INTRODUCTION

In the event of catastrophic avian mortality, such as in the case of avian influenza, the disposal of the carcasses needs to be accomplished quickly, environmentally safe and in such a way as to reduce the chance of spreading the disease. This guidance document will discuss the process of composting and its advantages when dealing with catastrophic loss.

COMPOSTING

Composting is the natural degradation of organic material by microorganisms. The process occurs faster and without objectionable odors in an aerobic (oxygen) environment. The microorganisms metabolize (breakdown) the organic material using water, oxygen and nutrients. The process produces heat and compost (a useable product) while releasing water vapor and carbon dioxide.

The main elements used in the composting process are nitrogen, oxygen, and carbon. The ratio of carbon to nitrogen in the material to be composted determines how fast and how completely the organic material degrades. The optimum ratio of carbon to nitrogen (C:N) is 25-40 parts carbon to 1 part nitrogen (25-40:1). However, composting can occur at ratios as low as 10:1 to as high as 100:1. At lower C:N ratios, there may be too much nitrogen, which can lead to the release of excess nitrogen in the form of ammonia and objectionable odors. At high C:N ratios there may not be enough nitrogen. This can lead to incomplete breakdown of organic material and inadequate heating. Oxygen is important because most favorable microbial activity is aerobic. Aerobic microbes breakdown organic material and produce only water, carbon dioxide and heat. Anaerobic microbes produce little heat and generate materials such as hydrogen sulfide and organic acids which have objectionable odors.

The other essential element in the composting process is water. Microorganisms need water to facilitate their chemical reactions (which break down the organic material), to transport the nutrients they need and to allow them to move about. Optimum moisture content in composting is between 40 -60%. Below 40%, the microbial activity can be restricted causing an inadequate heating of the pile. This results in slow or incomplete organic material breakdown. Above 60%, the excess water can restrict oxygen flow through the pile. Without adequate oxygen flow, microbial processes can become anaerobic. This can results in objectionable odors, inadequate pile heating, and can lead to incomplete breakdown of organic material.

Adequate heating is the most important indicator of pile activity. The warmer the pile, the faster the microbial processes occur. This heating is very important in inactivating diseases such as avian influenza. Temperatures in a compost pile should reach between 130ºF to 150ºF for 10 to 14 days. These temperatures inactivate many disease causing organisms, including avian influenza. Researchers in Maryland, Delaware, and North Carolina have shown that composting can effectively kill a variety of disease causing organisms including avian influenza (2). Temperatures of 132ºF for 3 hours or 140ºF or more for 30 minutes have also been shown to inactivate the avian influenza virus (4).
WHY COMPOST?

There are several options for catastrophic avian carcass disposal. Options include on-site burial, incineration, landfill disposal, rendering and composting. On-site burial has the potential for causing ground water pollution where ground water is shallow. Incineration is costly, requires additional material for burning, can cause air pollution, may require permitting and can be objectionable to the public. Landfilling and rendering require transport off-site, possibly enhancing the spread of disease. They also can be objectionable to the public. The USEPA and the USDA also prefers on-site management of the birds to minimize the spread of the AI virus by transportation (6,7).

Composting can be done on-site, which can limit off farm disease transmission. It also limits the risk of ground water and air pollution, requires a minimal amount of equipment (low cost) and can result in a usable product. In addition, composting is more acceptable to the public (2,3,4)

OBJECTIVES

There are two objectives with composting catastrophic avian losses. The first and primary objective is to inactivate the disease causing organism through the first heating cycle of the composting process. The second objective is to provide a usable product following complete composting. Although these two objectives work together, in many instances there isn’t enough available carbon at the beginning of composting to complete the composting process and provide a usable product at the end. Composting can still be used to inactivate the disease causing organism, and additional carbon material could be added later to finish the compost. The following describes the complete composting method.

COMPOSTING METHOD

The best method to compost catastrophic avian losses is to place the carcasses in a windrow with existing litter and additional carbon material if necessary. The windrow(s) can be constructed by layering the carcasses alternately with existing litter or carbon material OR by mixing the carcasses with the litter/carbon material and piling the mixture (2,3). Both methods will need the following equipment and supplies:

- Skid steer loader(s), tiller attachment, pallet or hay fork, and shovels
- litter, sawdust, woodchips, or other carbon material if available
- 1 long stemmed Compost thermometer: if composting in-house use one/house
- Power washer, disinfecting equipment and recommended disinfectants for decontaminating all equipment following use.
- Manure spreader to spread finished compost.

The windrow can be constructed in-house (preferred) or outside. If the windrow is constructed outside, additional base and covering material will be needed. The base and covering is necessary to prevent runoff from the pile and to protect the pile from excess moisture during precipitation events or prevent the pile from losing moisture during dry spells.

The following are some general guidelines for constructing a windrow compost pile.

**Determine composting needs**
The first step in building a windrow is to determine the amount of material available for composting. This is done by:

1. Determining the depth of litter in the house along with the barn dimensions to determine the amount of litter available for composting.
2. Determining the number of carcasses and their approximate average weight to determine the amount of poultry needing composting.

These amounts are then used to determine the C:N ratio of the mixture. The optimum C:N ratio is from 15-30:1. That is 15-30 parts carbon to 1 part nitrogen. The optimum moisture should be between 40-60%.

The Windrow dimensions, exact C:N ratios and moisture % can be determined from the MDA Excel spreadsheet ‘Poultrycompostcalculator2.xls’ or use the alternative calculations supplied in Attachment A.

**NOTE:** Composting is a forgiving process, exact ratios and moisture percentages are not needed. If values are within 10% of the suggested values, no changes to the construction are needed.

**Setting up the windrow (all appropriate personal protective equipment (PPE) must be used)**

1. If the existing litter is compacted, scrape or till the litter in the house to ‘fluff’ the litter. This will help with aeration in the compost pile. If additional organic material or water is needed to compost (determined in the MDA spreadsheet or calculations), mix it with the existing litter at this time. If no additional material is available, proceed through the first heat cycle of composting to inactivate disease causing organisms.
2. Place a 6-12 inch base layer of litter/organic material or other organic material for the base. The base should be 12 feet wide and is used to help insulate the pile and absorb any liquids generated during composting.
3. Build the windrow in workable sections (no longer than the equipment can reach), completing one section before starting the next.
4. Although water is important to the composting process, it is better to error on the dry side than to have too much water.
5. Regardless of which windrow system is used (layered or mixed) the carcasses should be covered (capped) with at least 6-8 inches of litter or organic material on the top and sides of the windrow. This will prevent objectionable odors, flies and will help insulate the pile during cold weather.

**Layered windrow** (Figure 1)

a) Place a layer of carcasses on top of the litter base. Any remaining feed, eggs, or other material should also be placed on top of the birds. Avoid overlapping the carcasses. Leave 6 inches of space along the edges of the windrow.

b) A layer of litter/organic material should be placed on top of the poultry layer. There should be enough litter to completely cover the carcasses. This litter layer should be followed by another layer of carcasses and the layers should be repeated until there...
are at least 3-4 layers of carcasses with a final layer of litter. There must be at least 3 layers of carcasses in order for the pile to heat effectively. The thickness of this layer can be determined using the MDA spreadsheet ‘Poultrycompostcalculator2.xls.’

c) Cap the windrow with 4-8 inches of litter/organic material. Enough litter/organic material should be used to ensure no bird parts are exposed.

**Mixed windrow**

a) Mix the carcasses and litter together along with any additional carbon source and water with the bobcat or skid steer.

b) Place the mixture on top of the 6-12 inch base litter or carbon source. The windrow should be 4-6 feet high and 12 feet wide (or to the capacity of the equipment or building). Remember to leave at least 6 inches of space along the edge of the windrow for the cap. The windrow must be at least 4 feet high to get effective composting. The base layer can be reduced if composting inside.

c) Construct the windrow in sections, capping each section with 6-8 inches of litter or carbon source. NO bird parts should be exposed.

d) Continue this process until all of the bird/litter mix has been added to the windrow.

e) Any remaining litter/organic material should be used to cap the windrow.

**Temperature Monitoring**

1. Divide the windrow into 25-50 foot intervals for temperature monitoring.

2. Using the long stemmed compost thermometer, take the windrow temperature in several places at the 25-50 foot intervals. The temperature should be taken at the top, middle and bottom of the pile.

3. The thermometer should be in contact with a carcass.

4. Chart the temperatures of the windrow daily and note if any parts of the pile do not heat (Figure 2).

5. Windrow temperatures should reach at least 130º F within the first week and remain high for at least 10 to 14 days. If temperatures do not rise or drop too quickly, check the trouble shooting guide and adjust the windrow as needed. Remember to follow all appropriate PPE while monitoring the pile in the first stages. In addition, all equipment used in the building should remain there and/or be decontaminated prior to removal.

**TURNING THE PILE**

1. Following the initial 10-14 day heat cycle, the temperature within the pile will drop. Once it drops below 125 º F, the pile will need to be turned to re-aerate it. At this point the AI virus should be inactivated but the compost is not yet complete and suitable for land application. MN testing requirements?

2. The pile can be re-constructed outside at this point. If possible/available use new organic material to construct a new windrow base. The organic carbon base material helps insulate the pile, especially outside and in cold temperatures.
3. Turning is accomplished by simply moving the pile, beginning at the bottom and sides, to the new location with a bobcat or front end loader. If additional carbon material is needed to finish the compost, add and mix in the material at this point.

4. The pile should be evaluated for moisture while turning the pile. If after squeezing a handful of the material, water runs out, then the pile is too wet and additional carbon material should be added to absorb the excess water. If the material is too dry, it will be powdery and not leave any trace of water when squeezed. Water should then be added to the pile. The most effective way to add water to the pile is to spray water on the material while the pile is being turned. Alternatively, water can be added with a soaker hose placed on top of the pile following pile completion.

5. The material should be lifted and dropped into place, not just pushed to allow for maximum aeration. At this stage, carcasses should be reduced to bones and feathers.

6. Another 4-6 inch cap of litter or organic material should be placed on top of the pile to cover it and help insulate it. If the pile is constructed outside, a cover should be placed on top of the pile to prevent precipitation runoff and runon.

FINISHING THE COMPOST

After turning the pile, the temperature of the windrow should again rise and equal or exceed the previous temperature peaks. After another 3-4 weeks, the composting process should be done. If any visible soft flesh is left, re-turn the compost pile and allow another heating cycle to occur. If all material is broken down, the material can be landspread. A sample should be collected and submitted for nutrient analysis prior to landspreading and the nutrients should be included in the fields’ credits. Once the State Veterinarian releases the material from quarantine, the compost may be land applied using a manure spreader (?MN requirements/testing?).
## TROUBLESHOOTING

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive flies or decaying odor</td>
<td>Exposed carcasses</td>
<td>Cover all exposed carcasses with additional organic material</td>
</tr>
<tr>
<td>Decaying odor</td>
<td>Excess water</td>
<td>Add additional carbon material, mix and cap</td>
</tr>
<tr>
<td>Ammonia odor</td>
<td>Excess nitrogen or water</td>
<td>Add additional carbon material, mix and cap. If water is not in excess, wait until temperature peaks before adding carbon material</td>
</tr>
<tr>
<td>Leachate from windrow</td>
<td>Inadequate base thickness, mixture too wet</td>
<td>Add additional carbon material, mix and cap. Contain all leachate with additional absorbent carbon material and place back in pile.</td>
</tr>
<tr>
<td>Temperature does not reach 130 ºF</td>
<td>Excess water OR inadequate water</td>
<td>If excess water, add additional carbon material to the pile, mix and rebuild. If inadequate water, add water to the pile with a soaker hose.</td>
</tr>
<tr>
<td>Temperature peaks and drops prior to reaching 130 ºF</td>
<td>Not enough oxygen flow in pile</td>
<td>Aerate* the pile or re-mix</td>
</tr>
</tbody>
</table>

### *AERATING THE WINDROW*

If the windrow temperature peaks and drops prior to reaching 130°F, the pile should be slowly forked and lifted with a hay or pallet fork along the entire length of the pile. The forking method does not disturb the cap and allows oxygen into the pile. If the temperature still does not increase, evaluate the moisture, carbon and nitrogen conditions of the pile and adjust as needed.

### SUGGESTED SUPPLEMENTAL ORGANIC MATERIAL

If the C:N ratio of the poultry litter and carcasses is too low (<15:1) then additional carbon material may need to be added to finish the compost. Suggested supplemental carbon material can include:

- Unused Litter
- Sawdust or fine wood chips
- Corn stalks
- Hay
- Straw

### WINTER COMPOSTING

Although the Minnesota winter does pose some challenges to composting, composting can proceed in the winter. The main problem with winter composting is temperature. Frigid temperatures can greatly decrease a compost piles temperature, preventing the inactivation of viruses. However, a properly constructed compost pile can still achieve the desired temperature if the following is kept in mind:

- Do not use cold or frozen carcasses to build a pile. This will just freeze the pile and no composting will occur.
- Do not turn or build the pile on a very cold day without heating the windrow building area. This will inactivate or greatly delay the microbial process.
- Increase the pile height if constructing in the winter. This will decrease the length of the pile needed but the additional height will help insulate the pile.
- Increase the thickness of the base and cap of the pile in the winter to help insulate the pile. Straw and Hay can be used to help insulate the pile at the base, top and sides if available.
- Use fleece or other insulating material to cover an outside pile (figure 3). This will help insulate the pile and prevent the pile from going cold.
Figure 1: Layered Windrow.

Figure 2. Temperature Log

Figure 3: Fleece Covering
REFERENCES


(8) Calculations adapted from: Moisture and Carbon/Nitrogen Ratio Calculation Spreadsheet, Developed by Tom Richard, Department of Agricultural and Biological Engineering, Cornell University http://compost.css.cornell.edu/science.html
ATTACHMENT A

Calculations were adapted from Moisture and Carbon/Nitrogen Ratio Calculation Spreadsheet, Developed by Tom Richard, Department of Agricultural and Biological Engineering, Cornell University

C:N RATIO CALCULATIONS:

To calculate the C:N ratio of the poultry and litter, you must know:
- the quantity (lbs or kgs) of poultry to be composted,
- the quantity of litter to be composted (cyds or cft) converted to lbs or kgs with the litter bulk density
- the % carbon, % nitrogen, and % moisture values of the poultry and litter (use literature or measured values)
- and the litter bulk density (use literature or measured values)

The following formula (8) will calculate the C:N ratio of the poultry and litter (all values should be in the same measurement system...e.g. pounds or kilograms):

\[
R = \frac{Q_p (C_p \times (100 - M_p) + Q_i (C_i \times (100 - M_i)))}{Q_p (N_p \times (100 - M_p) + Q_i (N_i \times (100 - M_i)))}
\]

in which:
- \(R\) = C:N ratio of poultry and litter
- \(M_p\) = moisture content (%) of poultry
- \(Q_p\) = mass of poultry (lbs or kgs)
- \(Q_i\) = mass of litter (lbs or kgs)
- \(C_p\) = carbon (%) of poultry
- \(C_i\) = carbon (%) of litter
- \(N_p\) = nitrogen (%) of poultry
- \(N_i\) = nitrogen (%) of litter
- \(M_i\) = moisture content (%) of litter

CALCULATING AMOUNTS OF ADDITIONAL CARBON NEEDED:

To calculate the amount of additional carbon material needed to bring the C:N ratio to a desirable ratio (10-50:1) you must know:
- the quantity (lbs or kgs) of poultry to be composted,
- the quantity of litter to be composted (cyds or cft) converted to lbs or kgs with the litter bulk density
- the % carbon, % nitrogen, and % moisture values of the poultry and litter (use literature or measured values)
- the litter bulk density (use literature or measured values)
- and the % carbon, % nitrogen, and % moisture values of the added carbon material

The following formula (8) will calculate how much of the additional carbon material is needed:

\[
Q_c = \frac{R Q_p N_p (100 - M_p) + R Q_i N_i (100 - M_i) - Q_p C_p (100 - M_p) - Q_i C_i (100 - M_i)}{C_c (100 - M_c) - R N_i (100 - M_i)}
\]
CALCULATING % MOISTURE

To calculate the % moisture of the existing compost mixture you must know:

- the quantity (lbs or kgs) of poultry to be composted,
- the quantity of litter to be composted (cyds or cft) converted to lbs or kgs with the litter bulk density
- the % carbon, % nitrogen, and % moisture values of the poultry and litter (use literature or measured values)
- the litter bulk density (use literature or measured values)
- and the % carbon, % nitrogen, and % moisture values of any added carbon material

\[
M_m = \frac{(Q_p \times M_p) + (Q_l \times M_l) + (Q_c \times M_c)}{Q_p + Q_l + Q_c}
\]

Where:

- \(M_m\) = moisture percent of mixture
- \(Q_p\) = mass of poultry (lbs)
- \(M_p\) = moisture (%) of poultry
- \(Q_l\) = mass of litter (lbs)
- \(M_l\) = moisture (%) of litter
- \(Q_c\) = mass of added carbon material (lbs)
- \(M_c\) = moisture (%) of added carbon material

If no additional carbon material is added, delete \(Q_c\) and \(M_c\) from this equation.

IF THE MIXTURES CALCULATED % MOISTURE IS < 40%

Water should be added. To calculate the amount of additional water needed, use the following equation:

\[
\text{water (gallons)} = \frac{(G \times Q_p) + (G \times Q_l) + (G \times Q_c) - (M_p \times Q_p) - (M_l \times Q_l) - (M_c \times Q_c)}{100 - G}
\]

Where:

- \(G\) = moisture goal
- \(Q_p\) = mass of poultry (lbs)
- \(M_p\) = moisture (%) of poultry
- \(Q_l\) = mass of litter (lbs)
- \(M_l\) = moisture (%) of litter
- \(Q_c\) = mass of added carbon material (lbs)
- \(M_c\) = moisture (%) of added carbon material
Needed water can be added to the pile by a hose or other watering system. In a layered windrow add and mix the required amount of water to the litter/organic material prior to building the windrow. Alternatively, the required amount of water can be sprayed on top of each poultry layer. In the mixed windrow, spray the water onto the poultry and litter prior to mixing and placing in the windrow or spray the water on after each lift of mixture is placed in the windrow.

**IF THE MIXTURES CALCULATED % MOISTURE IS > 60%**

Then additional carbon material should be added. To calculate the amount of additional carbon material needed to reduce the % moisture to 40-60% use the desired % moisture and the following equation and solve for $Q_c$:

$$M_m = \frac{(Q_p \times M_p) + (Q_i \times M_i) + (Q_c \times M_c)}{Q_p + Q_i + Q_c}$$

Where:
- $M_m$ = Desired moisture percent of mixture
- $Q_p$ = mass of poultry (lbs)
- $M_p$ = moisture (%) of poultry
- $Q_i$ = mass of litter (lbs)
- $M_l$ = moisture (%) of litter
- $Q_c$ = mass of added carbon material (lbs)
- $M_c$ = moisture (%) of carbon material

Remember that in order to reduce the % moisture of a mixture, you must add a carbon material with a % moisture that is less that the calculated mixture % moisture.