a valuable and useful nutrient source for crops. Composting is complete when the pile temperature declines and reaches ambient temperature, even after pile turning. The Solvita® maturity test kits can be used as a low-cost compost maturity indicator for quality control purposes in field application by farmers.

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